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DEAR READER,

The new issue of the Sport Science journal has arrived. It brings new scientific papers containing new knowledge and values promoted through the research results of our esteemed authors.

Numerous papers are being delivered to the journal, indicating that researchers have recognised our quality and effort to promote new scientific and professional achievements whose results contribute to sport science.

The Editorial Board has selected the papers for the new issue of Sport Science, where quality is a priority and a requirement for publishing. We would like to thank them for their efforts to select the papers which promote scientific thought and contribute to new findings in sport.

This issue contains papers from Indonesia, Italy, Greece, Spain, Russia, Serbia, Croatia, Lebanon, Iraq, Kosovo, Iran, Colombia, Algeria, North Macedonia, and Bosnia and Herzegovina.

Such papers are supported, as they present new knowledge and guide scientific thought towards solutions which open new areas and enrich the existing knowledge with new values.

Sport Science remains a platform for presenting new findings which will contribute to the development of sport science. Promoting the results and achievements represents an obligation for our journal to maintain trust and the quality that will satisfy the needs and expectations of our readers.

That is why we would like to invite the readers to participate in our work so that, together, we could contribute to science and find new solutions for problems in the world of sports.

Nihad Selimović, MD, MSc

Editor in chief



DRAGI ČITATELJU,

Pred Vama je novo izdanje časopisa Sport Science. I ovaj broj donosi naučne radove sa novim saznanjima i vrijednostima promovisanim kroz rezultate istraživanja naših cijenjenih autora.

U redakciju časopisa pristižu brojni radovi što ukazuje da su istraživači prepoznali naš kvalitet i nastojanje da promovišemo nova naučna i stručna dostignuća čiji rezultati doprinose nauci o sportu.

Recenzentski odbor je odabrao radove za novi broj časopisa Sport Science gdje kvalitet predstavlja prioritet i uslov za njihovu objavu. Zahvaljujemo im se na naporima pri odabiru radova koji promovišu naučnu misao i doprinose novim saznanjima u sportu.

U ovom broju objavljujemo radove iz Indonezije, Italije, Grčke, Španije, Rusije, Srbije, Hrvatske, Libana, Iraka, Kosova, Irana, Kolumbije, Alžira, Sjeverne Makedonije i Bosne i Hercegovine.

Takvim radovima dajemo podršku jer nude nova saznanja i usmjeravaju naučne misli prema rješenjima koja otvaraju nove prostore i obogaćuju postojeća znanja novim vrijednostima.

Sport Science ostaje platforma za predstavljanje novih saznanja koja će doprinijeti razvoju nauke o sportu. Promocija rezultata i dostignuća je obaveza našeg časopisa kako bi održao povjerenje i zadržao kvalitet koji će zadovoljiti potrebe i očekivanja naših čitatelja.

Zato pozivamo čitatelje da učestvuju u našem radu kako bismo zajedno doprinijeli nauci i pronašli nova rješenja za pitanja u svijetu sporta.

Mr. sci. dr. Nihad Selimović
Glavni urednik



THE EFFECTS OF AN INTERNET-BASED EXERCISE PROGRAMME OF STRETCHING AND SELF-MYOFASCIAL RELEASE ON CERVICAL ROM AND FUNCTIONAL ABILITY OF WOMEN WITH CHRONIC NECK PAIN

Katerina Daskalaki¹, Christina Koutra¹, Katerina Papadimitriou¹, Paraskevi Malliou¹

1. Department of Physical Education and Sport Sciences, Democritus University of Thrace, D.P.E.S.S, Greece

ABSTRACT

Neck pain (NP) is one of the leading causes of years lived with disability in middle-aged people. Although exercise is recommended as an effective treatment for NP, adherence to it is insufficient even when the programme is prescribed and home-based. A common barrier often mentioned is uncertainty about the correct execution of the exercises when those are prescribed in written form, a problem that could be solved through the use of digital technology. The aim of the present research was to investigate the effects of an internet-based exercise programme of myofascial training that included various types of stretching and self-myofascial release with foam rollers on cervical range of motion (ROM) and functional disability of women with chronic NP. 24 participants were allocated to two groups [Experimental Group (EG) and Control Group (CG)]. EG completed 18 prerecorded training sessions of approximately 30 min each in 6 weeks. As it was shown, the programme was effective in improving cervical ROM in all movements under examination as well as the functional ability of the participants from the EG. According to these results, an internet-based programme of myofascial training may be a feasible alternative for patients with chronic NP.

Keywords: cervical pain, online exercise programmes, foam rollers, myofascial training

INTRODUCTION

Neck pain (NP) is one of the leading causes of years lived with disability in middle-aged people, while

its global prevalence continuously increases (Hurwitz, et al., 2018). Although exercise is recommended as an effective treatment for NP, adherence to it is insufficient even when the programme is prescribed and home-based. A common barrier mentioned is uncertainty about the correct execution of the exercises, especially

when they are based on written instructions (Escobar-Reina et al., 2010). This problem can be solved through the use of digital technology that permits the delivery of exercise videos. However, although there are numerous telehealth applications for the self-management of spinal pain through exercise, more research is needed to test the effectiveness of such interventions (Machado et al., 2016).

On the other hand, even though various types of exercise may lead to positive outcomes in patients with NP, the optimal type has not been defined yet (O' Riordan et al., 2014). According to some approaches, the first step of a corrective exercise programme should target muscle fascia through Self-Myofascial Release (SMR) using special devices like Foam Rollers (FRs) (Fiore, 2014) and through different types of stretching (Schleip & Müller, 2013). These training methods are mainly connected with the enhancement of flexibility (Schleip, 2015); therefore, they seem appropriate for the management of NP which is associated with reduced active range of motion (ROM), which in turn leads to activity limitations and disability (Martijn et al., 2017).

With regard to stretching, an interesting approach is to use whole body stretches, as it is proposed, for example, in the theory of "Anatomy Trains". According to this theory, strain and tension travel up or down along certain fascial lines, creating problems not only locally but also at a distance from the site of pain. For this reason, it is suggested to treat and stretch not only single painful muscles but the entire myofascial lines (Myers, 2009). This kind of stretching is often seen in the postures of yoga and has been found to be effective in increasing neck ROM and functional ability (Cramer et al., 2013; Dunleavy et al., 2016; Michalsen et al., 2012). Nevertheless, the new concepts of fascial training suggest a variety of stretches (i.e., static, flowing and dynamic) and not only the static stretches that are traditionally seen in yoga classes. As for pressure techniques, previous research has focused on muscles of the neck and upper back area that presented myofascial trigger points (MTPs) and documented that SMR with FRs or small balls was effective in reducing MTPs and improving cervical ROM and functional ability in chronic NP (CNP) patients (Cabrera-Martos et al., 2022; Chan et al., 2015; Kim et al., 2016; Lee et al., 2017). Given that NP may also be caused by a stiffening of distant muscle groups, such as the hamstrings and lower back muscles (Mikkelsen et al., 2016), a total body treatment with SMR might also be proven effective.

Interestingly, the combination of stretching and SMR with FRs has been found to be superior to either of these modalities alone in the increase of flexibility of healthy adults (Mohr et al., 2014). However, according to our knowledge, the combination of these techniques for the improvement of cervical ROM and functioning in CNP patients has not yet been investigated. Additionally, both modalities, if designed in order to be safe in an unsupervised condition, could be delivered via the Internet and facilitate participation. Therefore, the aim of the present research was to investigate the effectiveness of an internet-based prerecorded exercise programme of myofascial training (i.e., stretching and SMR with FRs) on cervical ROM and functional ability in women with CNP.

MATERIAL AND METHODS

Participants

The research participants comprised 24 women with CNP (i.e., pain that lasted more than three months) of a mean age of 46.02 ± 7.24 years and pain intensity in the neck area of 4.67 ± 1.83 [measured through an eleven-point numerical pain scale (NRS)]. They were allocated in a semi-random way, according to the order of appearance, in two groups [Experimental Group (EG) = 12, Control Group (CG) = 12]. The participants of EG had a mean age of 46.58 ± 7.51 years and reported pain intensity of 4.83 ± 1.64 , and those of the CG had a mean age of 45.56 ± 2.09 and pain intensity of 4.50 ± 2.07 .

Measurements

The measurements were done in 4 different time points, i.e., "baseline measurement", "middle measurement" (after 3 weeks), "final measurement" (after 6 weeks), and "maintenance measurement" (2 weeks upon completion of the exercise programme).

Cervical ROM

Active cervical ROM was assessed with a Cervical Range of Motion (CROM) device (3-C Headgear, Fiber Metal, USA) (Figure 1).



Figure 1. The CROM device

The participant was seated on a chair, with the trunk and head in a neutral position, and was asked to move the head in the indicated direction as much as possible and up to the point that did not produce pain. Each participant performed three consecutive attempts in each direction in the following order: flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation. Before each trial and with the head in a neutral position, it was ensured that the inclinometer pointer was at 0 (Audette et al., 2010). Performance on this test was the average of the three trials.

Neck Disability Index (NDI)

Functional disability in the neck was assessed through the Greek modified version of the NDI. It

includes 10 questions that assess the degree of disability in various daily activities due to NP. The score in each question can be between 0 and 5, and the total score from 0 (no pain and no functional limitation) to 50 (maximum pain and maximum functional limitation) (Trouli et al., 2008).

Procedures

The participants of EG were provided with a smooth, 90-cm Eva Foam Roller, and they worked out 3 times a week for 6 weeks, completing 18 sessions of approximately 30 min each. The sessions were prerecorded and uploaded to YouTube. The participants were free to work out at a time that was convenient for them. During the entire duration of the intervention, CG did not engage in organised physical activity.

Exercise protocol

The exercise protocol can be found in Daskalaki (2021). A variety of stretching styles were used, including: "flowing", dynamic, static and "improvisational" stretches. Flowing stretches were original combinations of movements that targeted all or some of the basic myofascial lines, as described by Myers (2009) (i.e., Superficial Front Line, Superficial Back Line, Lateral Line, and Spiral Line). They involved continuous movements between different positions, and also dynamic stretches (i.e., soft elastic bounces of the torso or the lower limbs in a stretched position) and static stretches. All the mentioned lines were targeted through flowing stretches in all sessions. Additionally, the protocol included isolated static stretches for the spine (flexion, extension, lateral flexion, and rotation), the lower limbs (quadriceps, hamstrings, piriformis, and hip adductors), and the neck area (passive cervical and lateral flexion with the use of hands in a seated or standing position). The majority of static stretches had a duration of 20 sec. "Improvisational stretches" were based on the principle of "Slow Motion" (Carreri, 2007) and were free-chosen stretches: the participants were asked to move constantly in a slow rhythm and simultaneously stretch different areas of their bodies according to their needs, for 2 min. SMR with FRs focused on the lower limbs (glutei, hip abductors and adductors, hamstrings, quadriceps, ankle plantar flexors, and plantar fascia), and the torso (lower and upper back). It consisted of rolling back and forth over the targeted musculature following its central line. The pace used was 4 sec. per direction (i.e., 8 sec. per full roll), and the duration varied between 40 and 64 sec. For the hamstrings and the ankle plantar flexors, 8 full rolls were performed with 15 sec. of break after the 4th roll in order to avoid tiredness in the wrists. For these muscle groups and for quadriceps, after the 10th week, the 4 last rolls were done multi-directionally (i.e., the participant should constantly move the legs in different directions in order to exert pressure in different areas of the musculature). For the lower and upper back, in some sessions, a personally selected pace was suggested in order to allow the participants to also perform self-massage following

their needs. Most sessions ended with a rest pose in a supine position on the FR (the area in contact with the FR was from the head to the coccyx, the knees were bent or straightened, and the arms were relaxed on the ground in a 90° of shoulder abduction). At first, the participant should remain still and, after a while, perform slow lateral micro-movements from one scapula to the other, thus targeting mainly the adductors of the scapulae.

Analysis

The data were analysed with SPSS and two-way repeated-measures ANOVAs (2X4) were used for each one of the dependent variables. The independent variable was "group" (EG, CG), the dependent variable was "score" on the corresponding variable and the repeated factor was "time" (i.e., baseline, middle, final, and maintenance measurement). In case of a statistically significant interaction, pairwise comparisons were performed (adjustment for multiple comparisons: Sidak) and the interaction between time*group was analysed for every level of the factor "group" (within groups comparisons) and for every level of the factor "time" (between group comparisons). The statistical significance level was set at 0.05 ($p < 0.05$).

RESULTS

At baseline, there were no statistically significant differences between groups in any of the variables. A statistically significant interaction between time*group was documented at the score of the NDI ($F_{3,66} = 8.278$; $p = 0.000 < 0.05$), cervical flexion ROM ($F_{3,66} = 9.994$; $p = 0.000 < 0.05$), cervical extension ROM ($F_{3,66} = 5.219$; $p = 0.003 < 0.05$), cervical right lateral flexion ROM ($F_{3,66} = 8.875$; $p = 0.000 < 0.05$), cervical left lateral flexion ROM ($F_{3,66} = 5.636$; $p = 0.002 < 0.05$), cervical right rotation ROM ($F_{3,66} = 21.657$; $p = 0.000 < 0.05$), and cervical left rotation ROM ($F_{3,66} = 12.207$; $p = 0.000 < 0.05$). Therefore, for all variables, analysis was continued by performing pairwise comparisons.

NDI

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 9.268$, $p = 0.000 < 0.05$). In the EG, there was a statistically significant decrease in the score of the NDI in all measurements, compared to baseline (Table 1).

Table 1. Score in the NDI (Mean \pm SD)

| Measurement | Groups | |
|-------------|------------------|------------------|
| | EG | CG |
| Baseline | 11.25 \pm 5.06 | 10.17 \pm 5.31 |
| Middle | 8.75 \pm 4.71* | 9.58 \pm 5.02 |
| Final | 6.92 \pm 4.70* | 10.17 \pm 4.91 |
| Maintenance | 7.08 \pm 5.11* | 9.92 \pm 5.30 |

* = within group, compared to the baseline measurement

Cervical flexion ROM

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 9.268$, $p = 0.000 < 0.05$). In the EG, there was a statistically significant increase of cervical flexion ROM in all measurements, compared to baseline. Between groups, there was a statistically significant difference in the final ($F_{1,22} = 8.653$, $p = 0.008 < 0.05$) and maintenance measurement ($F_{1,22} = 8.764$, $p = 0.007 < 0.05$) in favour of EG (Table 2).

Table 2. Cervical flexion ROM (Mean \pm SD in degrees)

| Measurement | Groups | |
|-------------|-----------------------|-------------------|
| | EG | CG |
| Baseline | 47.44 \pm 13.5 | 49.08 \pm 11.53 |
| Middle | 56.96 \pm 10.60* | 48.75 \pm 10.89 |
| Final | 62.86 \pm 10.9 *,** | 49.36 \pm 11.58 |
| Maintenance | 64.22 \pm 9.97 *,** | 50.38 \pm 12.75 |

* = within group, compared to the baseline measurement, ** = between groups

Cervical extension ROM

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 4.737$, $p = 0.012 < 0.05$). In the EG, there was a statistically significant increase in the cervical extension ROM in the final measurement, compared to the baseline measurement. Between groups, there was a statistically significant

difference in the middle ($F_{1,22} = 6.302$, $p = 0.020 < 0.05$), final ($F_{1,22} = 14.610$, $p = 0.001 < 0.05$), and maintenance measurement ($F_{1,22} = 12.355$, $p = 0.002 < 0.05$) in favour of EG (Table 3).

Table 3. Cervical extension ROM (Mean \pm SD in degrees)

| Measurement | Groups | |
|-------------|----------------------|-------------------|
| | EG | CG |
| Baseline | 51.39 \pm 15.33 | 48.61 \pm 11.09 |
| Middle | 58.05 \pm 9.16 ** | 47.83 \pm 10.72 |
| Final | 63.3 \pm 7.92 *,** | 47.97 \pm 11.45 |
| Maintenance | 59.8 \pm 6.66 ** | 46.55 \pm 11.23 |

* = within group, compared to the baseline measurement, ** = between groups

Cervical right lateral flexion ROM

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 8.379$, $p = 0.001 < 0.05$). In the EG, there was a statistically significant increase in the cervical right lateral flexion ROM in the final and maintenance measurement, compared to the baseline measurement. Between groups, there was a statistically significant difference in the final ($F_{1,22} = 12.674$, $p = 0.002 < 0.05$) and in the maintenance measurement ($F_{1,22} = 8.677$, $p = 0.007 < 0.05$) in favour of EG (Table 4).

Table 4. Cervical right lateral flexion ROM (Mean \pm SD in degrees)

| Measurement | Groups | |
|-------------|------------------------|------------------|
| | EG | CG |
| Baseline | 36.25 \pm 8.42 | 36.75 \pm 10.2 |
| Middle | 42.22 \pm 11.99 | 34.33 \pm 5.84 |
| Final | 46.36 \pm 8.74 *,** | 35.44 \pm 6.03 |
| Maintenance | 45.72 \pm 11.36 *,** | 34.52 \pm 6.65 |

* = within group, compared to the baseline measurement,
 ** = between groups

Cervical left lateral flexion ROM

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 5.169$, $p = 0.008 < 0.05$). In the EG, there was a statistically significant increase in the cervical left lateral flexion ROM in the final and the maintenance measurement, compared to the baseline measurement. Between groups, there was a statistically significant difference in the final measurement ($F_{1,22} = 8.058$, $p = 0.010 < 0.05$) in favour of EG (Table 5).

Table 5. Cervical left lateral flexion ROM (Mean \pm SD in degrees)

| Measurement | Groups | |
|-------------|-----------------------|-------------------|
| | EG | CG |
| Baseline | 34.66 \pm 8.15 | 35.91 \pm 13.91 |
| Middle | 41.27 \pm 14.85 | 34.41 \pm 8.37 |
| Final | 45.83 \pm 12.3 *,** | 33.86 \pm 7.84 |
| Maintenance | 44.02 \pm 14.74* | 34.30 \pm 9.05 |

* = within group, compared to the baseline measurement,
 ** = between groups

Cervical right rotation ROM

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 28.650$, $p = 0.000 < 0.05$). In the EG, there was a statistically significant increase in the cervical right rotation ROM in all measurements, compared to the baseline measurement. Between groups, there was a statistically significant difference in the middle measurement ($F_{1,22} = 7.003$, $p = 0.015 < 0.05$), final measurement ($F_{1,22} = 25.342$, $p = 0.000 < 0.05$), and maintenance measurement ($F_{1,22} = 17.048$, $p = 0.010 < 0.05$) in favour of EG (Table 6).

Table 6. Cervical right rotation ROM (Mean \pm SD in degrees)

| Measurement | Groups | |
|-------------|--------------------------|------------------|
| | EG | CG |
| Baseline | 61.02 \pm 12.30 | 61.55 \pm 6.72 |
| Middle | 72.6 \pm 13.04 *,** | 61.11 \pm 7.53 |
| Final | 78.27 \pm 10.8 *,** | 60.28 \pm 6.07 |
| Maintenance | 76.19 \pm 11.8 *,** | 60.50 \pm 5.86 |

* = within group, compared to the baseline measurement,
 ** = between groups

Cervical left rotation ROM

Within groups, a statistically significant effect of the factor "time" was documented for the EG ($F_{3,20} = 15.519$, $p = 0.000 < 0.05$). In the EG, there was a statistically significant increase in the cervical left rotation ROM in all measurements, compared to the baseline measurement. Between groups, there was a statistically significant difference in the final ($F_{1,22} = 7.362$, $p = 0.013 < 0.05$) and in the maintenance measurement ($F_{1,22} = 8.694$, $p = 0.007 < 0.05$) in favour of EG (Table 7).

Table 7. Cervical left rotation ROM (Mean \pm SD in degrees)

| Measurement | Groups | |
|-------------|----------------------------|------------------|
| | EG | CG |
| Baseline | 60.94 \pm 14.16 | 61.14 \pm 8.83 |
| Middle | 71.02 \pm 15.59* | 62.44 \pm 7.90 |
| Final | 74.19 \pm 14.86 *, ** | 61.16 \pm 7.46 |
| Maintenance | 74.86 \pm 14.66 *, ** | 60.72 \pm 7.80 |

* = within group, compared to the baseline measurement,

** = between groups

DISCUSSION

The present research aimed to investigate the effects of an internet-based exercise programme of myofascial training in women with CNP. As it was shown, the programme was effective in improving the cervical ROM in all movements and the functional ability of the participants of the EG. In the majority of the variables, there was a statistically significant improvement even at the middle measurement, which is after only 9 training sessions. Additionally, except for neck extension, in all other neck movements, the positive results remained statistically significant even after 2 weeks of no training. The increase of cervical ROM is often attributed to the reduction of pain (Cramer et al., 2013), and indeed, by means of the NDI, pain and disability were significantly reduced in EG. Previous research has also indicated that measures of active cervical ROM in flexion, extension and rotation are significantly associated with disability scores (Piva et al., 2006), so in order to maximize the function of the cervical spine, it is suggested to increase cervical ROM (Thoomes-de Graaf et al., 2020). Under this prism, the increase of cervical ROM in all movements examined was probably the factor that led to the reduction of disability in our participants.

Previous research that used yoga as a means of treatment and measured cervical ROM in the same movements as the present research concluded in either smaller (Cramer et al., 2013) or non-existent improvements (Dunleavy et al., 2016). Specifically, in the research by Cramer et al. (2013), although a statistically significant difference was reported for cervical ROM after 9 weeks of practice, this difference referred to the cumulative score of all movements and not to each movement separately, while the improvements in the individualised movements were smaller in comparison with the present research. In the research by Dunleavy et al. (2016), which also measured cervical ROM after 6 and 12 weeks of either yoga or Pilates practice, there weren't statistically significant improvements for either group.

As for the reduction of disability, although yoga was effective in fulfilling this goal, the combined protocol of myofascial training used here seems to be more effective in terms of percentualized comparisons. In more detail, in our participants, there was a statistically significant decrease of 38.49% after 6 weeks of training which was greater in comparison with other yoga research, i.e., 33.3% after 9 weeks in Cramer et al. (2013), 21.88% after 6 weeks and 36.7% after 12 weeks in Dunleavy et al. (2016), 9.06% after 4 weeks and 27.56% after 10 weeks in Michalsen et al. (2012). It should be reported though that in all the research, the baseline score in NDI was greater than in the present research. On the other hand, the duration and frequency of sessions were much greater in those yoga studies, indicating that maybe the combination of different types of stretching and SMR with FRs speeds up the positive outcomes by offering diverse beneficial stimuli to the myofascial system.

As for studies that used SMR in adults with neck and back pain, they mainly focused the pressure techniques on isolated muscle groups of the neck area where MTPs were found (Chan et al., 2015; Kim et al., 2016; Lee et al., 2017). The existence of MTPs in the neck and upper back area in patients with CNP is well documented, but their exact location and severity vary in different studies (Daskalaki et al., 2019). Therefore, if the goal is to create a generalised internet-based, unsupervised protocol, the treatment of the whole body and not of isolated muscles appears to be an optimal choice, considering the positive results found here. The use of FR for application of self-massage in various muscle groups of the torso and lower limbs instead of isolated muscles of the subtle neck area also seems to be a safer option for an unsupervised condition, considering that hard massage tools may increase muscular tension in the neck instead of lowering it (Kim et al., 2019). In plus, if the goal is to reduce and relax MTPs, apart from using sustained pressure in a muscle, another way is the application of slow, gentle stretches in a non-painful ROM (Simons, 2002), as it was done in the present research.

Finally, in the present investigation, a new approach to stretches was proposed (i.e., improvisational stretches) and, in some instances, the pace of SMR was individually chosen. This approach permitted the participants to also follow their own needs. In our opinion, this was a useful adjunct to the programme and part of its effectiveness could be also due to this parameter. Additionally, the freedom to choose the time of training facilitated adherence to the programme, proving that internet-based programmes constitute a feasible and effective alternative for patients with CNP.

CONCLUSION

As it was shown, an online prerecorded exercise programme that included stretching and SMR with FRs was effective in improving cervical ROM and functional ability of women with CNP. According to these results, an internet-based programme of myofascial training may be a solution for patients with CNP who otherwise might not have the

possibility to engage in face-to-face supervised exercise.

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REFERENCES

1. Audette, I., Dumas, J. P., Côté, J. N., & De Serres, S. J. (2010). Validity and between-day reliability of the cervical range of motion (CROM) device. *Journal of Orthopaedic and Sports Physical Therapy*, 40(5), 318–323.
2. Cabrera-Martos, I., Rodríguez-Torres, J., López-López, L., Prados-Román, E., Granados-Santiago, M., & Valenza M.C. (2022). Effects of an active intervention based on myofascial release and neurodynamics in patients with chronic neck pain: A randomized controlled trial. *Physiotherapy Theory and Practice*, 38 (9), 1145-1152.
3. Carreri, R. (2007). *Tracce – Training e storia di un' attrice dell' Odin Teatret*. Milano: Il principe costante Edizioni.
4. Chan, Y. C., Wang, T. J., Chang, C. C., Chen, L. C., Chu, H. Y., Lin, S. P., & Chang, S. T. (2015). Short-term effects of self-massage combined with home exercise on pain, daily activity, and autonomic function in patients with myofascial pain dysfunction syndrome. *Journal of Physical Therapy Science*, 27(11), 217–221.
5. Cramer, H., Lauche, R., Hohmann, C., Lu, R., Haller, H., Michalsen, A., Langhorst, J., & Dobos, G. (2013). Randomized-controlled trial comparing yoga and home-based exercise for chronic neck pain. *The Clinical Journal of Pain*, 29(3), 216–223.
6. Daskalaki, K. (2021). Exercise with techniques of performing arts and therapeutic exercise for the functional management of chronic musculoskeletal pain in the spine: Comparative study, [Unpublished doctoral dissertation]. Democritus University of Thrace, Department of Physical Education and Sport Science, Greece.
7. Daskalaki K., Gioftsidou A., Bebetos E., Beneka A., Malliou P. (2019). Trigger points in patients with chronic neck pain – Review. 2nd International Conference on Functional Rehabilitation of Injuries in Athletes and Trainees, Komotini, Greece, 8-9 November 2019.
8. Dunleavy, K., Kava, K., Goldberg, A., Malek, M. H., Talley, S. A., Tutag-Lehr, V., & Hildreth, J. (2016). Comparative effectiveness of Pilates and yoga group exercise interventions for chronic mechanical neck pain: quasi-randomised parallel controlled study. *Physiotherapy (United Kingdom)*, 102(3), 236–242.
9. Escolar-Reina, P., Medina-Mirapeix, F., Gascán-Cánovas, J. J., Montilla-Herrador, J., Jimeno-Serrano, F. J., de Oliveira Sousa, S. L., del Bão-Aledo, M. E., & Lomas-Vega, R. (2010). How do care-provider and home exercise program characteristics affect patient adherence in chronic neck and back pain: A qualitative study. *BMC Health Services Research*, 10.
10. Fiore, R. D. (2014). The corrective exercise continuum. In: M. A. Clark, S. C. Lucett, & B. G. Sutton, *NASM Essentials of Corrective Exercise Training* (pp. 204–218), USA: Jones & Bartlett Learning.
11. Hurwitz, E. L., Randhawa, K., Yu, H., et al. (2018). The Global Spine Care Initiative: A summary of the global burden of low back and neck pain studies. *Eur Spine J* 27 (Suppl 6), 796–801.
12. Kim, Y., Hong, Y., & Park, H. S. (2019). A soft massage tool is advantageous for compressing deep soft tissue with low muscle tension: Therapeutic evidence for self-myofascial release. *Complementary Therapies in Medicine*, 43, 312–318.
13. Kim, M., Lee, M., Kim, Y., Oh, S., Lee, D., & Yoon, B. (2016). Myofascial pain syndrome in the elderly and self-exercise: A single-blind, randomized, controlled trial. *Journal of Alternative and Complementary Medicine*, 22(3), 244–251.
14. Lee, M., Kim, M., Oh, S., Choi, Y. J., Lee, D., Lee, S. H., & Yoon, B. C. (2017). A self-determination theory-based self-myofascial release program in older adults with myofascial trigger points in the neck and back: A pilot study. *Physiotherapy Theory and Practice*, 33(9), 681–694.
15. Machado, G. C., Pinheiro, M. B., Lee, H., Ahmed, O. H., Hendrick, P., Williams, C., & Kamper, S. J. (2016). Smartphone apps for the self-management of low back pain: A systematic review. *Best Practice and Research: Clinical Rheumatology*, 30(6), 1098–1109.
16. Michalsen, A., Traiteur, H., Lüdtkke, R., Brunnhuber, S., Meier, L., Jeitler, M., Büssing, A., & Kessler, C. (2012). Yoga for chronic neck

pain: A pilot randomized controlled clinical trial. *Journal of Pain*, 13(11), 1122–1130.

17. Mikkelsen, L. O., Nupponen, H., Kaprio, J., Kautiainen, H., Mikkelsen, M., & Kujala, U. M. (2006). Adolescent flexibility, endurance strength, and physical activity as predictors of adult tension neck, low back pain, and knee injury: A 25 year follow up study. *Br J Sports Med*, 40, 107–113.
18. Mohr, A. R., Long, B. C., & Goad, C. L. (2014). Foam rolling and static stretching on passive hip flexion range of motion. Effect of foam rolling and static stretching on passive hip-flexion range of motion. *Journal of Sport Rehabilitation*, 23(4), 296–299.
19. Myers, T. W. (2009). *Myofascial meridians for manual and movement therapists*. New York: Elsevier
20. O' Riordan, C., Clifford, A., Van De Ven, P., & Nelson, J. (2014). Chronic neck pain and exercise interventions: Frequency, intensity, time, and type principle. *Archives of Physical Medicine and Rehabilitation*, 95 (4), 770–783.
21. Piva, S. R., Erhard, R. E., Childs, J. D., & Browder, D. A. (2006). Inter-tester reliability of passive intervertebral and active movements of the cervical spine. *Manual Therapy*, 11 (4), 321–330.
22. Schleip, R., & Müller, D. (2015). Fascial fitness. In R. Schleip, & A. Baker (Eds.), *Fascia in Sport and Movement* (pp. 180–192). Edinburgh: Handspring Publishing.
23. Schleip, R. (2015). Fascia as a sensory organ. In R. Schleip, & A. Baker (Eds.), *Fascia in Sport and Movement* (pp 68–80). Edinburgh: Handspring Publishing.
24. Simons, D. G. (2002). Understanding effective treatments of myofascial trigger points. *Journal of Bodywork and Movement Therapies*, 6(2), 81–88.
25. Thoomes-de Graaf, M., Thoomes, E., Fernández-de-las-Peñas, C., Plaza-Manzano, G., & Cleland, J. A. (2020). Normative values of cervical range of motion for both children and adults: A systematic review. *Musculoskeletal Science and Practice*, 49.
26. Trouli, M. N., Vernon, H. T., Kakavelakis, K. N., Antonopoulou, M. D., Paganas, A. N., & Lionis, C. D. (2008). Translation of the Neck Disability Index and validation of the Greek version in a sample of neck pain patients. *BMC Musculoskeletal Disorders*, 9, 1–8.

EFEKTI INTERNET PROGRAMA VJEŽBI ISTEZANJA I SAMO-MIOFASCIJALNOG OTPUŠTANJA NA CERVICALNI RASPON POKRETA I FUNKCIONALNU SPOSOBNOST ŽENA SA HRONIČNIM BOLOVIMA U VRATU

SAŽETAK

Bolovi u vratu predstavljaju jedan od glavnih uzroka života sa poteškoćama kod osoba srednje životne dobi. Iako je vježbanje preporučeno kao efikasan tretman za bolove u vratu, pridržavanje istom je nedovoljno čak i u slučaju kada je program propisan i predviđen za provođenje kod kuće. Opća prepreka koja se često navodi je nesigurnost o pravilnom izvođenju vježbi kada su one date u pisanom obliku, a što je problem koji se može riješiti korištenjem digitalne tehnologije. Cilj ovog istraživanja je ispitati efekte internet programa vježbi miofascijalnog treninga koji uključuje različite vrste istezanja i samo-miofascijalno otpuštanje korištenjem pjenastih valjaka na cervikalni raspon pokreta (ROM) i funkcionalne poteškoće kod žena sa hroničnim bolovima u vratu. 24 učesnika je podijeljeno u dvije grupe [Eksperimentalnu Grupu (EG) i Kontrolnu Grupu (CG)]. EG je izvodila 18 prethodno snimljenih serija vježbi u prosječnom trajanju od 30 minuta za svaku, a unutar 6 sedmica. Pokazalo se da je program efikasan u poboljšavanju cervikalnog ROM-a u svim pokretima koji su ispitivani kao i za funkcionalnu sposobnost učesnika EG-a. Na osnovu ovih rezultata, internet program miofascijalnog treninga može biti praktična alternativa za pacijente sa hroničnim bolovima u vratu.

Ključne riječi: cervikalni bolovi, online programi vježbi, pjenasti valjci, miofascijalni trening

Correspondence to: Katerina Daskalaki

Department of Physical Education and Sport Sciences, Democritus University of Thrace, D.P.E.S.S, Greece

E-mail: adaskala@phyed.duth.gr

WEIGHT TRAINING PROGRAMME TO IMPROVE THE BIOMOTOR POWER COMPONENT IN FUTSAL ATHLETES: VALIDITY AND RELIABILITY APPROACHES OF CONSTRUCTED CONTENTS

Yulvia Miftachurochmah¹, Tomoliyus¹, Endang Rini Sukamti¹, Fatkurahman Arjuna², Gallant Pamungkas²

1. Department of Sports Coaching Education, Faculty of Health and Sports Science, Yogyakarta State University, Indonesia

2. Department of Sport Science, Faculty of Health and Sports Science, Yogyakarta State University, Indonesia

ABSTRACT

Background: Different training stimuli can cause different responses and adaptations in the muscles and body. These stimuli can reach their peak in a certain scheme and make the body's adaptation response more optimal. **Purpose:** To develop a weight training programme to adapt to the development of power training, especially for futsal athletes. **Design/methodology/approach:** This research applied the research and development method supported by the quantitative approach and involved five physical conditioning experts and two futsal coaches. The data analysis on the construct validity of the weight training programme was conducted using content validity with the Delphi technique. A questionnaire with a scale of 1 to 5 (very relevant, relevant, quite relevant, less relevant, and irrelevant) was also used as the research instrument. The collected data were analysed using Aiken's V formula to test the content validity, while the ICC formula was used to test the agreement between raters. **Results:** The results showed that the weight training programme for futsal athletes showed high content validity (≥ 0.75), with strong agreement between raters (0.887) and good consistency values for each rater (0.530). **Conclusion:** The developed training programme was feasible to increase futsal athletes' biomotor power component. Even so, this training programme still needs further research to determine its effectiveness using experimental methods.

Keywords: weight training, futsal, power, validity, reliability

INTRODUCTION

The best performance in futsal is highly determined by physical, technical, tactical, and mental

aspects (Ribeiro et al., 2020). Those aspects are closely related, with each formation having its developments. Physical aspects are needed to obtain better technical skills, which are prepared to acquire tactical abilities to achieve the skills of competitive maturity. Out of these various factors, the physical factor is the most important

factor for futsal (Nikolaidis et al., 2019; Ramos-Campo et al., 2016). Therefore, every futsal athlete must maintain and develop their physical abilities to always be in prime and maximum condition.

According to Naser et al. (2017), futsal athletes must have a high intermittent endurance capacity, repeated sprint ability, leg power, agility, and coordination to achieve higher performances. To upstage their opponents, they are not only required to have a good ability in handling balls and great aerobic and anaerobic endurance, but they also must have a big explosive power (such as speed in kicking and running) (Sekulic et al., 2021). Leg muscle power is one of the most important factors in achieving the highest level of performance (Permana et al., 2022) because good control of power can help young athletes compete at the senior level. Muscle power is crucial in futsal, especially in shooting, passing and heading techniques. Without good leg muscle power, an optimal kick or header technique will not be created (Palucci Vieira et al., 2021). However, young futsal athletes' leg muscle power abilities are generally not optimal (Parmadi et al., 2022) (Afrizal & Soniawan, 2021). In addition, chronic hip, knee and ankle (part of the leg muscles) injuries, which are very common problems worldwide, can hinder development in several sectors, including athletes' training and performances. Judging from the importance of leg muscle power in futsal athletes, but not balanced with the existing reality, this can cause many athletes to have insufficient leg muscle power that is mature at their age, and cause them to get injured and not be able to reach their highest performances.

One method that can be used to train athletes' power is the weight training method, an effective intervention to increase muscle adaptation (Kang et al., 2012). Optimising this adaptation requires manipulating the weight training variable (Suchomel et al., 2018). The changes in the weight, or the amount of weight lifted in one set, are widely considered a very important variable (Marques et al., 2019). Evidence shows that changes in weight training can affect acute metabolic, hormonal, nervous, and cardiovascular responses to exercise (Hoeger et al., 2018).

According to Bompá & Buzzichelli (2019), good intensity of power training is using 40%-60% of the maximum weight (1RM). According to Torres-Torrel et al. (2017), the good intensity of power training is 2-3 sets and 4-6 repetitions at 45-60% of 1RM. Schoenfeld et al. (2021) divide the dose of weight training into three. The first is a low repetition intensity scheme with a heavy weight (1 to 5 repetitions per set at 80% to 100% of a maximum of 1 repetition (1RM). The second is a moderate-intensity repetition scheme with a moderate weight (from 8 to 12 repetitions per set at 60% to 80% of 1RM). The last one is a high repetition intensity scheme with light weight (15+ repetitions per set with a weight below 60% of 1RM).

Even so, there are still many mistakes regarding determining intensity in power training. Frequent power exercises still use excessive weights and are not in accordance with the rules (seemingly perfunctory). The rules state that athletes must have good muscle strength before being given power training (Afrizal & Soniawan, 2021; Mcguigan, 2017; Swinnen, 2016). Understanding

how weight can interfere with the development of adaptations in the human body, coaches and weight training practitioners need to be able to design more effective and efficient training programmes.

Therefore, the researchers aimed to develop a construction related to the development adaptation of power training for athletes, especially in futsal sports, by testing the validity of the weight training programme according to the dosage and needs of the futsal sport.

MATERIALS AND METHODS

This study applied the research and development method, supported by a quantitative approach (Edmonds & Kennedy, 2016; Hong et al., 2019; Petrovic et al., 2017). It involved five physical conditioning experts and two futsal coaches. The data analysis on the construct validity of the weight training programme was conducted using content validity. This research was carried out in four steps to validate the content. First, the authors collected relevant research sources and conducted a participatory observational study as a preliminary of the development. The second step was the product assessment stage, carried out using the Delphi technique by ten experts. The results of a questionnaire with a rating scale of 1 to 5 show consensus from experts (Doolan-Noble et al., 2019; Hong et al., 2019). The third step was analysing the quantitative data from the seven experts' assessments using Aiken's V formula. The fourth step was testing the agreement among raters using the Intraclass Correlation Coefficients (ICC) formula (Portney & Watkins, 2009) and with the help of the SPSS application Version 25.

The conclusions from Aiken's V calculation results, according to the V table based on ten raters using the 1 to 5 scale and a 5% confidence level would be declared as 'valid' if the V count is greater than the V table, in which the V table is 0.75 (Aiken, 1985). Meanwhile, the value of agreement among the raters (ICC) is described as adopting property (Portney & Watkins, 2009):

Table 1. ICC Value Category

| ICC Value | Interpretation |
|-------------|-----------------------|
| 0.00 - 0.50 | Poor Reliability |
| 0.51 - 0.75 | Moderate Reliability |
| 0.76 - 0.90 | Good Reliability |
| 0.91 - 1.00 | Excellent Reliability |

RESULTS AND DISCUSSION

Results

The literature reviews through various documents, such as relevant scientific articles and textbooks, found that weight training programmes increase the power component, especially leg muscle power in futsal athletes, as seen in Table 2.

The training programmes compiled by the researchers not only focus on the leg muscles (lower body), but also the whole body because playing futsal requires the upper body. Thus, the muscles of the whole body are trained even though they are still centred on the leg muscles. This exercise programme can be done in a fitness centre (gym) because it adopts the Maximum Repetition Continuum theory. In addition, this training programme is recommended to be carried out at the special preparation stage,

where athletes must have received maximum strength training in general preparation.

Furthermore, Table 3 presents Aiken's V coefficient values of all items. The first item shows the Aikens V coefficient value of 1.00, the second item shows the Aiken V coefficient value of 0.89, and the third item shows the Aiken V coefficient value of 0.82. Furthermore, the fourth item shows the Aiken V coefficient value of 0.79, the fifth item shows the Aiken V coefficient value of 0.82, the sixth item shows the Aiken V coefficient value of 0.75, the seventh item shows the Aikens V coefficient value of 0.96, the eighth and ninth items show the calculated Aiken V coefficient value of 0.75, respectively, and the last shows the calculated Aiken V coefficient value of 1.00. Thus, the weight training programme in this study was declared valid for power training because the calculated Aiken V coefficient value was greater than the V table, where the V table value was 0.75.

Table 2. Weight Training Programme to Improve Power

| Week | Training Item | Training Dose |
|------|--|---|
| 1-2 | 1. Romanian Deadlift 2. Calf Raises 3. Rear Delt Raise 4. Leg Extension 5. Total Abdominal 6. Side Lunges 7. Cable Row 8. Multi-Hip Abductor 9. Cable core Rotation 10. Arm Curl | Frequency: 2-3/week Intensity: 60%-65% 1RM Set: 2-3 Repetition: 8-12 Rhythm: High Velocity Rest: 2-3 minutes Method: Set System |
| 3-4 | 1. Power Back Squad 2. Russian Twist 3. Shoulder Press 4. Side Bend 5. Pull Down 6. Side Squat with Plate 7. Butterfly 8. Single Leg Deadlift 9. Triceps Pushdown | Frequency: 2-3/week Intensity: 65%-70% 1RM Set: 3 Repetition: 8-10 Rhythm: High Velocity Rest: 2-4 minutes Method: Set System |
| 5-6 | 1. Squad Jump 2. Leg Curl 3. Upright Row 4. Bulgarian Squat 5. Chest Press 6. Plate Wood Chop 7. Hip Thrust 8. Cable Crunches 9. Close Grip Reverse Pull Down 10. Triceps Extension | Frequency: 2-3/week Intensity: 75%-80% 1RM Set: 3 Repetition: 8 Rhythm: High Velocity Rest: 2-5 minutes Method: Set System |

Table 3. Content Validity Test Results

| Jur y | Item 1 | | Item 2 | | Item 3 | | Item 4 | | Item 5 | | Item 6 | | Item 7 | | Item 8 | | Item 9 | | Item 10 | |
|-----------|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|
| | Sco re | S | Sco re | S | Sco re | S | Sco re | S | Sco re | S | Sco re | S | Sco re | S | Sco re | S | Sco re | S | Sco re | S |
| A | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 5 | 4 | 4 | 3 | 4 | 3 | 5 | 4 |
| B | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 2 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 5 | 4 |
| C | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 5 | 4 | 4 | 3 | 4 | 3 | 5 | 4 |
| D | 5 | 4 | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 5 | 4 | 4 | 3 | 4 | 3 | 5 | 4 |
| E | 5 | 4 | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 5 | 4 | 4 | 3 | 4 | 3 | 5 | 4 |
| F | 5 | 4 | 5 | 4 | 5 | 4 | 5 | 4 | 5 | 4 | 4 | 3 | 5 | 4 | 4 | 3 | 4 | 3 | 5 | 4 |
| G | 5 | 4 | 5 | 4 | 5 | 4 | 5 | 4 | 5 | 4 | 4 | 3 | 5 | 4 | 4 | 3 | 4 | 3 | 5 | 4 |
| Σs | 28 | | 25 | | 23 | | 22 | | 23 | | 21 | | 27 | | 21 | | 21 | | 28 | |
| V | 1 | | 0.89 | | 0.82 | | 0.79 | | 0.82 | | 0.75 | | 0.96 | | 0.75 | | 0.75 | | 1 | |

Then, the agreement results among the raters are presented in Table 4 below.

Table 4. Intraclass Correlation Coefficient Analysis Result

| | Intraclass Correlation ^b | 95% Confidence Interval | | F Test with True Value 0 | | | |
|------------------|--|-------------------------|-------------|--------------------------|-----|-----|------|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .530 | .284 | .808 | 11.889 | 9 | 54 | .000 |
| Average Measures | .887 | .735 | .967 | 11.889 | 9 | 54 | .000 |

Based on Table 4 above, each rater has a consistency of 0.530. Meanwhile, the average inter-rater agreement is 0.887. This result is included in the category of good reliability, and it can be concluded that the agreement among the raters is strong and that each rater has a good consistency.

DISCUSSION

Futsal is a sport that has the characteristics of speed with maximum power (Miftachurochmah et al., 2023; Naser et al., 2017). According to Spyrou et al. (2020), who studied the physiological characteristics of futsal games, 17% of futsal matches used moderate intensity with 65-85% MHR, while the other 83% use high intensity with more

than 85% MHR. As seen from the intensity of the match, futsal is a sport that predominantly uses an anaerobic threshold energy system. This anaerobic threshold zone has an intensity range of 85-90% MHR (Gaidos & dos Santos, 2015). The biomotor power component is important for futsal athletes because it supports the performance and skills of playing futsal, such as shooting, passing, heading, explosive movements, etc.

One of many ways to increase power is by applying the weight training method. It is widely accepted that training volume (weight × repetitions × sets) plays an important role in weight training (Kubo et al., 2021). This study aimed to develop a weight training programme to increase the power abilities of futsal athletes. The results of the content validity test for the developed training programme stated that the training programme was valid in all aspects

assessed, with strong agreement between raters.

Independent test validity is a very important part of the development process. This validity test can describe the extent to which the design of the weight training programme can increase the power abilities of futsal athletes.

In this study, the designed exercise dose adopts the Maximum Repetition Continuum theory, which uses a moderate repetition intensity exercise dose scheme with moderate weight (from 8 to 12 repetitions per set with 60%-80% of 1RM) and aims to achieve hypertrophy training adaptation (Schoenfeld et al., 2021). According to Schoenfeld, the dose of exercise in the hypertrophy training zone scheme can also be used as a power training zone. However, the focus of the implementation is that it must be done at maximum speed (fast rhythm). In line with the results of this study, Pareja-Blanco et al. (2017) proved that by intervention using a dose of weight training of three sets x 8 repetitions at 75% 1RM with maximum speed. The results of half squats, leg presses and hamstring curls significantly increase the ability of power jumps, sprints and repeated sprints in professional futsal players.

Research conducted by (Lopez et al., 2021) states that using a low repetition volume and high weight or intensity (< 8RM) can enhance the strength and hypertrophy biomotor components, compared to using a high repetition volume and low weight or intensity. In line with this, research according to French & Ronda (2021) states that a more optimal increase in strength is found at higher intensities.

On the other hand, although recommendations regarding the ideal weighting dose for biomotor speed are still being debated, the existing literature agree that weight training can increase speed (Kristensen et al., 2006; Prieske et al., 2018). According to Fossmo & van den Tillaar (2022), the speed component can be trained through weight training with lightweight intensity, but done quickly or explosively. These compiled exercises can help activate all high-threshold motor units, firing frequency and better intramuscular coordination. In this case, Cormie et al. (2011) explain that exercises for the development of maximal speed can be achieved optimally through the application of maximal mobilisation, where the exercises are structured close to the characteristics of a specific sport (executed quickly, such as, running, jumping or throwing).

Hill's curve theory explains that maximum power execution can only be done with a slow muscle shortening speed, whereas fast muscle shortening speeds tend to generate less force. Speed training using high-intensity weight can also help adapt the development of the speed component. Meanwhile, Fossmo & van den Tillaar (2022) explained their findings that weight training, with a light weight, has a range of 30-60% of 1 RM, moderate weight covers 60-85% of 1 RM, and heavy or maximum weight includes 85-100% of 1 RM, can increase the speed. The maximum weight range impacts

speed development more than training at other ranges. Furthermore, when applied to athletes with good strength, the range of light and explosive weight or combined with heavy weight training is more prioritised to develop speed.

In developing training strategies, the coach must remember that strength, power, and speed are inherently related to one another. Therefore, coaches are expected to pay attention to the component's characteristics so that the training programme matches the requirements; otherwise, the programme does not develop.

In conclusion, based on the results and discussion above, it can be summarised that increasing power ability can use weight training interventions. The researchers recommend weight training with moderate repetition intensity, moderate weight and fast rhythms.

CONCLUSION

Based on the results and discussion, it can be concluded that the weight training programme for futsal athletes shows high content validity, with strong agreement between raters and good consistency for each rater. Thus, the developed exercise programme is feasible to increase the biomotor power component in futsal athletes. However, this training programme still needs further research to determine its effectiveness using the experimental method.

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REFERENCES

1. Afrizal, S., & Soniawan, V. (2021). A contribution of leg muscle explosion power and flexibility to football shooting accuracy. 35(Icssht 2019), 1–6. <https://doi.org/10.2991/ahsr.k.210130.001>
2. Aiken, L. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement*, 45, 131–141.
3. Bompa, T. O., & Buzzichelli, C. (2019). *Periodization: Theory and methodology of training*. Human kinetics.
4. Doolan-Noble, F., Barson, S., Lyndon, M., Cullinane, F., Gray, J., Stokes, T., & Gauld, R. (2019). Establishing gold standards for System-Level Measures: A modified Delphi consensus process. *International Journal for Quality in Health Care*, 31(3), 205–211. <https://doi.org/10.1093/intqhc/mzy122>
5. Edmonds, W. A., & Kennedy, T. D. (2016). *An applied guide to research designs: Quantitative, qualitative, and mixed methods*. Sage Publications.
6. Gaidos, O. F., & dos Santos, I. (2015). Mobile system of monitoring and training cyclists with smartphone. In A. Braidot & A. Hadad (Eds.), *VI Latin American Congress on Biomedical Engineering CLAIB 2014, Paraná, Argentina 29, 30 {–} 31 October 2014* (pp. 59–62). Springer International Publishing.
7. Hoeger, W. W. K., Hoeger, S. A., Hoeger, C. I., & Fawson, A. L. (2018). *Lifetime physical fitness and wellness*. Cengage Learning.
8. Hong, Q. N., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M. P., Griffiths, F., Nicolau, B., O’Cathain, A., Rousseau, M. C., & Vedel, I. (2019). Improving the content validity of the mixed methods appraisal tool: A modified e-Delphi study. *Journal of Clinical Epidemiology*, 111, 49–59.e1. <https://doi.org/10.1016/j.jclinepi.2019.03.008>
9. Kang, H. J., Lee, Y. S., Park, D. S., & Kang, D. H. (2012). Effects of 12-week circuit weight training and aerobic exercise on body composition, physical fitness, and pulse wave velocity in obese collegiate women. *Soft Computing*, 16(3), 403–410. <https://doi.org/10.1007/s00500-011-0724-1>
10. Kubo, K., Ikebukuro, T., & Yata, H. (2021). Effects of 4, 8, and 12 repetition maximum resistance training protocols on muscle volume and strength. *Journal of Strength and Conditioning Research*, 35(4), 879–885. <https://doi.org/10.1519/JSC.0000000000003575>
11. Marques, D. L., Travassos, B., Sousa, A. C., Gil, M. H., Ribeiro, J. N., & Marques, M. C. (2019). Effects of low-moderate load high-velocity resistance training on physical performance of under-20 futsal players. *Sports (Basel, Switzerland)*, 7(3). <https://doi.org/10.3390/sports7030069>
12. McGuigan, M. (2017). *Developing power*. Human Kinetics.
13. Miftachurochmah, Y., Tomoliyus, Sukamti, E. R., Budiarti, R., Nurfadhila, R., Delano, E. H., & Amalia, I. G. (2023). The effect of small side games and coordination trainings on the aerobic endurance ability of male futsal athletes. *International Journal of Human Movement and Sports Sciences*, 11(3), 517–526. <https://doi.org/10.13189/saj.2023.110302>
14. Naser, N., Ali, A., & Macadam, P. (2017). Physical and physiological demands of futsal. *Journal of Exercise Science and Fitness*, 15(2), 76–80. <https://doi.org/10.1016/j.jesf.2017.09.001>
15. Nikolaidis, P. T., Chtourou, H., Torres-Luque, G., Rosemann, T., & Knechtle, B. (2019). The relationship of age and BMI with physical fitness in futsal players. *Sports*, 7(4), 1–10. <https://doi.org/10.3390/sports7040087>
16. Palucci Vieira, L. H., Kalva-Filho, C. A., Santinelli, F. B., Clemente, F. M., Cunha, S. A., Schimidt, C. V., & Barbieri, F. A. (2021). Lateral preference and inter-limb asymmetry in completing technical tasks during official professional futsal matches: The role of playing position and opponent quality. *Frontiers in Psychology*, 12(August), 1–11. <https://doi.org/10.3389/fpsyg.2021.725097>
17. Pareja-Blanco, F., Sánchez-Medina, L., Suárez-Arrones, L., & González-Badillo, J. J. (2017). Effects of velocity loss during resistance training on performance in professional soccer players. *International Journal of Sports Physiology and Performance*, 12(4), 512–519.
18. Parmadi, M., Wigunani, S. A., Budi, A. S., Murtiansyah, W., & Susanto, A. (2022). Correlation between limb muscle exploitative strength to futsal shooting ability. *JUMORA: Jurnal Moderasi Olahraga*, 2(2), 148–160. <https://doi.org/10.53863/mor.v2i2.533>
19. Permana, H., Sukamti, E. R., Suhadi, & Miftachurochmah, Y. (2022). The impacts of plyometric circuit training before and after technical training on cardiorespiratory and power abilities of junior male volleyball athletes. *International Journal of Human Movement and Sports Sciences*, 10(4), 823–831. <https://doi.org/10.13189/saj.2022.100423>
20. Petrovic, A., Koprivica, V., & Bokan, B. (2017). Quantitative, qualitative and mixed research in sport science: A methodological report. *South African Journal for Research in Sport, Physical Education and Recreation*, 39(2), 181–197.

21. Portney, L. G., & Watkins, M. P. (2009). Foundations of clinical research: Applications to practice (Vol. 892). Pearson/Prentice Hall Upper Saddle River, NJ.
22. Ramos-Campo, D. J., Rubio-Arias, J. A., Carrasco-Poyatos, M., & Alcaraz, P. E. (2016). Physical performance of elite and subelite Spanish female futsal players. *Biology of Sport*, 33(3), 297–304. <https://doi.org/10.5604/20831862.1212633>
23. Ribeiro, J. N., Gonçalves, B., Coutinho, D., Brito, J., Sampaio, J., & Travassos, B. (2020). Activity profile and physical performance of match play in elite futsal players. *Frontiers in Psychology*, 11(July). <https://doi.org/10.3389/fpsyg.2020.01709>
24. Schoenfeld, B. J., Grgic, J., Van Every, D. W., & Plotkin, D. L. (2021). Loading recommendations for muscle strength, hypertrophy, and local endurance: A re-examination of the repetition continuum. *Sports*, 9(2). <https://doi.org/10.3390/sports9020032>
25. Sekulic, D., Pojskic, H., Zeljko, I., Pehar, M., Modric, T., Versic, S., & Novak, D. (2021). Physiological and anthropometric determinants of performance levels in professional futsal. *Frontiers in Psychology*, 11(January), 1–14. <https://doi.org/10.3389/fpsyg.2020.621763>
26. Spyrou, K., Freitas, T. T., Marín-Cascales, E., & Alcaraz, P. E. (2020). Physical and physiological match-play demands and player characteristics in futsal: A systematic review. *Frontiers in Psychology*, 11(November). <https://doi.org/10.3389/fpsyg.2020.569897>
27. Suchomel, T. J., Nimphius, S., Bellon, C. R., & Stone, M. H. (2018). The importance of muscular strength: Training considerations. In *Sports Medicine*. <https://doi.org/10.1007/s40279-018-0862-z>
28. Swinnen, B. (2016). Strength training for soccer. Routledge.
29. Torres-Torrel, J., Rodríguez-Rosell, D., & González-Badillo, J. J. (2017). Light-load maximal lifting velocity full squat training program improves important physical and skill characteristics in futsal players. *Journal of Sports Sciences*, 35(10), 967–975. <https://doi.org/10.1080/02640414.2016.1206663>

PROGRAM TRENINGA SA OPTEREĆENJEM ZA POBOLJŠANJE BIOMOTORIČKE KOMPONENTE SNAGE KOD IGRAČA FUTSALA: PRISTUPI VALJANOSTI I POUZDANOSTI KONSTRUISANOG SADRŽAJA

SAŽETAK

Kontekst: Različiti trenažni podražaji mogu prouzrokovati različite odgovore i adaptacije mišića i tijela. Ovi podražaji mogu dostići vrhunac u određenoj šemi i optimizovati odgovor tijela putem adaptacije. **Svrha:** Razviti program treninga sa opterećenjem koji će se prilagoditi razvoju treninga snage, a posebno za igrače futsala. **Dizajn/metodologija/pristup:** U istraživanju je korištena metoda istraživanja i razvoja uz pomoć kvantitativnog pristupa, a u njemu je učestvovalo 5 stručnjaka iz oblasti fizičke kondicije i 2 trenera futsala. Analiza podataka o konstruktivnoj valjanosti programa treninga sa opterećenjem je provedena korištenjem valjanosti sadržaja uz Delphi tehniku. Upitnik sa skalom od 1 do 5 (iznimno važno, važno, prilično važno, manje važno i nevažno) je korišten kao instrument istraživanja. Prikupljeni podaci su analizirani uz pomoć Aikenove V formule za testiranje valjanosti sadržaja, dok je ICC formula korištena za testiranje slaganja između ocjenjivača. **Rezultati:** Rezultati su pokazali da je trening sa opterećenjem za igrače futsala pokazao visoku valjanost sadržaja ($\geq 0,75$) uz iznimno slaganje između ocjenjivača (0,887) i dobru konzistenciju za svakog ocjenjivača (0,530). **Zaključak:** Razvijeni program treninga je uspješan u povećanju biomotoričke komponente snage kod igrača futsala. Ipak, ovaj program treninga još uvijek zahtijeva dodatno istraživanje kako bi se utvrdila njegova efikasnost korištenjem eksperimentalnih metoda.

Ključne riječi: trening sa opterećenjem, futsal, snaga, valjanost, pouzdanost

Correspondence to: Yulvia Miftachurochmah

Department of Sports Coaching Education, Faculty of Health and Sports Science, Yogyakarta State University, Indonesia

E-mail: yulviamiftachurochmah.2022@student.uny.ac.id

EXERCISE AND SPORT SCIENCES ITALIAN MASTER'S DEGREES: A STUDY ON THEIR PROFESSIONAL OUTCOMES

Francesca D'Elia¹

1. University of Salerno, Italy

ABSTRACT

In Italy, three master's degree programmes in Exercise and Sport Sciences (ESS) are available: Organisation and Management of Sports and Physical Activities (LM47), Sciences of Preventive and Adapted Physical Activities (LM67) and Sports Science and Technique (LM68). These programmes qualify students for professions as sports managers (LM47), kinesiologists specialising in preventive and adapted physical activities (LM67) and sports kinesiologists (LM68). All three programmes have prerequisites for obtaining teaching specialisation qualifications. Numerous studies have highlighted training discrepancies across the country, with a prevalence of specific disciplinary focuses: biomedical for LM67, legal-economics for LM47 and sport/physical activity (M-EDF disciplines) for LM68. The study aims to assess the coherence between the educational objectives of ESS degree programmes and the specific educational goals of courses, particularly in relation to physical education (PE) teaching. A documentary analysis was conducted of the educational objectives of the three ESS master's degree programmes and the specific educational goals of the 63 active master's degree programmes in Italy, focusing on the M-EDF-related educational activities. The analysis revealed that the coherence and congruence of M-EDF training activities with the professional outcomes of the three ESS master's degrees is not fully realised. Specifically, M-EDF training is lacking in LM47, influenced by biomedical aspects in LM67, and characterised by high-level sports content in LM68. The analysis of the specific educational objectives further demonstrates that the ESS master's degree programmes do not adequately prepare students to meet the professional requirements of PE teaching. It is imperative to develop a 'core curriculum' for ESS master's degrees, ensuring alignment between the specific learning objectives, particularly those related to M-EDF training activities, and the professional outcomes of ESS programmes.

Keywords: master's degree programmes, Exercise and Sport Sciences, educational objectives, physical education

INTRODUCTION

In Italy, currently, in light of the requirements for the implementation of the National Recovery and Resilience Plan (PNRR), the training of physical education (PE) teachers primarily involves obtaining a master's degree in one of the three-degree classes in Exercise and Sport Sciences (ESS): Organisation and management of sports and physical activities (LM47), Sciences of preventive

and adapted physical activities (LM67) and Sports science and technique (LM68). These ESS degree classes not only play a crucial role in preparing future PE teachers but also significantly contribute to shaping the research landscape of Italian Exercise and Sport Sciences. Integrating these two aspects is essential for advancing the field and ensuring that the educational landscape aligns with the scientific objectives of Italian researchers (Raiola, 2019a). The LM47 class qualifies students as sports managers,

responsible for overseeing and organising sports and physical activities (Official Gazette, 2022). This professional track plays a key role in the effective management of sports institutions and the development of sports programmes nationwide. In addition to their managerial role, graduates of LM47 programmes also make substantial contributions to the scientific identity of Italian Exercise and Sport Sciences. They engage in research related to sports management, sports economics and legal aspects of sports. This multidimensional role of LM47 graduates is essential for both the professional and research dimensions of Exercise and Sport Sciences in Italy.

Similarly, the LM67 class equips students with the knowledge and skills to become specialised kinesiologists in preventive and adapted physical activities. The role of kinesiologists extends beyond their professional responsibilities; they also make significant contributions to the scientific identity of Italian Exercise and Sport Sciences. Research in preventive and adapted physical activities is integral to promoting public health and improving the well-being of diverse populations. Italian researchers in this field make vital contributions to international literature on kinesiology and adapted physical activity, enhancing the scientific reputation of the country.

For LM68 graduates, who become sports kinesiologists, the emphasis on the science of sports and technique is central to their professional identity. Yet, this also positions them as key contributors to the scientific community within the field of Exercise and Sport Sciences. Their research often delves into biomechanics, performance enhancement and technical aspects of sports, which are of great importance in contemporary sports science. Thus, the scientific identity of Italian researchers in this class is intricately linked with their professional role. Moreover, to obtain the teaching specialisation as PE teachers, students must acquire an additional 60 European Credit Transfer System (ECTS) credits. It's worth noting that the scientific identity of Italian Exercise and Sport Sciences researchers is intertwined with their role as educators. The contributions of these professionals to the field of education, particularly in physical education, are essential for advancing the scientific understanding of physical activity, sports pedagogy and curriculum development (Raiola, 2020b). The recent reforms for the implementation of the PNRR directly and indirectly affect the future of PE teaching and reinforce the need for alignment between the scientific objectives of researchers and the pedagogical objectives of the ESS degree classes.

Various studies (D'Elia et al., 2023a; D'Isanto et al., 2023; Raiola, 2019b) have highlighted differences in training across the national territory, emphasising the need for a unified approach. Heterogeneity was found in the distribution of ECTS credits across different university locations, despite the same degree class, which not only impacts student training but also the research landscape. This diversity in training can enrich the field with a variety of

perspectives or create inconsistencies between research and practice, making collaboration and harmonisation of efforts among researchers in ESS essential (Raiola, 2020a). The distribution of ECTS credits in the core training area, which should focus on physical activity and sports, showed significant differences between Italian universities (D'Elia et al., 2023a). The scientific identity of Italian ESS should reflect the latest advancements in the field, and disparities in training could hinder this alignment (Raiola, 2019c).

Furthermore, a prevalence of biomedical discipline specificities was found for the LM67, economic-legal for the LM47, and sports-related for the LM68. These specificities reflect the diverse research interests of Italian Exercise and Sport Sciences researchers, each contributing valuable knowledge to their respective domains. However, it is vital for the academic and professional communities to collaborate and ensure that these specificities do not create isolated compartments within the field but contribute to a comprehensive understanding of Exercise and Sport Sciences. Due to these disciplinary specificities and the lower number of ECTS credits in physical training and sports methodology, compared to other areas, the training in the ESS degree classes appears to be incongruent with the expected professional outcomes for PE teachers. This lack of congruence emphasises the importance of continuous dialogue and collaboration between the different ESS degree programmes to ensure that training and research objectives align with the needs of the PE teacher profession. The scientific identity of Italian researchers in ESS can play a crucial role in bridging these gaps and fostering a holistic approach to the field.

Given that ESS master's degree classes qualify for three specific professions and at the same time need to have a common framework to establish the requirements for access to the specialisation class to become a teacher, the aim of the study was to verify, in the context of PE teaching, the coherence between the qualifying objectives of the study classes in ESS and the specific educational objectives of the degree classes in light of the recent reforms for the implementation of the PNRR, which also directly and indirectly affect the future of PE teaching. In particular, the educational learning outcomes of the training activities in academic disciplines related to physical training and sports sciences methodology (M-EDF/01 and M-EDF/02) were analysed to verify their coherence with both the kinesiologist and sports manager professions and the PE teacher profession. This examination serves as a critical step in aligning the educational and research dimensions of Italian Exercise and Sport Sciences, promoting a cohesive, multidisciplinary approach that benefits both professionals and researchers in the field while advancing the PNRR's goals for physical education and sports in Italy.

METHOD

A document analysis and literature review was carried out, based on the qualifying educational objectives of the three master's degree classes in ESS (LM47, LM67,

LM68) and the specific educational objectives of the 63 master's degree classes, according to M-EDF/01 and M-EDF/02, comparing the results of the document analysis with the new legislation. A synoptic table was used to summarise data.

RESULTS

Two studies were analysed. A detailed description is showed in Table 1.

Table 1. Studies focused on ESS master's degree classes

| Study | ESS master's degree class | Analysis |
|-----------------------|---------------------------|---|
| Raiola (2023) | LM68 | No relationship among the 3 essential fields. The ECTS in physical activity-sports field were predominant, but with high value of standard deviation. |
| | LM67 | The biomedical field was taken as a benchmark among universities of different location, with respect to the other 2 fields. The ECTS in biomedical were predominant, but with high standard deviation values. |
| | LM47 | No shared criteria among universities. High degree of heterogeneity in the distribution of ECTS in the 3 essential fields, with a predominance of the economic-legal one. |
| D'Elia et al. (2023a) | LM68 | Higher prevalence of ECTS allocated to M-EDF/02. |
| | LM67 | Higher prevalence of ECTS allocated to M-EDF/01. |
| | LM47 | No prevalence. |

DISCUSSION

The results showed that in ESS master's degrees, coherence, strictly connecting learning outcomes and competencies (Tuning matrix), and congruence, the amount of M-EDF/01 and M-EDF/02 ECTS that provide coherence, of training activities with private professional profiles required by the law (2 types of Kinesiologists and sport manager) and the public one regarding the teaching of PE, were not fully ensured. This was particularly evident for the PE teacher in LM47 (Esposito et al., 2023) and LM67 degree classes. Also, the educational objectives of master's degree classes confirmed educational heterogeneity, so the issue was not only the number of ECTS. In LM68 Italian master's degree classes, there was no relationship between the 3 fields considered. No one field predicted the ECTS of the other 2 fields. The LM68 classes design appears self-referential. The ECTS in physical activity-sports field were predominant, but with high value of standard deviation. The LM68, compared with LM47 and LM67, had a higher prevalence of ECTS

allocated to M-EDF/02. In LM67 Italian master's degree classes, the biomedical field was taken as a benchmark among universities of different location, with respect to the other two fields. Also, the scientific production of university professors in ESS went in the same direction (D'Elia et al., 2023b). The ECTS in biomedical were predominant, but with high standard deviation values. This choice could be consistent with the profile of the kinesiologist of preventive and adapted physical activities due to its health and wellbeing peculiarities, but was not consistent with the PE teacher. The LM67 had a higher prevalence of ECTS allocated to M-EDF/01 than LM68 and LM47. The LM47 Italian master's degree classes had a high degree of heterogeneity in the distribution of ECTS in the 3 essential fields, with a predominance of the economic-legal one. Here too, as LM68, it seemed that each university did not apply shared criteria that could guarantee the graduates in ESS to achieve the same qualification with the same basic competences. The LM47 did not prevail in both M-EDF/01 and M-EDF/02. In summary, the analysis of the specific educational objectives confirms the

educational heterogeneity of the master's degree programmes in ESS with reference to the M-EDF/01 and M-EDF/02 educational activities which, in responding to the need for specific professional training, did not produce adequate training to face the professional outcomes both of the kinesiologists/manager and of the PE teacher. Institutions should work to homogenise the ECTS in the physical activity sports field.

CONCLUSIONS

The innovation processes deriving from the application of the PNRR reforms must be accompanied by a scientific-cultural action that leads to the development of a "core curriculum" which does not concern the minimum number of ECTS or the types of activities that are already well defined by

the ministry and which will become more flexible, but which especially concerns the coherence of the specific learning objectives, in particular of the M-EDF/01 and M-EDF/02 training activities of study classes in ESS with the qualifying objectives of the degree classes in ESS consistently with the innovations envisaged by the PNRR reforms.

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REFERENCES

1. D'Elia, F., D'Isanto, T., Aliberti, S., Altavilla, G., & Raiola, G. (2023a). Distribution analysis of ECTS credits allocated to physical training sciences and methodology (M-EDF/01) and sport sciences and methodology (M-EDF/02) in Italian master's degree programs in exercise and sport sciences. *Sport Sciences for Health*, 1-8. <https://doi.org/10.1007/s11332-023-01085-5>
2. D'Elia, F., D'Isanto, T., Esposito, G., Altavilla, G., & Raiola, G. (2023b). Physical activity and sports science in Italian scientific research products. *Health, Sport, Rehabilitation*, 9(2), 38-47. <https://doi.org/10.34142/HSR.2023.09.02.03>
3. D'Isanto, T., D'Elia, F., Altavilla, G., Aliberti, S., Esposito, G., Di Domenico, F., & Raiola, G. (2022). In Italy compatibility between qualifying training objectives of degree courses in sport sciences and exercise and the kinesiologist profile. *Trends in Sport Sciences*, 29, 99-105. <https://doi.org/10.23829/TSS.2022.29.3-3>
4. Esposito, G., D'Isanto, T., Ceruso, R., Di Domenico, F., & Raiola, G. (2023). The university training of the sports manager in Italy between legislative misapplications and overlapping degree courses. *Sport Sciences for Health*, 1-13. <https://doi.org/10.1007/s11332-023-01115-2>
5. Official Gazette (2022). Legislative Decree no. 163. Supplementary and corrective provisions to Legislative Decree no. 36 of February 28, 2021, in implementation of article 5 of law no. 86 of August 8, 2019, on the reorganization and reform of provisions on professional and amateur sports bodies and sports labor. Retrieved from: <https://www.gazzettaufficiale.it/eli/id/2022/11/02/22G00174/sg>. Accessed 12 January 2023
6. Raiola, G. (2019a). Comparison of exercise and sport sciences epistemology between European research council structure panel and Italian academic system. *Sport Science*, 12, 112-120.
7. Raiola, G. (2019b). Survey on exercise and sport sciences in Italy. *Journal of Human Sport and Exercise*, 14 (Proc4), S1163-S1168.
8. Raiola, G. (2019c). Complex study for an epistemology of exercise and sport sciences: A) key concepts of both ERC subpanels and CUN keywords; b) physical training and sport methodology sciences academic disciplines in pedagogy recruitment sector and biomedical one: A correlations study. *Journal of Physical Education and Sport*, 19, art. no. 255, 1748-1754.
9. Raiola, G. (2020a). Proposal of rearrangement of physical training and sport sciences methodology academic disciplines in Italian university body. *Sport Science*, 14 (1), 43-47.
10. Raiola, G. (2020b). The movement and sport science in Italy towards the European Research Council. *Physical Culture and Sport, Studies and Research*, 86 (1), 37-48.
11. Raiola, G. (2023). University training for physical education teachers, sports and preventive and adapted physical activities kinesiologists and sports manager. *Acta Kinesiologica*, 17(1). https://akinesiologica.com/ojs_3.3.0-7/index.php/akinesiologica/article/view/71

DIPLOMSKE STUDIJE SPORTSKIH NAUKA I TJELOVJEŽBE U ITALIJI: ISPITIVANJE NJIHOVIH PROFESIONALNIH REZULTATA**SAŽETAK**

U Italiji su dostupna tri programa diplomskog studija Sportskih nauka i tjelovježbe (ESS): Organizacija i menadžment sportskih i fizičkih aktivnosti (LM47), Nauka preventivnih i adaptivnih fizičkih aktivnosti (LM67) i Sportska nauka i tehnika (LM68). Ovi programi kvalifikuju studente za profesije sportskih menadžera (LM47), kineziologa koji su specijalizovani na polju preventivnih i adaptivnih fizičkih aktivnosti (LM67) te sportskih kineziologa (LM68). Sve tri programa imaju preduslove za dobijanje nastavne specijalizacije. Brojne su studije naglasile odstupanja u obučavanju širom zemlje uz učestalost specifičnih disciplinarnih fokusa: biomedicinskih za LM67, pravno-ekonomskih za LM47 i sportskih/fizičkih aktivnosti (M-EDF disciplina) za LM68. Ova studija nastoji procijeniti usklađenost između obrazovnih ciljeva studijskih programa ESS-a i specifičnih obrazovnih ciljeva predmeta, a posebno u vezi za podučavanjem fizičkog obrazovanja (PE). Analiza dokumentacije je provedena za obrazovne ciljeve tri diplomska studijska programa ESS-a i specifične obrazovne ciljeve 63 aktivna diplomska studijska programa u Italiji gdje je fokus stavljen na obrazovne aktivnosti povezane sa M-EDF-om. Analiza je otkrila da usklađenost i podudarnost aktivnosti podučavanja M-EDF-a sa profesionalnim rezultatima tri diplomska studijska programa ESS-a nisu u potpunosti ispunjene. Naime, podučavanje M-EDF-a nedostaje u LM47, a utiče na biomedicinske aspekte u LM67 i karakteriše se visokim nivoom sportskog sadržaja u LM68. Analiza specifičnih obrazovnih ciljeva dalje pokazuje da diplomski studijski programi ESS-a neadekvatno pripremaju studente za ispunjavanje profesionalnih uslova podučavanja fizičkog obrazovanja. Iznimno je važno razviti 'temeljni nastavni plan i program' za diplomski studij ESS-a uz osiguravanje podudarnosti između specifičnih obrazovnih ciljeva, a posebno onih koji se odnose na aktivnosti podučavanja M-EDF-a i profesionalne rezultate programa ESS-a.

Ključne riječi: diplomski studijski programi, Sportske nauke i tjelovježba, obrazovni ciljevi, fizičko obrazovanje

Correspondence to: Francesca D'Elia
University of Salerno, Italy
E-mail: fdelia@unisa.it

PHYSICAL EDUCATION IN EUROPEAN PRIMARY SCHOOLS: AN UP-TO-DATE OVERVIEW

Sara Aliberti¹

1. Facultad de Deporte, UCAM Universidad Católica de Murcia, Murcia, Spain

ABSTRACT

In Italy, 2021/2022 saw reforms concerning the teaching of physical education (PE) in primary schools, including the compulsory 2 hours and the gradual introduction of the specialist teacher, a master's graduate in sport science, only in Classes IV and V. This reform contributes, although still in a preliminary way, to achieving the goals set by the United Nations (UN) 2030 Agenda for Sustainable Development Goals (SDGs), in particular Goals 3 and 4 that deal with promoting health and well-being and providing quality education. PE is a discipline that can achieve these goals. Concerning the rest of Europe (EU), the latest Eurydice report (2013) entitled "Physical Education and Sport at School in Europe" stated that many countries were engaged in reforms to improve PE and sport at school through national strategies and large-scale initiatives, curriculum reforms, teacher training, and improvement of school equipment and infrastructure. As this report is 10 years old, it is not possible to infer how PE teaching in primary schools has evolved in the EU countries. The aim of the study was to provide a comparative analysis between EU countries regarding PE teaching in primary schools in recent years through reports from public and private bodies. The European PE Association was the most recent body to monitor the state of PE in Europe since Eurydice, showing that the situation of PE teaching in Italy was similar to many EU countries, in some cases better and in others worse: the presence of the generalist teacher in the first classes of primary school and the specialist in the last ones, the compulsory 2 PE hours per week, and the presence of a specific curriculum. However, to provide QPE and achieve the SDGs, it is necessary to work on several aspects. The study showed an up-to-date picture of the state in the field concerning the teaching of PE in primary schools in different EU countries. By comparing and identifying the strengths and weaknesses of each country, the aim is to improve PE teaching in primary schools in Italy.

Keywords: wellbeing, movement, report, SDGs, Eurydice, EUPEA

INTRODUCTION

In Italy, the reform concerning the teaching of physical education (PE) in primary schools, including the compulsory 2 hours of PE and the gradual introduction of the specialist teacher, a master's graduate in sports sciences, only in IV and V classes, was introduced by the year 2021/2022. This reform is aimed to achieve the goals of the National Recovery and Resilience Plan (PNRR), inherent to the assumption of behaviours and lifestyles appropriate to the harmonious development of the person, psycho-physical well-being, and the best possible state of health (G. U., 2022). Several studies (D'Elia, 2023; D'Isanto, 2023) investigated the impact of this reform on internal and external stakeholders,

including headmasters, future generalist teachers and undergraduates in sports science, who were aware of the required specific training to teach PE, possessed by the specialist teacher, wishing for its introduction in all primary school classes. Providing quality education is one of the main global goals to improve the living conditions of society. Without it, it is difficult to ensure food security, physical and mental well-being. The reform contributes, albeit still in a preliminary way, to the achievement of the goals set by the 2030 Agenda for Sustainable Development (SDGs) of the United Nations (UN). The 2030 Agenda is an action programme which aims to achieve 17 SDGs and 169 sub-goals to find common solutions to the challenges the planet is facing, including the educational emergencies of contemporary society. Specifically, goal no. 3 aims to ensure health and well-being for all and all ages, while goal no. 4 strives to provide quality, equitable

and inclusive education and learning opportunities for all (UN, 2015).

PE is a discipline that can achieve these goals; in fact, the UN has established that physical activity is a fundamental right of all and, therefore, is a crucial component of equitable and quality education. Not to mention that being a cross-cutting subject, it can also contribute to the achievement of other goals set in the UN 2030 Agenda. According to the UN Educational, Scientific and Cultural Organisation (UNESCO, 2015) the parameters that determine quality PE (QPE) are a minimum of 120 min PE per week, adequate sports equipment and facilities, adequate periodic assessment of both pupils and teachers, the support to PE teachers by headmasters, school directors, counsellors, and a specific curriculum, including inclusive policies, physical literacy, healthy cooperation and competition, challenges, knowledge and skills to maintain an active lifestyle, promotion of the different domains of the person, and development of life skills to create future citizens. Concerning the rest of Europe (EU), the latest Eurydice report (2013) titled "Physical Education and Sport at School in Europe" stated that many countries were working on reforms to improve PE and sport at school through national strategies and large-scale initiatives (e.g., Denmark, Latvia, Austria, Romania, and Cyprus), school curriculum reforms, especially on the content and purpose of PE, teaching hours and pupil assessment (Cyprus, England, Finland, Portugal, Greece, Hungary, Czech Republic, Austria, and France), teacher training (Finland and France), and improving sports equipment and school infrastructure (e.g., Bulgaria and Hungary).

PROBLEM AND AIM

As the last Eurydice survey is 10 years old, it is not possible to infer how PE teaching in primary school has evolved in different EU countries.

The aim of the study was to provide a comparative analysis among EU countries regarding the teaching of PE in primary schools in recent years through reports from public and private bodies. Understanding the state in the field related to PE could provide further insights to improve the Italian reform in a content and practical sense to promote QPE.

METHODS

The study design was document-comparative. Information on PE teaching in primary school was obtained from official documents, surveys, reports, and surveys from both public and private bodies with cut-off dates ranging from 2018 to 2023. Key outcomes included: no. of PE hours per week, the type of teacher (generalist or specialist), curricula, and interesting reforms. A synoptic table was used to summarise data.

RESULTS

The European PE Association (EUPEA, 2023) was the most recent body to monitor the state of PE in Europe since Eurydice, organising the first PE Talk on an overview of PE in primary schools. Researchers from different countries collected data on this topic in South-East Europe regions, Central-East regions and Nordic regions. The results are showed in Table 1.

Table 1. An overview of PE in primary schools in different countries

| Countries and no. of PE hours per week | Responsible for PE classes |
|--|--|
| Bulgaria (3h), Cyprus, Kosovo, and Finland (2h) | The generalist teacher |
| Greece (3h in the first grades; 2h in the last grades) | The specialist teacher |
| Italy, Türkiye and Bosnia and Herzegovina (2h), Croatia and Cyprus (3h in the first grades; 2h in the last grade/s), North-Macedonia (3h), and Serbia (3/3.5h) | The generalist teacher (in the first grades) and the specialist one (in the last grades) |
| Portugal (1-3h), Spain (3h), France (3h), and Switzerland (2h) | The generalist teacher, often supported by a specialist |
| Czech Republic, Slovakia and Poland (2-5h), and Hungary (daily PE) | The generalist teacher and the specialist one |

All had a specific curriculum, except Kosovo. An interesting reform concerned the new curriculum in Finland (FNBE, 2016) related to the teaching of PE which adopted a new perspective: it abandons the teaching of specific sports to work on students' well-being by supporting their physical, social and psychological functional capacity and positive body image.

DISCUSSION

PE in Europe is developed differently, both in terms of terminology and content, given the different socio-cultural context (Čučković & Vrcelj, 2020). This leads to a different way of implementing PE at school, despite the common challenges to be faced, including obesity, sedentariness and inactivity. As of today, the situation of PE teaching in Italy is similar to many EU countries, in some cases better and in others worse: the presence of the generalist teacher in the first classes of primary school and the specialist in the last ones, the compulsory 2 PE hours per week, and the presence of a specific curriculum. Specifically, in Italy, Türkiye, and Bosnia and Herzegovina (2h), Croatia and Cyprus (3h in the first grades; 2h in the last grade/s), North-Macedonia (3h), and Serbia (3/3,5h), PE was performed by the generalist teacher (in the first grades) and the specialist one (in the last grades). In Bulgaria (3h), Cyprus, Kosovo and Finland (2h), there was only the generalist teacher, while in Greece (3h in the first grades; 2h in the last grades), there was only the specialist one. Finally, in Portugal (1-3h), Spain (3h), France (3h), and Switzerland (2h) there was the generalist teacher, often supported by a specialist, while in

Czech Republic, Slovakia, and Poland (2-5h), alongside Hungary (daily PE) there were both the generalist and the specialist teachers. However, to provide QPE and achieve the SDGs, it is necessary to work on several aspects: first of all, the number of PE hours. A good example is Hungary, which performed daily PE. A recent study (Dizmatsek et al., 2022) showed that daily PE, after 10 years of its implementation, increased the amount of physical activity students had in their leisure time.

A second step is the presence of the specialist teacher in the primary school. Italy is starting to work on this, hoping to extend this figure to all primary school classes. A good example is Greece, which is the only country that had only the presence of a specialist teacher to teach PE in primary schools. In terms of quality, work needs to be done on PE teacher training. There are two main figures involved in teaching PE: the generalist teacher, who has a degree in primary education sciences, and the specialist teacher, who has a master's degree in sport sciences and exercise (Raiola, 2013; 2020ab; 2023). The different university training generates different ways of approaching PE teaching (D'Isanto, 2021), including different objectives, contents and teaching methodologies ranging from prescriptive to heuristic ones (Raiola, 2019). However, as the content is too specifically related to health and physical well-being, a definitive choice needs to be made in the direction of the specialist for its greater competence than generalists (Invernizzi et al., 2020).

The third step is the promotion of a well-structured curriculum aimed to achieve the PNRR goals and SDGs. An example to consider as a basis for the future is the National curriculum guidelines in

Finland that became effective in 2016, based on the concept of shifting the focus from teaching specific sports to fundamental movement skills and using different sports as a tool to teach them. Furthermore, another important goal was to enhance pupils' perceived autonomy, competence and social relations, as well as their intrinsic motivation towards PE. Thus, the main goal was to influence pupils' well-being by supporting their physical, social, psychological functional capacity, and positive body image. The two main objectives were to guide pupils to adopt physically active lifestyle and to educate them through PE.

The school emphasises the importance of accompanying the building of knowledge with an education that can go outside the school walls (Altavilla et al., 2022) and influence the growth of children by providing them with the necessary means to be able to face the challenges of everyday life. One of the biggest problems to be solved is the lack of a skills base to cope with the demands of the working environment, i.e., transversal skills. This can be fostered through a heuristic approach to PE (D'Isanto et al., 2021; 2022). Not to be forgotten is the issue of school inclusion to combat stereotypes and prejudices and to guarantee equal opportunities for all students. The teacher must be able to create optimal learning conditions for all students, smoothing out difficulties and differences, to put every student in a position to discover, enhance and express his or her potential to the fullest extent (Di Domenico et al., 2022; Raiola et al., 2018).

The fourth and final step consists of the assessment, which must be based on the objectives set out in the curriculum and include not only the physical aspect, but also the motivational, relational, social and life skills development aspect. Assessment allows the teacher to obtain quantitative and qualitative data useful for planning, designing and periodising the annual programme for studying the effect of teaching-learning methods, pushing the pupils to improve and making them aware of their own level, as well as for identifying each pupil's strengths and weaknesses and for assessing whether they achieved the set goals (Altavilla, 2019). The use of assessment strategies can improve the quality of teaching and learning in PE and the perceptions of that discipline by both teachers and students (Ní Chróinín & Cosgrave, 2013). However, it is necessary, besides assessment sheets that can be personalised by the teacher, to identify standardised tools that are valid and reliable, such as Movement assessment battery for children-2 (MABC-2; Henderson et al., 2007) to assess children's motor performance or questionnaires for opinions and perceptions (Aliberti et al., 2022). To promote QPE and achieve the SDGs, it is important to work on all the variables mentioned above, both in Italy and in the rest of Europe.

CONCLUSIONS

The study showed an up-to-date picture of the state in the field concerning the teaching of PE in primary schools in different EU countries. By comparing and identifying the strengths and weaknesses of each country, the aim is to improve PE teaching in primary schools in Italy. To provide QPE, it is necessary to redesign the Italian curriculum for

PE, working on PE teacher training, extending its presence in all classes of primary school, and working on specific assessment.

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REFERENCES

1. Aliberti, S., Rago, V., D'Elia, F., & Raiola, G. (2022). Questionnaire of inclusion in Paralympic dance: Validation and pilot study. *Sport Sciences for Health*, 18(4), 1339-1347.
2. Altavilla, G. (2019). Monitoring training to adequate the teaching method in training: An interpretative concept. *Journal of Physical Education and Sport*, 19, art. no. 258, 1763-1766.
3. Altavilla, G., Ceruso, R., Esposito, G., Raiola, G., & D'elia, F. (2022). Physical education teaching in Italian primary school: Theoretical lines and operational proposals. *Pedagogy of Physical Culture and Sports*, 26 (3), pp. 151-157.
4. Čučković, A. Ž., & Vrcelj, S. (2020). Comparative analysis of the national curriculum of physical education in primary education in Europe based on vector model. *Universal Journal of Educational Research*, 8(12A), 7330 - 7334. <https://doi.org/10.13189/ujer.2020.082516>
5. D'Elia, F. (2020). Teachers' perspectives about contents and learning aim of physical education in Italian primary school. *Journal of Human Sport and Exercise*, 15(2), 279-288.
6. D'Elia, F. (2023). Physical education in primary school and impact on primary teacher education students from two different university sites. *Acta Kinesiologica*, 17(1). https://akinesiologica.com/ojs_3.3.0-7/index.php/akinesiologica/article/view/66
7. D'Isanto, T., Di Domenico, F., Aliberti, S., D'Elia, F., & Raiola, G. (2022). Criticisms and perspectives of heuristic learning in physical education. *Pedagogy of Physical Culture and Sports*, 26 (2), pp. 93-100.
8. D'Isanto, T., Di Domenico, F., D'Elia, F., Aliberti, S., & Esposito, G. (2021). The effectiveness of constraints-led training on skill development in football. *International Journal of Human Movement*, 9(6), 1344-1351.
9. D'Isanto, T. (2019). State of art and didactics opportunities of physical education teaching in primary school. *Journal of Physical Education and Sport*, 19, 1759-1762.
10. D'Isanto, T. (2023). Physical education in primary school and impact on educational leadership. *Acta Kinesiologica*, 17(1). https://akinesiologica.com/ojs_3.3.0-7/index.php/akinesiologica/article/view/65
11. Di Domenico, F., D'Isanto, T., Altavilla, G., D'Elia, F., & Raiola, G. (2022). Inclusive physical activity to promote the participation of people with disabilities: A preliminary study. *International Journal of Statistics in Medical Research*, 11, 12-18.
12. Dizmatsek, I. B., Ling, J., Tóth, L., Hamar, P., & Soós, I. (2022). The effect of the introduction of daily physical education classes on the leisure activities of Hungarian students. *Cognition, Brain, Behavior*, 26(1). <https://doi.org/10.24193/cbb.2022.26.01>
13. European Physical Education Association [EUPEA]. (2023). PE in primary schools in Europe. The roots for the development of an active and physically educated citizen. Retrieved from: <https://eupea.com/replay-pe-in-primary-schools-in-europe/>
14. Eurydice. (2013). Physical Education and Sport at School in Europe Eurydice Report. Luxembourg: Publications Office of the European Union. Retrieved from: <https://eurydice.eacea.ec.europa.eu/publications/physical-education-and-sport-school-europe>
15. Finnish National Board of Education [FNBE]. (2016). National Core Curriculum for Basic Education 2014. National core curriculum for basic education intended for pupils in compulsory education. Finnish National Board of Education.
16. Gazzetta Ufficiale [G. U.]. (2022). Gazzetta Ufficiale. State budget for the financial year 2022 and multi-year budget for the three-year period 2022-2024. Retrieved from: <https://www.gazzettaufficiale.it/eli/id/2021/12/31/21G00256/sg>
17. Henderson, S. E., Sugden, D., & Barnett, A. L. (2007). Movement assessment battery for children-2. *PsycTESTS Dataset*.

18. Invernizzi, P. L., Signorini, G., Colella, D., Raiola, G., Bosio, A., & Scurati, R. (2020). Assessing rolling abilities in primary school children: Physical education specialists vs. generalists. *International Journal of Environmental Research and Public Health*, 17(23), 8803.
19. Ní Chróinín, D., & Cosgrave, C. (2013). Implementing formative assessment in primary physical education: teacher perspectives and experiences. *Physical Education and Sport Pedagogy*, 18(2), 219-233.
20. Raiola, G. (2013). Body knowledge and motor skills. *Knowledge Cultures*, 1(06), 64-72.
21. Raiola, G. (2017). Motor learning and teaching method. *Journal of Physical Education and Sport*, 17, 2239-2243.
22. Raiola, G. (2020a). The movement and sport science in Italy towards the european research council. *Physical Culture and Sport. Studies and Research*, 86(1), 37-48.
23. Raiola, G. (2020b). Proposal of rearrangement of physical training and sport sciences methodology academic disciplines in Italian university body. *Sport Science*, 14 (1), pp. 43-47.
24. Raiola, G., D'Elia, F., Altavilla, G. (2018). Physical activity and sports sciences between European Research Council and academic disciplines in Italy. *Journal of Human Sport and Exercise*, 13, S283-S295.
25. United Nations [UN]. (2015). The 17 goals. Retrieved from: <https://sdgs.un.org/goals>
26. United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2015). Quality physical education (QPE). Guidelines for policy-makers. Retrieved from: <https://unesdoc.unesco.org/ark:/48223/pf0000231101>

FIZIČKO OBRAZOVANJE U EUROPSKIM OSNOVNIM ŠKOLAMA: AŽURIRANI PREGLED

SAŽETAK

U Italiji je tokom 2021/22 došlo do reformi u podučavanju fizičkog obrazovanja (PE) u osnovnim školama, uključujući obavezna 2 sata i postupno uvođenje nastavnika koji je završio diplomski studij sportskih nauka, i to samo u IV i V razredu. Iako je još uvijek preliminarna, ova reforma doprinosi postizanju ciljeva Agende 2030 za Ciljeve održivog razvoja Ujedinjenih nacija (UN), a posebno ciljeve 3 i 4 koji se odnose na promociju zdravlja i dobrobiti te pružanje kvalitetnog obrazovanja. Fizičko obrazovanje je disciplina koja može postići ove ciljeve. Kada je u pitanju ostatak Europe (EU), posljednji izvještaj Eurydicea (2013.) naziva „Fizičko obrazovanje i sport u školama u Europi“ navodi da su mnoge zemlje provele reforme za poboljšanje fizičkog obrazovanja i sporta u školi kroz nacionalne strategije i opsežne inicijative, reforme nastavnog plana i programa, obuke učitelja i poboljšanje sportske opreme i infrastrukture. Obzirom da je ovaj izvještaj napravljen prije 10 godina, nije moguće zaključiti kako se podučavanje fizičkog obrazovanja u osnovnim školama razvilo u zemljama EU. Cilj ove studije je napraviti komparativnu analizu zemalja EU po pitanju podučavanja fizičkog obrazovanja u osnovnim školama posljednjih godina kroz izvještaje javnih i privatnih tijela. Od osnivanja Eurydicea, Europska asocijacija za fizičko obrazovanje je najnovije tijelo koje nadzire stanje fizičkog obrazovanja u Europi te ukazuje da je situacija sa podučavanjem fizičkog obrazovanja u Italiji slična onoj u mnogim zemljama EU (u nekim slučajevima je bolja, a u nekim je lošija): prisustvo učitelja u prvim razredima osnovne škole i nastavnika u posljednjim, obavezna 2 sata fizičkog obrazovanja sedmično i prisustvo posebnog nastavnog plana i programa. Međutim, da bi pružili kvalitetno fizičko obrazovanje (QPE) i postigli Ciljeve održivog razvoja (SDG), potrebno je raditi na nekoliko aspekata. Studija je dala ažuriranu sliku stanja na polju podučavanja fizičkog obrazovanja u osnovnim školama različitih zemalja EU. Poređenjem i identifikacijom prednosti i mana svake zemlje, cilj je poboljšati podučavanje fizičkog obrazovanja u osnovnim školama u Italiji.

Ključne riječi: dobrobit, kretanje, izvještaj, SDG, Eurydice, EUPEA

Correspondence to: Sara Aliberti
Facultad de Deporte, UCAM Universidad Católica de Murcia, Murcia, Spain
E-mail: saliberti@alu.ucam.edu

COMPLICATION OF DISTANCES BY INTRODUCING SECTIONS WITH DIFFERENT ENVIRONMENTAL CONDITIONS FOR INCREASING THE ENTERTAINMENT OF MARATHON SWIMMING

Egor M. Shchelkanov¹, Edward A. Chibrikov¹, Sergei A. Yakushin¹, Vladimir M. Bobylev²

1. State University of Education, Russia
2. Moscow Swimming Academy, Russia

ABSTRACT

The article provides a brief analysis of the features of open water swimming in various environmental conditions: water salinity, current intensity, temperature, and wave load. On the one hand, these conditions objectively “break” the swimming technique practiced for years in indoor pools; on the other hand, it is these complexities that return swimming to its origins and bring intrigue and unpredictability. The purpose of the presented work is to identify the effect of the factors listed on the technique of open water swimming. Methods: The analysis of the data presented in the scientific literature or specialised websites on the Internet; the formulated working hypotheses were tested using experimental swims at distances over 3 km during sports camps in fresh and salty water. Salinity, current intensity, temperature, and wave load create ever-acting and ever-changing complexities, which give advantages to athletes with different morphological features and functional training as well as the level of readiness for dynamic adaptations. Some of the most universal techniques for overcoming emerging technical ambiguities that swimmers do not encounter in indoor pools, but constantly struggle with in open water, are described. The paper concludes that the entertainment of marathon swimming can be increased by the purposeful introduction of several segments with different conditions into the distance.

Keywords: open water swimming, water salinity, current intensity, temperature, wave load, entertainment

INTRODUCTION

Marathon swimming is a sports discipline in which athletes compete for the speed of passing significant (at least 3 km) distances in natural reservoirs. The latter has served as a training and competition venue for a long time since the first indoor pools began to appear only at the end of the XIX century, and the rule of mandatory registration of swimming speed records in them was introduced by the International Swimming Federation in 1908.

Throughout the XX century, the improvement of swimming techniques with 4 main styles (butterfly, backstroke, breaststroke, and crawl) and their combinations (complex swimming, freestyle and mixed relay races) was carried out in indoor pools, allowing to exclude the influence of uncontrolled external factors: wind, wave load, water salinity, currents, insolation, and temperature differences (Bobylev & Shchelkanov, 2011). At the beginning of the XXI century, the material and technical equipment of sports swimming tried to reach a new qualitative level through the use of wetsuits both in the training process and in competitions. This of course interesting technological experiment has led to excessive professionalization and commercialisation of swimming to the detriment of its sports content and mass accessibility. Suffice it to recall that during 2008 alone, swimmers dressed in polyurethane Speedo LZR Racer suits broke world records at all distances; however, these records were cancelled after the ban on wetsuits with increased buoyancy by the new rules of 2010 (Politko, 2015).

Marathon swimming does not just return swimming to its origins, but to a significant extent compensates for the excessive professionalization of this sport while maintaining the requirements for the physical, moral, volitional, and technical preparedness of athletes. However, the banal lengthening of the distance, which leads to an increase in the duration of viewing, not only does not lead to an increase in the entertainment of competitions, but may even reduce their attractiveness. New progressive approaches are required that can make the audience of marathon swimming truly massive (Throsby, 2016).

MATERIALS AND METHODS

The purpose of this work is a brief analysis of approaches to improving the entertainment of marathon swimming by introducing segments of varying complexity into the distance, requiring a change of techniques, which entails the appearance of unpredictability of sports results.

In accordance with the stated purpose, the study included the following tasks: (1) to establish the role of salinity of water on the change of swimming technique; (2) to establish the influence of currents

as a factor complicating the process of passing the distance; (3) to establish the main types of wave load that require various mechanisms of adaptation of swimming technique.

Taking into account the huge variety of natural conditions of open reservoirs, in which open water competitions can be held, it is very difficult if at all possible to conduct an experimental assessment of swimming in them by one team. Therefore, the main methodological approach of the presented article was based on searching information among specialised websites: International Swimming Federation (in French: FINA – Fédération Internationale de natation) ("Website FINA", 2023), All-Russian Swimming Federation ("Website ARSF", 2023), Belarusian Swimming Federation ("Website BSF", 2023), Chinese Swimming Association ("Website CSA", 2023), Marathon Swimmers Federation ("Website MSF", 2023), Strait of Gibraltar Swimming Association ("Website SGSA", 2023), and Strait of Bonifacio Swimming Association ("Website SBSA", 2023), using keywords and surnames of leading athletes. The search for scientific literature was carried out using catalogues on specialised information resources: Russian Scientific Electronic Library, Russian State Library, Google Academy, and National Library of Medicine.

Verification of the theoretically formulated theses was carried out in the conditions of natural reservoirs during the summer sports camps at the Istra Reservoir (Moscow Region), as well as in the Amur, Novick and Ussuri Bays in the vicinity of Vladivostok (Primorsky Krai). Immediately after passing the distance, the swimmer recorded his feelings and the effectiveness of his actions for each of the environmental factors: wind, waves, current, insolation, cooling effect of water, and salinity (the latter - when swimming in the sea). The actions of the athlete with the help of optics were observed by a doctor, a coach and two other actual swimmers of the same age, each of whom also left notes about the nature of the swimmer's movements during the distance, possible errors and the proposed ways to correct them.

RESULTS

It has been established that one of the most significant environmental factors affecting the swimming technique and the schedule of the distance is the salinity of the water. The usual training in the pool takes place in fresh water, so swimming in the open water of marine waters dramatically changes the body position in the liquid that is familiar to the swimmer and significantly aggravates the effect of other external factors. To understand this effect from a physical point of view, it is necessary to take into account that gravity is applied to the centre of mass of the swimmer's body, which is shifted towards the pelvis, and the pushing Archimedean force is applied to the geometric centre of the body volume, which is closer to the chest. At the same time, the positions of both the centre of mass and the geometric centre of the body change when the volume of the lungs changes during breathing as well as when the arms and legs carry out their movements. As a result, there is a torque that increases drag and reduces

speed. A complex of stabiliser muscles is involved in dampening the emerging oscillatory movements, in which the leading role is assigned to the oblique and rectus abdominal muscles. Therefore, the advantage of marathon swimming in salt water is obtained by athletes whose morphological and functional features reduce the above-mentioned rotational moment: elongated limbs with longitudinally shortened lungs and long layers of abdominal muscles consisting mainly of slow aerobic fibres. As for the back muscles, they – on the contrary – should contain a significant proportion of fast aerobic fibres that could respond to changes in body position as a result of exposure to waves that are common for open water and are not typical for swimming pools.

Fluid currents create additional rotational moments, which depend on the angle of action of the fluid on the body, taking into account the phase of the stroke movement. With strong lateral currents, it is advantageous to drastically reduce the depth of immersion of the hand when rowing, which significantly changes the technique, compared to calm water in the pool. Moreover, in the presence of a strong current, breaststroke generally turns into an undesirable swimming style, since it is characterised by significant immersion of various parts of the body under water. At first glance, it may seem that swimming in a pool with a turbine counterflow is an excellent training technique for practicing swimming techniques, at least with a counter current. However, this is not entirely true, since the turbine counterflow in the basin is created as laminar as possible, while our observations show that the currents in the natural reservoir have a high degree of turbulence. At the level of the swimmer's sensations, this is expressed in the constant fixation of the inefficiency of the usual technical actions; any attempts to adapt the nature of movement to the constantly changing micro-conditions created by the flow of fluid only aggravate the situation and finally break the technique. Strong currents bring guaranteed interference to the predicted results of swimmers of any level and are able to bring victories to unsuspecting competitors. According to the athletes, in swimming under the pressure of currents, strong-willed qualities and the ability to undergo objective difficulties come to the fore. For waters with significant currents, the psychological preparation of a swimmer means more technical preparedness. On the other hand, the advantage is given to athletes who are well acquainted with such waters – at the same time, as a rule, there are no visible changes in swimming technique, but there is a psychological readiness for emerging difficulties.

Waves on the liquid-air interface have various laws of energy dispersion depending on the conditions of their formation (depth, bottom relief, the presence of ships moving nearby, the proximity of the surf zone, and the relief of the coast). In our study, we could not even claim theoretical coverage of all possible wave modes, let alone experimental verification of their influence on the marathon swimming process. However, according to the reviews of professional marathon swimmers, many natural reservoirs have wave loads characteristic of them (at least for a fixed time of year and weather conditions), the knowledge of which and the presence of swimming skills in which significantly help to improve sports results. The most convenient type of waves when swimming in open water are long low sea waves. The

length of such a wave is greater than the length of the swimmer's body, and the height of the wave is less than the length of the swimmer's body (and therefore less than the wavelength). Overcoming such long sloping waves requires several rowing cycles and can do without changing the swimming technique. However, athletes who swim a lot among long sloping waves still describe the need to adapt the technique when entering the crest of such a wave and when descending down: at a minimum, it is better to reduce the sliding time on the first type of site, and on the second, on the contrary, to increase it. When swimming on long low waves, the swimming technique cannot be changed in all styles. The most inconvenient are medium waves, when the wave length, the swimmer's body length and the wave height are comparable in relation to each other (such waves are formed in strong winds and in stormy weather). When swimming across the crests against the course of the waves, there is a danger of being in a semi-standing position with the prospect of almost a complete stop of movement. The swell variant, when the swimmer's body length is greater than the height and wave length, presents the main difficulties for swimming along the wave crests, since the flat position of the body is disturbed, and it is difficult to take breath in the direction of the incoming wave.

DISCUSSION

Marathon swimming requires from an athlete not only a different muscular activity, compared to swimming in the pool (Bobylev & Shchelkanov, 2012), but also fundamentally new types of activity, since diverse and changeable environmental factors and interaction with other athletes in the group require a swimmer to constantly analyse the current situation during the distance, adapt swimming techniques to them and develop appropriate methods of the training process (Barbashov & Kozydub, 2015; Bobylev & Shchelkanov, 2012; Karyakin & Nizhnik, 2020). Moreover, difficult distances, during which multiple changes of the conditions of the situation are consciously laid, can significantly increase the entertainment and attractiveness of marathon swimming – just as biathlon precisely by its unpredictability allowed to attract the audience's sympathies for skiing at the time (Baklanov, Yakushin, Chibrikov & Chibrikova, 2021; Chibrikov et al., 2022; Koldashov, Yakushin, Chibrikov & Moshkov, 2022).

The density of fresh water is maximum at +4°C and is equal to 1.00 g/cm³ decreasing slightly both with a decrease and with an increase in temperature. The density of the human body is about 1.01–1.03 g/cm³, so slightly higher than the density of water, and acquires positive buoyancy only after a deep breath, becoming equal to 0.94–0.97 g/cm³. When swimming in salt water, positive buoyancy can occur even without taking into account respiration: the density of the World Ocean is 1.02–1.03 g/cm³ at a salinity of 35 g/l (Kennish, 2001). In drainless reservoirs, the values

of density and salinity can be even higher: in lakes Elton (Russia, Pallasovsky district of the Volgograd region) and Baskunchak (Russia, Akhtubinsky district of the Volgograd region) – 280–300 g/l, 1.37–1.45 g/cm³, in the Great Salt Lake (USA, Utah) – 250–300 g/l, 1.35–1.42 g/cm³, in the Caspian Gulf of Kara-Bogaz-Gol (Turkmenistan) – 285 g/l, 1.40 g/cm³, and in the Dead Sea (on the border of Israel and Jordan) – 265 g/l, 1.35–1.40 g/cm³ (Mikhailov, 2008). In salt water, even powerful muscular athletes with a large muscle mass, who prevailed in swimming during the use of polyurethane swimming suits (1996–2009), artificially increased buoyancy, have additional buoyancy (and at a density above 1.03 g/cm³ – guaranteed positive buoyancy) (Politko, 2015).

The most difficult types of distances in marathon swimming include those that are laid in waters with a salinity gradient. For example, in our field experiments, we covered a distance of 15 km several times from Cape Peschany to Cape Rechnoy in the waters of the Amur Bay (Primorsky Krai, Russia), during which the salinity drops from 19 g/l to 2 g/l (Hen, 2020). According to the reviews of swimmers, the most completely exhausting route is in the direction of reducing salinity (which falls due to the confluence of the Amba and Razdolnaya rivers into the bay), while the passage of the distance in the opposite direction is much easier. Based on the results obtained, we tried to complicate the distance as much as possible: the start from Cape Peschany (19 g/l) to Cape Atlasov (10 g/l) at the mouth of the Amba River (Hen, 2020) and back – modest 11 km distance caused serious difficulties (especially since the strong cold lateral current formed by the mouth of the river constantly squeezed swimmers from the shore). Laying distances for marathon swimming competitions in waters with a salinity gradient, at first glance, seems to be an unjustified additional complication, but such distances could be used for educational and methodological purposes to comprehensively increase the load on certain muscle groups, and most importantly can make the result of the swim completely unpredictable, and therefore more spectacular.

Marathon swimming is mainly associated with the aerobic mode of muscle tissue, but this mode is not the only one (Morozova, 1990). If an athlete – in addition to aerobic – has high-threshold anaerobic muscle fibres, then they can be used to perform additional work beyond the power of oxidative phosphorylation. First of all, this is the finishing spurt and overtaking acceleration. Being in zero gravity makes it possible for a marathon swimmer to “carry” a load of anaerobic muscle fibres that are not involved for most of the distance. The higher the buoyancy, the higher the “spare anaerobic capacity”. Thus, when marathon swimming in salty reservoirs (as opposed to fresh), athletes with an increased proportion of anaerobic fibres receive advantages, which allow additional acceleration, and this significantly changes the tactical pattern of the distance (Bobylev & Alexandrov, 2010).

The ability to have additional glycogen energy

capabilities provided by increased buoyancy in salt water is also essential for marathon swimming due to the relatively low temperatures that are often found in open water. The minimum allowable temperature for marathon swimming competitions, according to the rules of the International Swimming Federation, is +16°C. Water temperatures below +18°C are very “uncomfortable” for a long stay and require significant energy costs (Fayzullin, 1949). But these costs are incomparably higher in the case of winter marathon swimming, which is also gaining popularity – so far among amateurs (Timofeev, 2014). But we cannot rule out the rapid professionalization of this direction.

CONCLUSION

Increasing the entertainment of marathon swimming can be based on bringing elements of surprise and good sports intrigue into this sport. It is quite possible to do this if we consider marathon swimming not just as a long-distance swim, but to make up a distance of segments, on each of which specific efforts are required from the athlete and characteristic requirements for morphologic and functional fitness are imposed. Of course, such an approach on the one hand will require special specialisation of swimmers, and already at the early stages of sports training. For example, athletes whose morphologic and functional profile is best adapted to marathon swimming in salt water, starting from a certain level, begin to noticeably yield in performance to their peers in the pool and may prematurely end their career growth. Therefore, special breeding programmes are needed, focused on marathon swimming in various environmental conditions. In accordance with this, the training process should also include a set of methodological techniques for overcoming difficulties caused by the described environmental factors.

REFERENCES

1. All-Russian Swimming Federation (ARSF). Retrieved from: <http://russwimming.ru/> (accessed: 24/05/2023).
2. Baklanov, V. D., Yakushin, S. A., Chibrikov, E. A., & Chibrikova, M. E. (2021). Modeling of competitive activity in biathlon on the example of students of Moscow State University and Bauman Moscow State Technical University. *Proceedings of Tula State University. Physical Culture. Sport*, 11, 60-67. doi: 10.24412/2305-8404-2021-11-60-67
3. Barbashov, S. V., & Kozydub, O. V. (2015). Correlations of indicators of competitive activity of qualified athletes specializing in marathon swimming. In *Materials of the XIV All-Russian Scientific and Practical Conference with International Participation "Improving the System of Physical Education, Sports Training, Tourism and Health Improvement of Various Categories of the Population"* (pp. 16-19). Surgut.
4. Belarusian Swimming Federation (BSF). Retrieved from: <https://blrswimming.by/> (accessed: 24/05/2023).
5. Bobylev, V. M., & Alexandrov, A. Yu. (2010). The relationship between physical development and swimming fitness of highly qualified marathon athletes. *Theory and Practice of Physical Culture*, 3, 71-73.
6. Bobylev, V. M., & Shchelkanov, M. Y. (2011). Specific features of adaptation of marathon swimmers in conditions of fresh and saline open surface waters. *Physical culture: education, upbringing, training*, 5, 37-39.
7. Bobylev, V. M., & Shchelkanov, M. Y. (2012). Perfection of training of marathon swimmers in big experimental tanks. *Theory and Practice of Physical Culture*, 8, 66-71.
8. Chibrikov, E. A., Yakushin, S. A., Lifanova, E. S., Nikitinskaya, V. N., Diedrich, A. P., & Voronina, A. V. (2022). Using the game method to develop and adjust the technical abilities of young skiers. *Scientific Notes of the P.F. Lesgaft University*, 11, 598-602. doi: 10.34835/issn.2308-1961.2022.11.p598-602
9. Chinese Swimming Association (CSA). Retrieved from: <http://swimming.sport.org.cn/> (accessed: 24/05/2023).
10. Fayzullin, I. G. (1949). *Distant voyages*. Moscow: Voenizdat Press.
11. International Swimming Federation (FINA). Retrieved from: <https://www.worldaquatics.com/> (accessed: 24/05/2023).
12. Karyakin, R. E., & Nizhnik, G. N. (2020). Preparation of athletes for contact wrestling in open water swimming. *Scientific Notes of the P.F. Lesgaft University*, 8, 64-68. doi: 10.34835/issn.2308-1961.2020.7.p157-161
13. Kennish, M. J. (2001). *Practical handbook of marine science*. CRC Press.
14. Khen, G. (2020). History of Peter the Great Bay discover and oceanographic surveys in the Japan Sea till the middle 20th century. *Proceedings of All-Russian Scientific Research Institute of Fisheries and Oceanography*, 200, 3-23. doi: 10.26428/1606-9919-2020-200-3-23
15. Koldashov, A. I., Yakushin, S. A., Chibrikov, E. A., & Moshkov, A. D. (2022). Physical fitness of skiers-riders of the Moscow State Education University. In *Materials of the V All-Russian Scientific and Practical Conference with International Participation under the Auspices of the Russian Biathlon Union "Modern Trends in the Development of the Theory and Methodology of Physical Culture, Sports and Tourism"* (pp. 117-123). Moscow.
16. Marathon Swimmers Federation (MSF). Retrieved from: <https://marathonswimmers.org/> (accessed: 24/05/2023).
17. Mikhailov, V. N. & Dobrovolsky, A. D. (2008). *Hydrology*. Moscow: Higher School.
18. Morozova, V. I. (1990). *Biochemistry of sports*. Leningrad: Leningrad Research Institute of Physical Culture.
19. Politko, E. V. (2015). The influence of wetsuits on the dynamics of the highest sports achievements of the strongest swimmers. In *The basics of building a training process in cyclic sports* (pp. 61-66). Kharkov: Kharkov State Academy of Physical Culture Press.
20. Strait of Bonifacio Swimming Association (SBSA). Retrieved from: <https://swimmingstraitofbonifacio.com/> (accessed: 24/05/2023).
21. Strait of Gibraltar Swimming Association (SGSA). Retrieved from: <https://www.acneg.com/en/> (accessed: 24/05/2023).
22. Throsby, K. (2016). Who are you swimming for? In *Immersion* (pp. 101-117). Manchester, UK: Manchester University Press.
23. Timofeev, D. S., & Dokuchaev, O. E. (2014). International swim across the Bering Strait. Medical problems. *Successes of Modern Natural Science*, 10, 18-20.

KOMPLIKOVANJE DistanCI UVOĐENJEM DIONICA SA RAZLIČITIM OKOLIŠNIM USLOVIMA ZA POVEĆANJE ZANIMLJIVOSTI MARATONSKOG PLIVANJA**SAŽETAK**

Rad predstavlja kratku analizu karakteristika plivanja na otvorenom u različitim okolišnim uslovima: salinitet vode, intenzitet struje, temperatura i valno opterećenje. S jedne strane, ovi uslovi objektivno "lome" tehniku plivanja koja se godinama praktikuje u zatvorenim bazenima; s druge strane, upravo te kompleksnosti vraćaju plivanje na početak i donose intrige i nepredvidivost. Svrha prezentovanog rada je utvrditi uticaj navedenih faktora na tehniku plivanja na otvorenom. Metode: Analiza podataka predstavljenih u naučnoj literaturi ili na specijaliziranim web stranicama na Internetu; formulisane radne hipoteze testirane su eksperimentalnim plivanjem na udaljenostima većim od 3 km tokom sportskih kampova u slatkoj i slanoj vodi. Salinitet, intenzitet struje, temperatura i valno opterećenje stvaraju stalno aktivnu i stalno promjenjivu kompleksnost koja daje prednost sportašima različitih morfoloških karakteristika i funkcionalne pripremljenosti te nivoa spremnosti za dinamičke adaptacije. Opisane su neke od najuniverzalnijih tehnika za prevladavanje novonastalih tehničkih nejasnoća sa kojima se plivači ne susreću u zatvorenim bazenima, ali sa kojima se stalno bore na otvorenom. Zaključuje se da se zanimljivost maratonskog plivanja može povećati namjenskim uvođenjem nekoliko segmenata sa različitim uslovima u distancu.

Ključne riječi: plivanje na otvorenom, salinitet vode, intenzitet struje, temperatura, valno opterećenje, zanimljivost

Correspondence to: Egor M. Shchelkanov
State University of Education, Russia
E-mail:shchelkanov.sue@mail.ru

THE EFFECT OF HIGH-INTENSITY ANAEROBIC CAPACITY TRAINING ON BIOCHEMICAL AND PHYSIOLOGICAL INDICATORS AND PERFORMANCE IN 200 M SPRINTERS

Walid Awwad¹, Fadi Fayad²

1. Ministry of Education, Department of Education, Faculty of Physiology and Training of Sports, Al Anbar, Iraq
 2. Faculty of Education, Physical Education and Sport Department, Lebanese University, Beirut, Lebanon
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ABSTRACT

Background: The objective measurement of physiological indicators using reliable and repeatable tests forms the basis of the sports training planning. **Aim:** This study aims to investigate the effect of a high-intensity interval training protocol with anaerobic capacity on biochemical and physiological indicators and performance results in young elite 200 m sprinters using the Carlson Fatigue Test as an evaluation tool. **Methods:** Six sprinters from the youth Iraqi National Athletics Team underwent a twelve weeks' training programme of three sessions per week. The testing protocol included pre- and post-testing phases of the following tests: the basic biochemical and physiological markers: 1) Blood Haemoglobin, VO₂ Max, Calcium - CA, Phosphocreatine Kinase CPK, and Blood Phosphate PH, and 2) the overall performance of the 200 m sprinting contest. **Problem:** The research problem was whether the high-intensity interval training protocol with anaerobic capacity has an effect on the biochemical and physiological indicators and performance results in young elite 200 m sprinters. **Results:** The chosen biochemical and physiological indicators had improved significantly. Notably, (Blood Haemoglobin: 13.97/14.23, VO₂ Max: 47.67/51.12, CA: 8.666/9.021, CPK: 90.04/98.79, and PH: 13.97/14.23). Moreover, a significant difference ($p = 0.004$) between the pre-intervention (24.83 s) and post-intervention (23.98 s) average time of the 200 m runners had made notable gains in their performance measures. **Conclusion:** The high-intensity repetitive interval anaerobic capacity-based training strategy was beneficial in improving the basic physiological and biochemical markers and the 200 m sprint performance.

Keywords: training protocol, sprinters, biochemical markers, physiological markers, athletic performance, fatigue test

INTRODUCTION

In the 200-metre running competition, anaerobic capacity is considered as an important physiological factor (Simoes et al., 2017). Powers and Howley (2009) state that, since the performance of 200-metre runners is characterised by strength and speed, the ratio of anaerobic to aerobic work is estimated to be (95: 5%). This calls for the runner to develop high physical fitness in order to be able to cope with stages of acceleration, transitional speed and endurance of speed, in addition to the fast technical skills performed with high intensity.

While the maximum oxygen absorption value is consistently utilised as a measure of aerobic capacity despite being obtained using a variety of techniques and procedures, comparisons between studies of anaerobic aptitude are complicated by the sheer variety of tests that were employed. A wide range of protocols have been employed involving vertical jumps, stair climbs, sprints, maximal treadmill, and cycle ergometer efforts (Tønnessen, 2011; Seiler et al., 2009). The Carlson Fatigue Test (Carlson, 1949) is one of the crucial anaerobic tests that allows for the assessment of both anaerobic power and anaerobic capacity in a single exercise trial. One special component of this research is the use of the Carlson Fatigue Test as a practical perspective to evaluate the athletes' states of weariness during the training regimen. By combining this objective evaluation of tiredness with a focus on biomechanical and physiological adaptations, we want to learn more about the effectiveness of this specialised training programme and its implications for the development of 200 m sprinters.

The literature carries diversity of studies which investigated the effect of high-intensity interval anaerobic training on biomechanical markers, physiological adaptation and overall athletic performance. These studies that utilised the high-intensity interval anaerobic training have found significant improvements in the aforementioned factors, particularly in the physiological markers (VO₂ max) (Franchini, Cormack, & Takito, 2019; Abdul Salam, 2021), and biochemical markers (CK and LDH enzymes) (Brandao et al., 2020; Wiewelhove et al., 2015, 2016).

PROBLEM AND AIM

Sprinters must engage in high-intensity anaerobic capacity training as part of their pre-competition preparation and conditioning, particularly those competing in the taxing 200-metre event. In order to create a middle- to long-term physiological adaptation and to maximise performance, high-intensity anaerobic capacity training is widely considered to be an essential training component (Buchheit & Laursen, 2013). To achieve the greatest performance in these short-distance sports, it is

crucial to properly balance the development of peak anaerobic power with fatigue management. Trainers and sports scientists are looking into new training techniques to get around this problem, since they increase players' biomechanical and physiological indicators and enable a thorough analysis of their level of exhaustion during workouts (Kusy, 2015). Any exercise training session will challenge, at different respective levels relative to the training content, both the metabolic and the neuromuscular/musculoskeletal systems (Buchheit & Kuitunen, 2012; Vuorimaa, Vasankari, & Rusko, 2000).

For athletes training twice a day, and/or in team sport players typically taxing both metabolic and neuromuscular systems simultaneously (Hoff & Helgerud, 2004), both the anaerobic energy contribution and physiological strain associated with high-intensity anaerobic capacity training sessions should be considered in light of the demands of other physical and technical/tactical sessions so as to avoid overload and enable appropriate adaptation (i.e. maximise a given training stimulus and minimise musculoskeletal injury risk (Bompa & Haff, 2009; Francis, 1997).

Based on the aforementioned data, the authors hypothesise that there will be statistically significant differences between the pre- and post-tests of the experimental group in the basic biochemical and physiological indicators, power capability and the completion of the 200 m sprint under study, in favour of the post-tests.

Arab and especially Iraqi studies on this types of athletic performances are lacking; therefore, the purpose of this study was to investigate the impact of a high-intensity interval training protocol with anaerobic capacity on biochemical and physiological indicators and performance results in young elite 200 m sprinters using the Carlson Fatigue Test as an evaluation tool.

MATERIAL AND METHODS

Study Design

The study employed the applied deductive quantitative case study research using the quasi-experimental research design with pre-test and post-test for one experimental group of a purposive sample.

Sample Characteristics

For the experimental group of this study, six (6) young, elite runners from Iraq (< 20 years) were purposefully selected. Out of a population of 24 runners from 12 athletic teams (2 runners per team), which make up the Iraqi Athletics Federation, the sample selection and inclusion criteria were constructed on choosing the top six finishers in the 200-metre competition qualifiers. The research was conducted at Bagdad University's College of Physical Education and Sport Sciences in two Baghdad locations: the athletic track and field and two private medical labs. Additionally, each participant gave their agreement to take part in the study.

Training Protocol and Testing Procedures

Training Protocol

The test was conducted at the start of the season's preparation time. All subjects received training on the study's nature and purpose prior to the training and testing procedures. In this study, the training programme suitable for the training group was set by the Iraqi National Athletic Team trainers based on Buchheit and Laursen (2013) fitness training protocol explained below. The training protocol included a twelve-week athletic programme of high-intensity interval training distributed among three sessions per week (60-90 minutes/session) for three non-consecutive days. The training protocol sessions included high-intensity interval training drills and activities encompassing speed and plyometric training for about 70 minutes per session in addition to 10 minutes of warm-up and 10 minutes of cool-down exercises.

This programme was created and adapted in relation to the results of a significant fitness test: the Carlson Fatigue Test (Carlson, 1949) which was implemented to a group of young elite 200 m elite runners.

The training protocol set by the Iraqi Athletics Team has adapted 3 types of high-intensity interval training protocols proposed by Buchheit and Laursen (2013), as follows:

- High-intensity interval training using short intervals, with intensities equivalent or just above maximal aerobic power (up to approximately 120%), applying effort duration lasting less than 1 minute and work: rest ratios of 1:1, 2:1, or 3:1, mainly directed to develop aerobic power and the anaerobic systems;
- Repeated sprint training, using very short actions (5–8 seconds) at intensities around 120–160% VO₂ max, with very long recovery periods, and directed to neuromuscular and metabolic development frequently needed in team sports;
- Sprint interval training, using four to six 30-second all-out efforts separated by 3- to 4-minute intervals, allowing for full recovery, but resulting in very high aerobic and anaerobic demands.

Testing Procedures

The testing protocol was divided into three phases distributed among a pre- and post-training intervention protocol for each phase.

Phase 1: The Biochemical and Physiological Markers Testing:

The biochemical and physiological markers included the following parameters:

1. Blood Haemoglobin (g\dl)
2. Phosphocreatine Kinase CPK
3. Calcium (ca)
4. VO₂ Max (ml/kg/min)

These biochemical markers were tested in the morning

and were done while the sprinters were on an empty stomach, through a complete blood count (CBC) and relevant specialised medical assistance. However, the VO₂ max test was conducted on a treadmill according to the Mackenzie (2005) protocol.

Phase 2: The 200 metre sprint test:

The 200 metre sprint test was conducted twice before and after the training intervention programme according to the international 200 m dash standards (worldathletics.org, 2023).

Phase 3: The Carlson Fatigue Test

In order to further our analysis of the training intervention, we employed the Carlson Fatigue Test (Carlson, 1945) as a valuable instrument to assess the athletes' level of weariness at various stages in the training programme. Using this quantitative measure of exhaustion, we want to increase the precision of our evaluation and provide a full picture of the athletes' readiness and recovery levels throughout the training process.

Statistical Analysis

Descriptive data (mean and SD) was calculated for all variables. A paired t-test was utilised to determine the main differences between the means of the five tested variables among the (pre-test vs. post-test) phases.

The SPSS Windows software version 25 was used for all statistical analysis.

For all tests, the level of confidence (LoC) was set at 95%, and the p value was set at 0.05.

RESULTS

The paired t-test conducted on SPSS has determined significant differences between the pre- and post-tests' averages in all the tested constructs and parameters regarding the Carlson Fatigue Test, the biochemical, physiological markers, and the 200 metres sprint test. Results of the experimental group tests were shown in tables (1 and 2).

Table 1: Pre-test and post-test comparison analysis in the Carlson Fatigue Test.

| Variable | Pre-test Mean | Post-test | t | df | p |
|----------|------------------|-----------|-------|----|--------------|
| Runner 1 | 9 | 5 | 2.936 | 5 | 0.032 |
| Runner 2 | 13 | 9 | | | |
| Runner 3 | 10 | 5 | | | |
| Runner 4 | 14 | 10 | | | |
| Runner 5 | 15 | 9 | | | |
| Runner 6 | 4 | 6 | | | |

Table processed by the author

Table 2: Pre-test and post-test comparison analysis in the biochemical and physiological markers as well as 200 m performance.

| Variable | Pre-test Mean± SD | Post-test Mean± SD | t | df | p |
|-------------------------------|----------------------|-----------------------|-------|----|-------|
| Blood Haemoglobin (g\dl) | 13.97± 0.171 | 14.23 ± 0.208 | 6.04 | 5 | 0.002 |
| VO2 max (ml/kg/min) | 47.67 ± 4.58 | 51. 12 ± 4.29 | 3.455 | 5 | 0.039 |
| Phosphocreatine kinase (CPk) | 90.04 ± 1.93 | 98.79 ± 0.973 | 3.165 | 5 | 0.025 |
| Blood (pH) | 7.35 ± 0.314 | 7.58 ± 0.317 | 3.162 | 5 | 0.025 |
| Calcium (CA) | 8.666 ± 0.338 | 9.021 ± 0.248 | 3.274 | 5 | 0.022 |
| 200 metres sprint test (sec.) | 24.83 ± 0.467 | 23.98 ± 0.667 | 4.997 | 5 | 0.004 |

Table processed by the author

DISCUSSION

The findings of our study determined significant differences in the means of the pre- and post-tests of all the tested variables. These significant means' differences were indicated by the higher values of the paired t-test of the post-tests averages. This result was consistent with the studies' results of Franchini, Cormack, and Takito (2019), and Abdul Salam (2021), who found significant improvements in the aforementioned factors, particularly in the physiological markers (VO2 max) in investigating the effects of high-intensity interval training on Olympic combat sports athletes' performance and physiological adaptation.

Regarding the biochemical and physiological markers, the measurements of the CPK enzyme were positive and in favour of the post-tests, and this is expected at the procedural and scientific level, as the CPK enzyme is one of the enzymes that transport the phosphate molecule of the main source of energy ATP. In this regard, (Imaki, 1999) indicated that the CPK enzyme is very important for the work of skeletal muscles, as it has a major role in the transfer of the phosphate molecule from PC to ADP to give a high-energy adenosine triphosphate ATP compound. This result regarding CPK as a basic

biochemical marker contradicts the result of Brandao et al., (2020) study who investigated the effect of a high-intensity interval training (HIIT) protocol above the maximum in fifteen male recreational runners and found no statistical differences in this blood parameter. However, our study's results in this regard were in line with the study of Wiewelhove et al., (2015) and (2016), who demonstrated significant changes ($p < 0.05$) in muscle CPK levels (a moderate to large increase in CPK levels (ACT: ES = 0.76, $p > 0.05$; PAS: ES = 0.81, $p > 0.05$). Based on these data, (Gist et al., 2014) indicated that the enzyme activity increases with the repetition of extreme anaerobic exercise, which lasts for 30 seconds, signifying an increase in production and a delay in fatigue.

In addition, the increase in blood haemoglobin as a result of exercise could be an evidence of an increase in the functional capacity of the runner's vital organs when there is a lack of oxygen, as it constitutes approximately 4% of the volume of the red cell. According to that approach, (Salamah, 1994; Zaher, 2011) consider that exercises which increase blood volume as a result of an increase in the number of red blood cells are accompanied by an increase in the respiratory capacity to meet the energy requirements of the muscles, and this process increases the efficiency of the blood to carry the largest amount of oxygen when it is incapacitated.

While the blood pH measurements indicated the presence of significant differences in favour of the post-tests, the researcher believes that maintaining the blood pH value close to the state of equilibrium is a good indicator of the training status and the readiness gained from training for the maximum anaerobic capacity, despite the remnants of vital metabolism. In the same context, (Abdel-Fattah, 2000) confirms that the energy used for the metabolism of maximum anaerobic activities results in metabolic waste that changes the pH value of the blood.

Regarding the results of calcium (Ca^{++}) measurements in the blood, the test indicated the presence of significant differences in favour of the post-tests. The researchers attribute that to the use of short anaerobic exercises with maximum intensity according to standardised tests, and according to the requirements of the

CONCLUSION

In conclusion, the training protocol used with the maximum anaerobic capacity test and the high-intensity interval training method contributed to the development of the efficiency of the functional devices despite the lack of oxygen supplied to them, which resulted in delayed fatigue, and this can be inferred through the Carlson Fatigue Test.

energy systems operating for the exercised activity, it works to create a state of balance for the vital systems of the body, especially the nervous system. In this regard, (Abdel-Fattah, 2000; Banister, 1975) indicate that the calcium has an important role in transmitting the nerve signal through its contribution to the muscle contraction mechanism through the activation of the ATPase enzyme.

Regarding the performance of the 200 m dash running

test, significant difference in time between both pre- and post-tests were determined. This result could be attributed to the short anaerobic capacities by means of high-intensity interval training, and in this regard, (Bourdon, 2017) confirms that anaerobic capacity training gives the vital organs, especially the respiratory and nervous systems, a kind of adaptation to resist fatigue and delay it in conditions of a lack of oxygen. From this point of view, the researchers believe that anaerobic capacity exercises with maximum or near-maximum intensity create a kind of anaerobic endurance for the muscles exposed to high-repetition stimulation, (as in the case of a 200 metre sprint) to delay the state of fatigue.

Based on the previous discussion of the research results regarding the improvements in athletes' biochemical and physiological markers and 200 m achievement, we could say that the hypotheses of the research (that there will be statistically significant differences between the pre- and post-tests of the experimental group in the basic biochemical and physiological indicators and the completion of the 200 m sprint under study, in favour of the post-tests) was accepted.

As a final and general result, and based on the above conclusions, the 200 m sprinters' performance improved significantly in the explored young athletes. The study was further enhanced by the inclusion of the Carlson Fatigue Test, which provided insightful data on the athletes' states of fatigue. For coaches and trainers looking to optimise sprinter training plans and encourage efficient conditioning and performance improvement, these findings have immediate application. To investigate other factors and the long-term impact of the suggested training technique on various athlete groups, more research is necessary.

REFERENCES

1. Abboud, F. (2005). The effect of physical exertion on some concentrations of antioxidants, physiological responses, and the activity of the CPK enzyme. PhD thesis, College of Physical Education, University of Basra.
2. Abdulfattah, A. (1999). Sport Rehabilitation, Dar Alfikr al Arabi. Cairo, Egypt.
3. Abdulsalam, M. (2021). The effect of competition load on some biochemical and physiological markers in 5000 m young elite runners. Banha University, Egypt.
4. Banister, E. W., Calvert, T. W., Savage, M. V., & Bach, T. (1975). A systems model of training for athletic performance. *Aust J Sports Med*, 7(3), 57-61.
5. Bompa, T. O., & Haff, G. G. (2009). *Periodization: theory and methodology of training*. 5th Ed. Champaign: Human Kinetics.
6. Bourdon, P. C., Cardinale, M., Murray, A., Gastin, P., Kellmann, M., Varley, M. C., ... & Cable, N. T. (2017). Monitoring athlete training loads: Consensus statement. *International journal of sports physiology and performance*, 12(s2), S2-161.
7. Brandão, L. H. A., Chagas, T. P. N., Vasconcelos, A. B. S., de Oliveira, V. C., Fortes, L. D. S., De Almeida, M. B., ... & Da Silva-Grigoletto, M. E. (2020). Physiological and performance impacts after field supramaximal high-intensity interval training with different work-recovery duration. *Frontiers in Physiology*, 11, 1075.

8. Buchheit, M., Kuitunen, S., Voss, S., et al. (2012). Physiological strain associated with high-intensity hypoxic intervals in highly trained young runners. *J Strength Cond Res*, 26:94–105.
9. Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. *Sports medicine*, 43(5), 313–338.
10. Carlson, H. C. (1945). Fatigue curve test. *Research Quarterly. American Association for Health, Physical Education and Recreation*, 16(3), 169–175.
11. Daniels, L. (2020). pH of blood: What to know? *Medical News Today*. Retrieved from (23rd July 2023): <https://www.medicalnewstoday.com/articles/ph-of-blood>
12. Franchini, E., Cormack, S., & Takito, M. Y. (2019). Effects of high-intensity interval training on Olympic combat sports athletes' performance and physiological adaptation: A systematic review. *The Journal of Strength & Conditioning Research*, 33(1), 242–252.
13. Francis C. (2010). Training for speed. Canberra (ACT) Faccioni Speed & Conditioning Consultants, 1997. p. 206. 10. Iaia, F. M., & Bangsbo, J. (2010). Speed endurance training is a powerful stimulus for physiological adaptations and performance improvements of athletes. *Scand J Med Sci Sports*, (2):11–23.
14. Gist, N. H., Fedewa, M. V., Dishman, R. K., & Cureton, K. J. (2014). Sprint interval training effects on aerobic capacity: A systematic review and meta-analysis. *Sports medicine*, 44, 269–279.
15. Hammad, M. (1998) *Modern sports training, planning and leadership*: Cairo, Dar Al-Fikr Al-Arabi.
16. Hoff, J., & Helgerud, J. (2004). Endurance and strength training for soccer players: Physiological considerations. *Sports Med*, 3: 165–80.
17. Imaki, M. (1995). Evaluation of the effects of various factors on the serum alpha hydroxyl butyrate, dehydrogenase in young females. *Journal of sports med*.
18. Jacobs, I. (1981). Lactate, muscle glycogen and exercise performance in man. *Acta Physiol Scand Suppl*, 495:1–35.
19. Kalamen, J. (1968). Measurement of maximum muscular power in man. Doctoral thesis, Ohio State University.
20. Kusy, K., & Zielinski, J. (2015). Sprinters versus long-distance runners: How to grow old healthy. *Exerc Sport Sci Rev*, 43: 57–64
21. Mackenzie, B. (2005). 101 performance evaluation tests. Electric Word plc.
22. Margaria, R., Aghemo, P., & Rovelli, E. (1966). Measurement of muscular power (anaerobic) in man. *Journal of Applied Physiology* 221, 1662–1664.
23. Powers, S., & Howley, E. (2009). Theory and application to fitness and performance exercise physiology.
24. Salamah, B. (2000). *Sport physiology and performance*. Dar alfikr al Arabi, Cairo.
25. Seiler, S., & Tønnessen, E. (2009). Intervals, thresholds, and long slow distance: the role of intensity and duration in endurance training. *Sportscience*, 13.
26. Simoes, H. G., Sousa, C. V., dos Santos Rosa, T., da Silva Aguiar, S., Deus, L. A., Rosa, E. C. C. C., ... & Andrade, R. V. (2017). Longer telomere length in elite master sprinters: relationship to performance and body composition. *International journal of sports medicine*, 38(14), 1111–1116.
27. Tønnessen, E., Shalfawi, S. A., Haugen, T., & Enoksen, E. (2011). The effect of 40-m repeated sprint training on maximum sprinting speed, repeated sprint speed endurance, vertical jump, and aerobic capacity in young elite male soccer players. *The Journal of Strength & Conditioning Research*, 25(9), 2364–2370.
28. UCLA Health Journal. (2023). Normal Blood Calcium Levels in Humans. Retrieved from (23rd July 2023): <https://www.uclahealth.org/medical-services/surgery/endocrine-surgery/patient-resources/patient-education/normal-calcium-levels>
29. Vuorimaa, T., Vasankari, T., & Rusko, H. (2000). Comparison of physiological strain and muscular performance of athletes during two intermittent running exercises at the velocity associated with V02max. *Int J Sports Med*, 21:96–101.
30. Wiewelhove, T., Raeder, C., Meyer, T., Kellmann, M., Pfeiffer, M., & Ferrauti, A. (2015). Markers for routine assessment of fatigue and recovery in male and female team sport athletes during high-intensity interval training. *PloS one*, 10(10), e0139801.
31. Wiewelhove, T., Raeder, C., Meyer, T., Kellmann, M., Pfeiffer, M., & Ferrauti, A. (2016). Effect of repeated active recovery during a high-intensity interval-training shock microcycle on markers of fatigue. *International journal of sports physiology and performance*, 11(8), 1060–1066.
32. Zaher, A. (2011). *Encyclopedia of sports*. 1st edition: Cairo, Al-Kitab Center for Publishing.

33. Zaytoun, A. (2002). Human biology, principles in anatomy and physiology: Jordan, Amman, Dar Ammar for publication and distribution.

EFEKAT VISOKO INTENZIVNOG TRENINGA ANAEROBNOG KAPACITETA NA BIOHEMIJSKE I FIZIOLOŠKE INDIKATORE TE USPJEH TRKAČA NA 200 M

SAŽETAK

Kontekst: Objektivno mjerenje fizioloških indikatora korištenjem pouzdanih i testova koji se mogu ponavljati kreira osnovu za planiranje sportskih treninga. **Cilj:** Ova studija nastoji ispitati efekat visoko intenzivnog intervalnog treninga sa anaerobnim kapacitetom na biohemijske i fiziološke indikatore te uspeh mladih, elitnih trkača na 200 metara korištenjem Carlsonovog testa iscrpljenosti u vidu evaluacijskog instrumenta. **Metode:** Šest trkača iz omladinske Atletske reprezentacije Iraka je učestvovalo u programu treninga koji je trajao dvanaest sedmica uz tri treninga sedmično. Protokol testiranja je uključivao pretestiranje i posttestiranje za sljedeće testove: osnovni biohemijski i fiziološki markeri: 1) hemoglobin u krvi, VO2 Max, kalcij - CA, fosfokreatin kinaza CPK i fosfat u krvi PH te 2) ukupni uspeh u utrci na 200 m. **Problem:** Problem istraživanja je da li visoko intenzivni intervalni trening sa anaerobnim kapacitetom utiče na biohemijske i fiziološke indikatore te uspeh mladih, elitnih trkača na 200 m. **Rezultati:** Izabrani biohemijski i fiziološki indikatori su se značajno poboljšali, i to: (Hemoglobin u krvi: 13,97/14,23, VO2 Max: 47,67/51,12, CA: 8,666/9,021, CPK: 90,04/98,79 i PH: 13,97/14,23). Nadalje, značajna razlika ($p = 0,004$) između prosječnog vremena trkača na 200 m prije intervencije (24,83 s) i poslije intervencije (23,98 s) je poboljšana u mjerenju njihovog uspeha. **Zaključak:** Visoko intenzivni intervalni trening zasnovan na anaerobnom kapacitetu je bio koristan u poboljšanju osnovnih fizioloških i biohemijskih markera te uspeha u utrci na 200 m.

Ključne riječi: trening, trkači, biohemijskih markeri, fiziološki markeri, atletski rezultati, test iscrpljenosti

Correspondence to: Fadi Fayad

Faculty of Education, Physical Education and Sport Department, Lebanese University, Beirut, Lebanon

E-mail:fadiify@hotmail.com

SATISFACTION WITH THE QUALITY OF LIFE AND PREFERRED LIFESTYLE AMONG ACTIVE RECREATIONISTS

Ernest Šabić¹, Nijaz Skender¹, Nihad Selimović², Natalija Kurtović¹, Gordana Manić³

1. Faculty of Pedagogy, University of Bihać, Bosnia and Herzegovina

2. Faculty of Education, University of Travnik, Bosnia and Herzegovina

3. Faculty of Health, University of Sarajevo, Bosnia and Herzegovina

ABSTRACT

Physical exercise, as a determinant of physical activities that are recommended in the context of preserving and improving human health, is related to the general concept of the quality of life. As a complex phenomenon, it shows the character of multidimensionality, that is, it is structured by several interconnected and conditioned factors (physical health, psychological stability, social interaction, the level of independence and independence in social functioning, material stability, personal beliefs, religious commitments, etc.). Criteria for assessing the quality of life are mainly generated by external entities, most often different health and/or academic institutions. Therefore, in practice, the fact that the most objective indicator of the quality of life is precisely the individual perception of the person himself about it - how he lives - is often neglected. That is, the perspective of the person himself is rarely taken as a criterion for evaluation, and when it comes to certain processes (e.g., participants in sports and recreational activities) of the participants of that process themselves. A cross-sectional survey was conducted on a sample of 290 respondents, active recreationists, with the aim of identifying the individual perception of the quality of life through the context of the preferred lifestyle. As the basic research instrument, a questionnaire was used, specially constructed for this research. The results showed that the perception of a good or very good quality of life dominates among people who regularly practice physical exercise as one of their lifestyle habits. In middle-aged people who regularly engage in physical exercise, a certain connection can be observed between the perceived quality of life and the preferred lifestyle.

Keywords: quality of life, lifestyle, physical exercise

INTRODUCTION

Terms such as quality of life, lifestyle, health, physical activity, etc., have today become very exposed terminological determinants that are intensively exploited, both in everyday lay communication and in more serious professional and scientific discussions in academic and health

circles. In the context of kinesiological observations, physical activity, that is, physical exercise, is certainly the most dominant determinant that is incorporated into various aspects of consideration pertaining to the issue of the quality of life of all socio-age categories of the population. Physical activity, especially that which is determined as regular physical exercise, is closely and interactively connected with the general concept of the quality of life. As a complex term (and phenomenon) it includes several interconnected and conditioned

factors (physical health, psychological stability, social interaction, the level of independence and independence in social functioning, material stability, personal beliefs, religious commitments, etc.) which reflects its specific multidimensionality. That is, through emphasised complexity, it determines the synergistic relationship of the mentioned quality of life factors (Cummins, 2000). Regular physical activity is one of the important factors of a healthy lifestyle. So, insufficient physical activity, which is measured by functional abilities, negatively affects the body structure and triglycerides, which significantly affects the deterioration of student health (Skender, Cakar, Kurtović, & Šabić, 2022).

In addition to influencing the more successful manifestation of functional abilities, the morphological characteristics of students should be one of the more important conditions for the appearance of students in physical activities (Skender, 2004; Skender, Šabić, Selimović, Kurtović, & Karalić, 2022). Hypokinesia affects the population of all age groups, regardless of their place of residence, and so the consequences of such an inappropriate attitude towards physical exercise, as a measure to prevent the occurrence of painful conditions of lumbar syndrome, are increasing and noticeable (Nešić, Šabić, & Skender, 2020).

Such theoretical positions have been affirmed for a long time within the framework of the World Health Organisation (WHO, 1998) through the interpretation of the definition of the term quality of life as a personal observation of an individual's life position, which is contextually based on the cultural and value system in which the individual lives, as well as his relationship to the general accepted goals, expectations, set standards, and interests (Vuletić & Misajon, 2011). In this sense, the attitude that it is based on the individual perception of each individual based on a personal set of values is considered as a real and authentic standard for assessing the quality of life so that the sentence quality of life at the individual level is viewed as an experience of overall, general well-being, which includes objective factors and subjective evaluation of physical, material, social, and emotional well-being. This includes personal development through the application of purposeful life activities (Nešić et al., 2018).

Although the conceptual definition of lifestyle does not have a unique and generally accepted connotation, the sociological point of view treats it in the context of values, value orientations and social attitudes (Božilović, 2006; Nešić, 2012).

In this sense, the current lifestyles of the working part of the population can be treated as a characteristic population phenomenology observed through the prism of the patterns of their actions in everyday life and work interactions. As relatively stable patterns of behaviour, they are manifested in all areas of life, which consequently includes the space of free time in which individual needs for movement, recreation, etc. are met. The lifestyles of middle-aged people are in a kind of interdependence with the formed and adopted value orientations. The distinction between these two areas can be sought primarily within their target orientation. While value orientation can be considered the framework of a general goal, lifestyle is essentially a way to achieve it (Čejni, 2003). In this context,

lifestyles represent those behaviours that actualise certain values in specific life conditions (Nešić, 2012) so that the way of life of each part of the population is covered by a specific model of behaviour that assumes a specific life orientation in meeting individual needs, that is, the organisation of life, work, spending free time, etc., which creates a framework for accepting current lifestyles. Thus, lifestyle has the characteristic of following the individual needs of people while at the same time expressing their individual possibilities (Jensen, 2008).

Positive lifestyle habits that are oriented towards health (proper nutrition, regular physical activity, avoidance of addictive substances, regular health checks, etc.) are acquired and developed throughout life. Therefore, they can be contextually connected with the corresponding lifestyle. A number of earlier studies (Sharkey & Gaskill, 2008; Bendíková, 2014) related to a healthy lifestyle mainly emphasised physical exercise, sports and recreation as its main factors. However, active lifestyle should be viewed in a somewhat broader context. It is a multidimensional system of human behaviour that is not only determined by physical activities as a basic construct, but is also constituted by other behaviours/activities related to health (proper nutrition, preventive health examinations, stress control, elimination of harmful lifestyle habits, etc.) (Nešić et al., 2014). In the past period, the circumstances that drastically changed people's lives on a global level are related to the emergence of the COVID-19 pandemic, which was most felt in physical activities, especially physical exercise so that the trend of constant decline in physical activity at all ages is clearly observed, and life in a pandemic intensified this problem even more (Šabić, 2018; Šabić, Skender, Kurtović, & Nešić, 2021). Certainly, in the kinesiological approach to the issues of a healthy lifestyle, activities that are dominantly based on kinesiological operators are placed in the foreground so that the context of physical exercise, as an important aspect of improving the quality of life, is given the greatest attention (without diminishing or neglecting all other aspects). In this sense, the statement that a certain pattern of behaviour, which includes a synthesis of correct actions, healthy habits and a positive attitude towards oneself and others, constitutes the space of an active lifestyle is established as an affirmative attitude. This quality of life context is represented through the model of the "active lifestyle health doctrine" (Sharkey & Gaskill, 2008), which includes mutually integrated components: (a) regular physical activity, (b) healthy and proper nutrition, (c) weight control, (d) stress management, and (e) safety habits.

METHODS

Empirical research of transversal character, survey type, was carried out on a sample of 290 people who are engaged in sports and recreational activities within the framework of sports and sports and recreational organisations in the area of Una-Sana

Canton. Subsampling in the space of independent variables was performed: (a) in relation to the sex of the respondents and (b) in relation to age. The aim of the research was directed towards identifying the perception of the quality of life among active recreationists through the context of their preferred lifestyle. As the basic research instrument, a questionnaire was used, specially constructed for this research. The contextuality of the item structure of the questionnaire was based on similar instruments that were used in a number of earlier studies (Lazarević & Janjetović, 2003; Nešić, 2012; Šabić, 2018). The survey was anonymous.

Research variables are defined in two areas: (a) independent (gender and age of respondents) and (b) dependent (assessment of the quality of life, evaluation of lifestyles, preferred lifestyle, and regularity of sports and recreational activities). The variables that were used to determine the perception of the quality of life and the regularity of engaging in SRA among the respondents were arranged in the form of nominal item indicators, while for the identification of individual assessment of lifestyle, the item indicators were created as five-point Likert-type scales.

Statistical processing of empirical data was performed using appropriate statistical procedures. In the field of descriptive statistics, measures of central tendency (frequency distribution, standard deviation and scalar average - mean) were calculated. Contingency analysis - chi-square test (chi-square) was used as the dominant procedure for determining the association of categorical variables. Data processing was carried out using the SPSS.21 software, while statistical conclusions were made with a significance level of 0.05 ($p < .05$).

RESULTS

The empirical structure in the subsampled spaces indicated the characteristics of the research entity as a space of independent variables. Regarding the gender differentiation of the total sample ($N = 290$), the number of males was slightly higher ($N = 154$; 53.1%) than females ($N = 136$; 46.9%). In terms of age, the total sample was segmented using a statistical procedure (Visual Binning) into four categories: up to 40 years, from 41 to 45 years, from 46 to 50 years, and over 50 years of age. The average age in the sample was 45 years (min. = 24; max. = 59). In this regard, we can speak of a research sample that is considered a working part of the population and belongs to a part of the population that is considered middle-aged.

Identification of satisfaction with the quality of life was realised through the respondents' self-assessment on item-indicators from the space of dependent variables. In the context of the individual experience of the quality of life, the largest number of respondents believe that they have a good general quality of life

(42.4%). 38.3% of respondents declare that they live in an average quality, like most people in the area, while very good and excellent quality of life is perceived by about a third of respondents (29.3%). In this context, gender and age did not prove to be significant determinants, given that no statistically significant differences were found (Tables 1 and 2). In this sense, several indicators were observed that may have implications for the general quality of life. First of all, this referred to the self-assessment of the state of health, where it was determined that the largest number of respondents (90.7%) perceived themselves as completely healthy persons (good health - 64.1%; excellent health - 26.6%). This was expected, given that we are talking about people who regularly engage in sports and recreational activities. In this regard, their self-assessment of (physical) condition was also detected, and it was recorded that the majority (76.9%) perceive themselves as a person with good (41.4%), or excellent condition (35.5%). 23.1% assess their fitness as satisfactory, while there were no respondents with poor fitness.

Also, their attitude towards regularly engaging in sports and recreational activities can be seen as a significant indicator of the quality of life. In this respect, it was determined that the largest percentage of respondents (60.7%) practice some form of sports-recreational activity three times a week, while the frequency of recreational engagement of 3-4 times a week appears in about a third of the research entity (30.7%). When taking into account the respondents who exercise five to six times a week (8.6%), we can talk about people who have habits of regular exercise. In this context, gender proved to be a more significant determinant, given that statistically significant differences were found ($\text{Sig.} = .021$) (Table 1).

Table 1: Self-assessment of general quality of life - gender

| Self-assessment of general quality of life | Gender | | Σ |
|--|--------------|--------------|---------------|
| | Men | Women | |
| average | 60 20.7% | 51 17.6% | 111 38.3% |
| good | 69 23.8% | 54 18.6% | 123 42.4% |
| very good | 21 7.2% | 22 7.6% | 43 14.8% |
| excellent | 4 1.4% | 9 3.1% | 13 4.5% |
| Σ | 154 53.1% | 136 46.9% | 290 100.0% |
| Chi = 3.443 df = 3 Sig. = .328 | | | |

Table 2: Self-assessment of the general quality of life - age

| Ages | General quality of life | | | | Σ |
|--|-------------------------|--------------|-------------|------------|---------------|
| | average | good | very good | excellent | |
| up to 40 | 32 11.0% | 34 11.7% | 14 4.8% | 8 2.8% | 88 30.3% |
| 41 - 45 | 28 9.7% | 31 10.7% | 10 3.4% | 2 0.7% | 71 24.5% |
| 46 - 50 | 24 8.3% | 29 10.0% | 10 3.4% | 0 0.0% | 63 21.7% |
| 50+ | 27 9.3% | 29 10.0% | 9 3.1% | 3 1.0% | 68 23.4% |
| Σ | 111 38.3% | 123 42.4% | 43 14.8% | 13 4.5% | 290 100.0% |
| Chi = 8.355 df = 3 Sig. = .499 | | | | | |

Table 3: Regularity of engaging in sports and recreational activities - gender

| Frequency of physical exercise | Gender | | Σ |
|--|--------------|--------------|---------------|
| | Men | Women | |
| three times a week | 95 32.8% | 81 27.9% | 176 60.7% |
| three to four times a week | 40 13.8% | 49 16.9% | 89 30.7% |
| five to six times a week | 19 6.6% | 6 2.1% | 25 8.6% |
| Σ | 154 53.1% | 136 46.9% | 290 100.0% |
| Chi = 8.012 df = 2 Sig. = .018 | | | |

The identification of the context of lifestyle perception was realised through two segments. In the first, respondents were asked to rate how much they liked each of the listed lifestyles on a five-point scale (the value "1" expressed the least importance of the lifestyle, and the value "5" determined the highest level of importance). The respondents were offered the following lifestyles, with their brief descriptions: (1) Hedonistic (indulge in the present, enjoy pleasures because the future is quite uncertain and life is fleeting; do not save too much earned money, but spend it as much as possible on the realisation of the immediate pleasures in life), (2) Utilitarian (work, save money and spend it on useful things; equip and organise the household well and buy things useful for the house and family; provide your family and offspring with complete material security), (3) Altruistic (helping other people; being kind and generous to others, even sacrificing for others), (4) Aesthetic (enjoying everything that is beautiful and harmonious; observing and enjoying works of art and natural beauty; the search for the beautiful should be basic goal of life), (5) Orientation to power and reputation (to strive for that life that provides a person with great power, reputation and respect in society; to have a significant and recognised position and exert a great influence on other people), (6) Orientation to knowledge (dedicate one's life to discovering new knowledge, finding out the truth about the world, nature and man; studying nature, society and man; devoting oneself to the search for truth), (7) Self-realisation (the meaning of a person's life should first of all be to be active, to act and create and so manifest what he can

and knows), (8) Promethean activism (being constantly active in changing conditions and relationships in the environment and wider society; fighting for far-reaching goals and ideas even when we do not succeed in this and when we encounter resistance in the environment; when necessary, give up immediate gratification at the expense of those ideas) and (9) Active lifestyle (be physically active; exercise regularly, eat properly, avoid alcohol and cigarettes; take care of your health, monitor it regularly). In relation to the established scalar averages (mean), it can be seen that among respondents, receptivity to lifestyle is focused most intensively on Power and prestige (3.91), then on Active lifestyle (3.87), and somewhat less on Self-realisation (3.60), Altruistic (3.58) and Aesthetic (3.50) lifestyles. The least desirable lifestyles for the respondent were Knowledgeable (1.58) and Hedonistic (2.73) ones (Table 4).

Table 4: Likeability of lifestyles

| No. | Lifestyle | Mean | Std. err. of mean | Std. dev |
|-----|----------------------|------|-------------------|----------|
| 1 | Hedonistic | 2.73 | .026 | .444 |
| 2 | Utilitarian | 3.27 | .058 | .985 |
| 3 | Altruistic | 3.58 | .064 | 1.085 |
| 4 | Aesthetic | 3.50 | .059 | 1.006 |
| 5 | Power and reputation | 3.91 | .058 | .985 |
| 6 | Cognitive | 1.58 | .044 | .751 |
| 7 | Self-realisation | 3.60 | .049 | .840 |
| 8 | Promethean activism | 3.53 | .042 | .721 |
| 9 | Active lifestyle | 3.87 | .066 | 1.116 |

In the second segment, respondents were asked to name the one they currently live in, out of the nine offered lifestyles. Empirical data show that the largest percentage of them are determined towards the style of Power and reputation (42.1%), as well as Aesthetic (30%). About a quarter of the respondents (25.9%) prefer the Altruistic lifestyle, while only 2.1% of the respondents identify as Utilitarian. In this context, gender proved to be

a significant determinant (statistical differences at the level of Sig. = .000). It is observed that women most intensely experience the Aesthetic (20.3%) and Altruistic lifestyle (13.8%), while men are much more oriented towards the Power and Prestige (29.3%) and slightly less towards the Altruistic (12.1%) one (Table 5).

Table 5: Preferred lifestyle - gender

| Current lifestyle | Gender | | Σ |
|---|--------------|--------------|---------------|
| | Men | Women | |
| Utilitarian | 6 2.1% | 0 0.0% | 6 2.1% |
| Altruistic | 35 12.1% | 40 13.8% | 75 25.9% |
| Aesthetic | 28 9.7% | 59 20.3% | 87 30.0% |
| Power and reputation | 85 29.3% | 37 12.8% | 122 42.1% |
| Σ | 154 53.1% | 136 46.9% | 290 100.0% |
| Chi = 35.283 df = 3 Sig. = .000 | | | |

Differences in preferences for a certain lifestyle can also be observed in relation to age. The largest percentage of respondents under the age of 40 believe that the style of Power and prestige is something that represents their direction in the framework of social interaction with the

environment (30.3%). As the age increases, so does the preference for a certain lifestyle. Therefore, somewhat older respondents (41-45 years old) opt for the attractiveness and predominance of the Altruistic lifestyle (10.7%), while the group of the oldest (over

50 years old) prefers the Aesthetic lifestyle (10.7%). In part of the sample (ages 46-50), the commitment to attractiveness of the lifestyle is relatively evenly distributed between Altruistic, Aesthetic and Power

and prestige. The differences detected in this way also showed a level of statistical significance (Sig. = .000) (Table 6).

Table 6: Preferred lifestyle - age

| Age | Current lifestyle | | | | Total |
|--------------|-------------------|------------|-------------|----------------------|--------|
| | Utilitarian | Altruistic | Aesthetic | Power and reputation | |
| up to 40 | 0 | 17 | 22 | 49 | 88 |
| | 0.0% | 5.9% | 7.6% | 16.9% | 30.3% |
| 41 - 45 | 0 | 31 | 12 | 28 | 71 |
| | 0.0% | 10.7% | 4.1% | 9.7% | 24.5% |
| 46 - 50 | 6 | 15 | 22 | 20 | 63 |
| | 2.1% | 5.2% | 7.6% | 6.9% | 21.7% |
| 50+ | 0 | 12 | 31 | 25 | 68 |
| | 0.0% | 4.1% | 10.7% | 8.6% | 23.4% |
| Total | 6 | 75 | 87 | 122 | 290 |
| | 2.1% | 25.9% | 30.0% | 42.1% | 100.0% |
| Chi = 45.906 | | df = 9 | Sig. = .000 | | |

DISCUSSION

The study of various aspects of the functioning of middle-aged persons is one of the useful and important activities that contribute to the efforts of a certain social community in creating conditions for improving the quality of life. One of the reasons is that the largest part of the working population, and therefore the most productive part of the population, is in this stage of life. According to one of the still valid criteria (WHO, 1982), middle age is generally considered to be the period between 35 and 65 years of age. However, its boundaries are fundamentally difficult to determine, given that the perception of middle age in society often varies and is conditioned by numerous factors (a person's physical appearance, reproductive health, social class, social tendencies, current social trends, etc.) (Schaie & Willis, 2001).

Experts from the field of kinesiology agree that questions about preserving and improving the quality of life of middle-aged people can be more intensively

affirmed in the population when the importance of physical exercise as its essential content factor is apostrophised as a motivational basis (Šabić, 2018). In addition to this, the context of accepting a certain lifestyle that nurtures and corresponds with all aspects of health preservation is certainly connected. Criteria for assessing the quality of life usually refer to external assessments and standards established by various health and similar institutions. However, the fact that the most objective indicator of the quality of life is precisely the individual perception of the person himself about whether he lives well or not, what are the key factors of such and such a life, what dominantly influences it, etc. is often overlooked. That is, it is rarely used as a criterion for the evaluation is taken from the perspective of the person himself, and when it comes to certain processes (e.g., participants in sports and recreational activities) of the participants of that process themselves (Gill et al., 2013).

The attitudes of regular consumers of sports and recreational activities on the context of the relationship between quality of life and physical exercise represent authentic indicators of effects that are often individually set at the goal level. Today, it is already quite certain that

regular physical activities, especially physical exercise, positively contribute to the improvement of all aspects of the quality of life (Bize, Johnson, & Plotnikoff, 2007). So, it is about a holistic impact on the quality of life. This is confirmed by recent studies (Bauman, et al., 2012; Phillips, Wojcicki, & McAuley, 2013; Saridi et al., 2019; Bull et al., 2020) which included an adult working population and detected a positive correlation between physical activities /exercises and quality of life. Regular physical activities of a sports-recreational nature (especially predominantly aerobic) in middle-aged and elderly people enhance various positive preventive and therapeutic effects, which improves their quality of life (compared to physically less active people) (Puciato, Borysiuk, & Rozpara, 2017).

One interesting piece of information could be observed in this research, which is that the respondents do not consider the Active lifestyle as one of the more intensely desirable and/or preferred. Regardless of the fact that we are talking about active recreationists, where it is expected that there is an awareness of the value of regular physical exercise, the reasons can be found in the fact that these are middle-aged people who dominantly seek their life achievements in other ways of life and that regular physical activity is only one of the segments that can contribute to the quality of their life. It is obvious that other values, which are relevant to life, have a more dominant share in the feeling of satisfaction with the quality of life. However, what has been detected as an implicit indicator is research information that can be interpreted through the context of preferred lifestyle and physical exercise. Thus, the Power and prestige style, which is dominant among men, can be considered appropriate when it comes to regular recreational exercise, given that the connotation of a healthy body, strength, ability and health fits perfectly with the other determinants of social power and prestige, which the majority of the middle-aged male population strive for. On the other hand, women are mostly more inclined to aesthetic experiences of life so that even through physical exercise, they strive for the effects and ultimate results of this process, primarily

in terms of aesthetic benefits (beautiful body, harmonious figure, reduction of body weight, fresh appearance, etc.) . Also, it is known that middle age is characterised by a significant level of life experience, where a certain number of people feel accomplished in their family, society and workplace. On the other hand, the modern way of living and working creates tendencies towards increasing the individualisation of people (especially in urban areas). And people, by their anthropological nature, are essentially social beings and tend towards social cohesion and togetherness. In this sense, altruism, as a way of life functioning of an individual, implies an aspiration towards helping others, cultivating generosity, etc. In this context, participation in sports and recreational activities (especially group programmes) is an ideal environment in which interpersonal relationships of altruistic physiognomy come to the fore. This, in our research, turned out to be an interesting piece of data when it comes to women and the age that is marked as the fifth decade of life (41-50 years).

In this research, it was determined that the relationship between the perception of the current quality of life and the preferred lifestyle among active recreationists is in a certain degree of correlation. Statistical significance (Sig. = .040) and coefficient (.120) indicate a relatively low degree of mutual influence (Table 7). Although regular physical exercise and recreation are found as characteristics of respondents that occupy a significant place in both research areas (quality of life and lifestyle), it obviously does not represent a dominant factor in the construct of their mutual connection. It can be assumed that other factors of the quality of life and lifestyle of middle-aged people make a more significant contribution to the overall composition of their life and social habitus. This does not diminish the importance of regular physical exercise as a permanent recommendation for improving the quality of life.

Table 7: Correlation of research areas

| | | Current quality of life | Current lifestyle |
|-------------------------|---------|----------------------------|----------------------|
| Current quality of life | Pearson | | |
| | Correl. | 1 | .120* |
| | Sig. | | .040 |
| Current lifestyle | Pearson | | |
| | Correl. | .120* | 1 |
| | Sig. | .040 | |

*. Correlation is significant at the 0.05 level (2-tailed).

CONCLUSION

Starting from the fact that lifestyle implies the way in which certain human needs are met, and that the perception of the quality of life is one of the important determinants of good social and personal functioning, it can be considered that their acceptance is a kind of shaping of the personal and social identity of middle-aged people. Lifestyles that are in agreement with the feeling of quality of life in today's social environment also impose demands that come from individuals in search of activities that determine models of social connection. One of these activities is sports recreation. The results of the empirical research, which was conducted on a sample of 290 active recreational players, can be summarised as follows:

- that the perception of a good or very good quality of life dominates among people who regularly practice physical exercise as one of their lifestyle habits;

- that gender can be taken into account as a significant determinant for the differentiation of individual factors of individual perception of the quality of life, bearing in mind, first of all, the frequency of engaging in sports and recreational activities on a weekly basis;

- that age has no significant influence on the perception of quality of life among middle-aged people who regularly engage in sports and recreational activities;

- that, among people who regularly engage in physical exercise and were included in the specific research population, lifestyles marked as Power and prestige, Aesthetic and Altruistic dominate;

- that gender and age can be significant determinants in preferences for a certain lifestyle;

- that in middle-aged persons who regularly engage in physical exercise, and who were detected as research entities, a certain connection between perceived quality of life and preferred lifestyle can be observed.

REFERENCES

1. Bauman, E. A., et al. (2012). Correlates of physical activity: Why are some people physically active and others not? *Physical Activity*, 380(9838), 258-271.
2. Bendíková, E. (2014). Lifestyle, physical and sports education and health benefits of physical activity. *European Researcher*, 69 (2), 3434-348.
3. Bize, R., Johnson, J. A., & Plotnikoff, R. C. (2007). Physical activity level and health-related quality of life in the general adult population: A systematic review. *Preventive Medicine*, 45(6), 401-415.
4. Božilović, N. (2006). Identitet i značenje stila u potkulturi. *Filozofija i društvo*, 2, 233-249.
5. Bull, C. F., et al. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, 54(21), 1451-1462.
6. Cummins, R. A. (2000). Personal income and subjective well-being: A review. *Journal of Happiness Studies*, 1, 133-158.
7. Čejni, D. (2003). *Životni stilovi*. Beograd: Clio.
8. Gill, D., et al. (2013). Physical activity and quality of life. *Journal of Preventive Medicine & Public Health*, 46(1), 28-34.
9. Jensen, M. (2008). Defining lifestyle. *Environmental Sciences*, 4:2, 63-73.
10. Lazarević, D., & Janjetović, D. (2003). Vrednosne orijentacije studenata budućih vaspitača. *Zbornik instituta za pedagoška istraživanja*, 35, 289-307.
11. Nešić, M. (2012). Životni stil kao odrednica opredeljenja prema sportu na Univerzitetu. *Nastava i vaspitanje*, 51(4), 766-786.
12. Nešić, M., Šabić, E., & Skender, N. (2020). Relationship to physical training of persons with lumbal syndrome. *Acta Kinesiológica* 14, Issue 2:10-18, Split.
13. Nešić, M., Srdić, V., Jovanović, M., & Vukajlović, V. (2014). Aktivni životni stil kao činilac očuvanja zdravlja u savremenom životnom i radnom okruženju. In: Jovanović, M. and Nićin, Đ. (Eds.). 4. međunarodna naučna konferencija "Sportske nauke i zdravlje", Zbornik radova, Banja Luka: Univerzitet Apeiron, 277-285.
14. Nešić, M., Romanov, R., Jezdimirović, T., Lepeš, J., & Andrašić, S. (2018). Validacija skale namenjene proceni kvaliteta života osoba sa lumbalnim sindromom. *Sportske nauke i zdravlje*, 8(1), 28-41.
15. Puciato, D., Borysiuk, Z., & Rozpara, M. (2017). Quality of life and physical activity in an older working-age population. *Clinical Interventions in Aging*, 12, 1627-1634.

16. Phillips, M. S., Wojcicki, R. T., & McAuley, E. (2013). Physical activity and quality of life in older adults: An 18-month panel analysis. *Quality of Life research*, 22, 1647-1654.
17. Sardi, M., et al. (2019). Correlating physical activity and quality of life of healthcare workers. *BMC Res Notes*, 12, 208.
18. Sharrkey, J. B., & Gaskill, E. S. (2008). *Vežbanje i zdravlje*. Beograd: Datastatus.
19. Schaie, K. W., & Willis, S. L. (2001). *Psihologija odrasle dobi i starenja*. Jastrebarsko: Naklada Slap.
20. Skender, N., Cakar, S., A., Kurtović, N., & Šabić, E. (2022). Level of students functional abilities as a parameter for determining differences in triglyceride cholesterol blood sugar and body composition in students. *Sportske nauke i zdravlje – Apeiron*, 12(1):23-30.
21. Skender, N. (2004). *Transformacioni procesi motoričkih sposobnosti i morfoloških karakteristika pod uticajem sedmomjesečnog tretmana kod učenika 3. i 4. razreda osnovne škole*. Unpublished doctoral dissertation. Sarajevo: Faculty of Sport and Physical Education, University of Sarajevo.
22. Skender, N., Šabić, E., Selimović, N., Kurtović, N., & Karalić, T. (2022). Analysis of Differences in Morphological Characteristics Based on the Level of Functional Ability in Students of the University of Bihać. *Sports Science*, 15(1):97-103.
23. Šabić, E. (2018). *Fizičke aktivnosti u stilovima života osoba srednje životne dobi u Republici Srpskoj*. Novi Sad: Fakultet za sport i turizam (doctoral dissertation).
24. Šabić, E., Selimović, N., Skender, N., & Nešić, M. (2020). Sports and recreational activities as the leisure time content of middle-aged persons in Bosnia and Herzegovina. *Sport Science*, 13(1), 96-105.
25. Vuletić, G., & Misajon, R. A. (2011). Subjektivna kvaliteta života. In: G. Vuletić (Ed.). Vuletić, G., et al. (2011). *Kvalitet života i zdravlje*. Osijek: Filozofski fakultet, 9-16.
26. World Health Organization. (1982). *Provisional guidelines standard international age classification*. New York: United Nations.
27. World Health Organization Quality of Life Group. (1998). *The World Health Organization Quality of Life Assessment (WHOQOL-BREF): Introduction, administration, scoring and generic version of the assessment*. Field trial version. Geneva: Programme on mental health.

ZADOVOLJSTVO KVALITETOM ŽIVOTA I PREFERIRANI ŽIVOTNI STIL KOD AKTIVNIH REKREATIVACA

SAŽETAK

Fizičko vježbanje, kao determinanta fizičkih aktivnosti koje se preporučuju u kontekstu očuvanja i unaprjeđenja zdravlja čovjeka, povezano je sa opštim pojmom kvaliteta života. Kao kompleksna pojava pokazuje karakter višedimenzionalnosti, odnosno, strukturira ga više međusobno povezanih i uslovljenih činilaca (fizičko zdravlje, psihološka stabilnost, socijalna interakcija, nivo nezavisnosti i samostalnosti u društvenom funkcionisanju, materijalna stabilnost, lična uvjerenja, religijska opredjeljenja, itd.). Kriteriji za procjenu kvaliteta života se uglavnom generišu od strane eksternih subjekata, najčešće različitih zdravstvenih i/ili akademskih institucija. Stoga se u praksi često zapostavlja činjenica da je najobjektivniji pokazatelj kvaliteta života upravo individualna percepcija same osobe o tome – kako živi. Drugim riječima, rijetko se kao kriterij za ocjenu uzima perspektiva same osobe, a kada se radi o određenim procesima (npr. učesnika u sportsko-rekreativnim aktivnostima) samih učesnika toga procesa. Na uzorku od 290 ispitanika, aktivnih rekreativaca, realizovano je transversalno istraživanje, sa ciljem da se identifikuje individualna percepcija kvaliteta života kroz kontekst preferiranog životnog stila. Kao osnovni istraživački instrument primjenjen je upitnik, namjenski konstruisan za ovo istraživanje. Rezultati su pokazali da među osobama koje redovno upražnjavaju fizičko vježbanje kao jednu od životnih navika dominira percepcija o dobrom ili veoma dobrom kvalitetu života. Kod osoba srednje životne dobi koje se redovno bave fizičkim vježbanjem može se uočiti određena povezanost između percipiranog kvaliteta života i preferiranog životnog stila.

Ključne riječi: kvalitet života, životni stil, fizičko vježbanje

EXPERT MODELLING OF SPORT PREPARATION IN HANDBALL

Zoran Ante Nikolić¹, Nenad Rogulj², Marijana Čavala²

1. Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

1. Faculty of Kinesiology, University of Split, Split, Croatia

ABSTRACT

Based on the evaluation of ten competent top handball experts, we have established the importance of three different preparations: tactical, conditioning and psychological preparation, including their components for efficiency in senior handball. Additionally, we have determined the possibilities of influencing certain types and components of sport fitness within the corresponding sport preparation. According to research findings, we created a simple mathematical model to determine the training time required to implement certain types of sport preparation and their components in top senior handball. Research findings suggest that, in the training process for senior handball, an almost equal amount of attention should be paid to all three types of preparation: conditioning, tactical and psychological, and that each one requires approximately one third of the total available time. The contemporary training process tends to integrate the elements of technical, tactical and conditioning preparation by using specific situation operators, while psychological preparation requires separate training time which is often neglected. The model is applicable in planning and programming annual or monthly cycles, weekly micro cycles or a single training session, particularly during the preparation period.

Keywords: conditioning, psychological and tactical preparation, model, period

INTRODUCTION

Periodisation can be defined as a planned distribution of specific variations introduced into training methods at regular time intervals to optimise gains in strength, power, muscular hypertrophy, and motor skills, while at the same time minimising the risks of overtraining (Fleck, 1999; Fleck & Kraemer, 1997; Zatsiorsky, 1995). Physical training should be organised with pre-planned, systematic variations in training specificity, intensity and volume in different periods or cycles within the overall training programme for the season (Michalsik, 2015). It is necessary to strive for proper provisioning of competition functioning conditions, training tasks at different stages and periods of an annual cycle, and as a result, it is necessary to know not only the structure of competition functioning but also the factors which condition its effectiveness and positively influence sports result (Tyshchenko, 2015).

Designing periodised training programmes for team sports athletes poses unique challenges and difficulties. Indeed, athletes are required to work on multiple aspects of their individual fitness and physical readiness to perform, while concurrently participating in extensive technical and tactical team training sessions to prepare for upcoming matches, as well as extended periods of competition itself (Gamble, 2006).

Dosing, modelling and optimal combining of certain types of sport preparation are an everyday challenge for coaches and a kind of a creativity test. The eternal question is: how to use available resources, such as players, material and infrastructure resources, to achieve a set sports result in a given environment and at a given time. Sport preparation can, more or less, be distributed over the preparation period before or after competitions, as well as focus on preparation during the competition period.

One of the biggest challenges for coaches and athletes of all calibres is to design their long- and short-term training

programmes to induce optimal training adaptations and maximise performance at the desired moments of the competitive season (Mujika et al., 2018).

Senior handball is dominated by three types of preparation: tactical, conditioning and psychological, while technical and theoretical preparation should not be included due to the fact that knowledge obtained from those is completely acquired by younger categories.

Starting from the importance of optimal sport preparation modelling in top senior handball, the purpose of this paper is to suggest a simple mathematical model to calculate the optimal time period for a certain type of preparation and their components in a training process based on the opinion analysis of top handball experts on the significance of certain types of preparation and their components, in addition to their opinion on the potential effect on improving knowledge and abilities in players via the training process within each preparation.

The paper starts from the assumption that the greater the significance of a certain preparation in the result efficiency in handball, and the greater the possibility to influence this component during the training process, the greater its frequency proportion in the training process.

METHODS

Research sample

The sample of international handball experts includes ten top handball experts fulfilling the criteria of the highest formal handball education as university professors or kinesiology teachers with a specialty area and an MA degree in handball coaching, with referential professional competences as long-term coaches of top senior teams and national teams with remarkable international success.

Variables

The experts evaluated the significance and possibility to influence three types and eight components of sport preparation, i.e., physical fitness in top senior handball: positioning attack tactics, positioning defence tactics and transition tactics within tactical preparation; situational speed, speed endurance and strength within conditioning preparation, in addition to psychological stability and motivation included in psychological preparation.

Data processing

Data processing and updating has been done by implementing a modified Analytical Hierarchical Process (AHP method) through pairwise comparison.

On the Likert scale from 1 to 5, the experts evaluated the quantitative significance of the significance criterion and the possibility of influence for certain time frequencies of each type of sport preparation within the training process.

RESULTS

Table 1. Evaluation obtained by summing up points given by experts in pairwise comparisons, divided by the number of experts and the corresponding number of comparisons

| Type/component | Efficiency significance (OV) | Possibility for influence (OU) |
|-------------------------|---------------------------------|-----------------------------------|
| Tactical | 2.95 | 3.05 |
| Attack tactics | 3.10 | 2.40 |
| Defence tactics | 3.55 | 3.25 |
| Transition tactics | 2.35 | 3.35 |
| Conditioning | 2.95 | 3.45 |
| Situational speed | 3.75 | 2.35 |
| Speed endurance | 2.60 | 3.35 |
| Strength | 2.65 | 3.25 |
| Psychological | 3.10 | 2.50 |
| Psychological stability | 3.40 | 2.30 |
| Motivation | 2.60 | 3.70 |

According to the experts' opinion, in top senior handball, psychological preparation is most important for result efficiency (3.10), while tactical and conditioning preparation are equally significant, but to a smaller degree (2.95). Within psychological preparation, the experts consider psychological stability more important than motivation (3.40 – 2.60). In tactical preparation, the most important tactics is positioning defence tactics (3.55), followed by positioning attack tactics (3.10), while the least important is transition phase tactics (2.35). In conditioning preparation, the experts consider situational speed (3.75) more significant for result efficiency, compared to strength (2.65) and speed endurance (2.60).

In assessing the possibility of influencing certain components of sport fitness regarding sport preparation, the experts consider training procedures mostly affect the conditioning component of sport fitness (3.45), followed by the tactical one (3.05), while they least affect the psychological component (2.50).

Regarding conditioning fitness components, the experts' opinion is that speed endurance (3.35) could mostly be influenced, and strength (3.25) can be influenced less. In tactical preparation, one may

mostly affect sport fitness in transition tactics (3.35), followed by positioning defence tactics (3.25), while positioning attack tactics is least influenced (2.40). In psychological fitness, the experts think we may achieve greater influence on motivation (3.70) rather than on psychological stability (2.30).

By evaluating the two mentioned criteria (Table 2), the experts' assessment is that, for determining the time frequency of certain types and components of sport preparation in a training process, it is more important to respect the criterion of possible influence on a certain aspect of sport fitness (4.37) than the hypothetical significance of the relating sport preparation itself on result efficiency (3.85).

Table 2. The significance of criteria for determining the time frequency of a certain type of sport preparation in a training process

| Evaluation of the significance of criteria importance (OZV) | Evaluation of the significance of possible influence criteria (OZU) |
|--|--|
| 3.85 | 4.37 |

DISCUSSION

According to the experts' opinion in this research, psychological preparation is far more significant than tactical or conditioning preparation. Psychological demands in handball (Cruz & Geron, 2008) are high and span from the motivation to achieve the goals, to the activation in the implementation of actions, the focus on the game play, the player's confidence in his/her own powers, the cohesion of collective team play, and the ability to make the right decision at the right time (according to Daza, 2012).

In top professional sport, when participating in a competition, athletes and teams are becoming more equal in conditioning and tactical preparation, considering these two types of preparation, unlike the psychological one, are most frequent and most systematically implemented both in the training process and match preparation. Under these circumstances, when the teams are equal in tactics and conditioning fitness, psychological preparation may prevail and lead the team to victory, which was obviously recognised by experts due to their long-term competition experience. Psychological preparation may be less implemented than others, since coaches unconsciously neglect it or do not have enough time, knowledge or conditions to implement it. Based on their experience, the experts also assessed that in result efficiency, psychological stability is more significant than motivation. Despite the fact motivation is crucial and necessary, for every male or female player, it is more important to possess the ability of staying calm in stressful and conflicting competition circumstances, especially in terms of an uncertain result outcome and under the negative external influences, such as energy destruction and aggressive play by the opponent, in addition to being able to bring fast and rational decisions and keep self-confidence.

Although psychological preparation is particularly important (Daza, 2012; Mujika, 2018), the experts all agree that the components of psychological preparation, especially psychological stability, cannot be influenced to such an extent as the tactical or conditioning preparation components. Experts are not professionally trained psychologists; however, they have pointed out their experience knowledge based on positive and negative experiences from numerous matches and competitions.

According to the findings, tactical and conditioning preparation are equally or even slightly less important for efficiency than psychological preparation. In tactical preparation, positioning defence tactics is considered to be most significant, followed by positioning attack tactics and transition tactics. As a game phase, defence and positioning defence tactics have been detected in previous research as most important for efficiency in handball (Rivilla et al., 2011; Balint, 2013). On the other hand, experts consider that coaches can mostly influence transition tactics in their training procedures, followed by positioning defence tactics, while positioning attack tactics can be least influenced. These attitudes are in accordance with the complexity of kinesiological structures and mental requirements of certain phases, since the

positioning attack phase is the most complex from the technical-tactical perspective, with accentuated information loadings, and requires increased mental and psychological engagement in players (Massuça, 2011).

As far as conditioning preparation components are considered, experts think situational speed is far more significant than speed endurance or strength. Speed is a dominant ability that generates result efficiency, primarily in modern handball, and it is a part of all situational activities in attack and defence, with or without the ball. However, this research, in addition to numerous previous research, has shown that, in the experts' opinion, situational speed may be significantly less influenced than speed endurance or strength.

Summarising the results of this research, i.e., expert evaluation of the significance of certain sport preparations and the possibility of training influence on physical fitness, we may suggest a simple model to calculate training time for certain preparations. The model is based on the assumption that areas important for efficiency should be given more training attention, in addition to those areas that can be easily improved by training. Unfortunately, or luckily, these two categories are frequently opposed to one another; therefore, psychological stability is most important for efficiency within psychological preparation, as is situational speed within conditioning preparation, and on the other hand, these components are most difficult to influence. The question is: is it more useful to train something that is more significant for the result or something that can be more easily influenced by training? Naturally, the answer is a compromise, so we asked the experts the same question. Based on their opinion, we calculated criterion ponderers used to multiply the corresponding evaluation grades for significance, i.e., the possibility for influence. For every type or a component in sport preparation, pondered grades for significance and influence are to be summed up and put into correlation with the total available training time to determine the optimal training time necessary to provide for the implementation of a certain type or the component of sport preparation.

The relation is as follows:

$$TVK_i = UTV \frac{KOM^i}{TKOM}$$

where:

TVK – is the optimal training time to implement a certain type or a component in sport preparation

UTV – is the total available training time

KOM – is the evaluation grade of a certain type or component of preparation in points, required to calculate *TVK*

TKOM – is the value in points of all types or preparation components, i.e.

$$TKOM = \sum_{i=1}^n KOM_i$$

The value in points of a type or a preparation component is to be calculated via the following relation:

$$KOM_i = OV_i pV + OU_i pU$$

where:

- expert evaluation grade of significance for a certain type or a sport preparation component for result efficiency (Table 1)

- expert evaluation grade of the possibility for training influence on a certain type or sport fitness component via the corresponding sport preparation (Table 1)

pV – is a ponder for the significance criterion calculated from $pV = OZV/5 = 0.77$

pU – is a ponder for the significance criterion calculated from $pU = OZU/5 = 0.87$, where:

OZV – is the significance evaluation grade of the importance criterion (Table 2)

Through the given model, we may determine how

much training time is useful to spend on a certain preparation compared to the total amount of given time, regardless of the fact it is a single training session, weekly micro cycle, monthly or annual cycle. Time variables may be expressed in any time unit. For instance, in the following table (Table 3) we presented an example for determining the amount of training time for a certain type of preparation within a single 90-minute training session.

CONCLUSION

Research findings suggest that, in the training process for senior handball, an almost equal amount of attention should be paid to all three types of preparation: conditioning, tactical and psychological, and that each one requires approximately one third of the total available time. The contemporary training process tends to integrate the elements of technical, tactical and conditioning preparation by using specific situation operators, while psychological preparation requires separate training time which is often neglected.

This type of model is applicable in the first phases of preparation and during the transition period, while in the final phase of the preparation period and during the competition period, for the given parameters and when calculating training time, it may be advisable to introduce the criterion for quality relations of the team in a certain type of preparation or in a certain sport fitness component.

Table 3. Example for determining the amount of training time for a certain type of preparation

| PREPARATION | OV | OU | OZV | OZU | pV | pU | KOM | TKOM | UTV | TVK |
|---------------|------|------|------|------|------|------|------|-------|------|--------|
| Psychological | 3.1 | 2.5 | | | | | 4.56 | | | 27.8 m |
| Tactical | 2.95 | 3.05 | 3.85 | 4.37 | 0.77 | 0.87 | 4.92 | 14.75 | 90 m | 30.0 m |
| Conditioning | 2.98 | 3.45 | | | | | 5.27 | | | 32.2 m |

Example questions for the importance of preparation type in result efficiency:

| TACTICAL PREPARATION – CONDITIONING PREPARATION | |
|---|---|
| 1 | Tactical preparation is far more significant than conditioning preparation |
| 2 | Tactical preparation is slightly more significant than conditioning preparation |
| 3 | Tactical preparation is equally significant as the conditioning preparation |
| 4 | Conditioning preparation is slightly more significant than tactical preparation |
| 5 | Conditioning preparation is far more significant than tactical preparation |

Example questions for the possible influence on certain types of sport fitness within the corresponding sport preparation

| TACTICAL - CONDITIONING | |
|-------------------------|--|
| 1 | It is possible to influence the improvement of tactical sport fitness significantly more than conditioning |
| 2 | It is possible to influence the improvement of tactical sport fitness more than conditioning |
| 3 | It is possible to equally influence the improvement of tactical and conditioning sport fitness |
| 4 | It is possible to influence the improvement of conditioning sport fitness more than tactical |
| 5 | It is possible to influence the improvement of conditioning sport fitness significantly more than tactical |

REFERENCES

- Balint, E. (2013). The importance of anticipation in increasing the defense efficiency in high performance handball. *Procedia-Social and Behavioral Sciences*, 76, 77-83.
- Cruz, A., & Gerona, T. (2008). *Psicología aplicada al balonmano*. Paidotribo.
- Daza, G. (2012). A proposal of psychological intervention in handball. Barcelona. University of Barcelona - INEFC Barcelona center (ESP). Retrieved from: http://cms.eurohandball.com/PortalData/1/Resources/4_activities/3_pdf_act/A_proposal_of_psychological_intervention_in_handball_UUHT_Gabriel_Daza_Spain_.pdf
- Fleck, S. J. (1999). Periodized strength training: A critical review. *J Strength Cond Res* 13: 82-89.
- Fleck, S. J., & Kraemer, W. J. (1997). *Designing resistance training programs*. Champaign, IL: Human Kinetics Books, pp. 45-66.
- Gamble, P. (2006). Periodization of training for team sports athletes. *Strength and conditioning journal*, 28(5), 56. doi:10.1519/00126548-200606000-00009
- Massuça, L. M. (2011). Expertise evaluation of technical and tactical proficiency in handball: differences between playing status. *EHF Scientific Conference, Vienna*, 282-286.
- Matveev, L. P. (2001). *Obshchaia teoriia sporta i ee prikladnye aspekty* [The general theory of sport and its applied aspects], Moscow, News, 333p
- Michalsik, L. B. (2015). Preparation and training of elite team handball players. In *Medical aspects in handball—preparation and the game: scientific and practical approaches*. Proceedings of the third International Conference on Science in Handball, Bucharest, Romania, pp. 60-67.
- Mujika, I., Halson, S., Burke, L. M., Balagué, G., & Farrow, D. (2018). An integrated, multifactorial approach to periodization for optimal performance in individual and team sports. *International journal of sports physiology and performance*, 13(5), 538-561.
- Rivilla, J., Lorenzo, J., Ferro, A., & Sampedro, J. (2011). Effect of the decision-making process in the speed of defensive displacement in handball. *EHF Scientific Conference, Vienna*, 101-103.
- Tyshchenko, V. A. (2015). Features of the training process of handball players of higher qualification between rounds in the competitive period. *Pedagogics, psychology, medical-biological problems of physical training and sports*, (1), 73-78.
- Zatsiorsky, V. M. (1995). *Science and practice of strength training*. Champaign, IL: Human Kinetics Books, pp. 34-43.

EKSPERTNO MODELIRANJE SPORTSKE PRIPREME U RUKOMETU**SAŽETAK**

Na osnovu procjena deset kompetentnih vrhunskih rukometnih stručnjaka utvrđena je važnost tri vrste priprema: taktičke, kondicijske i psihološke te njihovih komponenti za uspjeh u seniorskom rukometu. Također, utvrđene su i mogućnosti uticanja na pojedine vrste i komponente sportske forme u okviru pripadajuće sportske pripreme. U skladu sa istraživačkim nalazima kreiran je jednostavni matematički model za određivanje trenažnog vremena za provedbu pojedinih vrsta sportske pripreme i njihovih komponenti u vrhunskom seniorskom rukometu. Istraživački nalazi ukazuju da u trenažnom procesu seniorskog rukometa gotovo podjednaku pažnju treba posvetiti svim trima pripremama: kondicijskoj, taktičkoj i psihološkoj te da je za svaku potrebno odvojiti otprilike trećinu ukupnog raspoloživog vremena. Savremeni trenažni proces nastoji integrisati elemente tehničke, taktičke i kondicijske pripreme korištenjem specifičnih situacijskih operatora, dok za psihološku pripremu treba osigurati zasebno trenažno vrijeme, što se često zanemaruje. Model je primjenjiv kod planiranja i programiranja godišnjeg ili mjesečnog ciklusa, sedmičnog mikrociklusa ili pojedinačnog treninga, a naročito u pripremnom periodu.

Ključne riječi: kondicijska, psihološka i taktička priprema, model, period

Correspondence to: Marijana Čavala
Faculty of Kinesiology, University of Split, Split, Croatia
E-mail: marijana.cavala@kifst.eu

REHABILITATION OF VISUALLY IMPAIRED INDIVIDUALS THROUGH SPORTS

Nadir Ibrahimović¹

1. Faculty of Health Studies, University "Vitez", Vitez, Bosnia and Herzegovina

ABSTRACT

This paper is a literature review that focuses on rehabilitation of visually impaired people through sports. The aim of the paper is to investigate the rehabilitation of visually impaired people through sports and to point out its importance. For every person, and especially for people with visual impairment or another type of disability, sport can significantly affect the quality of life and, through its action, enrich the athlete's life many times over. The development of a sense of equality, self-respect, self-confidence, and security through sports activities is very important for people with visual impairments, which greatly facilitate and enable greater psychophysical independence and also ensure psychological stability. The choice of sports and physical activities that blind and visually impaired people can engage in is very large, and the choice of activity depends on the preferences of the individual. Some of the sports in which the blind and visually impaired people participate are goalball, cycling, judo, athletics, horse riding, futsal, sailing, rowing, and swimming.

Keywords: rehabilitation, visual impairment, sports

INTRODUCTION

Vision is the sense that allows a person to discern the shapes, sizes, distance, and colour of the objects he/she observes (Schwiegerling, 2004). People with visual impairment are people who have an impaired sense of vision, caused by genetic predisposition, disease, early birth, or by some traumatic injury. Visual impairment can be complete and such persons are categorised as blind persons, while people with partial and incomplete vision loss are categorised as visually impaired persons. Depending on the cause and disease, the state of vision can be better or worse, which means that the conditions and light of the space affect the visibility of the same (Nenadić, Šubarić, & Dumančić, 2015).

According to the data of the Association of the Blind in the Sarajevo Canton and the Association of the Blind of the Federation of Bosnia and Herzegovina, it is assumed that there are between 400-500 visually impaired people in the Sarajevo Canton, out

of which about 50% are blind and 50% are visually impaired. When it comes to the Federation of Bosnia and Herzegovina, it is assumed that the number of visually impaired person gravitates to around 2,700-3,000 of visually impaired people, out of whom around 50% are blind and 50% visually impaired. Since there is no register of blind and visually impaired people, it is assumed that the total number of this population in BiH is around 5,000 (Association of the Blind in Sarajevo Canton, 2015).

This population has much more favourable living conditions in foreign countries than in Bosnia and Herzegovina. Throughout their life, the blind and visually impaired people face numerous difficulties, and in addition to the handicaps they have, they have to struggle with realising the right to aids, accessible and non-discriminatory education, an accessible environment, etc.

PROBLEM AND AIM

The research problem of the work focuses on the rehabilitation of visually impaired people. Rehabilitation aims to enable people with disabilities to achieve and maintain an optimal level of sensory, physical, psychological, intellectual, and social efficiency and thus acquire the ability to change their lives in order to achieve greater independence. The aim of this paper is to investigate the rehabilitation of these people through sports. A literature review will be used for this purpose. This article gives a glance at new opportunities in the rehabilitation of visually impaired people through sports.

RESULTS

A high level of health (one of the basic determinants of the quality of life) contributes to the quality life as a whole. The basic indicators of the degree of health are the level of psychophysical and functional abilities, the increase of which can be influenced by regular and continuous physical exercise within sports activities. Sports activities include various motor activities of a variable and dynamic character through which a person satisfies the need for movement, develops abilities, traits and sports knowledge, and preserves and improves health. Also, through sports activities, a person is provided with opportunities for sports expression and creativity, as well as achieving sports results at all levels of competition (Radišić, Miletić, & Berković, 2017).

Regular physical activity helps a person to preserve and improve his/her health, both physical, psychological and mental (Oguma et al., 2002). Therefore, it can be said that physical activity is a very important segment of human life. Sport, as a specific type of physical activity, represents a large area and a wide range of possibilities for influencing the development and life of every person. For every person, and especially for people with visual impairment or another type of disability, sport can significantly affect the quality of life and, through its action, enrich the athlete's life many times over. Among other things, thanks to sports, there is a better mutual interaction between visually impaired people and the environment (Ciliga, Trkulja Petković, & Delibašić, 2006).

Sport, as a way of life, is the most important factor in achieving and maintaining health in all its aspects, and as a lifestyle, it increases the quality of life in all areas. The development of a sense of equality, self-respect, self-confidence, and security through sports activities is very important for people with visual impairments, which greatly facilitate and enable greater psychophysical independence and also ensure psychological stability. By cooperating with other participants in sports activities, in addition to making new acquaintances and friendships, athletes

with visual impairments develop a sense of tolerance and cooperation, which also increases their sense of self-worth and usefulness. In this way, they confirm their abilities and skills, achieve social recognition and actively participate equally in the life of the community (Kovačević, 2011). Therefore, it can be said that all of the above is even more pronounced within this specific population of athletes.

Sports involving visually impaired people and the necessary adaptations

Adjustments to the rules in sports and modifications to physical activity have expanded the range of activities in which visually impaired people can participate. Some of the sports in which the blind and visually impaired people participate are goalball, cycling, judo, athletics, horse riding, futsal, sailing, rowing, and swimming (Kamelska & Mazurek, 2015). The choice of sports and physical activities that blind and partially sighted people can engage in is very large, and the choice of activity depends on the preferences of the individual.

Certain sports do not require any adjustments, i.e., specifics in field dimensions, rules and penalties, while some sports are intended exclusively for people with disabilities. Recently, there has been a connection between interactive games and physical activities (exergames), which are specially adapted for people with visual impairments (Kamelska & Mazurek, 2015).

Participation of visually impaired people in the Paralympic Games

The Paralympic Games are related to the Olympic Games, but the difference between them is that the participants in the Paralympic Games have some form of disability. It is an event that emphasises the achievements of people with disabilities, not their impairments. The Paralympic Games are held every four years in the host city where the Olympic Games took place two to three weeks earlier. They were created after the 2nd World War, and they were threatened by the Stoke Mandeville games. The Stoke Mandeville Games held in Rome in 1960 are considered the first summer Paralympic Games. The first winter Paralympic Games were held in 1976 in Toronto. The International Paralympic Committee was founded in 1989, and its membership includes National Paralympic Committees (NPC), International Federations (IF), regional organisations and International Sports Organisations for Persons with Disabilities (IOSD), out of which the IBSA for the visually impaired (Ponchilla, Ponchillia, & Strause, 2002). The most common sports for the blind and partially sighted at the Summer Paralympic Games are goalball, judo, cycling, athletics, swimming, rowing, futsal, and triathlon. In the Winter Paralympic Games, blind and partially sighted people compete in biathlon and skiing (Beljak, 2018).

People with visual impairment compete according to categories of impairment: B1 - without functional vision, B2 - visual acuity is less than 20/400 or visual field of less than 5 degrees, B3 - visual acuity 20 / 200-20 / 400 or visual field of 5-20 degrees. The purpose of classifying athletes according to the degree of visual impairment is to ensure equal and fair competition. Vision classification

should ensure all athletes the security of competing against other athletes under equal conditions (Bon, 2017).

International Blind Sports Federation – IBSA

The Paralympic Committee targets different groups of people with disabilities, while the IBSA targets only the visually impaired people. Its main role is to promote sports, organise competitions, create rules for certain sports and raise awareness about the participation of visually impaired people in sports. IBSA holds the World Championship two years after the Olympic Games, and the sports covered are: archery, alpine skiing, futsal, athletics, goalball, judo, swimming, Nordic skiing, bowling, powerlifting, shooting, showdown (a sport similar to table tennis), tandem cycling, and torball (a game with characteristics of goalball and volleyball) (Ponchilla et al. 2002).

through sports of the professional team and family, and constant mutual communication is of crucial importance. Integration into society, overcoming prejudices and discriminatory approaches is a struggle and a long journey that the blind and visually impaired people must bravely face.

When it comes to physical activity, visually impaired people face many barriers. Some of these barriers originate from the damage itself, but some are the product of ignorance and misunderstanding of the environment. However, in the end, it is important to emphasise that visual impairment cannot and must not be an obstacle to participation and engagement in sports activities. The blind and visually impaired people should be equal members of society who can contribute both to themselves and to the social community with their capacities and work.

CONCLUSION

It is concluded that with a timely and adequate process of rehabilitation of visually impaired persons through sports, it is possible to achieve a high degree of competence and independence. Involvement in the rehabilitation process

REFERENCES

1. Association of the Blind in Sarajevo Canton. (2015). Retrieved from: <https://www.slijepi-sa.org.ba/>
2. Coakley, J. (2018). Physical exercise and sports activities of visually impaired people [Tjelesno vježbanje i sportske aktivnosti osoba sa oštećenjem vida]. (Master's thesis). Zagreb: Faculty of Kinesiology, University of Zagreb.
3. Bon, I. (2017). Competitors in alpine skiing with physical disabilities [Natjecatelji u alpskom skijanju s tjelesnim invaliditetom]. (Master's thesis). Zagreb: Faculty of Kinesiology, University of Zagreb.
4. Ciliga, D., Trkulja Petkovic, D., & Delibasic, Z. (2006). Quality of work in the field of sports and sports recreation for persons with disabilities [Kvaliteta rada u području sporta i sportske rekreacije osoba s invaliditetom]. Proceedings of the 15th summer school of kinesiologists of the Republic of Croatia, Rovinj, (pp. 282-285). Zagreb: Croatian Kinesiology Association.
5. Kamelska, A. M., & Mazurek, K. (2015). The assessment of the quality of life in visually impaired people with different level of physical activity. *Physical Culture and Sport Studies and Research*, 67(1), 31-41.
6. Kovacevic, Z. (2011). The influence of kinesiology engagement on anthropological status and health [Utjecaj kineziološke angažiranosti na antropološki status i zdravlje]. Retrieved from: <http://www.scribd.com/doc/51340160/web-predavanje-kovacevic>
7. Nenadic, K., Subaric, Z. & Dumancic, J. (2015). People with visual impairment - our patients: A guide to access for blind and visually impaired people [Ozone s oštećenjem vida – naši pacijenti: Vodič za pristup slijepim i slabovidim osobama]. Zagreb: Croatian Association of the Blind.
8. Oguma, Y., Sesso, H. D., Paffenbarger, R. S., & Lee, I. M. (2002). Physical activity and all cause mortality in woman: A review of the evidence. *British Journal of Sports Medicine*, 36 (3), 162-172.
9. Ponchillia, P., Ponchillia S., & Strause B. (2002). Athletes with visual impairments: Attributes and sport participation. *Journal of visual impairment and blindness*, 96 (4), 267- 272.
10. Radisic, D., Miletic, M., & Berkovic, M. (2017). Povezanost fizioterapije i sporta osoba sa invaliditetom. *Physiotherapia Croatica*, 14 (1), 118-121.
11. Schwiegerling, J. (2004). Field guide to visual and ophthalmic optics. WA, Bellingham: SPIE Press.

REHABILITACIJA OSOBA S OŠTEĆENJEM VIDA KROZ SPORT**SAŽETAK**

Ovaj rad je pregled literature koji se fokusira na rehabilitaciju osoba s oštećenjem vida kroz sport. Cilj rada je istražiti rehabilitaciju osoba s oštećenjem vida kroz sport i ukazati na njen značaj. Kod svake osobe, a naročito kod osoba s oštećenjem vida ili drugom vrstom invaliditeta, sport može bitno uticati na kvalitet života te svojim djelovanjem višestruko obogatiti život sportaša. Osobama s oštećenjem vida kroz sportske aktivnosti vrlo je važan i razvoj osjećaja ravnopravnosti, samopoštovanja, samopouzdanja i sigurnosti koji im uveliko olakšavaju i omogućavaju veću psihofizičku samostalnost, a osiguravaju i psihičku stabilnost. Izbor sportova i fizičkih aktivnosti kojima se slijepe i slabovidne osobe mogu baviti je veoma velik, a odabir aktivnosti ovisi o preferencijama pojedinca. Neki od sportova u kojima slijepi i slabovidni učestvuju su goalball, biciklizam, džudo, atletika, jahanje, futsal, jedrenje, veslanje i plivanje.

Ključne riječi: rehabilitacija, oštećenje vida, sport

Correspondence to: Nadir Ibrahimović
Faculty of Health Studies, University "Vitez", Vitez, Bosnia and Herzegovina
E-mail: nadir.ibrahimovic@gmail.com

THE EFFECT OF EIGHT WEEKS OF SAUNA AND PHYSICAL ACTIVITY ON CARDIOVASCULAR PERFORMANCE AND BODY COMPOSITION OF FEMALE NON-ATHLETES

Gholamreza Sharifi¹, Alireza Babaei Mazreno¹, Zahra Asadi¹, Iman Nazerian

1. Department of Sports Science, Islamic Azad University, Khorasgan Branch, Isfahan, Iran
 2. Department of Sports Science, Islamic Azad University, Dolatabad Branch, Isfahan, Iran
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ABSTRACT

Background: Lack of physical activity and failure to pay attention to daily calorie intake cause the structure of the body to be disturbed. **Purpose:** This study aims to investigate the effect of sauna and physical activity on cardiovascular performance and body composition of female non-athletes. **Methods:** In a semi-experimental research, 30 women aged 25 ± 5 years old who live in Yazd city were randomly selected, and the samples were divided into sauna and physical activity groups, where each group was randomly assigned 15 subjects. Before and after 8 weeks of physical activity and sauna, changes in heart rate, blood pressure, body fat percentage, fat weight and lean body mass were measured. Finally, the SPSS21 software was employed to study and analyse the collected data. **Results:** For the group which used sauna, the results showed that there were significant changes ($p \leq 0.05$) in heart rate, systolic blood pressure, total weight, lean body mass, fat weight, and body fat percentage, while there were no significant changes in diastolic and average blood pressure ($p \geq 0.05$). Additionally, the subjects who used the cycle ergometer, showed a significant change ($p \leq 0.05$) in heart rate, average blood pressure, total weight, body fat percentage, fat weight, and lean body mass, while systolic and diastolic blood pressure did not change significantly ($p \geq 0.05$). **Conclusion:** The results of this research showed that sauna and physical activity improve the cardiovascular function and body composition of non-athlete women.

Keywords: sauna, physical activity, cardiovascular function, body composition

INTRODUCTION

The abilities and capabilities of individuals in performing sports activities depend on the efficiency and performance of different systems of the body (Ambrosetti et al., 2021). It seems that body systems have the ability to adapt to different stimuli and changes, and the tissues adjust themselves according to the incoming stimuli and the needs of the body with new conditions (Anker et al., 2020). All the organs of the body play a great role in performing sports activities, but the key role of the heart in providing metabolic needs to the continuation of life, and especially physical activities, is undeniable (Bozkurt et al., 2021). A healthy heart works with a special process throughout life, but if it is influenced by regular activities, it will not get old. As a result of continuous activities, the heart undergoes quantitative and qualitative changes, which ultimately lead to beneficial adaptations in the heart (Cho et al., 2021). Research has shown that, during sports activities, there are more structural and functional changes of the left ventricle than other parts of the heart (de Barcelos et al., 2022). However, the exact effects of exercise on the structure and function of the heart depend on the type, intensity and duration of exercise, the level of initial physical fitness, heredity, and gender (Fujiwara et al., 2021).

A sauna is a hot environment that puts a person under thermal stress. In such conditions when the temperature of the environment is higher than the temperature of the skin and deep parts of the body, the importance of evaporation for heat loss increases. Increasing dependence on evaporation means increasing the need to sweat (Lee et al., 2022). Sauna can be considered as one of the environments that put a person under hot and humid pressures, and these pressures may cause certain physiological changes in the body. One of the modern and common ways to relieve fatigue is to use a sauna (Toro et al., 2021). The motivation and method of using a sauna are different and often not based on scientific findings. Generally, one group uses the sauna to relax and get rid of stress and mental tension, and another group goes to the sauna to lose weight and excess fat, while some believe that sauna improves the metabolism of the body and increases the work of the cardiovascular and respiratory system (Hussain & Cohen, 2021). The level of internal temperature of the sauna and its humidity percentage, the duration of being in the sauna, the use of different sauna steps and cold-water ponds, weight and body fat percentage, age, and gender are some of these items and components which affect heart rate, stroke volume, cardiac output, systolic and diastolic blood pressure, peripheral and central blood flow, and heart electrocardiogram changes (Laukkanen et al., 2021). The body of a healthy person in the sauna stands and fights against this heat stress by dilating skin vessels, increasing skin blood flow, and also increasing heart rate and sweating (de Barcelos et al., 2022). Therefore, the heart rate increases up to 2 times, and the heart output is about 70% higher than

the resting state, while the total peripheral resistance of blood vessels decreases by approximately 40% (Laukkanen et al., 2015). Encompassing a proper heart rate, normal blood pressure and a good body composition is a sign of physical health. Determining the heart rate is considered as one of the reliable indicators of the level of physical fitness related to the health of the body, and it is considered as a criterion for diagnosing cardio-respiratory fitness (Podstawski et al., 2014) and high percentage of body fat compared to the total weight which is related to the occurrence of some diseases and may lead to a heart attack. Regardless of the old age of sauna efficiency and the modernisation of their shape and structure, there is little and often incorrect knowledge about how to use a sauna and its positive and negative effects. Thus, it is necessary to conduct research in the field of sauna and its effects on the body structure, while more research should be done in the correct way. Several studies have been conducted on the use of saunas and participation in sports activities on body structure and composition, which can be seen in the research conducted by Lee et al. (2022), Toro et al. (2021), Hussain and Cohen (2018), and Schmid (2021) and Anker, (2021).

The gaps and contradictions still exist, since the findings of these studies are sometimes unable to generalise them to the target society.

Unfavourable physical conditions related to weight (metabolic syndrome of overweight and obesity) create grounds for analysis and destruction of cellular, molecular and functional structures of important and vital organs of the body, especially the cardiovascular system, and in this way, cause the onset of occurrence of cardiovascular diseases (Foroutan et al., 2019; Motamedy et al., 2015). Thus, at any time and any situation, it is of great importance and value to take an effective step in expanding the health of body organs with the lowest costs. On the other hand, the application and design of basic physical exercises related to research goals can answer many questions that remain unanswered in the field of the cardiovascular system adaptations (Sharifi et al., 2015). Because of previous studies, inconsistent and contradictory results in this field have been attributed to factors such as the type of training protocol and samples. Therefore, it is important and necessary to be able to answer these questions to some extent by considering the appropriate training protocol. Another issue that adds to the importance of this research is the female population of Yazd city. Finally, by using the designed exercise protocol in the present study, in addition to the possible changes that will occur in the body composition indicators of sedentary women from Yazd city, it is possible to determine the probability of the onset and occurrence of adaptations in the structure and function of their left ventricle. On the other hand, especially in relation to the sauna, the necessary information and awareness still do not seem to be enough.

RESEARCH METHODOLOGY

The semi-experimental pre- and post-study included 30 female non-athletes of Yazd city, with an age range of 25 ± 5 years, who were non-smokers, had no known endocrine diseases, diabetes, cardiac or chronic ailments. Additionally, after explaining the conditions, completing the written consent form, they were invited and purposefully participated in the research.

The limitations of this research are as follows: the impossibility of controlling the motivation of the study subjects, the lack of control of hidden diseases, the lack of accurate information related to menstruation, and the lack of recognition pertaining to the genetic differences of women that affect the efficiency of cardiovascular function and body composition.

In order to conduct the research, the subjects were requested to observe normal sleep patterns (at least 8 hours of sleep), daily activity patterns during the research, and refrain from any intense physical activity, food supplement consumption and medicine uptake, avoid coffee, tobacco and cocoa during 48 hours in the pre-test period.

In this research, the subjects were randomly divided into two sauna and physical activity groups. After providing a sufficient explanation regarding the test implementation method and completing the descriptive profile form of each subject, the heart rate, blood pressure, height, and weight were measured at least five minutes in the supine resting position. In the pre-test, both groups pedalled for 5 minutes on a cycle ergometer with 50 watts working pressure. The sauna group entered the sauna during a period of 10 minutes and stood on the stairs, which was conducted within 8 weeks (24 sessions), and there were 3 sessions per week. After leaving the sauna, their heart rate, blood pressure and weight were measured.

The second group immediately started pedalling with an increasing work pressure after 5 minutes of pedalling with a working pressure of 50 watts until their heart rate reached a maximum of 60% of the reserve heart rate.

60% of the reserve heart rate was calculated by Caronen's method as follows (3):

$$\text{Maximum} = \text{Age} - 220$$

$$\text{Reserve heart rate} = \text{Resting heart rate} - \text{Maximum heart rate}$$

$$A = 60\% \times \text{Reserve heart rate}$$

$$\text{The heart rate of each subject} = \text{Resting heart rate} + A$$

The method of performing the test with the cycle ergometer was that the subjects started and continued pedalling on the cycle ergometer during three minutes with a working pressure equal to less than 60% of the maximum heart rate, and at the same time, the work pressure was gradually increased until the heart rate of each subject reached above 60% of the maximum.

Pedalling on the cycle ergometer with the working pressure equal to the maximum heart rate continued for seven minutes, and at the end of this period, the heart rate and blood pressure of the subject were measured and recorded. All the above steps were repeated during 24 sessions, and in the final session, heart rate, blood pressure and weight were measured 2 hours in the post-test.

Fat weight, lean body mass and fat percentage of the subjects were calculated by measuring height (metres), weight (kilograms) and using the formula (Hugh et al., 1999).

$$(\text{Weight} - 148) / 2.8 = \text{LBM}$$

$$\text{FM} - \text{LBM} = \text{Total weight}$$

$$100 \times \text{Fat weight} / \text{Total weight} = \text{FM}\%$$

SPSS21 software was employed to study and analyse the collected data, and due to the normality of the data, to analyse the data and compare the averages in different stages, while the correlated t-test was used to compare the average variables in the pre-test and post-test. An independent t-test was used to compare the average of the measured variables in two groups (sauna and physical activity). Meanwhile, the confidence level for all tests was considered to be 95%.

RESULTS

The mean and standard deviation of the subjects' age, height and weight in the sauna group were 23.2 ± 6.7 , 159.6 ± 7.21 , 57.33 ± 4.27 , while they were 24.8 ± 2.79 , 161.60 ± 5 and 60.73 ± 11.14 in the physical activity group.

Table 1: The effects of sauna and physical activity on cardiovascular function and body composition

| Variable | Group | Before Training Mean \pm Standard Deviation | After 21 Training Sessions Mean \pm Standard Deviation | Observed t | Significance Level |
|--------------------------------------|-------------------|--|---|------------|-----------------------|
| Total Weight, (kg) | Sauna | 57.4 \pm 33.27 | 56.4 \pm 60.30 | 3.014 | .009 |
| | Physical Activity | 60.11 \pm 73.14 | 95.10 \pm 50.97 | 4.28 | .001 |
| Lean Body Mass, (kg) | Sauna | 57.9 \pm 99.29 | 56.9 \pm 95.20 | 4.20 | .001 |
| | Physical Activity | 55.3 \pm 10.79 | 54.3 \pm 48.86 | 2.97 | .01 |
| Fat Weight | Sauna | 19.2 \pm 5.73 | 18.2 \pm 6.54 | 4.34 | .001 |
| | Physical Activity | 22.7 \pm 2.97 | 21.7 \pm 1.57 | 3.23 | .006 |
| Body Fat Percentage (Percent) | Sauna | 41.2 \pm 6.06 | 39.2 \pm 3.03 | 4.34 | 0.001 |
| | Physical Activity | 38.1 \pm 4.17 | 37 \pm 1.13 | 3.30 | .005 |
| Heart Rate (Beats per Minute) | Sauna | 96.5 \pm 13.75 | 90 \pm 7.75 | 2.95 | .01 |
| | Physical Activity | 142.6 \pm 2.73 | 145.5 \pm 86.59 | 2.63 | .02 |
| Systolic Blood Pressure | Sauna | 113.11 \pm 3.2 | 131.7 \pm 3.45 | 2.11 | .053 |
| | Physical Activity | 76 \pm 12.98 | 128 \pm 7.74 | 1.19 | .252 |
| Diastolic Blood Pressure | Sauna | 66 \pm 22.29 | 62 \pm 24.8 | .471 | .645 |
| | Physical Activity | 62 \pm 22.74 | 131 \pm 7.43 | 2.33 | .035 |
| Average Blood Pressure | Sauna | 84.13 \pm 26.64 | 79.18 \pm 11.23 | 1.09 | .330 |
| | Physical Activity | 93.9 \pm 33.25 | 85.14 \pm 11.90 | 2.07 | .05 |

As the findings of Table 1 show, the group that used the sauna showed a significant change ($p \leq 0.05$) in heart rate, systolic blood pressure, total weight, lean body mass, fat weight, and body fat percentage, while there was no significant change in diastolic and average blood pressure ($p \geq 0.05$). Additionally, the

subjects who worked with the cycle ergometer showed a significant change ($p \leq 0.05$) in heart rate, average blood pressure, total weight, lean body mass, fat weight, and body fat percentage, while there was no significant change in systolic and diastolic blood pressure ($p \geq 0.05$).

DISCUSSION

As the results showed, heart rate decreased significantly after 8 weeks of sauna, which is consistent with the studies conducted by Lee et al. (2022). In their research, Toro et al. (2021) mentioned that using a sauna reduces the heart rate by 20-25%, which is consistent with the findings of the current research. However, the heart rate increased statistically significantly after 8 weeks of activity with the cycle ergometer, after the activity in the final session.

In addition, the results of the research indicated that after 8 weeks of sauna and different adaptations and heat, the systolic blood pressure did not decrease, but it increased. However, there was no significant difference in diastolic blood pressure. The results of Laukkanen, Laukkanen, and Kunutsor (2018) indicating that 10 minutes of sauna has no effect on systolic blood pressure for young individuals is not consistent with this research. But, in the case of diastolic blood pressure, the results are consistent, while the results of the same researcher's research on children showed that using a sauna causes blood pressure to drop. In any case, the results are consistent when it comes to diastolic blood pressure. Nevertheless, the above-mentioned researcher's results of the study related to the children suggest that using a sauna causes a drop in blood pressure (10). According to Hussain and Cohen (2018), whose study was conducted on heart patients, sauna use reduces systolic and diastolic blood pressure. In this group, pre-test average blood pressure increased by (5 mm Hg) and post-test average blood pressure increased by (2 mm Hg), which was not significant despite this increase.

In terms of systolic blood pressure, the subjects who worked with the cycle ergometer had an increase of (17 mm Hg) in the last test session, which was a significant increase. The diastolic blood pressure of the last session for this group increased by 22 mm Hg, which was statistically significant. The findings of this research showed that the weight loss in the sauna group was evident when compared with the initial session, which was a statistically significant difference. The research of Fujiwara et al. (2021) concluded that the use of a nutrition and exercise programme causes more weight

loss, compared to a programme that only uses a sauna, and this weight loss is the least harmful when compared to immediate and rapid weight loss in the sauna. When a person sweats, a small amount of electrolytes, such as sodium, potassium, chlorine, and magnesium, are excreted from the body along with water. This electrolyte excretion is higher in beginners, and exercises can also improve the retention of electrolytes (Podstawski et al., 2014; Motamedy et al., 2014; Hakimi et al., 2015; Imam Doust et al., 2014).

Additionally, the findings of the current research show that the lean body mass and fat weight of the subjects in the sauna group decreased significantly during the 21 sessions of using the sauna. After using the sauna, the subjects' fat percentage also decreased significantly. The findings of this research showed a significant difference in the decrease of lean body mass and fat weight of the subjects who worked on the cycle ergometer. There was a significant effect of the activity with the cycle ergometer on the subjects' fat percentage that causes a reduction in body fat. According to the results of Fujiwara (2021), the amount of fat percentage increases with increasing age among 3 groups of women, which is consistent with the current research in terms of fat percentage. In her research, Anker (2021) pointed out that there is a tendency of lean body mass and fat weight to increase in subjects with the age of 19-23, but the increase is not significant, which is contrary to the results of the present study.

CONCLUSION

The results of this research showed that sauna and physical activity improve the cardiovascular function and body composition of non-athlete women. And since the sauna causes weight loss through sweating and increasing the sublingual temperature, it is recommended to reduce the duration of continuous presence in the sauna and to consume liquids before and after the sauna.

REFERENCES

1. Ambrosetti, M., Abreu, A., Corrà, U., Davos, C. H., Hansen, D., Frederix, I., Zwisler, A. D. O., Olsen Zwisler, A. D. (2021). Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. *European journal of preventive cardiology*, 28(5), 460-495.
2. Anker, S. D., Butler, J., Filippatos, G., Ferreira, J. P., Bocchi, E., Böhm, M., ... Packer, M. (2021). Empagliflozin in heart failure with a preserved ejection fraction. *New England Journal of Medicine*, 385(16), 1451-1461.
3. Bozkurt, B., Coats, A. J., Tsutsui, H., Abdelhamid, M., Adamopoulos, S., Albert, N., & Zieroth, S. (2021). Universal definition and classification of heart failure: a report of the Heart Failure Society of America, Heart Failure Association of the European Society of Cardiology, Japanese Heart Failure Society and Writing Committee of the Universal Definition of Heart Failure. *Journal of cardiac failure*, 27(4), 387-413.

4. Cho, D. H., & Yoo, B. S. (2021). Current prevalence, incidence, and outcomes of heart failure with preserved ejection fraction. *Heart Failure Clinics*, 17(3), 315-326.
5. de Barcelos, G. T., Heberle, I., Coneglian, J. C., Vieira, B. A., Delevatti, R. S., & Gerage, A. M. (2022). Effects of aerobic training progression on blood pressure in individuals with hypertension: a systematic review with meta-analysis and meta-regression. *Frontiers in sports and active living*, 4.
6. Foroutan, Y., Pehpoor, N., Tadibi, V., & Danashyar, S. (2019). The effect of 8 weeks of concurrent training on serum leptin levels, lipid profiles and body composition of overweight inactive men. *Intern Med Today*, 25 (1): 57-63.
7. Fujiwara, K., Shimada, K., Nishitani-Yokoyama, M., Kunimoto, M., Matsubara, T., Matsumori, R., ... Minamino, T. (2021). Arterial stiffness index and exercise tolerance in patients undergoing cardiac rehabilitation: comparison between patients with preserved and reduced ejection fraction. *International Heart Journal*, 62(2), 230-237.
8. Hakimi, M., Sheikholeslami-Vatani, D., & Alimohamadi, M. (2015). Comparing the effect of 8-week resistance training with concurrent (resistance-massage) on leptin serum, lipid profile and body composition in overweight young male. *Sport Physiology*, 7(25), 15-32. [Persian]
9. Hussain, J., & Cohen, M. (2018). Clinical effects of regular dry sauna bathing: a systematic review. *Evidence-Based Complementary and Alternative Medicine*, 24 (2018): 1-30.
10. Imam Doust, S., Faramarzi, M., Bagheri, L., Otadi, K., Amiri, M., & Yazdani, T. (2014). The effect of a combined exercise training on resting plasma leptin levels and some hormonal factors in men overweight. *J Lorestan Univ Med Sci*, 16(1): 79-90. [Persian]
11. Laukkanen, J. A., Laukkanen, T., & Kunutsor, S. K. (2018). Cardiovascular and other health benefits of sauna bathing: a review of the evidence. In *Mayo clinic proceedings*, 93(8): 1111-1121.
12. Laukkanen, T., Khan, H., Zaccardi, F., & Laukkanen, J. A. (2015). Association between sauna bathing and fatal cardiovascular and all-cause mortality events. *JAMA internal medicine*, 175(4), 542-548.
13. Lee, E., Kolunsarka, I., Kostensalo, J., Ahtiainen, J. P., Haapala, E. A., Willeit, P., & Laukkanen, J. A. (2022). Effects of regular sauna bathing in conjunction with exercise on cardiovascular function: a multi-arm, randomized controlled trial. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 323(3), R289-R299.
14. Motamedy, P., Nikroo, H., & Hejazi, K. (2017). The effects of eight-week aerobic training on serum leptin levels, anthropometric indices and vo2max in sedentary obese men. *J Ergon*, 5(1):36-42. [Persian]
15. Podstawski, R., Boraczyński, T., Boraczyński, M., Choszcz, D., Mańkowski, S., & Markowski, P. (2014). Sauna-induced body mass loss in young sedentary women and men. *The Scientific World Journal*, 2014, 2014: 307421: 1-7.
16. Sharifi, G., Babai Mazreno, A., Mirjalili, M., Ehrampoush, M. H. (2014). The effects of daily rhythms on sports functions and physiological variables of immune elite swimmers. *International Journal of Pediatrics*, 2(4): 79-85.
17. Toro, V., Siquier-Coll, J., Bartolomé, I., Pérez-Quintero, M., Raimundo, A., Muñoz, D., & Maynar-Mariño, M. (2021). Effects of twelve sessions of high-temperature sauna baths on body composition in healthy young men. *International Journal of Environmental Research and Public Health*, 18(9), 4458. doi: 10.3390/ijerph18094458

EFEKAT OSAM SEDMICA KORIŠTENJA SAUNE I FIZIČKE AKTIVNOSTI NA FUNKCIONISANJE KARDIOVASKULARNOG SISTEMA I TJELESNU GRAĐU ŽENA KOJE SE NE BAVE SPORTOM

SAŽETAK

Kontekst: Nedostatak fizičke aktivnosti i neposvećivanje pažnje dnevnom unosu kalorija prouzrokuju smetnje u strukturi tijela. **Svrha:** Ova studija nastoji ispitati efekat korištenja saune i fizičke aktivnosti na funkcionisanje kardiovaskularnog sistema i tjelesnu građu žena koje se ne bave sportom. **Metode:** U kvazi-eksperimentalnom istraživanju nasumično je odabrano 30 žena u dobi od 25 ± 5 godina koje žive u gradu Jazd, a uzorci su podijeljeni u grupu koja je koristila saunu i onu koja se bavila fizičkom aktivnosti, dok je svakoj grupi nasumično dodijeljeno 15 ispitanika. Promjene srčane frekvencije, krvnog pritiska, postotka tjelesne masnoće, masnoće u tijelu i nemasne tjelesne mase su mjerene prije i nakon 8 sedmica fizičke aktivnosti i korištenja saune. Na kraju je korišten SPSS21 softver za analizu prikupljenih podataka. **Rezultati:** U grupi koja je koristila saunu, rezultati su pokazali da postoje značajne promjene ($p \leq 0,05$) srčane frekvencije, sistoličkog krvnog pritiska, ukupne težine, nemasne tjelesne mase, masnoće u tijelu i postotka tjelesne masnoće, dok značajne promjene nisu uočene u dijastoličkom i prosječnom krvnom pritisku ($p \geq 0,05$). Pored toga, ispitanici koji su koristili ergometarski bicikl su imali značajnu promjenu ($p \leq 0,05$) srčane frekvencije, prosječnog krvnog pritiska, ukupne težine, postotka tjelesne masnoće, masnoće u tijelu i nemasne tjelesne mase, dok se sistolički i dijastolički krvni pritisak nije značajno mijenjao ($p \geq 0,05$).

Zaključak: Rezultati ovog istraživanja su pokazali da korištenje saune i fizička aktivnost poboljšavaju funkcionisanje kardiovaskularnog sistema i tjelesnu građu žena koje se ne bave sportom.

Ključne riječi: sauna, fizička aktivnost, funkcionisanje kardiovaskularnog sistema, tjelesna građa

Correspondence to: Alireza Babaei Mazreno

Department of Sports Science, Islamic Azad University, Khorasgan Branch, Isfahan, Iran

E-mail: alireza.babaei.m@gmail.com

FACTORIAL VALIDITY OF TESTS FOR ASSESSING SHOOTING ACCURACY IN MINI BASKETBALL

Miodrag Milovanović

1. Faculty of Physical Education and Sports Management, Singidunum University, Belgrade, Serbia

ABSTRACT

Shooting accuracy is one of the most important technical elements in basketball, and that is why there was a need to verify the existence of specific arguments by testing shooting accuracy with a certain type of test. In order to find the answer in this research, an experiment was made, where the evaluation of certain tests was done to assess the accuracy of shooting in mini basketball. The aim of the results is to help coaches gain an insight into the motor skills of children of a certain age. The participants ($n = 42$), boys aged 10 to 11, took part in this research. The data obtained were analysed using a descriptive statistical analysis. Descriptive statistics for all monitored variables were expressed through SV and SD values. The principal component analysis (PCA), serving as an intermediate step for implementing other methods in this case of factorial validity, was used to interpret the correlation matrix. It can be concluded that the data obtained in this experiment showed satisfactory factorial validity in the tests for the assessment of shooting accuracy. All of these are direct variables for assessing shooting accuracy in young basketball players, acceptable for creating valid and efficient testing protocols.

Keywords: shooting accuracy, tests, mini basket, basketball players, factorial validity

INTRODUCTION

Basketball is one of the most popular sports, especially among children, together with football, handball and judo (Petrović et al., 2022). Accuracy is highly important in other sports as well, but the greatest wealth and essence in all sports is the huge talent possessed by many children for sport (Marković & Trivun, 2020). Basic sports (athletics, gymnastics and swimming) in preschools and schools aim to develop motor skills in children (Radošević, et al., 2018; Gadžić, et al., 2015). The accuracy of dart throwing, followed by throwing a ball into a horizontal target, as well as shooting a ball into a vertical target was also tested.

Shooting is one of the most important technical elements in group sports with a ball, and at a high

level of competition, in the attack phase, teams show homogeneity in shooting (Marković & Milošević, 2023).

In order to find the answer in this research, an experiment was made, where the evaluation of certain tests for assessing shooting accuracy in mini basketball was done with the aim of reaching certain results of that testing in order to help coaches gain an insight into the current shooting accuracy in children of a certain age. The expected experimental findings obtained from a relatively large and homogeneous group of subjects can significantly contribute to better clarification when working with children of a certain age, which is extremely important for the further training process. In order to obtain better findings, the factorial validity of the applied tests for shooting accuracy was tested. To understand and provide answers to these questions, it was necessary to look at shooting accuracy in mini basketball from different aspects. The importance of assessing shooting accuracy in mini basketball can be reflected in better planning and programming of certain training sessions for learning

and improving the basic technique in basketball so that children master the basic technical segments as well as possible. In order to achieve all that, it is necessary to have certain tests that would show the current shooting accuracy of children.

So far, in certain studies, the reliability, validity, specificity, and objectivity of certain tests on the tested sample of respondents was examined from the standpoint of metric characteristics. Factorial validity has not been examined so far in regard to shooting accuracy. One study used a modified free throw test (10 shots) at the age of 18 to 23, and three cameras. The test showed a certain degree of specificity (Takayuki et al., 2011).

In one study of boys and girls aged 9 to 12 years, the researchers used a test approved by the American Health Alliance, the lateral shooting test performed near the free throw line, where the subjects had 15 shots, and each hit was scored with 2 points, with a miss scoring 1 point (Haywood, 1978). The test was approved by the American Health Alliance and demonstrated specificity and validity.

In another research with 8 boys aged 10.5 years, a modified shooting test (10 shots) was used from a distance of 4 m from the basket. With the help of cameras, they performed a kinematic analysis of the movement during the jump shot. The results showed that the weight and size of the ball do not affect the changes in coordination when performing a jump shot by children. It can be stated that the mentioned test has specificity (Okazaki et al., 2005). In a large mini-basket study with girls aged 7 to 10, the researchers used a test designed for children aged 3 to 10 and measuring certain motor skills TGMD-2 (Ulrich, 2000; Fortousi et al., 2012). Another study found that certain shooting training in children aged 10 years old can improve shooting accuracy. They used three modified tests: the layup test, the free throw test (10 shots) and the 3 m jump shot test (10 shots). These tests have been shown to possess specificity. The jump shot test and free throw test showed reliability, as the results did not differ significantly at the beginning and end of the experiment (Zambova & Tomanek, 2012). In the study conducted in 2002, a shooting test was applied to 12-year-old male basketball players, which required the subject to kick and hit the ball as many times as possible from several places and a distance of 3.66 m from the basket in 90 seconds. Each successful hit was worth 1 point. This test showed high reliability 0.91 (Weinberg et al., 1991), objectivity and specificity (Perkos et al., 2002; Weinberg et al., 1991). In one study, participants performed a modified test by shooting 5 free throws with 3 balls of different sizes for a total of 15 shots, where each hit where the ball did not touch the hoop counted 2 points, while a hit when the ball touched the hoop counted 1 point, and a miss did not count. The test showed reliability because the results of repeated measurements with certain balls were approximately equal, except for the lightest ball. The test has shown that it has specificity and objectivity (Regimbal et al., 1992). A test (10 free throws) was used with 14-year-old basketball players in their research on shooting technique and free throw accuracy. Based on the results, this test showed objectivity, validity and specificity, while the high reliability of the test was in the results of the control group (Uzun & Pular, 2011).

In previous studies, the obtained results in mini basketball were mostly based on the method of monitoring respondents from matches. The tests that were used were mostly modified; only in some studies, standardised tests were used to assess shooting accuracy in basketball.

PROBLEM AND AIM

The research problem and aim was formulated on the basis of a limited number, but also of shortcomings in research related to tests concerning the shooting accuracy with the ball in mini basketball. In particular, based on previous research, there is currently no complete information when it comes to evaluating the metric characteristics of the appropriate tests for assessing technical skills with a ball in mini basket. In relation to the subject, the following research objectives were set in this paper: to examine the factorial validity of tests for assessing shooting accuracy in mini basketball.

MATERIALS AND METHODS

Participants

The participants in this research were members of the local basketball club from the city of Arandelovac (active mini basketball players) ($n = 42$), boys aged 10 to 11 years, with the height and body weight of (150.8 ± 7 and 42.5 ± 8.8), respectively, as well as BMI of (18.5 ± 2.7). It was verified whether all subjects were healthy, that they did not have any chronic diseases, heart problems, as well as injuries of the locomotor apparatus that would affect the test results. The participants were familiarised with the testing protocol and agreed to participate in the research voluntarily (Ilic et al., 2020). Written consent was obtained from the parents for the children's participation in this experiment. Consent for the implementation of the study was obtained from the Ethics Committee of the Faculty of Sports and Physical Education, University of Belgrade.

Testing protocol

The participants performed all the tests with balls smaller in size and weight than standard balls, as well as at the height of the basket which was 260 cm for mini basketball, instead of the standard 305 cm. Before the start of the experiment, all testing protocols were explained in detail to the participants. The research was conducted in two sessions. One included familiarising the subjects with the task, and the other was the experimental session. The sessions were separated by at least two to three days. The participants performed each test three times.

The following variables were used to determine reliability: test - quick shooting in 60 seconds (QS60s), test - shooting from 5 positions in 50 s (S5P50s), test - free throws in 10 shots (FT10S), and test - shooting from 5 positions without time limitations (S5P).

The QS60s test

The test comes from the test battery proposed by the American Alliance for Health, Physical Education, Recreation, and Dance (AAHPRED, 1984). It requires a basket, drawn dimensions of the field, a ball, and a stopwatch. The basketball player (participant) can start the task from any of the five marked positions behind the marked line that is at a distance for his age (for ages 10 to 11, the distance is 2.70 m from the centre of the basketball hoop).

The S5P50s test

This test was used in testing young Serbian basketball players of different ages from 12 to 17 (Karalejić & Jakovljević, 2009). It is highly popular in practice and is often performed in different variants. To perform the test, one requires a stopwatch, 15 balls (minimum 9), ball stands, marked 5 shooting positions, and a basketball hoop.

The FT10S test

This test was used occasionally in certain studies (Takayuki et al., 2011; Zambova & Tomanek, 2012; Uzun & Pular, 2011). It is also often used in training for basketball players of all ages. To perform the test, one needs a basket, a marked field and a ball.

The S5P test

This test was used in testing young Serbian

basketball players of different ages from 12 to 17 (Karalejić & Jakovljević, 2009). It is the same test as the 5-position shooting test with a time limit of 50 seconds. To perform the test, one needs a stopwatch, 15 balls (minimum 9), ball stands, marked 5 shooting positions, and a basketball hoop.

Data analysis

The data obtained in this research were analysed using descriptive statistical analysis. In order to examine the factorial validity of the tests for assessing shooting accuracy in mini basketball, the Pearson's correlation coefficient (r) was used as well as the corresponding 95% CI to determine the possible differences between the tests. The level of statistical significance was determined to be $p < 0.05$. The analysis of principal components (PCA) served as an intermediate step for the implementation of other methods; in this case of factorial validity, it was used to interpret the correlation matrix. The connection between variables (tests) for assessing shooting accuracy in mini basketball, along with factorial validity, was applied to certain mini-basketball shooting accuracy tests.

RESULTS

Table 1. shows the average values and standard deviations of 42 subjects aged (10.7 ± 0.5), their morphological characteristics, height and body mass (150.8 ± 7 and 42.5 ± 8.8) as well as BMI (18.5 ± 2.7).

Table 1. Basic descriptive indicators of the subjects' morphological characteristics in the first experiment (A \pm SD)

| Variables | N = 42 |
|-----------|----------------|
| Age | 10.7 \pm 0.5 |
| BH | 150.8 \pm 7 |
| BM | 42.5 \pm 8.8 |
| BMI | 18.5 \pm 2.7 |

BH - Body height (m); BM - Body mass (kg); BMI - Body mass index ($\text{kg} \times \text{m}^{-2}$);

Table 2. Presentation of the best results of their average values and standard deviation in the tests for assessing shooting accuracy in mini basketball

| Variables | SV | SD | N |
|---------------|-------------|--------------|----|
| QS60s | 8.31 | 2.533 | 42 |
| S5P | 8.05 | 1.975 | 42 |
| FT10S | 5.42 | 1.918 | 42 |
| S5P50s | 7.81 | 2.228 | 42 |

SV – mean; SD – standard deviation. Tests: QS60s – fast shooting for 60s; S5P – shooting from five positions; FT10S – free throws in 10 shots; S5P50s – shooting from five positions for 50s

The indicators in Table 2. represent the best results, data of the average values of four tests which speak about the estimation of shooting accuracy in mini basketball. The highest mean value and standard deviation was found in the QS60s test, where it was found (SV = 8.31) and (SD =

2.533) in 42 respondents (N = 42). The given value (SD) for the mentioned variable tells how much, on average, elements of the set deviate from the arithmetic mean of the given set.

Table 3. Correlation matrix of the best results for applied tests that serve in shooting accuracyaccuracy in mini basketball

| Correlation matrix | | | | |
|--------------------|---------|---------|---------|--------|
| Variables | QS60s | S5P | FT10S | S5P50s |
| QS60s | 1.000 | | | |
| S5P | 0.424** | 1.000 | | |
| FT10S | 0.466** | 0.417** | 1.000 | |
| S5P50s | 0.492** | 0.461** | 0.555** | 1.000 |

Tests: QS60s – fast shooting for 60s; S5P – shooting from five positions; FT10S – free throws in 10 shots; S5P50s – shooting from five positions for 50s; ** – correlation at the level of statistical significance 0.01.

Table 3. shows the factorial validity by presenting the correlation matrix of the best results of 4 tests for shooting accuracy; the variables used to determine shot accuracy were (QS60s, S5P, FT10S, and S5P50s). The highest correlation value was found between the variable FT10S and the variable S5P50s, where ($r = 0.555$). The direction of the relationship in this correlation is positive, which means that both mentioned variables decrease and increase simultaneously. Between these two observed variables, according to Cohen ($r = 0.50$ to 1.0), a strong relationship was found. The coefficient of determination

or percentage of shared variance is 30.80 , which means that the first variable explains almost 31% of the second mentioned variable. Additionally, a high value of Pearson's (r) correlation was found between the variables QS60s and S5P50s, where ($r = 0.492$). The direction of the relationship in this correlation is positive, while the average strength of the relationship between the variables was, according to Cohen, ($r = 0.30$ to 0.49). The percentage of common variance found was 24.20 ; the first variable explains almost 25% of the results of the second variable.

Table 4. Principal component analysis of the best results for certain shooting accuracy tests

| Principal components analysis | | | | | | |
|--------------------------------------|----------------------------|---------------|---------------|--|--------|--------|
| Components | Initial eigenvalues | | | Extraction of the sum of squared loadings | | |
| | Significance indicators | %Var. | Cum.% | Significance indicators | %Var. | Cum. % |
| 1 | 2.411 | 60.264 | 60.264 | 2.411 | 60.264 | 60.264 |
| 2 | .603 | 15.082 | 75.346 | | | |
| 3 | .547 | 13.669 | 89.015 | | | |
| 4 | .439 | 10.985 | 100.000 | | | |

Table 4. shows the analysis of the main components, which deals with the interpretation of the structure of the correlation matrix, the best test results related to shooting accuracy in mini basketball. The most significant values were found (a total of 2.411) as well as the percentage of variance amounting to 60.2%, which also represents a measure of dispersion; only

the deviation from the percentage changes from the first test as well as from the retest. Likewise, the cumulative percentage value of 60.2% showed the observed sum of the given tests. In the extraction of the sum of squared loadings, the same values as in the previous section are presented.

Table 5. Display of average results, their average values and standard deviation in the tests for assessing shooting accuracy in mini basketball

| Variables | SV | SD | N |
|------------------|-------------|--------------|----------|
| QS60s | 6.37 | 2.457 | 43 |
| S5P | 6.51 | 1.908 | 43 |
| FT10S | 4.06 | 1.498 | 43 |
| S5P50s | 6.24 | 2.071 | 43 |

SV – mean value; SD – standard deviation. Tests: QS60s – fast shooting for 60s; S5P – shooting from five positions; FT10S – free throws in 10 shots; 5P50s – shooting from five positions for 50s

Table 5. presents the average results, data of the average values of four tests which speak about the estimation of shooting accuracy in mini basketball.

As can be seen, the highest mean value was found in the S5P test, while the highest standard deviation was found in the QS60s test.

Table 6. Correlation matrix of the average results of the tests used for shooting accuracy

| Correlation matrix | | | | |
|---------------------------|--------------|------------|--------------|---------------|
| Variables | QS60s | S5P | FT10S | S5P50s |
| QS60s | 1.000 | | | |
| S5P | 0.459** | 1.000 | | |
| FT10S | 0.445** | 0.593** | 1.000 | |
| S5P50s | 0.496** | 0.637** | 0.627** | 1.000 |

Tests: QS60s – fast shooting for 60s; S5P – shooting from five positions; FT10S – free throws in 10 shots; S5P50s – shooting from five positions for 50s

** - correlation at the level of statistical significance 0.01.

In Table 6, the factorial validity is shown by the representation of the correlation matrix of the average results for 4 shooting accuracy tests; the variables used to determine shooting accuracy were (QS60s, S5P, FT10S, and S5P50s). The highest correlation value was found between the S5P variable and the S5P50s variable, where ($r = 0.637$). The direction of the relationship in this correlation is positive, which means that both mentioned variables decrease and increase simultaneously. Between these two observed variables, according to Cohen ($r = 0.50$ to 1.0), a strong relationship was found. The coefficient of determination or percentage of shared variance is 40.57,

which means that the first variable explains almost 41% of the second mentioned variable. Additionally, a high value of Pearson's (r) correlation was found between the variables S5P50s and FT10S, where ($r = 0.627$). The direction of the relationship in this correlation is positive, while the average strength of the relationship between the variables was, according to Cohen, ($r = 0.30$ to 0.63). The percentage of common variance found was 39.31, where the first variable explains almost 40% of the results of the second variable.

Table 7. Principal component analysis of average scores for certain shooting accuracy tests

| Principal components analysis | | | | | | |
|--------------------------------------|--------------------------------|---------------|---------------|--|--------------|--------------|
| Components | Initial eigenvalues | | | Extraction of the sum of squared loadings | | |
| | Significance indicators | %Var. | Cum.% | Significance indicators | %Var. | Cum.% |
| 1 | 2.637 | 65.936 | 65.936 | 2.637 | 65.936 | 65.936 |
| 2 | .603 | 15.086 | 81.022 | | | |
| 3 | .408 | 10.188 | 91.210 | | | |
| 4 | .352 | 8.790 | 100.000 | | | |

The indicators in Table 7. show the analysis of the main components, which deals with the interpretation of the structure of the correlation matrix, average results of tests related to shot accuracy in mini basketball. The most significant total values were found (2.637) as well as the variance percentage of 65.936%, which also represents

a measure of dispersion, i.e., only the deviation from the percentage changes from the first test as well as from the retest. Likewise, the cumulative percentage value of 65.936% shows the observed sum of the given tests.

DISCUSSION

Factor analysis is one of the multivariate techniques that aims to identify and understand the basic idea, i.e., the common characteristics of several variables. The aim of the factor analysis in this experiment was to determine a certain relationship between the tests for shooting accuracy that were applied as manifest variables in this experiment. It is very important to point out that, in the literature, so far, there are very few studies on the factorial validity of tests for assessing shooting accuracy in basketball; however, a similar study on the reliability and factorial validity of tests for assessing shooting accuracy with 19-year-old participants was conducted (Pojskić, et al., 2014). A satisfactory factorial validity of certain tests was obtained in this study, but until now, no research has been done on the factorial validity of tests for assessing the accuracy of mini basketball shooting in children aged 10 to 11. Although the results of factor analysis indicate that all tests have the same measurement goal, that is, shooting accuracy, the obtained results of the correlation matrix in this research show that the highest value for the best results was found between the variables FT10S test and the S5P50s test, as well as between the QS60s test and S5P50s test. In the case of average results, the highest value was found between the variables S5P and S5P50s tests, as well as between the S5P50s and FT10S tests, which means that most of the variables showed a high value of factorial validity in the assessment of shooting accuracy. The results of this experiment are very important, because the current literature offers no data on the assessment of the factorial validity of all these tests for the assessment of shooting accuracy in basketball players, especially mini-basketball players. The limitations of this experiment are related to the small number of subjects, indicating that the experiment should be done on a larger sample. The reliability of the tests should also be examined with younger as well as older children. In similar studies, very few tests were used for research purposes. In previous studies, shooting accuracy, especially in the mini-basket age group, was mostly assessed by following the subjects during games, while the tests that were standardised were mostly modified. The results of the factor analysis (only one extracted factor) indicate that all tests have a similar measurement objective, which is shooting accuracy, while some of the tests show a very small common variance. This little shared information between the tests is a product of different measurement procedures that evaluate the accuracy of a player's shooting from different positions and distances. Based on one factor, which can be shooting accuracy, the test indicated that there was a good factorial validity of the tests used in this research.

Out of all the mentioned tests, the more structurally and physiologically demanding tests produced greater variations in shooting accuracy, and the easier tests produced average and good results. Therefore, it can be concluded that the most reliable

tests are those performed from short distances. The results showed that all four tests have the same measurement objective, basketball shooting accuracy, but they do not measure the same aspects of basketball shooting accuracy. The tests can be used in future studies as reliable and valid instruments. In addition, the tests can be used as training exercises to improve basketball accuracy in children as well as to improve the fitness of players. The factor analysis included four variables (tests), according to the structure of the hypothetical model, for the assessment of situational-motor abilities, and their level of validity was determined for the treated sample of participants. Factor analysis is one of the multivariate techniques that aims to identify and understand the basic idea, i.e., the common characteristics of several variables. The mentioned tests would mean further testing of certain motor skills in children of different ages, as well as adults. It would be interesting to evaluate the factorial validity of the tests for the assessment of shooting accuracy with standard balls, as well as with basketball hoops of standard height, at the mentioned age.

CONCLUSION

The data obtained in this experiment indicate a high satisfactory factorial validity of the tests as a direct variable for assessing shooting accuracy in young basketball players, acceptable for creating valid and efficient testing protocols. These tests can be used in future research as reliable and valid instruments.

Testing shooting accuracy in basketball using these methods can help scientists, basketball coaches, and even physical education professors in their work. In addition, these tests can be used to train children in basketball. Future research may include further evaluation methods of the mentioned tests from this experiment, such as validity (factorial, construct), reliability in relation to younger age as well as older age, sensitivity to age, gender and objectivity, different measures, modification of existing and development of new tests and evaluation of variables for direct assessment of other technical skills in basketball.

This would provide useful information to coaches and physical education teachers in working with children in the form of testing, diagnostics, selection, and training.

REFERENCES

1. American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD). (1984). Basketball for boys and girls: skill test manual. VA: Reston.
2. Barrow, H., & McGee, R. (1979). A practical approach to measurement in physical education. Philadelphia: Febiger.
3. Blašković, M., Milanović, D., & Matković, B. (1982). Analiza pouzdanosti i faktorske valjanosti situaciono motoričkih testova u košarci [Reliability and factor validity analysis of situational motor tests in basketball]. *Kineziologija*, 14, 131-147.
4. Cohen, J. (1988). Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum Associates.
5. Fotrousi, F., Bagherly, J., & Ghasemi, A. (2012). The compensatory impact of mini-basketball skills on the progress of fundamental movements in children. *Procedia - Social and Behavioral Sciences*, 46, 5206 -5210.
6. Gadžić, A., Milojević, A., & Vučković, I. (2015). Influence of certain socio-demographic factors on the relationships between motor and cognitive abilities of primary school children. *TEME Journal for social sciences*, 39 (1), 143-155.
7. Haywood, K. M. (1978). Children's basketball performance with regulation and junior-sized basketballs. (Unpublished manuscript, University of Missouri, St. Louis, MO; ERIC Document Reproduction Service No. ED 164 452).
8. Ilic, R., Popović, J., Markovic, V., Nemec, V., & Milosevic, M. (2020). Work-related stress among primary health care workers. *Vojnosanitetski preglad*, 77(11), 1184-1191.
9. Jakovljević, S., Macura, M., Mandić, R., Janković, N., Pajić, Z., & Erčulj, F. (2016). Biological maturity status and motor performance in fourteen-year-old basketball players. *The International Journal of Morphology*, 34(2), 637-643.
10. Karalejić, M., & Jakovljević, S. (2009). Dijagnostika u košarci [Diagnostics in basketball]. Beograd: Fakultet sporta i fizičkog vaspitanja.
11. Karalejić, M., Jakovljević, S., & Macura, M. (2011). Anthropometric characteristics and technical skills of 12 and 14 year old basketball players. *Journal of Sports Medicine and Physical Fitness*, 51, 103-110.
12. Marić, K., Katić, R., & Jeličić, M. (2013). Relations between basic and specific motor abilities and player quality of young basketball players. *Collegium Antropologicum*, 37, 2, 55-60.
13. Markovic, V., & Milosevic, M. (2023). The influence of technical and tactical elements of water polo on victory and defeat in Champions League matches. *Jurnal of Physical Education and Sport*, 23 (5), 1297-1305
14. Markovic, V., & Trivun, M. (2020). Differences in the efficiency of ski training on snow and on a ski simulator. *Sport Science*, 3 (5), 136-144.
15. Okazaki, V. H. A., & Rodacki, A. L. F. (2005). Changes in basketball shooting coordination in children performing with different balls. *Fédération Internationale D'éducation Physique*, 75, 368-371.
16. Perkös, S., Theodorakis, Y., & Chroni, S. (2002). Enhancing performance and skill acquisition in novice basketball players with instructional ST. *The Sport Psychologist*, 16, 368-383.
17. Petrović, J., Momčilović, V., & Pelemiš, V. (2022). Gender as a determinant of parents and children's attitudes toward the inclusion of sports branches into the elementary school curriculum. *TEME Journal for social sciences*, 46 (4), 851-867.
18. Podmenik, N. L. B., & Erčulj, F. (2012). The effect of introducing a smaller and lighter basketball on female basketball players' shot accuracy. *Journal of Human Kinetics*, 31, 131-137.
19. Pojskić, H., Šeparović, V., & Užičanin, E. (2014). Reliability and factorial validity of basketball shooting accuracy tests. *Sport Scientific & Pracitcal Aspects*, 1, 25-32.
20. Radošević, I. Gavrilović, A. Veselinović, J. & Parčina, I., Preschool Sports Management: The role of basic sports in preschools. *Facta Universitatis, Series Physical Education and Sport*, Niš, Vol. 16, No. 2/18, pp. 487-492.
21. Regimbal, C., Deller, J., & Plimpton, C. (1992). Basketball size as related to children's preference, rated skill and scoring. *Perceptual and Motor Skills*, 75, 867-872.
22. Takayuki, W., Takeshi, S., & Shoji, I. (2001). Accuracy of skill performance in the basketball free throw shooting. *BIO Web of Conferences* 1.
23. Ulrich, D. A. (2000). Test of gross motor development-2. Austin: Prod-Ed.

24. Uzun, A., & Pulur, A. (2011). Effect of free-throw training program on improving shoot hit rate in young basketball players (14-15 years of age). *Nigde University Journal of Physical Education and Sport Sciences*, 5.
25. Weinberg, R. S., Fowler, C., Jackson, A., Bagnall, J., & Bruya, L. (1991). Effect of goal difficulty on motor performance: A replication across tasks and subjects. *Journal of Sport & Exercise Psychology*, 13, 160-173.
26. Zambova, D., & Tomanek, L. (2012). An efficiency shooting program for youth basketball players. *SportLogia*, 8, 87-92.

FAKTORSKA VALJANOST TESTOVA ZA PROCJENU PRECIZNOSTI ŠUTA U MINI KOŠARCI

SAŽETAK

Preciznost šuta je jedan od najbitnijih elemenata u košarci i zbog toga se javila potreba za provjerom postojanja konkretnih argumenata testiranjem preciznosti šuta određenom vrstom testova. Da bi se došlo do odgovora u ovom istraživanju napravljen je eksperiment gde je urađena evaluacija određenih testova za procjenu preciznosti šuta u mini košarci. Cilj rezultata je pomoći trenerima da steknu uvid u motoričke sposobnosti kod djece određenog uzrasta. U ovom istraživanju su učestvovali ispitanici ($n = 42$), dječaci uzrasta od 10 do 11 godina. Podaci dobijeni u ovom istraživanju su obrađeni primjenom deskriptivne statističke analize. Deskriptivna statistika za sve praćene varijable je izražena kroz SV i SD vrijednosti. Analiza glavnih komponenti (AGK) služi kao međukorak za provođenje drugih metoda u ovom slučaju faktorske valjanosti i korištena je za tumačenje korelacione matrice. Može se zaključiti da podaci dobijeni u ovom eksperimentu pokazuju zadovoljavajuću faktorsku valjanost kod testova za procjenu preciznosti šuta. Sve su to direktne varijable za procjenu preciznosti šuta kod mladih košarkaša prihvatljive za kreiranje valjanih i efikasnih protokola testiranja.

Ključne riječi: preciznost šuta, testovi, mini košarka, košarkaši, faktorska valjanost

Correspondence to: Miodrag Milovanović

Faculty of Physical Education and Sports Management, Singidunum University, Belgrade, Serbia

E-mail: mmilovanovic@singidunum.ac.rs

ANALYSING THE EFFECTS OF COVID-19 ON IRAN'S ECONOMY AND SPORTS INDUSTRY AND PROVIDING SOLUTIONS TO COMPENSATE FOR THESE LOSSES

Mohammad Saeid Kiani¹, Leila Nazari²

1. Department of Sports Management, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
 2. Sports Management, Kurdistan University, Sanandaj, Iran
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ABSTRACT

The spread of the COVID-19 virus has put Iran's economy in a state of stagnation and uncertainty. The coronavirus epidemic has shut down economic enterprises all over the world and has put all countries on the brink of a back-breaking recession. The purpose of this research is to analyse the effects of COVID-19 on Iran's economy and sports industry and to provide solutions to compensate for these losses. The present study was a descriptive-survey in terms of its practical purpose and the method of data collection. In the first (qualitative) part, to conduct field interviews, the statistical population of the research was examined by experts in the field of economics in the country and faculty members in the field of sports economics. 24 interviews with 24 people were conducted in this part. In the second (quantitative) part, the statistical population included all post-graduate students of sports management in the country, and 610 questionnaires were explained and analysed in person and virtually. The results of the research showed that the spread of the COVID-19 virus did not only have negative effects, but also had many positive effects on the sports industry. In fact, the sports industry can have a very high capacity to adapt to the crisis of the spread of COVID-19 and similar crises. Holding classes and workshops in various sports fields and sports sciences online, paying more attention to family sports, sports at home and open spaces and in the economic sector signified that, during the period of the COVID-19 epidemic, online sports businesses have flourished and the managers of sports complexes have found financial alternatives, but in general, the negative effects of the COVID-19 epidemic, especially its negative economic effects, have been more effective than the positive effects of the COVID-19 outbreak on sports, which is due to the sudden onset and rapid spread of the COVID-19 virus and the lack of the necessary preparation of the sports industry to deal with this crisis.

Keywords: sports industry, economy, COVID-19, sports management, online business

INTRODUCTION

Currently, the world is facing a very serious crisis called the coronavirus, and the epidemic this virus caused is still spreading (Craven et al., 2020). Athletes also sat at home during these turbulent days. In addition, the social distance plan was associated with consequences such as the closure of sports facilities (e.g., parks and gyms), and many facilities were not available to resume sports activities (Gilat & Cole et al., 2020). Interim closure of prestigious leagues and competitions in different countries, holding competitions without the presence of spectators, whispers of cancellation of some leading national and international competitions, and closure of health centres and sports clubs result in the stagnation of the retail and wholesale market of goods. Sports itself has witnessed the economic effects of this disease on various dimensions of the sports industry (AIS, 2020). One of the indirect effects of the spread of the coronavirus, apart from the economic effects resulting from the closure of sports clubs and even camps, parks and open sports spaces, is the reduction of the movement of the general public, which is undoubtedly evident during this period, and obesity is a consequence. It will intensify in the coming months, and due to this increase in inactivity and overweight, the growth of cardiovascular diseases and diabetes, abnormalities of the stature structure, etc. are not far from expected (Csato, 2020). Therefore, considering the importance of the emerging crisis and considering the significant impact it has had on all industries, it becomes necessary to identify the current and future challenges caused by this virus on all aspects of sports, and in line with that, measures for dealing with and improving the current and future situation. Therefore, the purpose of conducting this research was to identify the consequences of COVID-19 on sports in Iran. So far, no comprehensive study that includes all aspects of Iranian sports has been done. The results of foreign studies cannot be generalised to the domestic situation of the country. According to the mentioned cases, the innovation aspect of the research is confirmed in relation to the topic and the research objectives. Therefore, the results of this research can help in completing the existing theoretical foundations and the scientific richness of this field and can be used as a foundation for future studies, which shows the theoretical importance of this research.

METHODOLOGY

The current research is a descriptive-survey type of research which was conducted in the field, and in terms of its purpose, it is in the category of applied research. In the first stage, the qualitative method of content analysis was used to build the model, the descriptive-analytical quantitative method was used to test the model, and the correlation type based

on the structural equation model was used. The mixed research method was sequential exploratory. The tool used in this research was developed after conducting interviews and reaching theoretical saturation, which includes 33 items in the form of 2 main components of positive consequences and negative consequences in the form of five Likert options (very much, 5 points, to very little, 1 point) were compiled. In the first (qualitative) part, to conduct field interviews, the statistical population of the research was examined by experts in the field of economics in the country, members of the scientific association of economics in the country and members of the faculty in the field of sports economics. Qualitative research was selected (24 interviews with 24 people and continued until theoretical saturation). In the second (quantitative) part, due to the lack of precise tools in order to measure the variables investigated in the present research, firstly, based on library studies and the study of domestic and foreign articles, to examine the theoretical foundations of the research inside and outside and to get help from people who have been interviewed in the qualitative section, a researcher-made questionnaire was prepared and organised. The statistical population of the quantitative part of the research includes the students of Iran's sports management courses, which included the students of the provincial universities (Tehran, Alborz, Isfahan, East Azerbaijan, West Azerbaijan, Khuzestan, Razavi Khorasan, Kurdistan, Lorestan, Kermanshah, and Gilan). According to the financial and time limitations of the research, 700 questionnaires (according to the sample size of Cochran in uncertain conditions) were distributed in person and virtually among the students of post-graduate education (major and doctorate) majoring in sports management in the country, out of which 612 questionnaires were checked.

RESEARCH FINDINGS

In the first step of coding, each of the main categories related to the presentation of the analysis model of the effects of COVID-19 on Iran's economy and sports industry was extracted, which was done in the form of answering the main question of the research, and that was the answer to the question on the consequences caused by the COVID-19 virus on the sports industry and sports economy.

From the continuous comparative analysis of the initial results of open coding, in the form of positive and negative consequences, 5 core codes were revealed:

"Negative consequences: economic and sports, positive consequences: economic, sports and management."

Table 1. The negative consequences of the outbreak of COVID-19 on the sports industry and economy

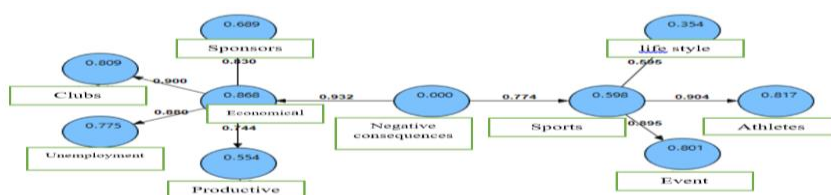
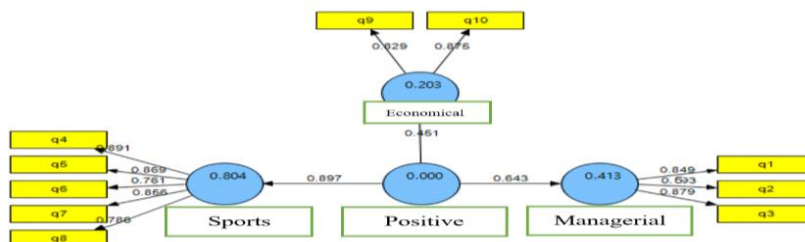
| Row | Features extracted from verbal propositions (concepts) | Categories | Main article |
|-----|--|--------------------------|--------------|
| 1 | Stopping sponsorships from sports teams | Sponsors | Economical |
| 2 | Cutoff of sponsorships from athletes | | |
| 3 | Problems in renting clubs | Clubs | |
| 4 | Closing of clubs | | |
| 5 | Financial loss to club owners | | |
| 6 | Coaches | Unemployment of manpower | |
| 7 | Professional athletes | | |
| 8 | Managers of private collections | | |
| 9 | Employees of private collections | | |
| 10 | Agents of holding events | | |
| 11 | Reducing the import of sports equipment | Productive | |
| 12 | Decrease in sales of sports equipment | | |
| 13 | Reduction of domestic production of sports equipment | | |
| 14 | Inactivity of the general public | Changing lifestyle | Sports |
| 15 | Excess weight due to not exercising | | |
| 16 | The habit of not exercising | | |
| 17 | Decreased motivation to exercise | | |
| 18 | Weakened physical fitness | Professional athletes | |
| 19 | Weakened mental preparation | | |
| 20 | Inactivity of disabled and veteran athletes | | |
| 21 | Change in the schedule of games | Sports events | |
| 22 | Postponement of major sporting events (Olympics) | | |
| 23 | Change in the way sports events are held (without being a spectator) | | |

Table 2. Positive consequences of the spread of COVID-19 on the sports industry and economy

| Row | Features extracted from verbal propositions (concepts) | Categories | Main article |
|-----|--|------------|--------------|
| 1 | Greater preparation of senior sports managers for any type of epidemic | Managerial | |
| 2 | Greater preparation of managers of sports complexes for unexpected events | | |
| 3 | Changing the direction of attention from championship sports to popular sports | Sports | |
| 4 | More preparation of athletes for unexpected events | | |
| 5 | Promotion of exercise at home | | |
| 6 | Promotion of online sports events | | |
| 7 | Changing the view of sports in outdoor environments | | |
| 8 | Familiarisation of people with all kinds of home sports | | |
| 9 | Finding financial alternatives by managers of sports complexes | Economical | |
| 10 | The boom of online sports businesses | | |

Therefore, the results of 24 conducted interviews, through content analysis and open and axial coding, showed that negative consequences include

economic and sports ones, and positive consequences include economic, sports and management ones.

Figure 1. Model for measuring negative consequences**Figure 2.** Measurement model of positive outcomes

To check the fit of the structural model of the research, several criteria are used, the first and most basic criteria are the significant t coefficients or t-values. If the value of these numbers exceeds 0.95, it indicates the correctness of the relationship between the variables and, as a

result, the research hypotheses are confirmed at the confidence level of 1.96. Of course, it should be noted that the numbers only show the accuracy of the relationship, and the intensity of the relationship between the variables cannot be measured with it.

Figure 3. Significant t coefficients (t-values) of negative outcomes

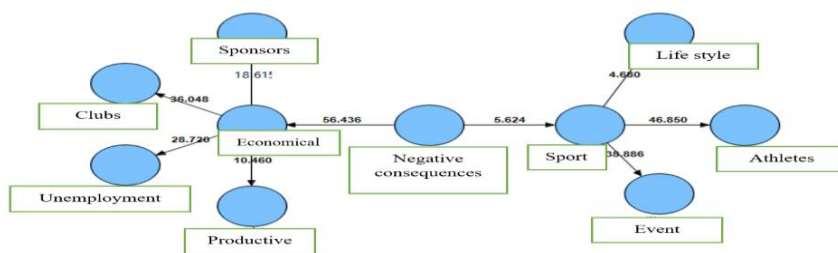
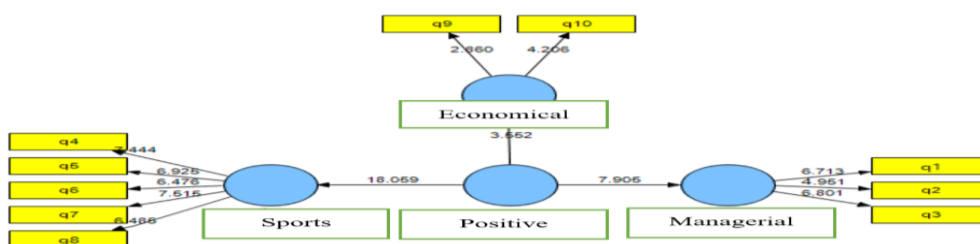


Figure 4. Significant t coefficients (t-values) of positive outcomes



R^2 value for exogenous or independent variables is equal to zero. In this part, the value of R^2 for all variables is greater than 0.32. Q2 value: This criterion for the endogenous variable of mental preparation is greater than 0.15, which shows that the exogenous (independent) variable is average in predicting the dependent variable, and more for all the endogenous variables of the model. It is 0.32, which shows that the exogenous (independent) variables are strong in predicting the dependent variables and confirms the appropriate fit of the structural model of the research.

Overall model fit: The overall model includes both measurement and structural model parts, and by confirming its fit, the fit check is completed in one model. Considering the three values of 0.01, 0.25 and 0.36, which are introduced as weak, medium and strong values for GOF, in all variables, a value greater than 0.36 was obtained, which indicates a strong overall fit of the model. In the following, the relationships in the research model resulting from the qualitative part will be examined.

According to the relationships in both models of negative outcomes and positive outcomes, the t-value in all relationships is greater than 2.58, so at the 0.99 level, each of the positive and negative outcomes is one of the consequences of the spread of the virus. COVID-19 is in the sports industry.

DISCUSSION AND CONCLUSION

With the spread of the coronavirus and people's concern about entering sports venues and engaging in sports and the restrictions that were placed in this field of sports, many jobs and businesses related to the sports industry faced a decrease in demand and a decrease in the sale of their goods and services. Of course, in addition to negative consequences, the created restrictions have also resulted in positive consequences. The findings of the research through content analysis and open and axial coding showed that the negative consequences of the spread of COVID-19 on the sports industry include economic and sports components, and the positive consequences include economic, sports and management components. One of the negative economic consequences of the spread of COVID-19 in professional sports is the termination of cooperation between sponsors and sports clubs and athletes. The results of the research showed that the spread of the COVID-19 virus did not only have negative effects, but also had many positive effects on the sports industry. For example, in the economic sector, during the COVID-19 pandemic, online sports businesses have flourished and managers of sports complexes have found financial alternatives.

Prohibition and reduction of traffic due to the fear of contracting the disease, not only in the sports industry but also in most manufacturing and service sectors, has led to the boom of online businesses and buying and selling online products, and probably after the end of the outbreak of COVID-19, due to the benefits of online buying and selling, online businesses continue to thrive. On the other hand, senior managers, managers of sports complexes, athletes, according to the experiences they have gained during the COVID-19 epidemic, have the necessary preparation to face any other crisis and can adapt themselves to critical conditions. Another positive consequence of the COVID-19 pandemic is paying more and more attention to public sports, sports at home, sports in outdoor environments and promoting the holding of online sports events, which have received less attention before. However, due to the restrictions created for professional sports and championships and activities in clubs, as well as the increase in free time due to the closure of schools and some businesses, more attention has been paid to the mentioned sectors. In the research of Ashneter et al. (2020) and Hamami et al. (2020), it has also been pointed out that there has been an increase in attention to exercise at home during the outbreak of COVID-19. In fact, the sports industry seems to have a very high capacity to adapt to the crisis of the spread of COVID-19 and similar crises. Holding classes and workshops in various sports fields and sports sciences online, paying more attention to family sports, sports at home and open spaces, holding many sports competitions, especially in the public and educational sector (student competitions) online and video recording, online shopping for sports equipment, running sports events without the presence of spectators and following health guidelines are just examples of ways to reduce the negative effects of the spread of COVID-19 on the sports industry. Not only that the spread of COVID-19 has not led to the closure of these sectors, but because of the reduction of many costs, it has been welcomed by many stakeholders of the sports industry. Probably, in the post-corona era, the sports industry will have a high desire to continue this trend and use new methods instead of traditional methods. Of course, due to the lack of necessary preparation and lack of crisis management in sports organisations, it seems that currently there is not enough infrastructure in the field of sports to implement these solutions as best as possible, and it is necessary for sports organisations to take the necessary measures to improve the necessary infrastructure. In general, it seems that the negative effects of the COVID-19 epidemic, especially its negative economic effects, have had more impact on sports than the positive effects of the COVID-19 outbreak, which is due to the sudden onset and rapid spread of the COVID-19 virus and the lack of preparation of the sports industry for coping with this crisis. The negative effects of the COVID-19 pandemic have not only harmed the sports industry, but it seems that many ancillary industries of the sports industry, including tourism, aviation, insurance and hotel management, etc., have also been affected by the negative effects of not holding competitions, etc.

However, this crisis was a wake-up call for the sports industry to pay more attention to crisis management in order to perform better in similar and possible crises in the future. Organisations and sports federations should design a comprehensive programme to properly train people and support athletes and implement these programmes in the best possible way. The findings of this research can be used as guidelines in similar crises, such as virus epidemics in the future, and the officials of sports organisations, before being in such a situation, according to the negative and positive consequences mentioned in this research, should take into account the alternative solutions for the sports industry. Sports organisations have the duty to take the sports industry out of the crisis by accurately identifying the harms and benefits caused by these conditions by holding effective meetings regarding the main issues, thinking together and planning practical and creative strategies. Considering the identification of the direct and indirect effects of the spread of the coronavirus and the discussions that were raised, it is suggested that sports clubs consider the capacity of the Internet, social networks and the virtual world more seriously in order to interact with their customers and to some extent reduce the concern. Also, providing training programmes to customers through cyberspace, designing sports programmes and software with the sports club brand, creating support platforms and financial support for club owners and sports coaches, creating a customer relationship management system in sports clubs and developing the system could help. Recording the information of sports club managers and coaches and providing different services at specific times are among the effective solutions for the owners of private sports clubs. Additionally, one of the sciences that helps in this critical situation is the science of marketing in sports. People who studied marketing topics took help from this science and created solutions for their business.

REFERENCES

1. Brett G. Toresdahl, & Irfan M. Asif. Coronavirus disease 2019 (COVID-19): Considerations for the competitive athlete. *Sage Journal*, 12(3): 221-224.
2. Brett, G., Toresdahl, M. D., & Irfan, M., Asif, M. D. (2020). Coronavirus disease 2019 (COVID-19): Considerations for the competitive athlete. *Sport health*, 12(3): 10-15.
3. Clarkson, B. G., Culvin, A., Pope, S., & Parry, K. D. (2020). COVID-19: Reflections on threat and uncertainty for the future of elite women's football in England. *Managing Sport and Leisure*, 27(1), 1-12.
4. Craven, M., Liu, L., Mysore, M., & Wilson, M. (2020). COVID-19: Implications for business. McKinsey & Company.
5. Crawford, J., Butler-Henderson, K., Rudolph, J., & Glowatz, M. (2020). COVID-19: 20 countries' higher education intra-period digital pedagogy responses. *Journal of Applied Teaching and Learning*, 3(1): 25-35.
6. Frank A., Fatke B., Frank W., Förstl H., & Hölzle P. (2020). Depression, dependence and prices of the COVID-19 crisis. *Brain, Behavior and Immunity*, 87: 99.
7. International Olympic Committee. (2020). Joint statement from the International Olympic Committee and the Tokyo 2020 Organising Committee. Retrieved from: <https://www.olympic.org/news/jointstatement-from-the-international-olympic-committee-and-the-tokyo-2020-organising-committee> (Accessed 30th March 2020).
8. Koshle, H., Kaur, R., & Basista, R. (2020). Breakdown of business and workers in India: Impact of Corona virus. Retrieved from: www.papers.ssrn.com (Accessed 20th March 2020).
9. Marca. (2020). Retrieved from: <https://www.marca.com/en/football/real-madrid/2020/05/30/5ed22def22601dae698b4604.html>
10. Narici, M., De Vito, G., Franchi, M., Paoli, A., Moro, T., Marcolin, G., & Di Girolamo, F. G. (2020). Impact of sedentarism due to the COVID-19 home confinement on neuromuscular, cardiovascular and metabolic health: Physiological and pathophysiological implications and recommendations for physical and nutritional countermeasures. *European Journal of Sport Science*, 1: 1-22.
11. Nhamo, G., Dube, K., & Chikodzi, D. (2020). Impact of COVID-19 on the global sporting industry and related tourism. Counting the cost of COVID-19 on the global tourism industry, First Online: 20th September, pp: 225-249.
12. Phelan, D., Kim, J. H., & Chung, E. H. (2020). A game plan for the resumption of sport and exercise after coronavirus disease 2019 (COVID-19) infection. *JAMA Cardiology*, 5(10), 1085-1086.
13. Pillay, L., van Rensburg, D. C. C. J., van Rensburg, A. J., Ramagole, D. A., Holtzhausen, L., Dijkstra, H. P., & Cronje, T. (2020). Nowhere to hide: The significant impact of coronavirus disease 2019 (COVID-19) measures on elite and semi-elite South African athletes. *Journal of Science and Medicine in Sport*, 23(7), 670-679.
14. Schnitzer, M., Schöttl, S.E., Kopp, M., & Barth, M. 2020. COVID-19 stay-at-home order in Tyrol, Austria: sports and exercise behaviour in change? *Public Health*, 185: 218-220.

ANALIZA EFEKATA COVID-19 NA IRANSKU EKONOMIJU I SPORTSKU INDUSTRIJU TE RJEŠENJA ZA KOMPENZACIJU GUBITAKA

SAŽETAK

Širenje virusa COVID-19 je dovelo iransku ekonomiju u stanje stagnacije i neizvjesnosti. Epidemija koronavirusa zatvorila je preduzeća širom svijeta i stavila sve zemlje na rub mukotrpne recesije. Svrha ovog istraživanja je analizirati efekte COVID-19 na iransku ekonomiju i sportsku industriju te pružiti rješenja za kompenzaciju gubitaka. Na osnovu njegove praktične primjene i načina prikupljanja podataka, ovo istraživanje predstavlja deskriptivnu anketu. U prvom (kvalitativnom) dijelu, za provođenje terenskih intervjua, statističku populaciju istraživanja ispitivali su stručnjaci iz područja ekonomije u zemlji i akademsko osoblje iz područja sportske ekonomije. U ovom dijelu obavljena su 24 intervjua s 24 osobe. U drugom (kvantitativnom) dijelu je statistička populacija obuhvatila sve studente postdiplomskih studija sportskog menadžmenta u zemlji, a 610 upitnika je objašnjeno i analizirano direktnim i virtuelnim kontaktom. Rezultati istraživanja su pokazali da širenje virusa COVID-19 nije imalo samo negativne, već i brojne pozitivne efekte na sportsku industriju. Sportska industrija, zapravo, može imati vrlo visok kapacitet prilagođavanja krizi širenja virusa COVID-19 i sličnim krizama. Održavanje online predavanja i radionica iz raznih sportskih područja i sportskih nauka, davanje pažnje porodičnom sportu, sportu kod kuće i na otvorenom

te u ekonomskom sektoru značilo je da su tokom epidemije COVID-19 sportske online kompanije napredovale i menadžeri sportskih kompleksa pronašli finansijske alternative, ali su opći negativni efekti epidemije COVID-19, a posebno njeni negativni ekonomski efekti, bili učinkovitiji od pozitivnih efekata COVID-19 na sport, a čemu je razlog iznenadna pojava i brzo širenje virusa COVID-19 i nedostatak spremnosti sportske industrije za suočavanje s ovom krizom.

Ključne riječi: sportska industrija, ekonomija, COVID-19, sportski menadžment, online poslovanje

Correspondence to: Mohammad Saeid Kiani

Department of Sports Management, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran

E-mail: mohammadsaeidkiani@gmail.com

LONG-COVID, RESPIRATORY SEQUELAE AND PHYSICAL ACTIVITY: A BIBLIOMETRIC ANALYSIS

Elkin Eduardo Roldán-Aguilar¹, Oliver Ramos Álvarez^{1, 2, 3, 4}, Stuart Josué Lisman Molina^{1, 5}, Charick Álvarez Torres¹, Andrés Felipe Jaramillo-Osorno¹, Samuel Correa Zapata¹, Carlos Alberto Zuleta Hinestroza¹, Víctor Arufe-Giraldez⁴

1. GESTAS Research Group, Exercise Physiology Research, Politécnico Colombiano Jaime Isaza Cadavid, El Poblado, Medellín, Colombia
2. Department of Education, Area of Physical Education and Sports, University of Cantabria, Avda, Los Castros, Spain
3. School Sport, Physical Education and Psychomotricity Research Unit (UNIDEF), Department of Specific Didactics, Research Methods and Diagnosis in Education, Faculty of Education, Elviña University Campus, University of A Coruña, Spain
4. Department of Economics, University of Cantabria, Health Economics and Health Services Management Research Group - Marqués de Valdecilla Research Institute (IDIVAL), Santander, Spain
5. Catholic University of Manizales CMS, Colombia

ABSTRACT

Background: In 2019, a new type of coronavirus was discovered that caused a new global pandemic within a few months, affecting all spheres of the world's population. This coronavirus was named SARS-CoV-2 or COVID-19. Today, this new coronavirus is living with the population with better control and lower death rates among those who suffer from it. However, this coronavirus continues to be a health problem for a part of the population that has suffered from the disease, affecting different areas. This is the so-called long-COVID. **Aim:** To carry out a bibliometric analysis of the scientific production related to long-COVID, respiratory sequelae and their implication with the practice of physical activity. **Methods:** The databases of PubMed, Scopus, Dialnet, and SportDiscus were reviewed. The results obtained were processed with the bibliographic manager Mendeley Reference Manager and the Microsoft Excel V. 16.75 spreadsheet for subsequent statistical analysis. **Results:** Given the topicality of the subject under study, the search was carried out without time restriction, and a total of 39 articles were selected. The years with the highest scientific production on the subject studied were 2021 and 2022 (46.15% and 41.03%, respectively). The scientific production was carried out in 17 different countries headed by Spain and Italy. All articles were of collaborative authorship between 12.00 and 7.00 authors. **Conclusion:** It is concluded that there is a need for more research related to long-COVID and respiratory sequelae associated with physical activity.

Keywords: long-COVID, respiratory sequelae, physical activity, health, exercise

INTRODUCTION

The coronavirus (COVID-19) pandemic that started in Hubei province in 2019 resulted in a serious global health problem. Although most patients with COVID-19 experienced mild to moderate illness, about 15% progressed to severe pneumonia, and about 5% of patients evolved to acute respiratory distress syndrome, due to abnormally elevated release of cytokines, leading to multiple organ failure in various organs, such as the heart, liver, kidneys, and especially the lungs. In the latter, the inflammatory process could lead to hyaline membrane formation and fracture of the alveolar wall (Leandro et al., 2020). As of February 2023, there had been approximately 759 million confirmed cases of COVID-19 infections worldwide and some people have experienced persistent symptoms, such as fatigue and shortness of breath, after recovering from the initial COVID-19 illness (Chaichana et al., 2023).

The impact of COVID was very significant in terms of mortality, but infection and mortality rates were not the only problem caused by COVID-19, as up to 19% of COVID survivors suffer from "Long-COVID-19" (LC, used for this article), also known as post-acute sequelae of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (PASC) or Post-Acute Sequelae of COVID-19/Post-COVID Condition. This syndrome is characterised by any symptoms (e.g., dyspnoea, headache, joint pain, fatigue, and cognitive changes) not present before infection and lasting three or more months after recovery from infection, as defined by the Centre for Disease Control and Prevention (CDC) (Iv et al., 2023).

It is estimated that there are approximately 100 million people suffering from LC worldwide, with the aggravating factor that understanding of the pathophysiology is still limited, hindering diagnosis, prognosis, therapeutic intervention, and care services (Perumal et al., 2023). Moreover, the economic burden of LC is expected to be staggering. In the US alone, up to 4 million people have been unable to work. The total burden has been estimated to be between \$2.6 and \$3.7 trillion, including reduced health-related quality of life and earning potential (Iv et al., 2023). Beyond disease-related disability and suffering, these patients have faced denial and stigmatisation, as well as the inability of healthcare providers to provide consistent and effective treatments. Among the main symptoms of LC are: tiredness or fatigue, difficulty thinking or concentrating (sometimes called "mental fog"), shortness of breath or difficulty breathing, headache, dizziness when standing, rapid or pounding heartbeat (known as heart palpitations), chest pain, cough, joint or muscle pain, depression or anxiety, fever, and loss of taste or smell. This list is not exhaustive. Some people also experience damage to multiple organs, including the heart, lungs, kidneys, skin, and brain (Perumal et al., 2023). However, the most common symptoms of prolonged COVID are fatigue and shortness of breath in 90% to

95% of COVID-19 survivors, regardless of the duration of infection, severity of illness or time since onset of illness, and many patients experience exercise intolerance after infection and recovery from COVID. As COVID infections continue to become common, the study of the long-term consequences of COVID on physical function has become increasingly important (Iv et al., 2023). The prevalence in athletes is unclear. However, in a UK cohort, 14% of young elite athletes continued with symptoms beyond 28 days, and 27% were unable to return to full participation in sports one month after initial infection (Rao et al., 2022).

One of the main sequelae and symptoms in the LC are respiratory conditions. Pulmonary fibrosis has been found mainly in diabetics who suffered COVID-19, persistence of the whole virus, microvascular thrombosis and lung parenchymal damage has been demonstrated (Perumal et al., 2023). However, exertional dyspnoea and chronic fatigue, which continue to occur after three months of mild or even asymptomatic COVID-19 in some people, cannot be explained by the findings in the respiratory system mentioned above. Some authors say that there is a broad overlap in symptomatology with myalgic encephalomyelitis/chronic fatigue syndrome. It all starts with hyperventilation during exertion, the product of a combination of a deficient skeletal muscle energy situation and autonomic dysfunction (excessive respiratory response), both of which are found in myalgic encephalomyelitis/chronic fatigue syndrome. Hyperventilation triggers metabolic alkalosis and this in turn leads to an outflow of protons from the intracellular space into the extracellular space, which loads the cells with sodium. High intracellular sodium has unfavourable effects on mitochondrial calcium, altering its energetic function. There is some indication that respiratory training may improve the clinical situation in post COVID-19 syndrome (Wirth & Scheibenbogen, 2022).

These respiratory manifestations of LC will affect the physical condition of individuals and physical rehabilitation, physical activity (PA) or exercise would be assumed to be a fundamental part of the treatment of these sufferers, as exercise has been shown to be beneficial in multiple pathologies with which LC syndrome shares similarities, both in its symptomatology and in its possible pathogenic mechanisms. For example, exercise reduces pain, improves cognitive and immune function, decreases dyspnoea and fatigue, among others, so it is worth considering the potential favourable effect it could have on the recovery of these patients (Jimeno-Almazán et al., 2021). However, an initial search of the PUBMED database found that much of the information on exercise and LC are expert opinions or consensus (Wirth & Scheibenbogen, 2022), letter to the editor (Kambic et al., 2022) and literature reviews (Perumal et al., 2023) (Jimeno-Almazán et al., 2021), but no bibliometric review was found that could guide us on the statistical patterns of publications, authors, institutions and types of documents published in order to offer a more complete picture and scientific dynamism of what really happens in research on this important topic (Llerena & Arévalo, 2021). Therefore, the aim of this research was to conduct a bibliometric review of papers published in scientific journals on exercise, PA, physical fitness or rehabilitation tests and respiratory sequelae in patients with LC.

AIM

The aim of this study was to carry out a bibliometric analysis of articles related to LC and its implication in the respiratory sequelae of people who have suffered from the disease and in relation to the practice of PA.

METHODOLOGY

Materials and methods

A bibliometric review was conducted using a structured methodology to collect, analyse and synthesise relevant information from the scientific literature with respect to the subject matter of the research objective. The inclusion and exclusion criteria for choosing the documents to be analysed in this bibliometric review are presented below:

Inclusion criteria

1. Documents that include within the abstract any of the following words: Exercise training, Functional capacity, Resistance exercise, Strength training, Respiratory muscle training, Cardiac rehabilitation, and Physical rehabilitation.
2. Population: Post-Acute COVID-19 Syndrome, LC or Post-COVID Conditions, and Chronic COVID syndrome.
3. Persistent symptoms or sequelae of COVID.

Exclusion criteria

1. Prevalence or mortality studies
2. Letter to editors
3. Clinical trials whose intervention is not physical exercise or physical training/rehabilitation.

The sources of information used to search for the documents were the databases: PubMed, Scopus, Dialnet, and SportDiscuss. Boolean operators (AND, OR, NOT) were used to combine the following key words in the effective search:

((“Long COVID” OR “Post-Acute Sequelae of SARS-CoV-2 infection” OR “Chronic COVID Syndrome”) AND (“Respiratory Sequelae” OR “Respiratory Complications” OR “Respiratory Symptoms”)) AND (“Exertional Dyspnoea” OR “Exercise-Induced Dyspnoea” OR “Effort-Related Dyspnoea”) AND (“Pulmonary” OR “Lung” OR “Respiratory” OR “Pulmonology”).

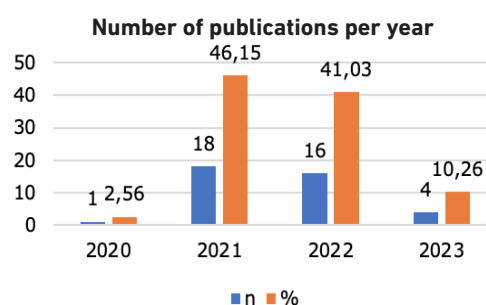
The bibliographic manager Mendeley Reference Manager was used to manage the documents collected from the search. Subsequently, the titles and abstracts of the studies obtained in the search for repeated papers were examined for exclusion and relevant papers that met the inclusion and exclusion criteria were selected.

Once the papers were selected, the following data were extracted and organised: author(s) with their respective country of origin and gender, year of publication, title, journal, journal quartile, impact factor, and type of article. The data were organised in a matrix in a Microsoft Excel spreadsheet to facilitate analysis and synthesis.

RESULTS

From a total of 112 articles initially found after the search, 73 articles were rejected because they did not meet the inclusion criteria or were within the exclusion criteria. A total of 39 articles were finally accepted for analysis. According to the search with the descriptor used, 112 documents related to LC were found. After applying the inclusion and exclusion criteria defined in this work, 39 articles related to LC and respiratory sequelae linked to the practice of PA were finally identified. In the search for documents in the databases consulted, no temporal criteria were applied given that the appearance of COVID-19 dates back to the last few years. The results show that the greatest number of documents were produced in the years when COVID-19 is most present in the population, specifically in the year 2021 ($n = 18$) and with a similar production in 2022 ($n = 16$), with 46.15 and 41.03%, respectively. In 2020, the year in which the World Health Organisation (WHO) declares a global pandemic due to the outbreak of SARS-CoV-2, only one article was published (2.56%). However, with much more scientific knowledge of LC, 4 papers were published in 2023, accounting for 10.26% of the total number of published papers on LC and respiratory sequelae associated with PA (Figure 1).

Figure 1. Distribution of publications by year



Note: n = frequency.

The results obtained according to the quartiles in which these papers have been published show that publications in the Q1 JCR quartile predominate with 53.85%. The papers published in the Q2 JCR obtained 30.77% of the total number of documents analysed (Table 1).

Table 1. Distribution of papers by JCR quartiles and year

| Quartile | 2020 | 2021 | 2022 | 2023 |
|----------|--------|----------|---------|--------|
| | n/% | n/% | n/% | n/% |
| Q1 | 1/2.56 | 11/28.21 | 8/20.51 | 1/2.56 |
| Q2 | | 5/12.82 | 5/12.82 | 2/5.13 |
| Q3 | | 2/5.13 | 3/7.69 | 1/2.56 |
| Q4 | | | | |

Note: n = frequency by year and quartile.

The journal with the highest number of papers published was the International Journal of Environmental Research and Public Health, an Open Access journal of the MDPI publishing group. A total of 6 studies were published in this journal during the years analysed, accounting for 15.38% of the production in this work.

According to the origin of the countries in which the research was produced, scientific papers were published in 17 different countries. Spain (20.51%) and Italy (10.26%) stand out in terms of the percentage of documents produced. The predominant language of the publications was English (97.44%), while one publication was in German (Table 2).

Table 2. Distribution of the documents by research country and year

| Country | 2020 | 2021 | 2022 | 2023 |
|-------------|--------|--------|---------|--------|
| Italy | | 3/7.69 | 1/2.56 | |
| France | | | 1/2.56 | 1/2.56 |
| Greece | | | 1/2.56 | |
| England | | 1/2.56 | 2/5.13 | |
| Iran | | 2/5.13 | | |
| Netherlands | | 1/2.56 | | |
| Germany | | | 2/5.13 | 1/2.56 |
| U. Kingdom | | 1/2.56 | | |
| Turkey | | 1/2.56 | 2/5.13 | |
| Spain | | 2/5.13 | 4/10.26 | 2/5.13 |
| Japan | | 2/5.13 | | |
| Australia | 1/2.56 | | | |
| Brazil | | 2/5.13 | 1/2.56 | |
| China | | | 1/2.56 | |
| Austria | | 1/2.56 | | |
| Egypt | | | 1/2.56 | |
| USA | | 2/5.13 | | |

Note: TP = total number of documents published.

Likewise, an analysis of the selected documents was carried out according to the type of document or research described in the published work. Following the inclusion and exclusion criteria defined in this bibliometric review, three types of scientific documents were distinguished: intervention research, systematic reviews and other types of research. The most abundant type of papers in the years analysed were other types of research (61.54%), compared to 25.64% of intervention research papers (Table 3).

Table 3. Distribution by document type and year

| Quartile | 2020 | 2021 | 2022 | 2023 |
|----------|--------|----------|---------|--------|
| | n/% | n/% | n/% | n/% |
| II | | 2/5.13 | 7/17.95 | 1/2.56 |
| RS | 1/2.56 | 2/5.13 | 2/5.13 | |
| OI | | 14/35.90 | 7/17.95 | 3/7.69 |

Note: n = frequency by years and type of document; II = intervention research; SR = systematic reviews; OI = other research; OA = other research.

In this bibliometric review, no single-authored papers have been selected, all the documents analysed being co-authored or collaboratively authored. The average number of authors per paper ranges from 12.00 in 2020 to 7.00 in 2023. Table 4 shows the percentage of collaboration per year.

Table 4. Distribution by authorship and year

| Author | 2020 | 2021 | 2022 | 2023 |
|--------|-------|-------|-------|-------|
| AU (n) | | | | |
| AU (%) | | | | |
| AC (n) | 1 | 18 | 16 | 4 |
| AC (%) | 2.56 | 46.15 | 41.03 | 10.26 |
| M | 12.00 | 11.44 | 8.00 | 7.00 |

Note: n = frequency by years and authorship; AU = single authorship; AC = collaborative articles; M = average number of authors per year; M = average number of authors per year.

Looking at the gender of the authorship of the documents, 61.54% of the authors participating in the different documents are men, compared to 38.46% women. In the case of scientific documents with the participation of women, the years 2021 and 2022 are the years with the highest percentage of female authorship, 12.82% in both years, compared to 33.33% and 28.21%, respectively, in the scientific production of men. The authors and institutions with the highest scientific production in the documents analysed belong to Spain and Japan (Table 5).

Table 5. Authors with the highest document production, their institution and country

| Author | n | Affiliation | Country |
|------------------------------|---|-----------------------------|---------|
| César Fernández-de-las-Peñas | 2 | King Juan Carlos University | Spain |
| Katsuhiko Suzuki | 2 | Waseda University | Japan |

Note: n = frequency of authored or co-authored projects.

DISCUSSION

The generation of scientific papers related to Long COVID-19 (LC) began in 2020, with the declaration of the COVID-19 pandemic by the World Health Organization (Pan American Health Organization, 2020). Until this review, no articles conducting bibliometric reviews (BRs) on LC and its respiratory consequences have been found, complicating a complete understanding of both the big picture and the particular patterns guiding research on respiratory consequences in LC survivors and the performance of physical activity (PA), physical exercise, rehabilitation or fitness assessment. Recently, a BR on respiratory muscle training over the last six decades (Ramli et al., 2023), includes publication profiles, citation analysis and research trends of relevant literature in the Scopus database. It showed an increase in research on respiratory muscle training over these six decades in all geographical locations and where medicine remains the main area of research, although other areas such as engineering, computer science and social sciences have grown. This work evidenced research collaboration between authors from different fields. They also suggest that further collaboration should be encouraged in the future to produce more impactful and beneficial research for people with respiratory disorders.

The link between respiratory muscle training and LC is based on the fact that two months after hospitalisation, 43% of patients continued to experience dyspnoea (Carfi et al., 2020) and 71%, who were never hospitalised, reported experiencing shortness of breath 79 days after infection. In addition, COVID-19 infection causes inflammatory damage to the lung parenchyma and reduces the ability of the lungs to expand, exacerbating the imbalance between respiratory demands and the ability of the respiratory muscles to generate force (Severin et al., 2020). In severe cases requiring mechanical ventilation, patients may experience rapid atrophy and weakness in the respiratory muscles, further worsening this imbalance (Farr et al., 2021). More recent evidence suggests that COVID-19 infection can cause damage to the diaphragm in critically ill patients, which may contribute to shortness of breath (Shi et al., 2021). In addition, patients recovered from COVID-19 not hospitalised and with negative PCR test results report persistent breathing difficulties for more than three months (Severin et al., 2020). This dysfunction is most notable in patients undergoing mechanical ventilation, so-called "ventilator-induced diaphragm

dysfunction" (Levine et al., 2008).

Despite the importance of the respiratory consequences, according to this BR, there are few articles (39 in total) addressing this issue. This lack of bibliometric analysis makes it difficult to identify the various forms of scientific production related to the topic (Llerena & Arévalo, 2021). The production of articles in 2020 was minimal, given that the acute cases of the pandemic were being attended to, and it was in April that the first publications began. In November 2020, the so-called post-COVID-19 conditions were conceptually described for the first time by the Centre for Disease Control and Prevention (CDC) (United States Government, 2021). For this reason, the highest scientific output occurs in 2021 (709 articles, 63.02%) and a BR on PA and COVID-19 is published (Wattanapisit et al., 2022). The proportion of people with LC in the US decreased from 35% in 2022 to 28% in 2023, but remains high (Burns, 2023).

33 of the 39 articles that met the study's selection criteria were published in the Q1 and Q2 quartiles of the JCR (84.61%), showing the importance these journals attached to the topic, especially in the context of the pandemic's rise, as evidenced by a previously conducted RB in 2020 on COVID-19-related publications in high-impact scientific journals (López-López, et al., 2020). International "Journal of Environmental Research and Public Health" was the journal that contributed the most articles, such as the BR conducted by Zhang et al. (2022) on PA and COVID-19. "The Lancet" accounted for 66% of the contributions (López-López, et al., 2020), and published another BR on the topic of COVID-19 in general.

In relation to the countries that published papers on respiratory sequelae of LC and PA, Spain (8 articles and 20.51%) doubled the number of articles published by Italy (4 and 10.26%). This behaviour differs from the trends observed in general COVID-19 publications, as evidenced by a BR where China, the United States and the United Kingdom led in terms of number of publications (López-López, et al., 2020). These countries also do not rank highly in terms of publications on respiratory muscle training, according to a recent BR (Ramli et al., 2023), where China published one paper, despite being the country of origin of the pandemic. This is possibly because China has published much of its research in its own databases, which were not consulted in this BR. One possible explanation for why Spain and Italy stand out in these publications could be that both countries were among the four European countries with the highest number of confirmed COVID-19 cases, along with Russia and the UK, reporting a total of 243,605 positive cases. Out of these, 216,468 (88.86%) are survivors, among whom respiratory sequelae have been identified (Barrera-Algarín et al., 2020).

Intervention studies or programmes are described as guidance and guidelines designed to promote PA (including exercise and movement) and reduce sedentary behaviours or the use of PA as a tool to

enhance health (Wattanapisit et al., 2022). In this BR, only 25.64% of the 10 articles analysed focused on delivering interventions. In the BR conducted by Ramli et al. (2023) on intervention tools and outcome measures, it was noted that less than half of the articles identified were classified as Randomised Controlled Trials (RCTs). These RCTs were subjected to detailed analysis in terms of outcome measures assessing lung function, respiratory muscle strength and muscle activity.

Another BR related to COVID-19 and PA, showed that the majority of publications (60.27% out of 678) were research articles. In this case, surveillance and trends in PA constituted the main area of focus, followed by health outcomes and correlates and determinants of PA. However, only 5.3% of the 1125 articles analysed were devoted to interventions (Wattanapisit et al., 2022), corroborating the low tendency to conduct this type of research in COVID-19. Interventions are fundamental for the definition of LC-specific treatment protocols, especially regarding the role of PA in patients' recovery (Jimeno-Almazán et al., 2021). One of the interventions performed in patients with Chronic Lung Disease (COPD) and other chronic respiratory diseases is Pulmonary Rehabilitation (PR), which is a therapeutic strategy based on combined PA (aerobic endurance and strength), has been very effective in improving functional capacity, dyspnoea and health-related quality of life (Meléndez-Oliva et al., 2023).

A scoping review of 40 publications highlighted pulmonary rehabilitation as a possible alternative

in working with COVID-19 patients, especially those who had undergone mechanical ventilation or experienced prolonged symptoms of the disease (Siddiq et al., 2020). Similarly, a meta-analysis from the start of the pandemic to January 2023 included 34 randomised, quasi-experimental and observational studies in which adults were diagnosed with COVID-19 in its subacute or prolonged phase and had received pulmonary rehabilitation as part of their treatment. This analysis revealed moderate to large effects on dyspnoea, physical function, quality of life, and depressive symptoms, compared to those who received conventional medical care. No significant differences were observed in fatigue, compared to the conventional care group or in anxiety levels. It was concluded that pulmonary rehabilitation may have the potential to improve health outcomes in patients with COVID-19 in its subacute or prolonged phase. However, due to the high risk of bias in the studies analysed, it is important to take these conclusions with caution (Meléndez-Oliva et al., 2023).

CONCLUSIONS

There is insufficient scientific evidence regarding the best way to perform PA or rehabilitation in patients with respiratory sequelae of Long COVID-19.

The tendency is to conduct research other than interventions, which means that fundamental elements for treating the respiratory sequelae of LC through exercise are lacking.

REFERENCES

1. United States Government. (2021). What is long COVID? (p. 3). <https://www.covid.gov/longcovid/definitions>
2. Barrera-Algarín, E., Maestre, F. E., Sarasola, J. L., & Andrada, A. V. (2020). Covid-19, neoliberalismo y sistemas sanitarios en 30 países de Europa: repercusiones en el número de fallecidos. *Revista española de salud pública*, (94), 57.
3. Berger, D., Bloechlinger, S., von Haehling, S., Doehner, W., Takala, J., Z'Graggen, W. J., & Schefold, J. C. (2016). Dysfunction of respiratory muscles in critically ill patients on the intensive care unit. *Journal of cachexia, sarcopenia and muscle*, 7(4), 403–412. <https://doi.org/10.1002/jcsm.12108>
4. Bliddal, S., Banasik, K., Pedersen, O. B., Nissen, J., Cantwell, L., Schwinn, M., Tulstrup, M., Westergaard, D., Ullum, H., Brunak, S., Tommerup, N., Feenstra, B., Geller, F., Ostrowski, S. R., Grønbæk, K., Nielsen, C. H., Nielsen, S. D., & Feldt-Rasmussen, U. (2021). Acute and persistent symptoms in non-hospitalized PCR-confirmed COVID-19 patients. *Scientific reports*, 11(1), 13153. <https://doi.org/10.1038/s41598-021-92045-x>
5. Burns, A. (2023). Long COVID: What do the latest data show? <https://www.kff.org/policy-watch/long-covid-what-do-latest-data-show/>
6. Carfi, A., Bernabei, R., Landi, F., & Gemelli Against COVID-19 Post-Acute Care Study Group. (2020). Persistent symptoms in patients after acute COVID-19. *JAMA*, 324(6), 603–605. <https://doi.org/10.1001/jama.2020.12603>
7. Chaichana, U., Man, K. K. C., Chen, A., Wong, I. C. K., George, J., Wilson, P., & Wei, L. (2023). Definition of post-COVID-19 condition among published research studies. *JAMA Network Open*, 6(4), e235856. <https://doi.org/10.1001/jamanetworkopen.2023.5856>
8. Department of Health and Human Services. (2023). What is long COVID? <https://www.covid.gov/longcovid/definitions>
9. Farr, E., Wolfe, A. R., Deshmukh, S., Rydberg, L., Soriano, R., Walter, J. M., Boon, A. J., Wolfe, L. F., & Franz, C. K. (2021). Diaphragm

- dysfunction in severe COVID-19 as determined by neuromuscular ultrasound. *Annals of clinical and translational neurology*, 8(8), 1745–1749. <https://doi.org/10.1002/acn3.51416>
10. Goërtz, Y. M. J., Van Herck, M., Delbressine, J. M., Vaes, A. W., Meys, R., Machado, F. V. C., Houben-Wilke, S., Burtin, C., Posthuma, R., Franssen, F. M. E., van Loon, N., Hajian, B., Spies, Y., Vijlbrief, H., van 't Hul, A. J., Janssen, D. J. A., & Spruit, M. A. (2020). Persistent symptoms 3 months after a SARS-CoV-2 infection: The post-COVID-19 syndrome? *ERJ open research*, 6(4), 00542-2020. <https://doi.org/10.1183/23120541.00542-2020>
 11. Iv, E. J. W., Hong, B., Hayashi, J., Goo, C., Carrazana, E., Viereck, J., & Liow, K. (2023). Mechanisms and severity of exercise intolerance following COVID-19 and similar viral infections : A comparative review. 15(5). <https://doi.org/10.7759/cureus.39722>
 12. Jimeno-Almazán, A., Pallarés, J. G., Buendía-Romero, Á., Martínez-Cava, A., Franco-López, F., Sánchez-Alcaraz Martínez, B. J., ... & Courel-Ibáñez, J. (2021). Post-COVID-19 syndrome and the potential benefits of exercise. *International Journal of Environmental Research and Public Health*, 18(10), 5329. <https://doi.org/https://doi.org/10.3390/ijerph18105329>
 13. Kambic, T., Hadžić, V., & Lainscak, M. (2022). Optimizing cardiopulmonary rehabilitation of long COVID-19 syndrome: Are we there yet? *European Journal of Preventive Cardiology*, 29(8), E268–E269. <https://doi.org/10.1093/eurjpc/zwac038>
 14. Leandro, C. G., Ferreira E Silva, W. T., & Lima-Silva, A. E. (2020). Covid-19 and exercise-induced immunomodulation. *NeuroImmunoModulation*, 27(1), 75–77. <https://doi.org/10.1159/000508951>
 15. Levine, S., Nguyen, T., Taylor, N., Friscia, M. E., Budak, M. T., Rothenberg, P., Zhu, J., Sachdeva, R., Sonnad, S., Kaiser, L. R., Rubinstein, N. A., Powers, S. K., & Shrager, J. B. (2008). Rapid disuse atrophy of diaphragm fibers in mechanically ventilated humans. *The New England journal of medicine*, 358(13), 1327–1335. <https://doi.org/10.1056/NEJMoa070447>
 16. Llerena, M. A., & Arévalo, M. E. (2021). Indicadores bibliométricos: Oigen, definición y aplicaciones científicas en el ecuador. *Espíritu Emprendedor TES*, 5(1), 130–153. <https://doi.org/10.33970/eetes.v5.n1.2021.253>
 17. López-López, W., Salas, G., Vega-Arce, M., Cornejo-Araya, C. A., Barboza-Palomino, M., & Ho, Y. S. (2020). Publicaciones sobre COVID-19 en revistas científicas con alto factor de impacto: Un análisis bibliométrico. *Universitas Psychologica*, 19, NA-NA.
 18. Meléndez-Oliva, E., Martínez-Pozas, O., Cuenca-Zaldívar, J. N., Villafaña, J. H., Jiménez-Ortega, L., & Sánchez-Romero, E. A. (2023). Efficacy of pulmonary rehabilitation in post-COVID-19: A systematic review and meta-analysis. *Biomedicines*, 11(8), 2213. <https://doi.org/10.3390/biomedicines11082213>
 19. Michalopoulos, A., & Falagas, M. E. (2005). A bibliometric analysis of global research production in respiratory medicine. *Chest*, 128(6), 3993–3998. <https://doi.org/10.1378/chest.128.6.3993>
 20. Organización Panamericana de la salud [OPS] (2020). La OMS caracteriza a COVID-19 como una pandemia. (p. 1). <https://www.paho.org/es/noticias/11-3-2020-oms-caracteriza-covid-19-como-pandemia#:~:text=Ginebra%2C%2011%20de%20marzo%20de,puede%20caracterizarse%20como%20una%20pandemia>
 21. Perumal, R., Shunmugam, L., Naidoo, K., Abdool Karim, S. S., Wilkins, D., Garzino-Demo, A., Brechot, C., Parthasarathy, S., Vahlne, A., & Nikolich, J. (2023). Long COVID: A review and proposed visualization of the complexity of long COVID. In *Frontiers in Immunology*, 14. <https://doi.org/10.3389/fimmu.2023.1117464>
 22. Rao, P., Peritz, D. C., Systrom, D., Lewine, K., Cornwell III, W. K., & Hsu, J. J. (2022). Orthostatic and exercise intolerance in recreational and competitive athletes with long COVID. *JACC: Case Reports*, 4(17), 1119–1123. <https://doi.org/https://doi.org/10.1016/j.jaccas.2022.07.007>
 23. Ramli, M. I., Hamzaid, N. A., Engkasan, J. P., & Usman, J. (2023). Respiratory muscle training: a bibliometric analysis of 60 years' multidisciplinary journey. *Biomedical engineering online*, 22(1), 50. <https://doi.org/10.1186/s12938-023-01103-0>
 24. Severin, R., Arena, R., Lavie, C. J., Bond, S., & Phillips, S. A. (2020). Respiratory muscle performance screening for infectious disease management following COVID-19: A highly pressurized situation. *The American journal of medicine*, 133(9), 1025–1032. <https://doi.org/10.1016/j.amjmed.2020.04.003>
 25. Severin, R., Franz, C. K., Farr, E., Meirelles, C., Arena, R., Phillips, S. A., Bond, S., Ferraro, F., Faghy, M., & HL-PIVOT Network (2022). The effects of COVID-19 on respiratory muscle performance: making the case for respiratory muscle testing and training. *European respiratory review: An official journal of the European Respiratory Society*, 31(166), 220006. <https://doi.org/10.1183/16000617.0006-2022>
 26. Shi, Z., de Vries, H. J., Vlaar, A. P. J., van der Hoeven, J., Boon, R. A., Heunks, L. M. A., Ottenheijm, C. A. C., & Dutch COVID-19 Diaphragm Investigators (2021). Diaphragm pathology in critically ill patients with COVID-19 and postmortem findings from 3 medical centers. *JAMA internal medicine*, 181(1), 122–124. <https://doi.org/10.1001/jamainternmed.2020.6278>
 27. Siddiq, M. A. B., Rathore, F. A., Clegg, D., & Rasker, J. J. (2020). Pulmonary rehabilitation in COVID-19 patients: A scoping review of current practice and its application during the pandemic. *Turkish journal of physical medicine and rehabilitation*, 66(4), 480–494. <https://doi.org/10.5606/tftrd.2020.6889>

28. Wattanapisit, A., Kotepui, M., Wattanapisit, S., & Crampton, N. (2022). Bibliometric analysis of literature on physical activity and COVID-19. *International journal of environmental research and public health*, 19(12), 7116. <https://doi.org/10.3390/ijerph19127116>
29. Wirth, K. J., & Scheibenbogen, C. (2022). Dyspnea in post-COVID syndrome following mild acute COVID-19 infections: Potential causes and consequences for a therapeutic approach. *Medicina (Lithuania)*, 58(3). <https://doi.org/10.3390/medicina58030419>
30. Zhang, Y., Chen, M., Liu, C., Zhang, Z., & Fu, X. (2022). A bibliometric analysis of COVID-19 and physical activity. *Medicine*, 101(39), e30779. <https://doi.org/10.1097/MD.00000000000030779>

DUGI COVID, RESPIRATORNE TEGOBE I FIZIČKA AKTIVNOST: BIBLIOMETRIJSKA ANALIZA

SAŽETAK

Kontekst: 2019. godine otkriven je novi tip koronavirusa koji je izazvao novu globalnu pandemiju u roku od nekoliko mjeseci, zahvativši sve sfere svjetske populacije. Ovaj koronavirus nazvan je SARS-CoV-2 ili COVID-19. Danas ovaj novi koronavirus živi sa populacijom, uz bolju kontrolu i nižu stopu mortaliteta među oboljelima. Međutim, ovaj koronavirus i dalje predstavlja zdravstveni problem za dio populacije koji je patio od ove bolesti, a zahvata različita područja. Ovo je takozvani dugi COVID. **Cilj:** Izvršiti bibliometrijsku analizu naučne produkcije povezane sa dugim COVID-om, respiratornim tegobama i njihovim implikacijama u izvođenju fizičke aktivnosti. **Metode:** Pregledane su baze podataka PubMed, Scopus, Dialnet i SportDiscus. Dobijeni rezultati su obrađeni bibliografskim menadžerom Mendeley Reference Manager i korištenjem programa Microsoft Excel V. 16.75 za dalju statističku analizu. **Rezultati:** S obzirom na aktuelnost predmeta istraživanja, pretraga je obavljena bez vremenskog ograničenja, a odabrano je ukupno 39 članaka. Godine sa najvećom naučnom produkcijom proučavane teme su 2021. i 2022. (46,15% odnosno 41,03%). Naučna produkcija je provedena u 17 različitih zemalja na čelu sa Španijom i Italijom. Svi članci su bili kolaborativnog karaktera između 12,00 i 7,00 autora. **Zaključak:** Zaključeno je da postoji potreba za dodatnim istraživanjima dugog COVID-a i respiratornih tegoba povezanih s fizičkom aktivnosti.

Ključne riječi: dugi COVID, respiratorne tegobe, fizička aktivnost, zdravlje, vježba

Correspondence to: Oliver Ramos-Álvarez

GESTAS Research Group, Exercise Physiology Research, Politécnico Colombiano Jaime Isaza Cadavid, El Poblado, Medellín, Colombia; Department of Education, Area of Physical Education and Sports, University of Cantabria, Avda, Los Castros, Spain; School Sport, Physical Education and Psychomotricity Research Unit (UNIDEF), Department of Specific Didactics, Research Methods and Diagnosis in Education, Faculty of Education, Elviña University Campus, University of A Coruña, Spain; Department of Economics, University of Cantabria, Health Economics and Health Services Management Research Group - Marqués de Valdecilla Research Institute (IDIVAL), Santander, Spain
E-mail: oliver.ramos@unican.es

MOTIVATION IN PARTICIPANTS INVOLVED IN NON-FORMAL EDUCATION PROGRAMMES FOR SPORTS EXPERTS

Ivana Novakov¹, Marija Volarov¹, Nikolina Kuruzović¹, Milan Nešić¹, Violeta Zubanov¹

1. Faculty of Sport and Psychology, Educons University, Novi Sad, Serbia

ABSTRACT

About a decade ago, according to the Law on Sports, vocational training became mandatory in Serbia for those who want to become sports professionals (e.g., coaches), but do not have an adequate formal education. Thus, we were interested in exploring motivational factors among 100 individuals enrolled in the non-formal education programme for sports experts in Serbia. Our results indicate that those who would voluntarily enrol in the programme were more intrinsically motivated to learn than those who would only enrol due to the law or were ambivalent. Our findings also imply that those individuals who only expected to gain a mandatory certificate (rather than knowledge) are less intrinsically motivated (to know, to accomplish, and to experience stimulation) and less extrinsically motivated (this pertains to the form of extrinsic motivation called regulation through identification). Additionally, our findings suggested some forms of intrinsic (the drive to know and to experience stimulation) and extrinsic motivation (regulation through identification) tend to decline with age.

Keywords: sports coaching, non-formal education, intrinsic motivation, extrinsic motivation

INTRODUCTION

It is well-known that the training process and sports competitions have a pivotal role in every sports organisation (Nešić & Nešić, 2020). Thus, the management of those organisations must provide highly skilled sports coaches. In the wide range of factors that determine the work success of sports experts (i.e., coaches), the dominant place is reserved for knowledge/competency, but also personality traits and motivation, job satisfaction, etc. In Serbia, sports coaches can acquire competencies through (a) formal higher education, such as academic and professional sports studies, or (b) through professional training in the system of non-formal education (NFE). This is worth noting because researchers have recently become

more interested in different ways sports coaches gain their knowledge and started emphasising the necessity of examining motivational factors that drive the coaches' willingness to learn (e.g., via various forms of learning, such as formal, non-formal and informal education) (Cushion et al., 2010; Perkins & Hahn, 2020).

Motivation for engaging in non-formal education programmes for sports experts - what do we know so far?

Motivation is the process of initiating, directing and maintaining human behaviour towards a specific goal (Ryan & Deci, 2000). If a person does something that fundamentally interests them or gives them pleasure, we say that they are intrinsically motivated. Alternatively, they are extrinsically motivated to do

something only because it leads to a certain result (e.g., obtaining a sports certificate or monetary benefits). In addition, the same behaviour can be driven by both intrinsic and extrinsic motivation simultaneously, but an entire lack of motivation is also possible.

Studies that aim to directly examine the motivation of sports coaches' who decide to enrol in NFE programmes are lacking (Cushion et al., 2010; Perkins & Hahn, 2020). Generally speaking, sports coaches have a positive attitude towards NFE, recognising its place in their long-term professional development (Hughes, 2005). While many coaches recognise the value of NFE (Brook, 2016; Mesquita et al., 2010; van der Merwe et al., 2015), some have criticised the execution of these programmes. Some coaches argue that education programmes do not meet their needs (Hannays, 2020; Kubayi et al., 2016; Vargas-Tonsing, 2007). They also point out lack of time, money and spatial proximity of NFE programmes as social setbacks that can diminish motivation for additional education (Hughes, 2005).

THE AIM OF THE CURRENT STUDY

In our study, we focus on motivational factors in participants who are involved in an NFE programme for sports experts in Serbia. For the past decade, NFE became mandatory for those who want to work as sports experts but who do not have the required formal education (Law on Sports, 2016). These regulations likely interfere with the motivation people have to develop professionally, at least when it comes to those who cannot become sports workers without completing the NFE programme. One can assume that some individuals would be interested in enrolment in such programmes simply because they have to if they want to acquire a certificate (this is of particular importance in cases of those individuals who were already employed as sports experts before the law has changed and conditioned them to gain a certificate through the NFE programmes). In those cases, it is questionable how much effort these individuals would be ready to invest to gain new skills. Thus, the main objective of this study is to explore the motivational structure of individuals enrolled in NFE programmes. Specifically, we aim to explore the differences in motivation between sports workers who would not enrol in such programmes if they were not required by the law and those who would willingly do so. The insights from our study could be valuable to educators.

METHOD

Sample and procedure

The study was conducted on 100 participants who took part in NFE programmes for sports experts from the Republic of Serbia (57% male), aged from 19 to 68 years ($M = 37.67$, $SD = 11.30$). Forty-five percent of participants reported that they had a high school degree, 10% graduated from college and 45% earned a faculty degree (4% being from the sports field). Finally, 35% stated that they were employed as sports workers at the time of research (most frequently as coaches). Taking part in the research was voluntary and anonymous. Before entering the research, the participants were provided with informed consent. The majority of respondents completed the instruments online, while a smaller part ($n = 14$) completed the battery via paper and pencil approach.

Instruments

The Sport Motivation Scale (SMS; Pelletier et al., 1995).

The SMS scale consists of 28 five-point Likert scale items which measure different aspects of sports motivation, and for our study items, they were modified to measure the sports workers' motivation for enrolling in the NFE programme. The instrument has seven subscales (4 items for every subscale), representing three different aspects of intrinsic motivation (IM) and three various forms of extrinsic motivation (EM), as well as amotivation (that we did not use in the study). The intrinsic motivation to know ($\alpha = .74$) is related to curiosity, the need to understand and to perform an activity due to satisfaction while learning and exploring something new. The intrinsic motivation towards accomplishments ($\alpha = .86$) can be described as engaging in challenging activities for the pleasure of accomplishing them. The intrinsic motivation to experience stimulation ($\alpha = .73$) refers to engaging in an activity to experience sensory or aesthetic pleasure, fun and excitement. Extrinsic motivation – external regulation ($\alpha = .81$) corresponds to participating in sports activities to obtain some type of external reward (e.g., material reward, praise, to please others or to avoid negative consequences such as criticism). Extrinsic motivation – introjection ($\alpha = .58$) occurs when a formerly external source of motivation becomes internalised in the form of internal pressures, such as anxiety, guilt or embarrassment (e.g., an athlete feels the pressure to be in good shape in order to satisfy aesthetic criteria). Extrinsic motivation – identification ($\alpha = .62$) comes into play when an activity is still performed for extrinsic reasons but is internally regulated as well (e.g., participating in sports events due to the belief that such an activity can foster personal growth and development).

RESULTS

Table 1 shows the descriptive statistics data for all motivation-related variables.

Table 1. Descriptive statistics for motivation variables

| | Min | Max | <i>M</i> | <i>SD</i> | <i>Sk</i> | <i>Ku</i> |
|--------------------------------|-----|-----|----------|-----------|-----------|-----------|
| IM - to know | 8 | 20 | 16.91 | 2.96 | -0.79 | 0.14 |
| IM - to accomplish | 5 | 20 | 16.54 | 3.39 | -1.05 | 0.63 |
| IM - to experience stimulation | 8 | 20 | 16.71 | 3.01 | -0.81 | -0.01 |
| EM - identified | 5 | 20 | 13.46 | 2.98 | -0.22 | -0.06 |
| EM - introjected | 7 | 20 | 14.68 | 3.47 | -0.38 | -0.70 |
| EM - external regulation | 4 | 20 | 8.65 | 4.20 | 0.78 | -0.12 |

Note: IM – intrinsic motivation, EM – extrinsic motivation, Sk – Skewness, Ku – Kurtosis. Skewness and kurtosis values of ± 1.5 were considered acceptable (Tabachnick & Fidell, 2013).

In Table 2, we can see the correlation coefficients between age and different aspects of IM and EM. The participants' age has a statistically significant negative correlation with IM to know and to experience stimulation, as well as with EM – identification. Also, all aspects of IM and EM are significantly and positively correlated.

Table 2. Pearson correlation coefficients between age and motivation

| | Age | (2) | (3) | (4) | (5) | (6) |
|--------------------------|-------|------|------|------|------|------|
| IM - to know (2) | - | | | | | |
| IM - to accomplish (3) | .24* | | | | | |
| IM - to exp. stimul. (4) | -.14 | .76* | | | | |
| EM – identified (5) | -.23* | .82* | .71* | | | |
| EM – introjected (6) | .21* | .70* | .76* | .65* | | |
| EM – external regulation | -.14 | .58* | .54* | .59* | .56* | |
| | -.07 | .31* | .32* | .21* | .49* | .48* |

Note: * $p < .05$, ** $p < .01$, IM – intrinsic motivation, EM – extrinsic motivation, to exp. stimul. – to experience stimulation.

Next, the participants were asked whether they would join the programme regardless of the law which makes it obligatory, and they could answer with the following options: yes ($n = 69$) / no ($n = 10$) / not sure ($n = 21$). We compared these three groups of motivation. One-way MANOVA was conducted with this three-level categorical

variable as an independent variable, while all types of IM and EM were treated as dependent variables. Box's M test confirmed the equality of covariance matrices across groups ($p = .441$), while Levene's test showed that the error variance for all dependent variables is equal across groups. On the multivariate level, a significant model was obtained, $F(12, 182) = 2.84$, $p = .001$, Wilks' $\Lambda = .71$, $\eta^2 = .16$. In Table 3, univariate results of the analysis are presented. Significant differences between the groups were found for all three types of IM (to know, to accomplish and to experience stimulation), while such differences were not detected for any type of EM. However, with alpha correction for multiple ANOVAs (Bonferroni correction with acceptable statistical significance at $p < .025$), only IM – to know remains statistically significant. The results of Scheffe post-hoc comparisons showed that the participants who would attend the programme even if it was not obligatory manifested significantly higher IM to know, compared to those who would not attend the programme ($p = .009$) or to those who are not sure if they would ($p = .041$).

Table 3. Univariate ANOVAs for intrinsic and extrinsic motivation relative to the readiness of the participants to join the training programme regardless of legislation

| Type of motivation | <i>F</i> | <i>df</i> ₁ | <i>df</i> ₂ | <i>p</i> | η^2 |
|--------------------------|----------|------------------------|------------------------|----------|----------|
| IM – to know | 7.02 | 2 | 96 | .001 | .128 |
| IM – to accomplish | 3.71 | 2 | 96 | .028 | .072 |
| IM – to exp. stimulation | 3.51 | 2 | 96 | .034 | .068 |
| EM – identified | 1.41 | 2 | 96 | .249 | .029 |
| EM – introjected | 1.18 | 2 | 96 | .310 | .024 |
| EM – external regulation | 0.14 | 2 | 96 | .865 | .003 |

Note: IM – intrinsic motivation, EM – extrinsic motivation, to exp. stimulation – to experience stimulation.

Furthermore, we asked the participants: "What do you expect to gain from this programme?", and they could answer with the following options: knowledge and skills ($n = 39$) / certificate ($n = 20$) / both ($n = 41$). We were interested in exploring if there were any statistically significant differences in various aspects of IM and EM between those who answered the question differently. As Box's test showed equality of covariance matrices across groups ($p = .151$), and Levene's test showed that the error variance for all dependent variables is equal across groups, one-way MANOVA was conducted. The multivariate test resulted in a statistically significant model, $F(12, 182) = 3.04$, $p = .001$, Wilks' $\Lambda = .694$, $\eta^2 = .17$. In Table 4, the results of univariate comparisons for different types of IM and EM are shown. After taking into account the Bonferroni correction (with acceptable statistical significance at $p < .025$), we can see that statistically significant differences were detected for all types of IM (to know, to accomplish and to experience stimulation), as well as for EM

– identified. For EM – introjected and external regulation, no such differences were found. The results of the post-hoc comparisons revealed that those participants who only joined the programme in order to gain the certificate have significantly lower levels of IM to know, compared to those who expected knowledge and skills ($p = .001$) or both ($p < .001$). The same trend continues for IM to accomplish and to experience stimulation. The post-hoc test suggested that participants who joined the programme only expecting a certificate manifested significantly lower levels of IM to accomplish in comparison with those who expected knowledge and skills ($p = .015$) or both ($p = .002$). Also, the participants who only wanted a certificate had significantly lower levels of IM to experience stimulation in comparison with those who expected knowledge and skills ($p = .001$) or both ($p < .001$). Finally, the post-hoc test showed that participants who expected only a certificate have significantly lower levels of EM – identified, compared to those who expected both knowledge and skills and a certificate ($p = .010$).

Table 4. Univariate ANOVAs for intrinsic and extrinsic motivation relative to expectations from the programme

| Type of motivation | <i>F</i> | <i>df</i> ₁ | <i>df</i> ₂ | <i>p</i> | ηp^2 |
|--------------------------|----------|------------------------|------------------------|----------|------------|
| IM – to know | 13.13 | 2 | 96 | .000 | .215 |
| IM – to accomplish | 7.00 | 2 | 96 | .001 | .127 |
| IM – to exp. stimulation | 14.43 | 2 | 96 | .000 | .231 |
| EM – identified | 4.88 | 2 | 96 | .010 | .092 |
| EM – introjected | 2.78 | 2 | 96 | .067 | .055 |
| EM – external regulation | 0.37 | 2 | 96 | .692 | .008 |

Note: IM – intrinsic motivation, EM – extrinsic motivation, to exp. stimulation – to experience stimulation.

We did not find significant differences in any IM or EM scales concerning gender, education or the phase of the programme in which the participants were at the time of the study.

DISCUSSION AND CONCLUSION

The main goal of our study was to explore the motivation of participants enrolled in an NFE for sports experts in Serbia. Our results showed that the younger the participants in the NFE programme are, the more IM (to know and to experience stimulation) and EM (regulation through identification) they will manifest. This result is in line with studies showing academic IM tends to decline with age (Gottfried et al., 2001; Lepper et al., 2005; Newman, 1990). However, there are also conflicting findings indicating that work-related IM might increase with age, while EM may decrease (de Lange et al., 2011; Kooij et

al., 2011). Yet, it may be that our results are specific to the population of sports experts, where age still plays an important role due to the necessary connection with physical agility.

Our results also imply that those participants who would attend the programme even if it was not mandatory manifest significantly higher IM – to know, compared to those who were unwilling to attend or were unsure. This result suggests that those individuals who enrolled in NFE programmes simply because they were obliged to acquire a certificate (or were unsure about their goals) had significantly less IM to acquire knowledge, compared to those experts who would enrol in the programme regardless of law requirements. Our finding follows the notions of other authors – that those individuals who are willing to engage in activities that promote life-long learning tend to have more IM (Crow, 2006).

Furthermore, those participants who expected to gain only a certificate from this programme, instead of knowledge and skills or both, do not only have less IM – to know, to accomplish and to experience stimulation, but also extrinsically, in terms of EM – identified. Those who expected to gain both knowledge and skills, and a certificate have shown to be the most intrinsically motivated – they attended this programme due to curiosity, the need to know and understand, but also to engage themselves in challenging activities and to experience sensory pleasure and excitement. It is interesting to note that those same experts had EM as well – in terms that former extrinsic reasons become internalised (they identified with the importance of additional education), which further creates the need to participate in an NFE programme in order to foster personal growth and development (Pelletier et al., 1995). Our findings showed that sports experts strive for professional achievement even after their own sports careers. For those who are ready to attend the professional development programme regardless of the legal obligation, it is possible to assume that the former IM for directly engaging in sports, has transformed over time into the IM for helping other people to assert themselves as athletes, to achieve successful performances and good sports results. In other words, it seems that for such sports experts, the former motivation for doing sports has moved towards the transfer of knowledge and skills to new generations, which represents the next level of self-realisation for sports experts. Therefore, there is room for affirmation of IM by promoting the importance and value of the role that coaches and mentors have in sports, as well as the need for their professional growth and development. Educators are advised to assess the motivation of trainees and adjust teaching methods accordingly, aiming to help them reach the level where their learning becomes internally regulated, which would provide skilful and competent sports experts.

Ultimately, it is essential to mention the limitations of this study, such as lower reliability of certain subscales that we used, as well as a relatively small sample size and the cross-sectional study design.

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REFERENCES

1. Bokanović, K. (2016). Informal learning in formal NCCP Coach Education. [Unpublished master's thesis]. Memorial University of Newfoundland.
2. Crow, S. (2006). What motivates a lifelong learner? *School Libraries Worldwide*, 12(1), 22–34. <https://doi.org/10.29173/slww6976>
3. Cushion, C. J., Nelson, L., Armour, K., Lyle, J., Jones, R. L., Sandford, R., & O'Callaghan, C. (2010). Coach learning and development: A review of literature. <https://www.researchgate.net/publication/265566741>
4. De Lange, A. H., Bal, P. M., Van der Heiden, B. I. J. M., de Jong, N., & Schaufeli, W. B. (2011). When I'm 64: Psychological contract breach, work motivation and the moderating roles of future time perspective and regulatory focus. *Work & Stress*, 25(4), 338–354. doi:10.1080/02678373.2011.632610
5. Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: A longitudinal study. *Journal of Educational Psychology*, 93(1), 3–13. doi:10.1037//0022-0663.93.1.3
6. Hannays, K. A. (2020). Attitudes of tennis coaches towards continuous education: A Caribbean perspective. *International Tennis Federation*, 80, 12–15. <https://doi.org/10.52383/itfcoaching.v28i80.62>
7. Hughes, B. J. (2005). Identifying attitudes and deterring factors towards continuing education among certified athletic trainers. *The Internet Journal of Allied Health Sciences and Practice*, 3(1), 1–12. <http://dx.doi.org/10.46743/1540-580X/2005.1059>
8. Kooij, D. T. A. M., de Lange, A. H., Jansen, P. G. W., Kanfer, R., & Dijkers, J. S. E. (2011). Age and work-related motives: Results of a meta-analysis. *Journal of Organizational Behavior*, 32, 197–225. doi:10.1002/job.665
9. Kubayi, A., Coopoo, Y., & Morris-Eyton, H. (2016). Coaches' preferences for continuing coaching education in South Africa. *Journal of Human Kinetics*, 50, 229–234. <https://doi.org/10.1515/hukin-2015-0160>
10. Lepper, M. R., Corpus, J. H., & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology*, 97(2), 184–196. doi:10.1037/0022-0663.97.2.184
11. Zakon o sportu [Law on Sports]. Sl. Glasnik RS § 10 (2016). https://www.paragraf.rs/propisi/zakon_o_sportu.html
12. Mesquita, I., Isidoro, S., & Rosado, A. (2010). Portuguese coaches' perceptions of and references for knowledge sources related to their professional background. *Journal of Sports Science and Medicine*, 9, 480–489.
13. Newman, R. S. (1990). Children's help-seeking in the classroom: The role of motivational factors and attitudes. *Journal of Educational Psychology*, 82(1), 71–80. <https://doi.org/10.1037/0022-0663.82.1.71>
14. Nešić, B., & Nešić, M. (2020). Mogućnosti primene SIPOC modela u upravljanju sportskim organizacijama [Possibilities of SIPOC model application in management of sports organisations]. *Poslovna ekonomija*, 14(2), 38–51. <http://dx.doi.org/10.5937%2Fposeko13-15838>
15. Pelletier, L. G., Fortier, M. S., Vallerand, R. J., Tuson, K. M., Brière, N. M., & Blais, M. R. (1995). Toward a new measure of intrinsic motivation, extrinsic motivation, and amotivation in sports: The Sport Motivation Scale (SMS). *Journal of Sport & Exercise Psychology*, 17, 35–53. <https://doi.org/10.1123/jsep.17.1.35>
16. Perkins, P., & Hahn, A. (2020). Considerations and suggestions for design of a learning and development program for sport coaches. *Open Journal of Social Sciences*, 8(12), 457–509. <http://dx.doi.org/10.4236/jss.2020.812036>
17. Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54–67. <https://doi.org/10.1006/ceps.1999.1020>
18. Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th Ed.). Pearson Education.
19. Van der Merwe, C., Malan, D. D. J., & Willemse, Y. (2015). The state of teacher-coaches' sport-specific training, participation and coaching experience, mentor interaction and methods of continued education in sport coaching. *African Journal for Physical, Health Education, Recreation & Dance*, 21(3:1), 733.

20. Vargas-Tonsing, T. M. (2007). Coaches' preferences for continuing coaching education. *International Journal of Sports & Coaching*, 2(19), 25–36. <https://doi.org/10.1260/174795407780367186>

MOTIVACIJA POLAZNIKA PROGRAMA NEFORMALNOG OBRAZOVANJA ZA SPORTSKE STRUČNJAKE

SAŽETAK

Prije desetak godina, prema Zakonu o sportu, u Srbiji je sportsko osposobljavanje postalo obavezno za one koji žele da budu sportski profesionalci (npr. treneri), ali nemaju odgovarajuće formalno obrazovanje. Naš cilj u okviru ovog istraživanja je bio da ispitamo motivacione faktore kod 100 polaznika programa neformalnog obrazovanja sportskih stručnjaka u Srbiji. Rezultati sugerišu da su ljudi koji izjavljuju da bi upisali program neformalnog obrazovanja čak i kada ne bi postojala zakonska obaveza intrinzično motivisaniji za sticanje znanja u poređenju sa onima koji su se izjasnili da se ne bi upisali na program da nije zakona i od onih koji su bili neodlučni po ovom pitanju. Naši nalazi takođe ukazuju da su osobe koje su se upisale samo zbog sertifikata manje intrinzično motivisane (da saznaju, da postignu nešto novo i dožive stimulaciju poput zadovoljstva) i manje ekstrinzično motivisane (ovo se odnosi na oblik ekstrinzične motivacije koji se naziva regulacija kroz identifikaciju). Pored toga, naši nalazi sugerišu da neki oblici unutrašnje motivacije (za saznanjem i doživljavanjem stimulacije) i ekstrinzične motivacije (regulacija kroz identifikaciju) imaju tendenciju da opadaju sa godinama.

Ključne riječi: sportski treneri, neformalno obrazovanje, intrinzična motivacija, ekstrinzična motivacija

Correspondence to: Ivana Novakov
Faculty of Sport and Psychology, Educons University, Novi Sad, Serbia
E-mail: ivana.novakov@tims.edu.rs

THE EFFECT OF IN-SEASON 2V2 SMALL-SIDED GAMES TRAINING ON LINEAR SPEED AND CHANGE OF DIRECTION SPEED IN YOUNG SOCCER PLAYERS

Aziz Souilah¹, Oussama Kessouri²

1. Laboratory of the Multiple Research Program in Sports Science and Human Movement, Institute of Sciences and Techniques of Physical and sports activities, University of Tissemsilt, Algeria
 2. Department of Sciences and Techniques of Physical and sports activities, Faculty of Human and social sciences, University of Jijel, Algeria
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ABSTRACT

Small-sided games (SSG) are one of the most recent training methods that have gained widespread popularity in both youth and adult soccer, given their similarity of performance to actual match scenarios. This study aimed to find out the effect of in-season SSG training programme in the 2v2 format on linear and change of direction speed in U15 young soccer players. For this purpose, a one-group pre-test and post-test design was employed on a sample of 16 players (age: 14.68 ± 0.47 years, height: 165.81 ± 4.44 cm and weight: 56.12 ± 4.39 kg). The 20m test and zigzag test were used to collect data, and after statistical processing using the SPSS program, statistically significant differences were obtained for both linear and change of direction speed ($p < 0.001$). In conclusion, the use of SSG method in the 2v2 format is effective in developing both the linear and change of direction speed among young soccer players. Therefore, the researchers recommend the necessity of utilising this form of SSG for the development of linear speed and change of direction speed.

Keywords: small-sided games, linear speed, change of direction speed, soccer

INTRODUCTION

From a general perspective, soccer is considered one of the most popular team sports and widespread in many countries around the world due to the high level of public and official interest it involves. It is considered one of the easiest sports to practice and train based on skill-creativity.

From a specific perspective, soccer is an intermittent team sport that requires high-intensity activities and movements throughout the 90-minute match, which Reche-Soto et al. (2019) confirmed, stating that it is a team sport characterised by intermittent high-intensity efforts during matches, where repeated fast running, rapid acceleration or deceleration and change of directions, jumping, kicking, tackles, and interventions are continuously implemented with incomplete rest. These movements and skills are dynamic and unpredictable with varying intensities and durations during competition.

During 90-minute soccer matches at the elite level, players run approximately 10 kilometres at an intensity close to the anaerobic threshold (80-90% of maximum heart rate), and within the context of this endurance over 90 minutes, there is a need for many explosive activities, including jumping, kicking, tackling, changing direction, sprinting, and maintaining strong contractions to maintain balance and control the ball against defensive pressure (Stølen et al., 2005). Of course, this is only achieved through proper planning of training programmes based on scientific foundations on the one hand and the coach's experience in applying them on the other hand, as well as the degree of good physical preparation of players.

The ability of soccer players to produce varied powerful and explosive actions, such as sprinting, jumping, tackling, kicking, and rapid changes of direction, greatly affects soccer match performance (Meylan et al., 2009), which with the ability to repeat these explosive activities are an important determinant of player performance during soccer matches (Strøyer et al., 2004).

The soccer game intersperses short-term high-intensity activities, for example, sprinting distances ranging from 10 to 20 metres, as well as high-intensity procedures, such as counterattacks with low to moderate intensity activities (walking and light running) (Di Salvo et al., 2007; Barros et al., 2009).

The total distance covered by soccer players during a match is somewhat a superficial way to evaluate the game. Therefore, the comprehensive analysis of the game should take into consideration the number and repetition of sprints and other maximum-intensity activities below the maximum threshold performed by players during the match (Andrzejewski et al., 2013).

The player's ability to perform high-intensity movements over short distances can be linked to the common demands of soccer, such as competing for the ball in one-on-one situations, because many of these actions occur over distances of less than 10 square metres. In this context, the ability to accelerate may be an important factor in successfully confronting players when gaining possession of the ball, dealing with players during defence and gaining the ball first in one-on-one competitions (Mara et al., 2017).

In addition, in many sports, especially soccer, players are required to accelerate, decelerate and change direction throughout the duration of play in matches (Çınarlı et al., 2018). They are required to accelerate from a standing start (i.e., linear acceleration) and immediately after rapid changes of direction (i.e., change-of-direction, acceleration) (Hewit et al., 2013). In modern soccer, coaches or strength and conditioning coaches usually make sure that players who have higher acceleration rates are able to accelerate, decelerate and reaccelerate faster when changing direction (Loturco et al., 2019).

Linear sprint speed and change of direction speed (rapidly changing direction) are important attributes in soccer, where maximum linear sprints typically occur every 90 seconds and each lasts between 2-4 seconds (Stølen et al., 2005). Faude et al. (2012) reported that in approximately 83% of cases during a soccer match, linear running is the most common action preceding a goal, followed by jumping actions and rapid changes of direction manoeuvres. They also confirmed that straight-line sprints in soccer are predominantly performed with the ball.

According to Joo (2018), high-speed motions in soccer require acceleration skills, maximum speed and agility, while Chapman et al. (2008) described speed in soccer as consisting of running speed, reaction speed and acceleration speed.

In recent years, training methods have evolved from conditioning exercises without the ball that develop physical capacities to new styles and exercises that can simultaneously improve physical capacities alongside the technical and tactical skills required for modern soccer matches (Sarmiento et al., 2018).

In this context, SSG are considered one of the most common training exercises used by coaches in soccer training. While SSG groups were primarily used in the past to improve player interaction and to develop technical and tactical capacities, they are now used by many amateur and professional teams as an effective tool for physical training (Halouani et al., 2014).

While SSG truly offer benefits and a tremendous opportunity to improve team play quality, proper application requires careful consideration to achieve the head coach's primary goals. Specifically, SSG must be tailored to the objective at hand with consideration for each team's physical, technical and tactical levels (Clemente et al., 2012). SSG also provide additional solutions for coaches to develop various aerobic and anaerobic physical attributes required in modern soccer. Therefore, the aim of this study was to determine whether

2v2 SSG training has an impact on linear speed and change of direction speed among young soccer players.

MATERIALS AND METHOD

Participants

Sixteen voluntary young players from U15 team of CS Ouled Rabah, Algerian amateur soccer club, participated in the study (age: 14.68 ± 0.47 years, height: 165.81 ± 4.44 cm and weight: 56.12 ± 4.39 kg). After explaining the experiment and potential risks to the players and their guardians, written informed consent was obtained from all participants for their involvement. This study followed the principles outlined in the Helsinki Declaration (World Medical Association, 2013).

Study design

The study aimed to examine the effects of SSG training on the linear speed and change of direction speed in young soccer players. To achieve this objective, a one-group pre-test and post-test design was employed. This design involved a single experimental group, and measurements were taken both before and after the SSG training intervention (Figure 1). The participants' linear speed was evaluated using the 20m test, while their change of direction speed was assessed using the zigzag test. Researchers chose this one-group pre-test and post-test design due to the team's training regimen, which involved two sessions per week encompassing the proposed SSG training programme alongside low-intensity tactical training. The experimental phase took place during the competition period, specifically in the second phase following the winter break for the 2022/2023 season. This timing was chosen to capture the potential impact of the SSG training in a competitive context.

Figure 1. Experimental design



Data collection

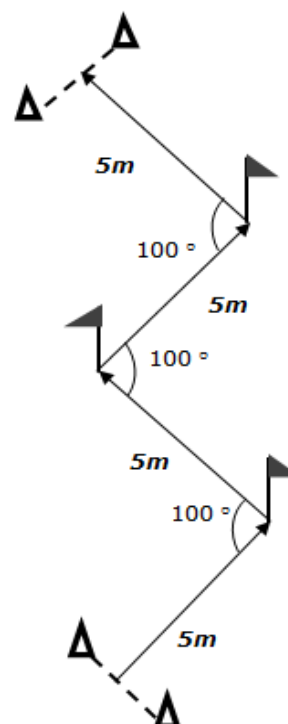
Linear speed 20m test

The test aims to measure the linear speed of soccer players. It is characterised by its validity and reliability in measuring speed in soccer (Altmann et al., 2019). The player covers a distance of 20 metres at the maximum possible speed after starting from a standing position behind the starting line, with a distance of approximately 0.5 metres (Şahin et al., 2020). After a sufficient rest period, the test is repeated, and the best attempt is recorded.

Change of direction speed zigzag test

The test aims to measure change of direction ability in soccer players. This test involves covering a distance of 20 metres with rapid running at the maximum possible speed and in the shortest possible time. This distance is divided into four curved sections of 5 metres each, and it includes 3 directional changes at specific angles of 100° . Before the starting signal is given, the player stands behind the starting line at a distance of 0.3 metres (Little & Williams, 2005). Players are allowed a maximum of two attempts, and the best attempt is recorded. The test was selected based on the results of the study by Mirkov et al. (2008), which showed that it is highly reliable ($r = 0.84$). Figure 2 provides a more illustrative depiction of the test's execution protocol:

Figure 2. A schematic presentation of the Zig-zag COD speed test



Intervention

The proposed training programme was implemented for 8 weeks, with a frequency of two sessions per week, totalling 16 training sessions. This was carried out during the return phase of the competition. The training objectives for the majority of sessions were predominantly “anaerobic,” with a gradual increase

in volume and intensity over the first five weeks. Following this, there was a sudden increment in training load during the sixth week, referred to as a “Surprise training cycle”. The seventh and eighth weeks were designed for recovery, with a reduction in volume and intensity to ensure better physical readiness for the players, and thus enhanced performance during subsequent physical assessments. Table 1 shows more details about the training programme.

Table 1. Characteristics of the proposed SSG training programme

| Week | Perceived RPE (1-10) | Number of players | Repetitions | Dimensions | Rest between sets | Type of rest |
|------|----------------------|-------------------|-------------|------------|-------------------|--------------|
| 1 | 6 | 2 v 2 | 6 × 2' | 10 × 15 | 1' 30'' | Passive |
| 2 | 7 | 2 v 2 | 8 × 1'30'' | 10 × 15 | 1' | Passive |
| 3 | 8 | 2 v 2 | 6 × 2' | 15 × 20 | 2' | Passive |
| 4 | 8 | 2 v 2 | 8 × 1'30'' | 15 × 20 | 2' | Passive |
| 5 | 8 | 2 v 2 | 6 × 2' | 20 × 25 | 2' | Passive |
| 6 | 9 | 2 v 2 | 8 × 2' | 15 × 20 | 1' | Passive |
| 7 | 7 | 2 v 2 | 6 × 2' | 10 × 15 | 1' 30'' | Passive |
| 8 | 6 | 2 v 2 | 8 × 1' | 15 × 20 | 2' | Passive |

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). All reported values are presented as mean ± standard deviation (SD). Paired-samples t-tests

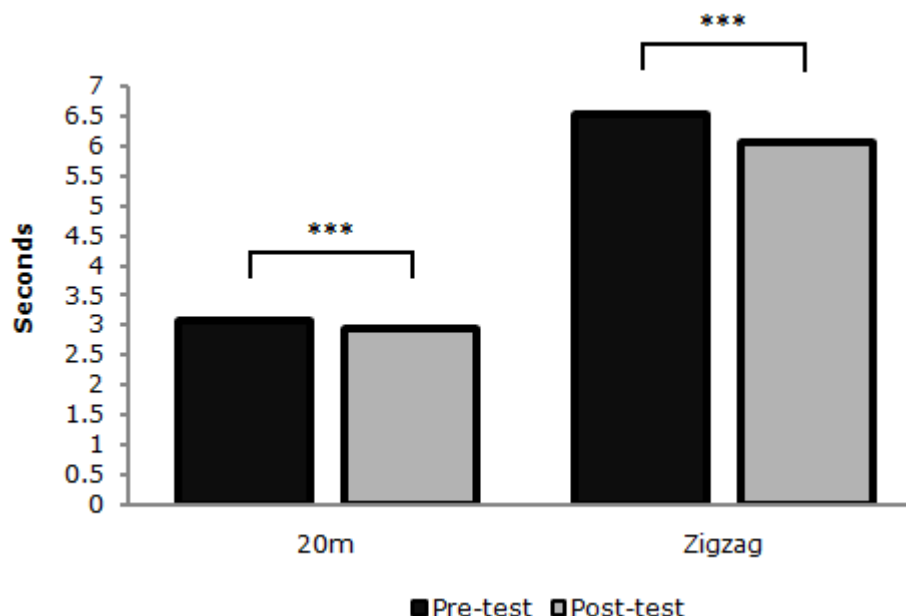
were employed to assess the significance of changes in linear and change of direction speed following the SSG training intervention. Significance level was considered $p \leq 0.05$. The percentage change for each variable was determined using the formula: $[(\text{Mean Post-test} - \text{Mean Pre-test}) / \text{Mean Pre-test}] \times 100$.

RESULTS

Table 2. Results of pre-tests and post-tests of linear and change of directions speed attributes

| Tests | Pre-test | Post-test | T | %Δ | P-value |
|------------|-------------|-------------|------|--------|----------|
| 20m (s) | 3.09 ± 0.07 | 2.94 ± 0.08 | 6.89 | - 4.85 | 0.000*** |
| Zigzag (s) | 6.54 ± 0.34 | 6.05 ± 0.14 | 6.22 | - 7.49 | 0.000*** |

*** $p < 0.001$

Figure 3. Change in means between pre-tests and post-tests of linear and change of direction attributes

For 20m linear speed, the results presented in Table 2 and Figure 3 indicate decrease in the mean completion time from 3.09 seconds (± 0.07) in the pre-test to 2.94 seconds (± 0.08) in the post-test, representing a reduction of approximately 4.85% ($t = 6.89$, $p < 0.001$).

Similarly, in the zigzag test, participants demonstrated a progress, with the mean completion time decreasing from 6.54 seconds (± 0.34) in the pre-test to 6.05 seconds

(± 0.14) in the post-test, signifying a substantial decrease of approximately 7.49% ($t = 6.22$, $p < 0.001$).

The p-values obtained from the paired t-tests confirmed the statistical significance of these improvements ($p < 0.001$), underscoring the efficacy of the 2v2 SSG training programme in enhancing both linear speed and change of direction speed.

DISCUSSION

This study aimed to investigate the impact of in-season SSG (2v2) on linear speed and change of direction speed among young soccer players. The main results indicated an improvement in these two attributes after implementing an eight-week training programme. As evident from Table 2 and Figure 3, the applied training programme utilising the SSG method in the 2v2 format yielded statistically significant differences between the pre-test and post-test results for the linear sprint test and change of direction speed test for the experimental sample. The researchers attributed this to SSG played with fewer players (2v2) in large spaces, providing more room for players while encouraging numerous accelerations and changes of direction performed over short distances less than 20m. In this context, Santos et al. (2021) found that in 1v1 small-sided games, U15 youth players engage in various maximum speeds, accelerations and explosive actions, and these actions consistently increase with the size of the field. This study aligns with numerous studies, prominently Arumugam's research confirming SSG training exhibited notable speed improvement, compared to the control group without SSG training (Arumugam, 2016). These results can be

reinforced by what Katis and Kellis (2009) mentioned - that reasons for including SSG in soccer training are they provide more space allowing players creativity and increased movements. This is the case for SSG exercises aiming to develop speed performed with fewer players in large areas permitting maximum speed efforts, decelerations, and directional changes. This confirms the effectiveness of SSG in impacting this attribute. The current study's results also agree with Dellal et al. (2012), finding that both SSG and high-intensity intermittent training interventions were equally effective in developing amateur soccer players' ability to perform intermittent runs with directional changes. This was validated by Young and Rogers (2014), who determined SSG effectively developed change of direction speed and planned interactive agility as measured via the Planned-AFL test. As concluded by Arslan et al. (2020), 2v2 SSG training may prove a more effective method for developing agility in soccer players. Additionally, improvements in linear speed are likely associated with enhanced change of direction performance due to the established correlation between these two attributes (Zhang et al., 2022). Given that acceleration improvement, which is a part of change of direction speed (Sheppard, & Young, 2006; Young et al., 2022), it may also contribute to the improvement of change of direction speed.

The current study has several limitations. The use of a one-group pre-test and post-test design without a control group for comparison restricts the ability to establish causal relationships and determine whether the observed changes are solely attributed to the intervention or could be influenced by other factors.

CONCLUSION

In conclusion, through our study which aimed to investigate the effect of training using SSG in the 2v2 format in developing linear speed and change of direction speed for under-15 soccer players, the results gathered during conducting the field research showed a statistically significant improvement in both linear speed and change of direction speed for

young soccer players. This indicates that the proposed training method is highly effective in developing both linear speed and the speed of changing direction by using the 2v2 SSG format with gradual increases in workload by controlling some variables during the games. Therefore, we recommend the necessity of relying on this form of SSG in developing the aforementioned physical variables, in addition to relying on some playing rules (especially playing space) that will help achieve the intended goal.

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REFERENCES

1. Altmann, S., Ringhof, S., Neumann, R., Woll, A., & Rumpf, M. C. (2019). Validity and reliability of speed tests used in soccer: A systematic review. *PloS one*, 14(8), e0220982. <https://doi.org/10.1371/journal.pone.0220982>
2. Andrzejewski, M., Chmura, J., Pluta, B., Strzelczyk, R., & Kasprzak, A. (2013). Analysis of sprinting activities of professional soccer players. *Journal of strength and conditioning research*, 27(8), 2134–2140. <https://doi.org/10.1519/JSC.0b013e318279423e>
3. Arslan, E., Orer, G. E., & Clemente, F. M. (2020). Running-based high-intensity interval training vs. small-sided game training programs: effects on the physical performance, psychophysiological responses and technical skills in young soccer players. *Biology of sport*, 37(2), 165–173. <https://doi.org/10.5114/biolsport.2020.94237>
4. Barros, R. M., Misuta, M. S., Menezes, R. P., Figueroa, P. J., Moura, F. A., Cunha, S. A., Anido, R., & Leite, N. J. (2007). Analysis of the distances covered by first division Brazilian soccer players obtained with an automatic tracking method. *Journal of sports science & medicine*, 6(2), 233–242.
5. Chapman, S., Derse, E., & Hansen, J. (2008). Soccer coaching manual. LA84 Foundation.
6. Çınarlı, F. S., Şahin Kafkas, A., & Kafkas, M. E. (2018). Relationship between linear running and change of direction performances of male soccer players. *Turkish Journal of Sport and Exercise*, 20(2), 93–99. doi: 10.15314/tsed.418840
7. Clemente, F. M., Couceiro, M.S., Martins, F. M., & Mendes, R. S. (2012). The usefulness of small-sided games on soccer training. *Journal of physical education and sport*, 12, 93.
8. Dellal, A., Varliette, C., Owen, A., Chirico, E. N., & Pialoux, V. (2012). Small-sided games versus interval training in amateur soccer players: effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction. *Journal of strength and conditioning research*, 26(10), 2712–2720. <https://doi.org/10.1519/JSC.0b013e31824294c4>
9. Di Salvo, V., Baron, R., Tschann, H., Calderon Montero, F. J., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International journal of sports medicine*, 28(3), 222–227. <https://doi.org/10.1055/s-2006-924294>
10. Faude, O., Koch, T., & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *Journal of sports sciences*, 30(7), 625–631. <https://doi.org/10.1080/02640414.2012.665940>
11. Halouani, J., Chtourou, H., Gabbett, T., Chaouachi, A., & Chamari, K. (2014). Small-sided games in team sports training: a brief review. *Journal of strength and conditioning research*, 28(12), 3594–3618. <https://doi.org/10.1519/JSC.0000000000000564>
12. Hewitt, J. K., Cronin, J. B., & Hume, P. A. (2013). Kinematic factors affecting fast and slow straight and change-of-direction acceleration times. *Journal of strength and conditioning research*, 27(1), 69–75. <https://doi.org/10.1519/JSC.0b013e31824f202d>
13. Joo, C. H. (2018). The effects of short term detraining and retraining on physical fitness in elite soccer players. *PloS one*, 13(5), e0196212. <https://doi.org/10.1371/journal.pone.0196212>

14. Katis, A., & Kellis, E. (2009). Effects of small-sided games on physical conditioning and performance in young soccer players. *Journal of sports science & medicine*, 8(3), 374–380.
15. Little, T., & Williams, A. G. (2005). Specificity of acceleration, maximum speed, and agility in professional soccer players. *Journal of strength and conditioning research*, 19(1), 76–78. <https://doi.org/10.1519/14253.1>
16. Loturco, I., A Pereira, L., T Freitas, T., E Alcaraz, P., Zanetti, V., Bishop, C., & Jeffreys, I. (2019). Maximum acceleration performance of professional soccer players in linear sprints: Is there a direct connection with change-of-direction ability? *PloS one*, 14(5), e0216806. <https://doi.org/10.1371/journal.pone.0216806>
17. Mara, J. K., Thompson, K. G., Pumpa, K. L., & Morgan, S. (2017). The acceleration and deceleration profiles of elite female soccer players during competitive matches. *Journal of science and medicine in sport*, 20(9), 867–872. <https://doi.org/10.1016/j.jsams.2016.12.078>
18. Meylan, C., & Malatesta, D. (2009). Effects of in-season plyometric training within soccer practice on explosive actions of young players. *Journal of strength and conditioning research*, 23(9), 2605–2613. <https://doi.org/10.1519/JSC.0b013e3181b1f330>
19. Mirkov, D., Nedeljkovic, A., Kukolj, M., Ugarkovic, D., & Jaric, S. (2008). Evaluation of the reliability of soccer-specific field tests. *Journal of strength and conditioning research*, 22(4), 1046–1050. <https://doi.org/10.1519/JSC.0b013e31816eb4af>
20. Reche-Soto, P., Cardona-Nieto, D., Diaz-Suarez, A., Bastida-Castillo, A., Gomez-Carmona, C., Garcia-Rubio, J., & Pino-Ortega, J. (2019). Player load and metabolic power dynamics as load quantifiers in soccer. *Journal of human kinetics*, 69, 259–269. <https://doi.org/10.2478/hukin-2018-0072>
21. Sahin, S., Yildirim, Y., & Yildirim, D. (2020). Relationship between reaction time agility and linear speed of amateur male soccer players. *International Journal of Physical Education, Fitness and Sports*, 9(2), 9-15. <https://doi.org/10.34256/ijpefs2022>
22. Santos, F. J. L. D., Ferreira, C. C., Figueiredo, T. P., & Espada, M. C. (2021). Influence of different 1v1 small-sided game conditions in internal and external load of U-15 and U-12 soccer players. *Trends in sport sciences*, 28(1), 45-53. 10.23829/TSS.2021.28.1-6.
23. Sarmiento, H., Clemente, F. M., Harper, L. D., da Costa, I. T., Owen, A., & Figueiredo, A. J. (2018). Small sided games in soccer – A systematic review. *International Journal of Performance Analysis in Sport*, 18(5), 693-749. doi: 10.1080/24748668.2018.1517288
24. Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of sports sciences*, 24(9), 919–932. <https://doi.org/10.1080/02640410500457109>
25. Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer: An update. *Sports medicine (Auckland, N.Z.)*, 35(6), 501–536. <https://doi.org/10.2165/00007256-200535060-00004>
26. Strøyer, J., Hansen, L., & Klausen, K. (2004). Physiological profile and activity pattern of young soccer players during match play. *Medicine and science in sports and exercise*, 36(1), 168–174. <https://doi.org/10.1249/01.MSS.0000106187.05259.96>
27. Subramani, A. (2016). Effect of small-sided games training on speed and agility among soccer players. *International Journal of Advance Research and Innovative Ideas in Education*, 1(2), 2395-4396.
28. World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA*, 310(20), 2191–2194. <https://doi.org/10.1001/jama.2013.281053>
29. Young, W. B., James, R., & Montgomery, I. (2002). Is muscle power related to running speed with changes of direction? *The Journal of sports medicine and physical fitness*, 42(3), 282–288.
30. Young, W., & Rogers, N. (2014). Effects of small-sided game and change-of-direction training on reactive agility and change-of-direction speed. *Journal of sports sciences*, 32(4), 307–314. <https://doi.org/10.1080/02640414.2013.823230>
31. Zhang, Q., Dellal, A., Chamari, K., Igonin, P. H., Martin, C., & Hautier, C. (2022). The influence of short sprint performance, acceleration, and deceleration mechanical properties on change of direction ability in soccer players - A cross-sectional study. *Frontiers in physiology*, 13, 1027811. <https://doi.org/10.3389/fphys.2022.1027811>

EFEKAT TRENINGA IGARA NA SKRAĆENOM PROSTORU U FORMATU 2:2 TOKOM TAKMIČARSKE SEZONE NA LINEARNU BRZINU I BRZINU PROMJENE SMJERA KRETANJA KOD MLADIH FUDBALERA**SAŽETAK**

Igre na skraćenom prostoru (SSG) su jedna od posljednjih metoda treninga koje su stekle iznimnu popularnost u omladinskom i fudbalu odraslih osoba, a obzirom na njihovu sličnost sa igrom u stvarnom kontekstu utakmice. Ova studija nastoji utvrditi efekat programa SSG treninga u formatu 2:2 tokom takmičarske sezone na linearnu i brzinu promjene smjera kretanja kod U15 mladih fudbalera. U tu svrhu je upotrebljen dizajn pretestiranja i posttestiranja jedne grupe sa uzorkom od 16 igrača (dob: $14,68 \pm 0,47$ godina, visina: $165,81 \pm 4,44$ cm i težina: $56,12 \pm 4,39$ kg). Test trčanja na 20 metara i cik-cak test su korišteni za prikupljanje podataka, a nakon statističke obrade uz pomoć SPSS programa, statistički značajne razlike su dobijene i za linearnu i za brzinu promjene smjera kretanja ($p < 0,001$). Zaključuje se da je korištenje SSG metode u formatu 2:2 efikasno u razvoju linearne i brzine promjene smjera kretanja kod mladih fudbalera. Prema tome, istraživači ukazuju na potrebu korištenja ovog oblika SSG-a za razvoj linearne brzine i brzine promjene smjera kretanja.

Ključne riječi: igre na skraćenom prostoru, linearna brzina, brzina promjene smjera kretanja, fudbal

Correspondence to: Aziz Souilah

Laboratory of the Multiple Research Program in Sports Science and Human Movement, Institute of Sciences and Techniques of Physical and sports activities, University of Tissemsilt, Algeria

E-mail: souilah.aziz@univ-tissemsilt.dz

RELATIONS BETWEEN MORPHOLOGICAL CHARACTERISTICS, BODY STRUCTURE AND EXPLOSIVE POWER IN YOUNG BASKETBALL PLAYERS

Dženis Musa¹, Nijaz Skender¹, Nihad Selimović², Gordana Manić³

1. Faculty of Pedagogy, University of Bihać, Bosnia and Herzegovina
2. Faculty of Education, University of Travnik, Bosnia and Herzegovina
3. Faculty of Health, University of Sarajevo, Bosnia and Herzegovina

ABSTRACT

The research was carried out on a sample of 35 basketball players (age = 12-13 years \pm 0.56), all members of KK "Koš" from Sarajevo, with the aim of determining the relationship between morphological characteristics, body structure and explosive strength in cadet basketball players. 8 variables were applied in the area of morphological characteristics, 5 variables in the area of body structure and 3 variables of explosive power. By using the SPSS 23 package, we determined descriptive parameters, correlation findings and regression analysis. Correlation analysis showed a high correlation of morphological characteristics with the variables of explosive power, waist skinfold $-.334^*$, $-.335^*$ with depth jump, while in the case of body structure, only one variable FM $-.399^*$ showed a correlation. As can be seen from the results, there is a negative correlation, which means that the respondents who have increased values of the morphological characteristics of the type of fat tissue and fat in the body structure achieved weaker results.

Regression analysis of the entire predictor set of morphological variables and the criterion variable depth jump - DRJ explained 53% (R Square) of the common variability with the criterion variable, while the multiple correlation coefficient was .73, which represents a high value. The mentioned association is statistically significant at the .01 level (Sig \leq .03)

By analysing the influence of individual variables, it is possible to see that the biggest and statistically significant (Sig \leq .05) influence on the criterion variable is body height - AVIS ($-.637$) and abdominal skinfold - AKNS ($-.762$).

On the basis of the above, it can be concluded that the negative association of the abdominal skinfold and the FM fat mass is inversely related to success in explosive strength.

Keywords: morphological characteristics, body structure, explosive power, basketball

INTRODUCTION

Basketball is a popular recreational or competitive sport enjoyed by many people of all ages and skill levels (Ivanić, 1988; Skender, 2004; Tabaković, Skender & Turković, 2006; Čeleš, 2009; Bajrić, O., Smigalović, Bašinac, & Bajrić, S., 2012; Musa Dž. 2023). Research has shown that this sport can solve problems of physical development and certain forms of behaviour. However, for the future growth and success of basketball, it is of primary importance that a large number of young people are attracted to it. Interest in playing basketball should be encouraged among young people for several reasons. One of them is the attractiveness and interest of a large part of the world public in following and playing this sport. Through regression analysis, we determined the association of depth jump with the predictor set of morphological characteristics.

The modern basketball game, which is characterised by a high intensity of activity throughout practically all 40 minutes of the game, requires players to have a wide range of anthropological characteristics, especially morphological characteristics, basic and specific motor and functional abilities. It is almost impossible to isolate one that does not participate to some extent in the success of the game. Explosive type strength, for the needs of starting, fast and short sprint, maximum jump in defence and attack, energetically dominates during the activity.

In relation to these characteristics, the greatest attention is paid in the training process of conditioning basketball players, and it is also paid to the development of explosive and speed strength, agility, aerobic and anaerobic abilities. Current practice in researching the importance of explosive strength in different sports (Santos & Janeiro, 2008; Jazvin, Palić, Ademović, & Skender, 2021; Karalić, Skender, Selimović, & Ernest, 2020) clearly show this. Many researchers have proven the connection between morphological characteristics and body structure with different motor skills (Skender, 2004; Skender et al., 2022; Čolakhodžić et al., 2019).

Therefore, the aim of this research was to see the relationship between morphological characteristics, body structure and explosive strength in cadet basketball players at the age of 12 and 13.

RESEARCH METHODS

The sample of respondents:

The sample of respondents in this research was represented by 35 basketball players (age = 12.45 ± 0.56), members of KK "Koš" from Sarajevo. All respondents included in the research had to meet the following criteria:

- To have a minimum of 15 months of continuous training process,
- That they are physically healthy (no injuries in the last 3 months), and
- To have written parental consent for access to testing.

Sample variables:

The sample of variables for the purposes of this research consisted of standard and sophisticated measuring instruments for determining and assessing the anthropological status of the respondents in the following areas:

- The space of morphological characteristics,
- Body structure space, and
- The area of motor skills – explosive strength.

All variables were measured by standard procedure, in the morning at 10 o'clock, at a temperature of 24 degrees with sufficient light.

A total of eight (8) variables were used to assess morphological characteristics:

Body height (AVIS), body mass (AMAS), arm span (ARR), subscapular skinfold (AKNSS), subiliac skinfold (AKNS), tibial circumference (APOTK), femur circumference (ANATK), and biceps circumference (AOBIC). Morphological characteristics were measured using the Martin Anthropometer.

A total of five (5) variables were used to assess body structure.

Body mass index (BMI), fat free mass (FFM), fat mass (FM), muscle mass (MM), and body water (BW).

Body composition parameters were measured with a Tanita BC-420MA digital scale (Tanita BC 420 MA Segmental Body Composition Analyser, Tanita Corp., Tokyo, Japan). The protocol implies that, after an all-night fast, before the actual weighing, the subject drinks a glass of water and stands for ten minutes. The measurement protocol implemented in this way provides reliability and precision with an error of up to 3 percent (Jebb, Cole, Doman, Murgatroyd, & Prentice, 2000; Čolakhodžić, Skender, & Pistotnik, 2011). On the landing surface of the scale, there are electrodes (four plates) on which the subject stands barefoot and minimally dressed. The scale emits a direct current of low strength through the contact plates and measures the total amount of current resistance in the body, which is created by the passage of current through fat tissue.

Based on the installed software, previously measured data (body height) and uploaded measurements (years of age and sex), they obtained the values of body mass, the proportion of fat tissue, muscle tissue and lean body mass, and the amount of water in the body. Parameters are calculated according to formulas.

All parameters are recorded in absolute and relative values. The measurement result for body composition values was read with an accuracy of 0.1 kg and 0.1 percent.

Variables for assessment of motor skills - explosive power Squat jump with preparation - Countermovement Jump (CMJ), Squat jump with preparation - free arms - Countermovement jump - Free arms (CMJFA), Jump in depth - Drop Jump (DRJ).

Explosive power was measured with the Microgate "Optojump" device. It is a diagnostic device consisting of a transmission and reception tape. The transmitting laser beams constantly "communicate" with the beams on the receiving strip. The system detects any interruptions in communication between lanes and calculates their duration. This allows measurement of flight and re-contact times during jumps with an accuracy of 1/1000 of a second. Dedicated software makes it possible to achieve a number of parameters related to the athlete's performance with maximum accuracy and in real time. The instrumentation has no moving mechanical parts, which ensures accuracy and high reliability. In addition to providing numerical data, the instrumentation, thanks to small cameras which can be positioned as desired, additionally enables the recording of performed tests, which perfectly harmonises them with the measurement of the test.

This additionally ensures the verification of data and images resulting from more detailed video analysis. All data is stored in a database, which means that access to the data is always available and that comparisons of results between different athletes or the same athlete at different times can be performed (www.optojump.com; self-translation).

A detailed description of the tests and the method of

performing the tests was made according to the recommendation of the authors Mašić et al., 2020.

RESULTS

Using the SPSS 23 mathematical-statistical program, the basic measures of central tendency, variability and distribution of morphological characteristics, body structure, and explosive power were calculated. For each specific set of variables, for clarity and easier analysis, the values of the specified sets of variables were determined separately and presented in a table.

Central dispersive parameters of morphological characteristics, body structure and explosive power

Based on the analysis of Table 1, which shows the values of the dispersive parameters of the morphological characteristics in this research, we can conclude that everything points to a normal distribution of results for almost all manifest variables. The following parameters were calculated: minimum score, maximum score, arithmetic mean, standard deviation, variance, skewness, and kurtosis. Based on the minimum and maximum results, we see a big difference between these two measures, but they were slightly reflected in two variables, namely AVIS, body height, where the kurtosis is 2.81, and the other variable AKNS, the abdominal skinfold of 3.84. The variables body height (AVIS) and subscapular skinfold (AKNSS) have a more pronounced positive asymmetry of the roundness value (kurtosis), so it can be concluded that their distribution shape is leptokurtic.

Table 1. Central dispersive parameters of morphological characteristics

| | N | Min. | Max. | Mean | Std. Deviation | Variance | Skewness | Kurtosis |
|--------|----|------|------|-------|----------------|----------|----------|----------|
| AVIS | 35 | 1.66 | 2.15 | 1.86 | 0.09 | 0.01 | 0.54 | 2.81 |
| ARR | 35 | 1.68 | 2.07 | 1.87 | 0.09 | 0.01 | -0.13 | -0.08 |
| AMAS | 35 | 57.9 | 99.3 | 77.59 | 12.13 | 14.23 | -0.04 | -1.13 |
| AKNS | 35 | 0.6 | 3.2 | 1.56 | 0.66 | 0.44 | 0.72 | -0.01 |
| AKNSS | 35 | 0.62 | 2.71 | 1.11 | 0.44 | 0.19 | 1.78 | 3.84 |
| AOPOTK | 35 | 30.8 | 44.5 | 36.54 | 3.21 | 10.28 | 0.41 | -0.06 |
| AONATK | 35 | 40 | 57.6 | 49.20 | 4.76 | 22.63 | -0.23 | -0.59 |
| AONADL | 35 | 24.8 | 34.2 | 28.73 | 2.83 | 7.99 | 0.22 | -1.14 |

Looking at the morphological characteristics of the total analysed sample of basketball players, it can be concluded that their morphological profile is characterised by medium values, namely: physical, with a height of 1.86 m, body mass of 77.59 kg and an arm span of 1.87 m. Basketball players had the following skinfold values: subscapular skinfold – 1.56 cm; and suprailiac abdominal skin fold – 1.11 cm.

The respondents also had the following circumference values: lower leg circumference – 36.54 cm; upper leg circumference – 49.20 cm; and upper arm circumference – 28.73 cm.

All analysed body structure values (Table 5) have a minimal positive asymmetry and meet all criteria for access to further analysis.

Table 2. Central dispersive parameters of body structure

| | N | Min. | Max. | Mean | Std. Deviation | Variance | Skewness | Kurtosis |
|-----|----|-------|-------|-------|----------------|----------|----------|----------|
| BMI | 35 | 16.40 | 30.70 | 22.56 | 3.47 | 12.07 | 0.49 | -0.21 |
| FFM | 35 | 53.50 | 88.30 | 67.39 | 8.55 | 73.12 | 0.04 | -0.53 |
| FM | 35 | 3.80 | 24.00 | 10.41 | 5.78 | 33.38 | 0.98 | 0.01 |
| MM | 35 | 50.80 | 84.00 | 64.06 | 8.16 | 66.63 | 0.04 | -0.53 |
| BW | 35 | 39.20 | 61.30 | 49.08 | 5.93 | 35.22 | -0.14 | -0.93 |

The characteristics of the analysed sample of basketball players in relation to body structure are: body mass index - 22.56; lean mass – 67.39 kg; fat mass – 10.41 kg; muscle mass – 64.06 kg; and body water – 49.08 kg.

Within the table (Table 3), it is possible to see low values of positive asymmetry of the three analysed variables. It is possible to state that their form of distribution approaches leptokurtic, which indicates a slightly increased homogeneity of the results.

Table 3. Central dispersive parameters of explosive power

| | N | Min. | Max. | Mean | Std. Deviation | Variance | Skewness | Kurtosis |
|-------|----|-------|-------|-------|----------------|----------|----------|----------|
| CMJ | 35 | 24.20 | 43.40 | 33.16 | 4.27 | 18.25 | 0.34 | 0.43 |
| CMJFA | 35 | 27.90 | 53.10 | 38.33 | 6.49 | 42.07 | 0.22 | -0.01 |
| DRJ | 35 | 26.70 | 53.90 | 38.61 | 6.50 | 42.20 | 0.12 | 0.04 |

Characteristics of the analysed sample of cadet basketball players in relation to motor skills - explosive strength of the jumping type: CMJ - 33.16 cm; CMJ - free hands - 38.33 cm; and DRJ – 38.61 cm.

It is interesting here that the results achieved by the respondents for two variables, namely CMJFA and DRJ, have very similar values, even though they are two completely opposite tests in terms of performance structure, while for the CMJ variable, those results are much weaker, compared to these two tests. In the continuation of the analysis, we will see what kind of results we will get in other analyses provided for in this work.

Correlation analysis

The sets of variables of morphological characteristics, body structure and explosive strength of the entire sample of basketball players were subjected to intercorrelation analysis by determining the value of the Pearson product moment correlation coefficient in order to gain insight into the intensities and directions of mutual connection. Cross-correlation relationships between all analysed variables were also determined.

Table 4. Pearson correlation coefficients of morphological characteristics and explosive power variables

| | AVIS | AMAS | ARR | AKNSS | AKNS | AOPOTK | AONATK | AONADL | CMJ | CMJFREE | DRJ |
|---------|--------|--------|-------|-------|--------|--------|--------|--------|--------|---------|-----|
| AVIS | 1 | | | | | | | | | | |
| AMAS | .334* | 1 | | | | | | | | | |
| ARR | .842** | .365* | 1 | | | | | | | | |
| AKNS | .063 | .319 | .084 | 1 | | | | | | | |
| AKNSS | -.099 | .530** | -.213 | .219 | 1 | | | | | | |
| AOPOTK | .018 | .855** | .069 | .266 | .622** | 1 | | | | | |
| AONATK | -.045 | .841** | .031 | .380* | .474** | .839** | 1 | | | | |
| AONADL | -.048 | .765** | -.076 | .244 | .633** | .794** | .784** | 1 | | | |
| CMJ | .086 | -.104 | .259 | -.176 | -.334* | -.222 | -.156 | -.217 | 1 | | |
| CMJFREE | -.099 | -.186 | .112 | -.189 | -.335* | -.264 | -.205 | -.155 | .821** | 1 | |
| DRJ | -.148 | -.275 | .000 | -.299 | -.324 | -.406* | -.242 | -.225 | .729** | .847** | 1 |

The Pearson product moment values of the correlation coefficients of morphological characteristics and explosive power variables are shown in Table 4. In most cases, the values indicate very high correlation coefficients at the statistical significance level ($p < .05$). The high significance of the correlation coefficient is particularly pronounced in the case of variables belonging to the same set.

When it comes to correlations of explosive power variables and variables of morphological characteristics, it is possible to observe relatively low correlation coefficients.

When it comes to body composition variables and their relationship with jump-type explosive strength variables, it is possible to see their relationship within Table 5.

Table 5. Pearson correlation coefficients of body composition and explosive power variables

| | BMI | FFM | FM | MM | BW | CMJ | CMJFREE | DRJ |
|---------|--------|--------|--------|--------|-------|--------|---------|-----|
| BMI | 1 | | | | | | | |
| FFM | .556** | 1 | | | | | | |
| FM | .887** | .396* | 1 | | | | | |
| MM | .556** | .800** | .396* | 1 | | | | |
| BW | .564** | .891** | .442** | .871** | 1 | | | |
| CMJ | -.198 | -.011 | -.252 | -.011 | -.005 | 1 | | |
| CMJFREE | -.196 | -.116 | -.272 | -.115 | -.122 | .821** | 1 | |
| DRJ | -.255 | -.141 | -.399* | -.141 | -.157 | .729** | .847** | 1 |

Analysing the achieved results, it is possible to observe relatively low correlation values of body composition and variables of explosive power of the jump type. The correlation coefficient of fat mass and depth jump (FM with DRJ = $-.399$) is moderate and the only achieved correlation indicator. We determined the relationship between morphological characteristics and motor ability of the type of explosive power based on regression analysis.

Regression analysis of the entire predictor set of morphological variables and the criterion variable

squat jump with preparation - CMJ (Table 6) does not reveal enough information about the influence of applied morphological variables on the success of jumping.

The predictor set of variables explained only 34 percent (R Square) of the common variability with the criterion variable, while the connection of the entire predictor system of variables with the criterion (multiple correlation coefficient) was $.58$, which represents a moderate value, but not statistically significant, ($\text{Sig} \leq .135$) and will not be further analysed.

Table 6. Regression analysis of the predictor set of variables and criterion variable squat jump with preparation - CMJ

| Model | R | R Square | Adjusted R Square | Std. Error of Estimate | | |
|-------|-------------------|----------|-------------------|------------------------|--|--|
| 1 | .583 ^a | .340 | .145 | 3.95 | | |

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|------------|----------------|----|-------------|-------|-------------------|
| Regression | 217.293 | 8 | 27.162 | 1.740 | .135 ^b |
| Residual | 421.576 | 27 | 15.614 | | |
| Total | 638.869 | 35 | | | |

Through the regression analysis of the entire predictor set of morphological variables and the criterion variable depth jump - DRJ (Table 7), it is possible to see enough information about the influence of the applied morphological variables and body composition variables on the success of performing the jump. The predictor set of variables explained 53 percent (R Square) of the common variability with the criterion variable, while the connection of the entire predictor system of variables

with the criterion (multiple correlation coefficient) was $.73$, which represents a high value. The mentioned association is statistically significant at the $.01$ level ($\text{Sig} \leq .03$).

By analysing the influence of individual variables (Table 8), it is possible to observe, identically to the previous jump, the greatest and statistically significant ($\text{Sig} \leq .05$) influence on the criterion variable body height - AVIS ($-.637$) and abdominal skinfold - AKNS ($-.762$).

Table 7. Regression analysis of morphological variables and criterion variable depth jump - DRJ

| Model | R | R Square | Adjusted R Square | Std. Error of Estimate | |
|-------|-------------------|----------|-------------------|------------------------|--|
| 1 | .733 ^a | .537 | .400 | 5.03 | |

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|------------|----------------|----|-------------|-------|-------------------|
| Regression | 793.537 | 8 | 99.192 | 3.919 | .003 ^b |
| Residual | 683.379 | 27 | 25.310 | | |
| Total | 1476.916 | 35 | | | |

Table 8. Regression analysis of individual variables of the predictor set and criterion variable "jump into depth" - DRJ

| Model | Unstandardised Coefficients | | Standardised Coefficients | t | Sig. |
|--------|-----------------------------|------------|---------------------------|--------|------|
| | B | Std. Error | Beta | | |
| AVIS | -46.375 | 18.424 | -.637 | -2.517 | .018 |
| ARR | 12.935 | 19.512 | .183 | .663 | .513 |
| AMAS | .330 | .252 | .617 | 1.311 | .201 |
| AKNS | -7.469 | 2.240 | -.762 | -3.334 | .002 |
| AKNSS | -2.933 | 2.902 | -.199 | -1.011 | .321 |
| AOPOTK | -.841 | .705 | -.415 | -1.193 | .243 |
| AONATK | -.186 | .447 | -.136 | -.416 | .681 |
| AONADL | .892 | .631 | .388 | 1.414 | .169 |

DISCUSSION

The results obtained in this research are fully in line with the research of Šimonek et al. (2016) because they point to the fact that basketball coaches should monitor and follow the development of players, as that process is crucial for progress and achieving top results. The quality and key factor in the selection process is the morphology and body structure of basketball players of younger age groups.

The analysis of the obtained results shows moderate statistically significant associations between morphological characteristics and body composition with variables of explosive power of the jumping type. The obtained connections are especially visible in the morphological measure of the abdominal skinfold, which has achieved a negative correlation with all three analysed jumps (CMJ = -.334; CMJFree = -.335; DRJ = -.324), and the lower leg circumference variable with the depth jump - DRJ (-.406). The obtained values are negative, which means that they are inversely proportional, i.e., that smaller values of the mentioned parameters imply better results (higher jump) in the analysed vertical reflection tests. The obtained results are in accordance with previous studies (Clemente-Suarez et al., 2017; MacDonald et al., 2013); however, the correlations are somewhat lower, and the possible reason is the age of the respondents, given that they are relatively young basketball players who are in the process of biological growth and development. The obtained results differ in some parts from the research conducted by researchers in some previous studies (Nikolaidis et al. 2015; Ribeiro et al. 2015). However, the results obtained in this study do not differ from the results in the research by Coelho e Silva et al. (2008), given that the subjects in this study

jump only 0.34 cm less than their peers on average, and that their body structure (adipose tissue, lean tissue and the amount of water in the body) makes almost no difference. The stated results obtained by this research can be attributed to the age and level of competition in which the tested players participate. This research includes the players of one club in Bosnia and Herzegovina that competes at the cantonal level (Sarajevo Canton), while most previous research is based on representative selections or a larger number of clubs that compete on the international stage. Another explanation can be attributed to the specificity of the tested age, in which the trend of growth and development is particularly pronounced, described in specialised literature (Malina, 1990).

When it comes to the correlations of the morphological variables with the performance of the jump-type explosive strength tests, the obtained results indicated that body height and the abdominal skinfold have a statistically significant influence on the jump height in the squat jump with preparation (free hand) - CMJFree and the depth jump - DRJ. The obtained results are correlated with many previous studies (Sharma et al., 2017; Nikolaidis et al., 2015; Ribeiro et al. 2015). Given that the abdominal skinfold is one of the general predictors of subcutaneous fat, this result is not surprising.

Since previous studies have pointed to the importance of body fat, subcutaneous fat tissue, player height, arm span, as well as body circumference as some of the main components of elite basketball players (Vaquera et al., 2015), this study confirmed the stated facts. Previous research and analysis of the physical characteristics of basketball players indicate that physical measurements are of crucial importance for the general selection process and for the allocation

of player positions (Ben Abdelkrim et al., 2012). In modern basketball, the explosive power of the jump type is considered one of the key parameters for achieving success. During a basketball game, players demonstrate this ability through jump shots, offensive/defensive jumps, blocks, dunks, and basket layups.

It was Ackland et al. (1997) who determined that during a basketball game a player makes an average of 46 ± 12 jumps.

CONCLUSION

The variables abdominal skinfold - suprailiac AKNS, and fat mass - FM had a significant negative contribution in connection with the explosive power variable of the deep jump type, which speaks of specific contractions, especially when it comes to eccentric contraction, where the results show that increased mass has a negative effect on these contractions, which is reflected in the reduced manifestation of explosive power of this type. The proposal to coaches is to control these parameters with their young players in order to successfully manage the career of young basketball players.

REFERENCES

1. Ackland, T. R., Schreiner, A. B., & Kerr, D. A. (1997). Absolute size and proportionality characteristics of World Championship female basketball players. *Journal of Sports Sciences*, 15 (5), 485-490.
2. Bajrić, O., Šmigalović, M., Ismet Bašić, I., & Bajrić, S. (2012). Globalne kvantitativne promjene bazičnih i situaciono-motoričkih sposobnosti pod uticajem programa odbojke [Global quantitative changes of basic and situational-motor abilities under the influence of programmed volleyball practice]. *Sports Science and Health*, Vol. 2, Issue 1, 22-29.
3. Ben Abdelkrim, N., Chaouachi, A., Karim, C., Karim, C., Show, C., et al. (2010). Role and competitive-level differences in elite-level men's basketball players. *The Journal of Strength and Conditioning Research*, 24(5):1346-55.
4. Čeleš, N. (2009). Uticaj programiranog vježbanja na transformaciju morfoloških karakteristika, motoričkih sposobnosti i usvojenosti elemenata tehnike odbojke. Doctoral dissertation. Tuzla: Fakultet za tjelesni odgoj i sport.
5. Clemente-Suarez, V. J., Knechtle, B., & Kasabalis, S. (2017). Who jumps the highest? Anthropometric and physiological correlations of vertical jump in youth elite female volleyball players. *J. Sports Med. Phys. Fit*, 57, 802-810.
6. Čolakhodžić, E., Novaković, R., Džedović, D., Popo A., Korjenčić, A., Vuk, N., Habul, Č., Palić, A., & Ademović, A. (2020). Condition of children's obesity of elementary school children in Bosnia and Herzegovina: Case study Hercegovina - Neretva Canton. *International Journal of Fitness, Health, Physical Education & Iron Games*, Vol 6, No. 1, 1-13.
7. Čolakhodžić, E., Skender, N., & Pistotnik, B. (2011). The changes of body composition dimensionality among soccer players at the age period 12 to 14 years. *US-China Education Review*, A 5; 657- 665.
8. Ivanić, S. (1988). Kriterijumi za procenu fizičkog razvoja i fizičkih sposobnosti dece i omladine uzrasta od 7 – 19 godina (normativi) [Criteria for evaluation of physical development and physical abilities of children and adolescents aged 7 – 19 years (norms)]. Belgrade, RS: Gradska samoupravna interesna zajednica fizičke kulture Beograda.
9. Jazvin, A., Palić, A., Ademović, A., & Skender, N. (2021). Correlation between sprint, agility and vertical jump of elite soccer players. *Romania: Science, Movement and Health*, Vol. XXI, ISSUE 2 Supplement.
10. Karalić, A., Skender, N., Selimović, N., & Ernest, Š. (2020). Prediction of young volleyball players quantitative motor skills based on basic anthropological characteristics. *Researchgate: Sport science*.
11. MacDonald, C. J., Israel, M. A., Dabbs, N. C., Chander, H., Allen, C. R., Lamont, H. S., & Garner, J. C. (2013). Influence of body composition on selected jump performance measures in collegiate female athletes. *Journal of Trainology*, 2(2), 33-37.
12. Malina, R. M. (1990). Research on secular trends in auxology. *Anthropologischer Anzeiger*, 209-227.
13. Musa, Dž. (2023). Analiza odnosa morfoloških karakteristika, strukture tijela i eksplozivne snage kod košarkaša uzrasta 12 i 13 godina. Graduate paper, Master's thesis. Nastavnički fakultet Univerziteta "Džemal Bijedić" Mostar.
14. Nikolaidis, P. T., Asadi, A., Santos, E. J., Calleja-González, J., Padulo, J., Chtourou, H., & Zemkova, E. (2015). Relationship of body mass status with running and jumping performances in young basketball players. *Muscles, Ligaments and Tendons Journal*, 5(3), 187.

15. Ribeiro, B. G., Mota, H. R., Sampaio-Jorge, F., Morales, A. P., & Leite, T. C. (2015). Correlation between body composition and the performance of vertical jumps in basketball players. *J. Exerc. Physiol. Online*, 18, 69-79.
16. Sharma, H. B., Gandhi, S., Meitei, K. K., Dvivedi, J., & Dvivedi, S. (2017). Anthropometric basis of vertical jump performance: A study in young Indian national players. *Journal of Clinical and Diagnostic Research, JCDR*, 11(2), CC01.
17. Skender N., Šabić E., Selimović, N., Kurtović N., & Karalić, T. (2022). Analysis of differences in morphological characteristics based on the level of functional ability in students of the University of Bihać. *Sport Science*, 15(1):97-103.
18. Skender, N. (2004). Transformacioni procesi motoričkih sposobnosti i morfoloških karakteristika pod uticajem sedmomjesečnog tretmana kod učenika 3. i 4. razreda osnovne škole. Unpublished doctoral dissertation. Sarajevo: Fakultet sporta i tjelesnog odgoja Univerziteta u Sarajevu.
19. Skender, N. (2008). Transformacioni procesi antropoloških obilježja. Bihać: Univerzitet u Bihaću, Pedagoški fakultet.
20. Šimonek, J. (2016). The effect of intervention on the changes of coordination factors in the youth sports preparation. *Sport Science*, 9(2), 77-81.
21. Tabaković, M., Skender, N. & Turković, S. (2006). Kvantitativne razlike motoričkih sposobnosti učenika nižih razreda osnovne škole poslije realizacije određenih programa. *Homosporticus*, Godina 9. br 2, 44-50. Sarajevo.
22. Vaquera, A., Santiago, S., Villa, H. G., & Vicente J. (2015). Anthropometric characteristics of Spanish professional basketball players. *Journal of Human Kinetics*, 462015(46):99-106.

RELACIJE MORFOLOŠKIH KARAKTERISTIKA, STRUKTURE TIJELA I EKSPLOZIVNE SNAGE KOD MLADIH KOŠARKAŠA

SAŽETAK

Na uzorku od 35 košarkaša (starosti = 12 do 13 godina \pm 0.56), članova KK "Koš" iz Sarajeva, izvršeno je istraživanje s ciljem utvrđivanja odnosa morfoloških karakteristika, strukture tijela i eksplozivne snage kod košarkaša kadeta. Primjenjeno je 8 varijabli u prostoru morfoloških karakteristika, 5 varijabli u području strukture tijela i 3 varijable eksplozivne snage. Primjenom SPSS 23 paketa su utvrđeni deskriptivni parametri, korelacioni nalazi i regresiona analiza. Korelaciona analiza je pokazala veliku povezanost morfoloških karakteristika sa varijablama eksplozivne snage, kožni nabor struka -0.334^* , -0.335^* sa skokom u dubinu, dok se kod strukture tijela, povezanost pokazala samo u jednoj varijabli FM -0.399^* . Kao što se vidi iz rezultata, radi se o negativnoj povezanosti što govori da su ispitanici koji imaju povećane vrijednosti morfoloških karakteristika tipa masnog tkiva i masnoće u strukturi tijela postizali slabije rezultate.

Regresionom analizom cjelokupnog prediktorskog seta morfoloških varijabli i kriterijske varijable skok u dubinu – DRJ objašnjeno je 53% (R Square) zajedničkog varijabiliteta s kriterijskom varijablom, dok je koeficijent višestruke korelacije iznosio .73, a što predstavlja visoku vrijednost. Navedena povezanost statistički je značajna na nivou .01 (Sig \leq .03)

Analizom uticaja pojedinačnih varijabli moguće je uočiti da je najveći i statistički značajan (Sig \leq .05) uticaj na kriterijsku varijablu tjelesna visina – AVIS (-0.637) i kožni nabor stomaka – AKNS (-0.762).

Na osnovu gore navedenog može se zaključiti da je negativna povezanost kožnog nabora stomaka i masne mase FM u obrnutom odnosu sa uspjehom u eksplozivnoj snazi.

Ključne riječi: morfološke karakteristike, struktura tijela, eksplozivna snaga, košarka

RISK FACTORS OF INJURY IN TENNIS SERVE AMONG JUNIOR PLAYERS: A SYSTEMATIC REVIEW AND META-ANALYSIS

Sandi Prayudho¹, Ahmad Nasrulloh¹, Widiyanto²

1. Faculty of Sport and Health Science, State University of Yogyakarta, Yogyakarta, Indonesia

2. Sport Department, Sports Science Faculty, Yogyakarta State University, Karangmalang, Yogyakarta, Indonesia

ABSTRACT

Studies of tennis injuries have identified the incidence rate, location and type of injury. Most studies have many perspectives on epidemiology, biomechanics and performance, but few studies have identified the risk factors for injury. Until now, there has been no systematic literature review identifying risk factors for tennis service injuries, especially in junior players.

Purpose: The aim of this study was to identify and critically assess the evidence relating to risk factors for tennis service injuries, particularly in junior players.

Materials and methods: The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) framework. Articles were searched using Google Scholar, PubMed and Scopus.

Results: The results of 9 selected articles revealed risk factors for tennis service injuries in junior players, namely, age and gender, weak muscles or muscle imbalances, racket use, grip on racket grips (hand grip), service technique, previous injury history, duration of training, overuse, and kinetic chains.

Conclusion: It can be concluded that the risk factors for tennis service injuries in junior players are age and gender, weak muscles or muscle imbalances, racket use, grip on racket grips (hand grip), service techniques, previous injury history, duration of training, overuse, and kinetic chains. The study was unable to identify most of the studies that met the criteria, and this was not due to restrictions, but because of poor study quality or no studies addressing the issue. Despite all the risk factors, tennis requires validated workload monitoring methods to examine workload behaviour during practice and matches and to identify potential injury associations. The need for more epidemiological studies of different age and performance groups of players and different skill levels is strongly encouraged and more research is needed to examine the mechanisms behind tennis injuries. Finally, identifying risk factors for service injuries in junior players can be beneficial to doctors, sports scientists and coaches to design exercise strategies and programmes for effective injury prevention, and it can improve performance.

Keywords: tennis, serve, biomechanics, injury, junior

INTRODUCTION

Tennis is a very popular sport in the world. About 25 million people play tennis in the United States, and nearly 10% of people play tennis more than 20 times a year. In Indonesia, tennis is known as an upper middle class sport, but it remains the choice of parents, adults, teenagers, and children. This is an option because it can be done to get a healthy body or achievements (Jatra & Firdaus, 2023)

Tennis continues to develop and improve. These developments and improvements can be seen through technological improvements in rackets, improved practice methods and improved playing styles. This is what causes increased emphasis, speed and strength in the game of tennis (Abrams et al., 2011). Tennis differs from other sports in terms of match duration (exposure), playing surface and equipment (Kibler & Safran, 2005). Tennis can be said to be a repetitive sprint sport, characterised by intermittent attacks and performed with high intensity interspersed with periods of rest (Fernandez et al., 2006). This can lead to injury (Kibler & Safran, 2005).

A tennis player needs a combination of fine and gross motor skills, agility, and strength to perform certain movements, such as serve, ground stroke, and volley (Munson et al., 2020). The success of a tennis player can be determined by several factors, such as physical condition, technical skills and tactical strategies (Delgado-García et al., 2019). One of them is service techniques.

The serve is an important stroke in tennis. A well-trained serve is a great advantage for a tennis player (Girard et al., 2005). Serving is complex and requires good technical and physical skills. The complexity of movement comes from the combination of leg and joint movements required to transmit force from bottom to top through kinetic chains and out into the sphere (Kovacs & Ellenbecker, 2011). Service strokes are improved and trained throughout the player's career process, from beginner to professional level (Whiteside et al., 2013). As a result, this can cause potential injuries to players, one of which is junior and youth players.

Biomechanics plays an important role in the understanding, prevention and management of injuries caused by sports training and competition. Therefore, it is important to analyse the service technique of tennis players in order to explain the risk factors and potential for injury to the junior tennis player's serve. The purpose of this literature review is to collect articles over the past eight years, evaluate service techniques and explain risk factors and potential injuries to serve based on junior tennis player biomechanics. As far as the researchers know, there is still no literature that explains injuries due to serve, specifically reviewed through player biomechanics in junior tennis.

MATERIALS AND METHODS

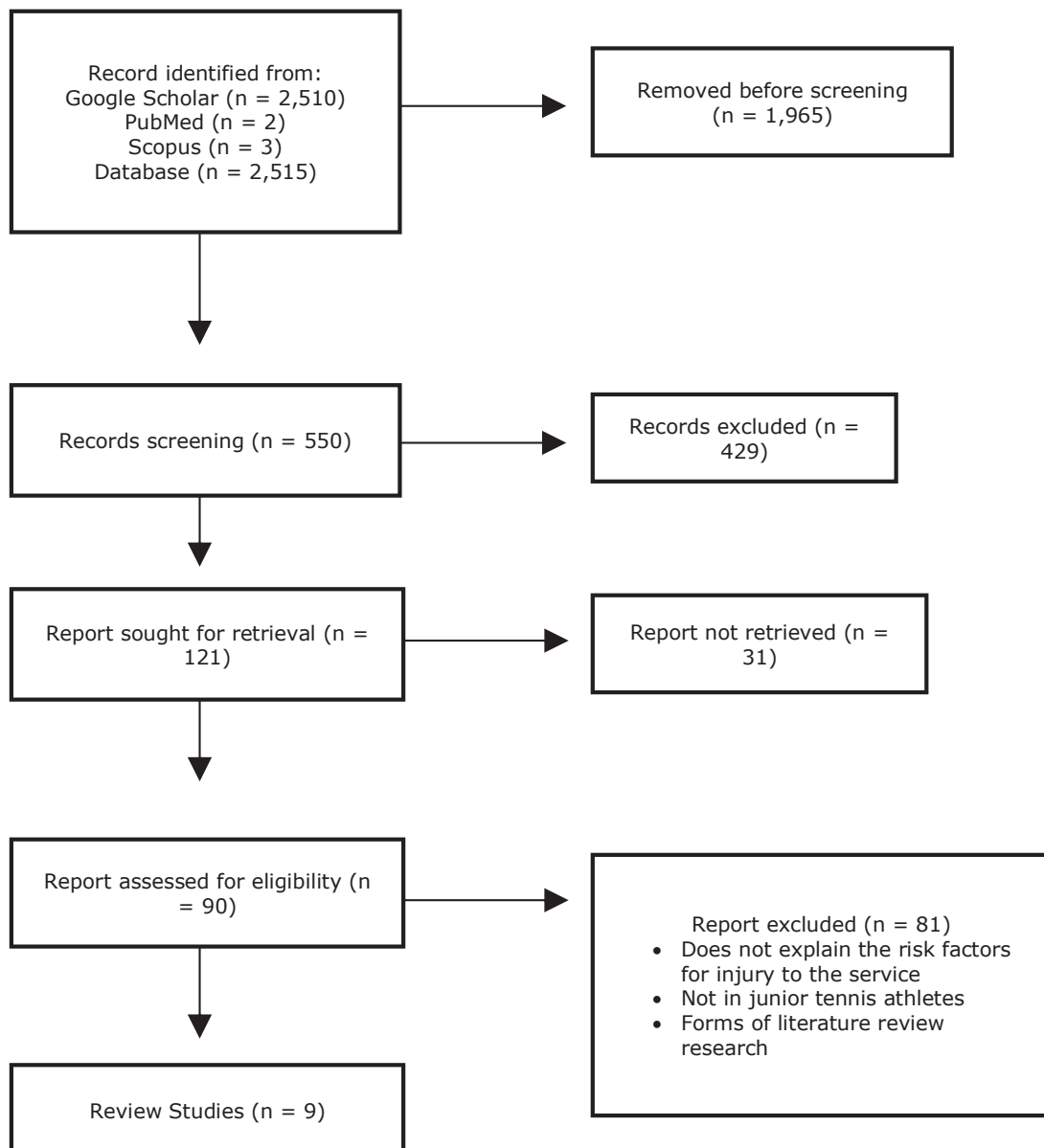
The design of this study uses the literature review method. A systematic literature review study is a research design using secondary data related to a particular topic. The literature review study aims to conclude the theory from some of the results of previous research. This article review data collection method uses access to Google Scholar, PubMed and Scopus. The literature review data collection stage uses the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow method. The search for research journals is determined on criteria (1) variables according to needs, (2) data collection methods are consistent, (3) research results are measured valid, and (4) data analysis is clearly and precisely defined.

Researchers searched for articles on the topic of biomechanics analysis of injury in tennis serve using databases, Google Scholar, PubMed, and Scopus. Google Scholar, PubMed, and Scopus were chosen because of their ease of access and eligibility to get complete and in-depth articles. In addition, researchers are looking for open access articles so that they can access them for free. Keywords used include tennis, serve, biomechanics, and injury.

The selection of study types is carried out through a screening process and determination of eligibility to be made in the meta-analysis. The selection of studies in this research used several criteria: 1) articles related to tennis, serve, biomechanics, and injury, and 2) published in the last 8 years. Next, the researcher selected all titles and abstracts to check for duplication using the Mendeley application. The search results and the process of selecting articles will be outlined using a flow chart. The 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart was used to summarise the study selection process.

RESULTS

From the search that has been carried out, researchers found 9 journals related to risk factors for tennis service injuries in junior players through biomechanical analysis. In the last 8 years, these journals have been reviewed and obtained a variety of research methods and different results. The following are the authors' names, year, study design, research sample, number of samples, and risk factors for injury.

Figure 1. Literature Search Methods

| Author | Years | Design Study | Journal | Risk Factor Injury |
|--|-------|-------------------------|--|--|
| Danielle T. Gescheit, Stuart J. Cormack, Rob Duffield, Stephanie Kovalchik, Tim O. Wood, Melanie Omizzolo, and Machar Reid [10] | 2019 | Prospective Cohort | Journal of Science and Medicine in Sport | Age and Gender |
| Jaime Fernandez-Fernandez, David Sanz-Rivas, and Alberto Mendez-Villanueva (Fernandez-Fernandez et al., 2019) | 2019 | Experiment | Plos One | Muscle strength |
| Pierre Touzard, Chloé Lecomte, Benoit Bideau, Richard Kulpa, Loïc Fourel, Maxime Fadier, Nicolas Cantin, and Caroline Martin(Touzard et al., 2023) | 2023 | Experiment | Frontiers in Psychology | Using a scaled racket has the advantage of reducing shoulder and elbow loads without compromising service performance. |
| Kristin Kalo, Lutz Vogt, Johanna Sieland, Winfried Banzer, and Daniel Niederer (Kalo et al., 2020) | 2020 | A cross-sectional study | BMC Musculoskeletal Disorders | Previous injury history and length of training |
| Tomáš Vodička, Martin Zvonař, Jiří Pačes, Damir Knjaz, Pavel Ružbarský, and Jiří Zháněl (Vodička et al., 2018) | 2018 | Comparative | Kinesiology | Muscle imbalance |
| Pierre Touzard, Richard Kulpa, Benoit Bideau, Bernard Montalvan, and Caroline Martin (Touzard et al., 2019) | 2019 | Experiment | European Journal of Sport Science | Technique and Hand grip |
| Christos Mourtzios, Ioannis Athanailidis, Vasilia Arvanitidou, and Eleftherios Kellis ABSTRACT (Mourtzios et al., 2022) | 2022 | Comparative | European Journal of Sport Science | Kinetic Chain |
| Nathanial Maraga, Rob Duffield, Danielle Gescheit, Thomas Perri, and Machar Reid (Maraga et al., 2018) | 2018 | Experiment | International Journal of Performance Analysis in Sport | Overuse during competitions of up to 3 matches in a day |
| Benoît Gillet, Mickaël Begon, Marine Diger, Christian Berger-Vachon, and Isabelle Rogowski (Gillet et al., 2018) | 2018 | A cross-sectional study | Physical Therapy in Sport | Previous injury resulted in a lower external/internal glenohumeral muscle strength ratio |

An overview of the study identification process is described in Figure 1. In the initial search, we found 2,515 articles consisting of 2,515 articles from Google Scholar, 2 articles from PubMed and 3 articles from Scopus. After going through the selection process, 1,965 articles were automatically deleted and 550 potentially relevant articles were obtained to go through the next selection process. Out of the 550 articles, a total of 429 articles were removed that did not meet the inclusion criteria and a total of 121 articles was found. Out of the 121 articles reviewed through research titles and abstracts, 31 articles were deleted and the remaining 90 articles were worthy of analysis. Out of the 90 articles analysed by researchers, 9 articles were found to be reviewed. The deletion of 81 articles was caused by (1) the article did not explain the risk factors for service injury specifically (2) the sample used was not in accordance with inclusion, namely junior tennis players, and (3) the existing types of research use a more systematic literature review.

DISCUSSION

This study is a systematic review that evaluates the risk factors for tennis service injury in junior tennis players based on biomechanical analysis. A total of 9 risk factors have been investigated, namely, age and sex, weak muscles or muscle imbalance, racket use, grip on the racket grip (hand grip), service technique, previous injury history, duration of exercise, overuse, and kinetic chain.

OVERUSE

Overuse and fatigue are the most common risk factors that can lead to injury. A study reports that the most common injuries are in the knees and shoulders (Acquaye et al., 2020). Playing many matches with limited recovery time can result in accumulated fatigue (Fernandez-Fernandez et al., 2009). Poorly programmed exercise can also lead to excessive use and fatigue (Acquaye et al., 2020). A study explains the physical, physiological and perceptual responses to three tennis matches played for 90 minutes in one day in junior players. This is felt to increase pain and fatigue evidenced by a decrease in internal and external rotation of the shoulder along with a decrease in slowing directional speed (Maraga et al., 2018). It is confirmed that playing tennis for a long time can cause risk factors for upper extremity injuries in tennis players (Moore-Reed et al., 2016). A study reports that playing tennis more than 6 h per week were identified as risk factors for back pain (Hjelm et al., 2012).

In addition, it is explained that the game of tennis can put a high load on the knee, with short movements that are done repeatedly, and this can cause injury to the lower extremities (Abrams et al., 2012). In

addition, the shoulder is another part of the body that is often injured. This can be associated with repetitive service movements. The serve is the most difficult and powerful blow, as a result of which repeated use can cause injury (Abrams et al., 2012). Often, the outcome of a competitive tennis match depends on the effectiveness of the serve (Maquirriain et al., 2016). However, the serve will not be effective when the body feels fatigue; a decrease in the external rotation of the shoulder may indicate a change in service kinematics to maintain service speed after several matches on the same day (Martin, Bideau, et al., 2016).

RACKET

The racket is a tool used in the game of tennis. Previous studies reported that racket size, racket grip size, string tension, and proposed use of vibration dampers would have an effect on lateral epicondylitis (De Smedt et al., 2007). The use of racket sizes that are too heavy can overload upper extremities and potentially cause injury to young tennis players (Miller, 2006). In addition, other studies report that racket grips of different sizes can cause changes in the quality of strokes and kinematics of the wrist joint. This can result in poor technique and can increase risk factors for injury (Hatch et al., 2006).

The use of a racket size that is too heavy will burden the upper extremities (Hennig, 2007). The increased racket swing load for junior tennis players will have an impact on decreasing the maximum shoulder internal rotation speed and wrist flexion speed (Whiteside et al., 2014). A study reported that 13% of U-10 players and 61% of U-12 players in an academy suffered injuries during 2 years of tennis practice. The data showed the highest frequency of injuries to the upper extremities, namely the shoulders and elbows (O'Connor et al., 2020). Advice from a study reported that using rackets with a scale of 23 inches has more advantages to reduce shoulder and elbow loads without reducing service performance (ball speed and maximum racket head speed) in junior tennis players with an average age of 9.9 years. This can help junior players avoid the risk of injury that will occur in the long run (Touzard et al., 2023).

TECHNIQUES

Service technique is an important thing to train for junior tennis players. The skill and technique level in tennis has been identified as a risk factor for upper extremity injuries and shoulder strain, especially during serves and smashes that are directly related to a player's skill level. Professional tennis players can place a lower burden on the kinetics of the shoulder joint, thereby reducing the percentage of shoulder, elbow or wrist injuries (Martin et al., 2013).

The impact of tennis on shoulder flexibility, specifically the internal rotation of the shoulder has been

investigated. Both studies revealed that tennis players showed significant changes in the dominant nature of shoulder rotation (Cools et al., 2010; Kibler & Chandler, 2003). Another study identified waiter's serve in the upper body loading phase as a pathomechanical one that occurs in junior tennis athletes. Higher loads on upper extremity body parts on the waiter's serve will result in overuse injury (Touzard et al., 2019).

The injury directly related to the waiter's serve is an elbow injury. This can be seen through the grasp of the player's racket (Touzard et al., 2019). Lateral epicondylitis injury or "tennis elbow" injury is identified as one of the injuries caused by excessive use, especially in young tennis players (De Smedt et al., 2007). So, a coach needs to be careful and pay attention to good and correct service techniques to avoid mistakes and injuries to junior tennis players.

PREVIOUS INJURY HISTORY

A history of previous injuries is associated as one of the most common and frequent intrinsic factors in sports (Bahr & Krosshaug, 2005). A study reports range of motion (ROM) deficits often occur in athletes who were previously injured (Johnson et al., 2018). A systematic review revealed that tennis players who had shoulder injuries showed altered shoulder kinematics and higher shoulder kinetics, compared to players with no injury history (Martin, Kulpa, et al., 2016). Loss of glenohumeral internal rotation in young tennis players is due to increased training and a history of injuries (Kalo et al., 2020). A finding in the study explained that players with a history of shoulder injuries have a higher ratio of external and internal glenohumeral rotation as well as rotator muscle imbalances (Gillet et al., 2018).

Changes resulting from injury to the lower extremities have the potential to result in future injury (Fulton et al., 2014). Previous ACL reconstruction is a risk factor for ACL injury in several prospective studies (Waldén et al., 2006). Players with a history of ACL reconstruction had a higher incidence of new knee injuries of any type, compared with players without a history of ACL injury (Waldén et al., 2006). A finding in the study explained that a previous injury regardless of body location was found to be an injury risk factor (Hjelm et al., 2012) and can cause excessive injury (Giroto et al., 2017).

AGE AND GENDER

Increasing age and changes in upper body performance have been studied extensively in the past. A study explained that male U-15 years had better strength when compared to male U-13 and female U-13 and U-15, but the results showed that the decrease in the range of motion (ROM) in male U-15 coincided with a higher and specific internal rotational bilateral deficit, compared to male U-13 and female U-13 and U-15 (Fernandez-Fernandez et al., 2019). However, the decrease in the range of motion

(ROM) has nothing to do with age; it is more related to the length of exercise (Kalo et al., 2020).

A study that conducted a comprehensive and longitudinal examination of the incidence and severity of injuries in junior tennis players reported that, with age, the number of injuries suffered by players also increased (Gescheit et al., 2019). Injuries suffered by male junior players have a higher severity than those of female junior players (Gescheit et al., 2017). The increased incidence of injuries in junior players is generally experienced at the age of 13-15 years (Van Der Sluis et al., 2015), where at this age, there is physical growth, an increase in the volume and intensity of training and an increase in the intensity of matches. This increased load is associated with injury risk factors (Myers et al., 2016).

KINETIC CHAIN

Service movements are very complex multi-joint movements that require good muscle coordination and special skill development. Good service can be determined by complex interactions with several factors, including the maximum force that can be generated by the muscles involved and their joints. Most of the force exerted at the time of service comes from the muscles of the lower extremities (Komi & Nicol, 2010). One study explains that junior tennis players need to strengthen their ankle and knee joints during the loading phase of serve, when trying to serve slice and top spin (Mourtziou et al., 2022). In addition, a study explains and evaluates service biomechanics and provides a kinetic chain review of the three types of services, namely, flat serve, slice serve and top spine serve. It is explained that the top spine service has a greater potential for injury to the back and shoulders (Abrams et al., 2011).

After going through the kinetic chain process in the lower extremity muscles, the energy is transferred through the abdominal muscles to the shoulder. The scapula plays a very important role; it converts the potential energy developed in the legs and body into kinetic energy in the upper extremities when the ball is hit. Scapula dyskinesis involving pathological movements and position of the scapula is a common breaking point in the kinetic chain and has been implicated in successive injuries (Saini et al., 2020).

MUSCLE STRENGTH

Muscular strength is one of the most important components of physical performance in sport, in terms of both high-level performance and injury occurrence (Lehance et al., 2009). Muscle weakness can have an impact on tennis service injuries. Tomáš Vodička (2018) explains that the incident aspect of injury can arise as a result of shoulder instability (Vodička et al., 2018). Ellenbecker and Roetert (2003) tried to define the ratio between external and internal rotational force levels, and recommended a ratio of external and internal rotator strength of 66-75% for competitive elite tennis players (Ellenbecker & Roetert, 2003). If the number is close to 50%, it may be said to be a high risk of injury related to shoulder joint instability (Vodička et al., 2018). A study reported that preseason weakness of external rotation and supraspinatus strength is associated with in-season throwing-related injury resulting in surgical intervention in professional baseball pitchers (Byram et al., 2010).

The suggestion of a study explains the need to focus on strengthening the external rotator (concentric and eccentric modes) and internal rotator (eccentric mode) to provide stability to the head of the humerus during upper extremity movement in athletes who do overhead. The importance of giving training weights must be emphasised optimally, considering the frequency of matches and the intensity of training is getting higher and can predict injuries (Tooth et al., 2020). A finding of a study explains that a short-term training programme for young tennis players, using minimum equipment and effort, can result

in improved tennis performance (i.e., serve velocity) and a reduction in the risk of a possible overuse injury, reflected by an improvement in shoulder external/internal range of motion (Fernandez-Fernandez et al., 2013).

CONCLUSIONS

From all the explanations above, it can be concluded that the risk factors for tennis service injuries in junior players are age and gender, weak muscles or muscle imbalances, racket use, grip on racket grips (hand grip), service techniques, previous injury history, duration of training, overuse, and kinetic chains. The study was unable to identify most of the studies that met the criteria, and this was not due to restrictions, but because of poor study quality or no studies addressing the issue.

Despite all the risk factors, tennis requires validated workload monitoring methods to examine workload behaviour during practice and matches and to identify potential injury associations. The need for more epidemiological studies of different age and performance groups of players and different skill levels is strongly encouraged and more research is needed to examine the mechanisms behind tennis injuries. Finally, identifying risk factors for service injuries in junior players can be beneficial to doctors, sports scientists and coaches to design exercise strategies and programmes for effective injury prevention, and it can improve performance.

REFERENCES

1. Abrams, G. D., Renstrom, P. A., & Safran, M. R. (2012). Epidemiology of musculoskeletal injury in the tennis player. *British Journal of Sports Medicine*, 46(7), 492–498. <https://doi.org/10.1136/bjsports-2012-091164>
2. Abrams, G. D., Sheets, A. L., Andriacchi, T. P., & Safran, M. R. (2011). Review of tennis serve motion analysis and the biomechanics of three serve types with implications for injury. *Sports Biomechanics*, 10(4), 378–390. <https://doi.org/10.1080/14763141.2011.629302>
3. Acquaye, G., Quartey, J., & Kwakye, S. (2020). Pattern of injuries amongst tennis players in Accra, Ghana. *South African Journal of Physiotherapy*, 76(1), 1–8. <https://doi.org/10.4102/SAJP.V76I1.1429>
4. Bahr, R., & Krosshaug, T. (2005). Understanding injury mechanisms: A key component of preventing injuries in sport. *British Journal of Sports Medicine*, 39(6), 324–329. <https://doi.org/10.1136/bjism.2005.018341>
5. Byram, I. R., Bushnell, B. D., Dugger, K., Charron, K., Harrell, F. E., & Noonan, T. J. (2010). The American Journal of Sports Medicine Measurements in Professional. <https://doi.org/10.1177/0363546509360404>
6. Cools, A. M., Johansson, F. R., Cambier, D. C., Velde, A. Vande, Palmans, T., & Witvrouw, E. E. (2010). Descriptive profile of scapulothoracic position, strength and flexibility variables in adolescent elite tennis players. *British Journal of Sports Medicine*, 44(9), 678–684. <https://doi.org/10.1136/bjism.2009.070128>
7. De Smedt, T., De Jong, A., Van Leemput, W., Lieven, D., & Van Glabbeek, F. (2007). Lateral epicondylitis in tennis: Update on aetiology, biomechanics and treatment. *British Journal of Sports Medicine*, 41(11), 816–819. <https://doi.org/10.1136/bjism.2007.036723>
8. Delgado-García, G., Vanrenterghem, J., Muñoz-García, A., Ruiz-Malagón, E. J., Mañas-Bastidas, A., & Soto-Hermoso, V. M. (2019). Probabilistic structure of errors in forehand and backhand groundstrokes of advanced tennis players. *International Journal of Performance Analysis in Sport*, 19(5), 698–710. <https://doi.org/10.1080/24748668.2019.1647733>

9. Ellenbecker, T., & Roetert, E. P. (2003). Age specific isokinetic glenohumeral internal and external rotation strength in elite junior tennis players. *Journal of Science and Medicine in Sport*, 6(1), 63–70. [https://doi.org/10.1016/S1440-2440\(03\)80009-9](https://doi.org/10.1016/S1440-2440(03)80009-9)
10. Fernandez-Fernandez, J., Ferrauti, A., Ellenbecker, T., Sanz-Rivas, D., & Ulbricht, A. (2013). Effects of a 6-week junior tennis conditioning program on service velocity. September 2012, 232–239.
11. Fernandez-Fernandez, J., Nakamura, F. Y., Moreno-Perez, V., Lopez-Valenciano, A., Coso, J. Del, Gallo-Salazar, C., Barbado, D., Ruiz-Perez, I., & Sanz-Rivas, D. (2019). Age and sex-related upper body performance differences in competitive young tennis players. *PLoS ONE*, 14(9), 1–18. <https://doi.org/10.1371/journal.pone.0221761>
12. Fernandez-Fernandez, J., Sanz-Rivas, D., & Mendez-Villanueva, A. (2009). A review of the activity profile and physiological demands of tennis match play. *Strength and Conditioning Journal*, 31(4), 15–26. <https://doi.org/10.1519/SSC.0b013e3181ada1cb>
13. Fernandez, J., Mendez-Villanueva, A., & Pluim, B. M. (2006). Intensity of tennis match play. *British Journal of Sports Medicine*, 40(5), 387–391. <https://doi.org/10.1136/bjism.2005.023168>
14. Fulton, J., Wright, K., Kelly, M., Zebrosky, B., Zanis, M., Drvol, C., & Butler, R. (2014). Injury risk is altered by previous injury: A systematic review of the literature and presentation of causative neuromuscular factors. *International Journal of Sports Physical Therapy*, 9(5), 583–595. <http://www.ncbi.nlm.nih.gov/pubmed/25328821> <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4196323>
15. Gescheit, D. T., Cormack, S. J., Duffield, R., Kovalchik, S., Wood, T. O., Omizzolo, M., & Reid, M. (2017). Injury epidemiology of tennis players at the 2011–2016 Australian Open Grand Slam. *British Journal of Sports Medicine*, 51(17), 1289–1294. <https://doi.org/10.1136/bjsports-2016-097283>
16. Gescheit, D. T., Cormack, S. J., Duffield, R., Kovalchik, S., Wood, T. O., Omizzolo, M., & Reid, M. (2019). A multi-year injury epidemiology analysis of an elite national junior tennis program. *Journal of Science and Medicine in Sport*, 22(1), 11–15. <https://doi.org/10.1016/j.jsams.2018.06.006>
17. Gillet, B., Begon, M., Diger, M., Berger-Vachon, C., & Rogowski, I. (2018). Shoulder range of motion and strength in young competitive tennis players with and without history of shoulder problems. *Physical Therapy in Sport*, 31, 22–28. <https://doi.org/10.1016/j.ptsp.2018.01.005>
18. Girard, O., Micallef, J. P., & Millet, G. P. (2005). Lower-limb activity during the power serve in tennis: Effects of performance level. *Medicine and Science in Sports and Exercise*, 37(6), 1021–1029. <https://doi.org/10.1249/01.mss.0000171619.99391.bb>
19. Giroto, N., Hespanhol Junior, L. C., Gomes, M. R. C., & Lopes, A. D. (2017). Incidence and risk factors of injuries in Brazilian elite handball players: A prospective cohort study. *Scandinavian Journal of Medicine and Science in Sports*, 27(2), 195–202. <https://doi.org/10.1111/sms.12636>
20. Hatch, G. F., Pink, M. M., Mohr, K. J., Sethi, P. M., & Jobe, F. W. (2006). The effect of tennis racket grip size on forearm muscle firing patterns. *American Journal of Sports Medicine*, 34(12), 1977–1983. <https://doi.org/10.1177/0363546506290185>
21. Hennig, E. M. (2007). Influence of racket properties on injuries and performance in tennis. *Exercise and Sport Sciences Reviews*, 35(2), 62–66. <https://doi.org/10.1249/JES.0b013e31803ec43e>
22. Hjelm, N., Werner, S., & Renstrom, P. (2012). Injury risk factors in junior tennis players: A prospective 2-year study. *Scandinavian Journal of Medicine and Science in Sports*, 22(1), 40–48. <https://doi.org/10.1111/j.1600-0838.2010.01129.x>
23. Jatra, R., & Firdaus, K. (2023). Forehand and backhand tennis exercises : Study literature review. 3(1), 96–105.
24. Johnson, J. E., Fullmer, J. A., Nielsen, C. M., Johnson, J. K., & Moorman, C. T. (2018). Glenohumeral internal rotation deficit and injuries: A systematic review and meta-analysis. *Orthopaedic Journal of Sports Medicine*, 6(5), 1–10. <https://doi.org/10.1177/2325967118773322>
25. Kalo, K., Vogt, L., Sieland, J., Banzer, W., & Niederer, D. (2020). Injury and training history are associated with glenohumeral internal rotation deficit in youth tennis athletes. *BMC Musculoskeletal Disorders*, 21(1), 1–7. <https://doi.org/10.1186/s12891-020-03571-0>
26. Kibler, W. B., & Chandler, T. J. (2003). Range of motion in junior tennis players participating in an injury risk modification program. *Journal of Science and Medicine in Sport*, 6(1), 51–62. [https://doi.org/10.1016/S1440-2440\(03\)80008-7](https://doi.org/10.1016/S1440-2440(03)80008-7)
27. Kibler, W. B., & Safran, M. (2005). Tennis injuries. *Epidemiology of Pediatric Sports Injuries*, 48, 120–137.
28. Komi, P. V., & Nicol, C. (2010). Stretch-shortening cycle of muscle function. *Neuromuscular Aspects of Sport Performance*, 17, 15–31. <https://doi.org/10.1002/9781444324822.ch2>
29. Kovacs, M., & Ellenbecker, T. (2011). An 8-stage model for evaluating the tennis serve: Implications for performance enhancement and injury prevention. *Sports Health*, 3(6), 504–513. <https://doi.org/10.1177/1941738111414175>

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30. Lehance, C., Binet, J., Bury, T., & Croisier, J. L. (2009). Muscular strength, functional performances and injury risk in professional and junior elite soccer players. *Scandinavian Journal of Medicine and Science in Sports*, 19(2), 243–251. <https://doi.org/10.1111/j.1600-0838.2008.00780.x>
 31. Maquirriain, J., Baglione, R., & Cardey, M. (2016). Male professional tennis players maintain constant serve speed and accuracy over long matches on grass courts. *European Journal of Sport Science*, 16(7), 845–849. <https://doi.org/10.1080/17461391.2016.1156163>
 32. Maraga, N., Duffield, R., Gescheit, D., Perri, T., & Reid, M. (2018). Playing not once, not twice but three times in a day: the effect of fatigue on performance in junior tennis players. *International Journal of Performance Analysis in Sport*, 18(1), 104–114. <https://doi.org/10.1080/24748668.2018.1452110>
 33. Martin, C., Bideau, B., Delamarche, P., & Kulpa, R. (2016). Influence of a prolonged tennis match play on serve biomechanics. *PLoS ONE*, 11(8), 1–14. <https://doi.org/10.1371/journal.pone.0159979>
 34. Martin, C., Kulpa, R., Ezanno, F., Delamarche, P., & Bideau, B. (2016). Influence of playing a prolonged tennis match on shoulder internal range of motion. *American Journal of Sports Medicine*, 44(8), 2147–2151. <https://doi.org/10.1177/0363546516645542>
 35. Martin, C., Kulpa, R., Ropars, M., Delamarche, P., & Bideau, B. (2013). Identification of temporal pathomechanical factors during the tennis serve. *Medicine and Science in Sports and Exercise*, 45(11), 2113–2119. <https://doi.org/10.1249/MSS.0b013e318299ae3b>
 36. Miller, S. (2006). Modern tennis rackets, balls, and surfaces. *British Journal of Sports Medicine*, 40(5), 400–405. <https://doi.org/10.1136/bjsm.2005.023283>
 37. Moore-Reed, S. D., Kibler, W. Ben, Myers, N. L., & Smith, B. J. (2016). Acute changes in passive glenohumeral rotation following tennis play exposure in elite female players. *International Journal of Sports Physical Therapy*, 11(2), 230–236. <http://www.ncbi.nlm.nih.gov/pubmed/27104056> <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4827366>
 38. Mourtziou, C., Athanailidis, I., Arvanitidou, V., & Kellis, E. (2022). Ankle and knee joint kinematics differ between flat, slice and topspin serves in young tennis players. *European Journal of Sport Sciences*, 1(2), 16–22. <https://doi.org/10.24018/ejsport.2022.1.2.13>
 39. Munson, E. H., Orange, S. T., Bray, J. W., Thurlow, S., Marshall, P., & Vince, R. V. (2020). Sodium ingestion improves groundstroke performance in nationally-ranked tennis players: A randomized, placebo-controlled crossover trial. *Frontiers in Nutrition*, 7(September), 1–10. <https://doi.org/10.3389/fnut.2020.549413>
 40. Myers, N. L., Sciascia, A. D., Kibler, W. Ben, & Uhl, T. L. (2016). Volume-based interval training program for elite tennis players. *Sports Health*, 8(6), 536–540. <https://doi.org/10.1177/1941738116657074>
 41. O'Connor, S., Huseyin, O. R., Whyte, E. F., & Lacey, P. (2020). A 2-year prospective study of injuries and illness in an elite national junior tennis program. *Physician and Sportsmedicine*, 48(3), 342–348. <https://doi.org/10.1080/00913847.2020.1714512>
 42. Saini, S. S., Shah, S. S., & Curtis, A. S. (2020). Scapular dyskinesis and the kinetic chain: Recognizing dysfunction and treating injury in the tennis athlete. *Current Reviews in Musculoskeletal Medicine*, 13(6), 748–756. <https://doi.org/10.1007/s12178-020-09672-6>
 43. Tooth, C., Gofflot, A., Schwartz, C., Croisier, J. L., Beaudart, C., Bruyère, O., & Forthomme, B. (2020). Risk factors of overuse shoulder injuries in overhead athletes: A systematic review. *Sports Health*, 12(5), 478–487. <https://doi.org/10.1177/1941738120931764>
 44. Touzard, P., Kulpa, R., Bideau, B., Montalvan, B., & Martin, C. (2019). Biomechanical analysis of the “waiter’s serve” on upper limb loads in young elite tennis players. *European Journal of Sport Science*, 19(6), 765–773. <https://doi.org/10.1080/17461391.2018.1539527>
 45. Touzard, P., Lecomte, C., Bideau, B., Kulpa, R., Fourel, L., Fadier, M., Cantin, N., & Martin, C. (2023). There is no rush to upgrade the tennis racket in young intermediate competitive players: The effects of scaling racket on serve biomechanics and performance. *Frontiers in Psychology*, 14(February), 1–8. <https://doi.org/10.3389/fpsyg.2023.1104146>
 46. Van Der Sluis, A., Elferink-Gemser, M. T., Brink, M. S., & Visscher, C. (2015). Importance of peak height velocity timing in terms of injuries in talented soccer players. *International Journal of Sports Medicine*, 36(4), 327–332. <https://doi.org/10.1055/s-0034-1385879>
 47. Vodička, T., Zvonar, M., Pačes, J., Knjaz, D., Ružbarský, P., & Zháněl, J. (2018). Strength values of shoulder internal and external rotators in junior tennis players. *Kinesiology*, 50(2), 181–187. <https://doi.org/10.26582/K.50.2.9>
 48. Waldén, M., Häggglund, M., & Ekstrand, J. (2006). High risk of new knee injury in elite footballers with previous anterior cruciate ligament injury. *British Journal of Sports Medicine*, 40(2), 158–162. <https://doi.org/10.1136/bjsm.2005.021055>

49. Whiteside, D., Elliott, B., Lay, B., & Reid, M. (2013). The effect of age on discrete kinematics of the elite female tennis serve. *Journal of Applied Biomechanics*, 29(5), 573–582. <https://doi.org/10.1123/jab.29.5.573>
50. Whiteside, D., Elliott, B., Lay, B., & Reid, M. (2014). The effect of racquet swing weight on serve kinematics in elite adolescent female tennis players. *Journal of Science and Medicine in Sport*, 17(1), 124–128. <https://doi.org/10.1016/j.jsams.2013.03.001>

FAKTORI RIZIKA OD POVREDA PRILIKOM IZVOĐENJA TENISKOG SERVISA KOD JUNIORA: SISTEMATSKI PREGLED I META-ANALIZA

SAŽETAK

Istraživanja teniskih povreda su identifikovala stopu incidencije, lokaciju i vrstu povrede. Većina studija iskazuje stanovišta o eipdemiologiji, biomehanici i efikasnosti, ali malo njih identifikuje faktore rizika od povreda. Do sada se nije proveo sistematski pregled literature koji identifikuje faktore rizika od povreda prilikom izvođenja teniskog servisa, a posebno kod juniora.

Svrha: Cilj ove studije je identifikovati i kritički procijeniti dokaze koji se odnose na faktore rizika od povreda prilikom izvođenja teniskog servisa, a posebno kod juniora.

Materijali i metode: Sistematski pregled je proveden u skladu sa PRISMA okvirom - Preferirane stavke izvještavanja za sistematske preglede i meta-analize. Pretraga radova je izvršena korištenjem Google Scholar, PubMed i Scopus baza.

Rezultati: Rezultati odabranih 9 radova su otkrili faktore rizika od povreda prilikom izvođenja teniskog servisa kod juniora, i to: dob i spol, slaba muskulatura ili mišićna neravnoteža, korištenje reketa, stisak drške reketa (stisak ruke), tehnika serviranja, historija povreda, trajanje treninga, prekomjerna upotreba i kinetički lanci.

Zaključak: Možemo zaključiti da su faktori rizika od povreda prilikom izvođenja teniskog servisa kod juniora dob i spol, slaba muskulatura ili mišićna neravnoteža, korištenje reketa, stisak drške reketa (stisak ruke), tehnika serviranja, historija povreda, trajanje treninga, prekomjerna upotreba i kinetički lanci. Istraživanje nije moglo identifikovati mnogo studija koje ispunjavaju kriterije, a razlog tome nije bio zbog ograničenja, nego zbog loše kvalitete studija ili nedostatka studija koje se bave ovim pitanjem. Uprkos svim faktorima rizika, tenis zahtijeva potvrđene metode monitoringa opterećenja kako bi se isto ispitalo tokom treninga i mečeva te identifikovale potencijalne povezanosti sa povredom. Potreba za više epidemioloških studija različitih dobnih grupa igrača i različitih nivoa vještina se ohrabruje te je potrebno više istraživanja koja ispituju mehanizme teniskih povreda. Na kraju, identifikovanje faktora rizika od povreda prilikom izvođenja servisa kod juniora može biti korisno za doktore, sportske naučnike i trenere kako bi dizajnirali trenažne strategije i programe za efektivnu prevenciju povreda uz poboljšanje efikasnosti.

Ključne riječi: tenis, servis, biomehanika, povreda, junior

Correspondence to: Sandi Prayudho

Faculty of Sport and Health Science, State University of Yogyakarta, Yogyakarta, Indonesia

E-mail: sandiprayudhoo@gmail.com

KINEMATIC ANALYSIS OF THE BALL RELEASE PHASE FOR TWO-POINT SHOT IN BASKETBALL

Diellza Kelmendi¹, Nazim Myrtaj², Kastriot Shaqiri³

1. Kosovo Olympic Academy, Kosovo Olympic Committee, Pristina, Kosovo
2. Faculty of Physical Culture and Sports, AAB College, Pristina, Kosovo
3. Faculty of Physical Education, State University, Tetovo, North Macedonia

ABSTRACT

The aim of the research was to conduct a kinematic analysis of the ball release phase for the two-point shot in basketball. This research was conducted with twenty elite basketball players from the following Kosovo Super League teams: Pristina, Kerasan and Lipjani. Methods: Video recordings of the shooting performance techniques are done with three Canon HD cameras, set at 90 degree angles, which can reproduce sixty pictures per second. 10 variables were selected for kinematic analysis. The data collected were processed by IBM SPSS Statistics 20 statistical software, and statistical parameters were determined using the following methods: arithmetic mean, standard deviation, minimum score, maximum score, skewness, and kurtosis. Results: In the results of the Pearson's correlation coefficients of the kinematic analysis of the ball release phase for two-point shot, the variables that showed high correlations with statistical significance at the level ($p = 0.01$) are: the distance between the centre of gravity and the ball in the final position and the height of the ball release with correlation coefficients in the value of (0.75); the distance between the centre of gravity and the ball in the initial position and the height of the release of the ball with correlation coefficients in the value of (0.63). Conclusion: The results of this study on the release phase of the ball, the trajectory of horizontal, vertical movement, height of the ball release, angle of the ball release, and the total time are very significant indicators for the two-point shooting and a very important guide for experts in this field.

Keywords: basketball, kinematics, trajectory, two-point shot, Pearson's correlation

INTRODUCTION

Basketball is a multidimensional game involving more than one skill and using movement components of running, jumping, throwing, shooting, and receiving patterns (Krause et al., 1999). Shooting accuracy is the application of the correct kinematic characteristics, degree of force and rhythmic quality, regardless of the

distance and position of the basket (Walters et al., 1990). In basketball studies, biomechanical research has focused on various aspects including basic shooting techniques (Brancazio, 1981; Hay, 1994). One of the kinematic parameters of shooting is the trajectory of the ball in the sport of basketball (Satti, 2004). Ball trajectory analysis in basketball has been an interesting but also important topic for many researchers around the world. The purpose of this research is the kinematic analysis of the trajectory

of the ball movement from the two-point shot, with a long jump from a distance of 6.25 m, conducted on a sample of twenty professional Kosovo Super League basketball players (players from basketball clubs: Pristina, K. B. Kerasan and K. B. Lipjani.

MATERIALS AND METHODS

Filming of the shootings for measurements were conducted during the 2018 training season of basketball players. Inclusion criteria were: active athlete at the level of performance level, age between 18-25 years. For analysis, only one successful shot was taken from each player. The description of the ball release phase includes the moment from the release of the ball from the hands, the trajectory of the movement of the ball until the entry of the ball into the basket. 10 variables were selected for kinematic analysis, such as: distance between the centre of gravity and ball at starting position (DCGSP), distance between the centre of gravity and ball in the final position (DCGFP), height of the ball release (HBR), the trajectory of the ball movement (horizontal displacement) (THD), the trajectory of the ball movement (vertical displacement) (TVD), angle of the ball release (ABR), angle of the ball entrance (ABE), ball movement speed (BMS), ball movement time (BMT), and total time (TT). The filming of the basketball shooting performance techniques is done with three Canon Hz video cameras, set at optimal angles, which can reproduce 60 frames per second (Tang & Shung, 2005). Analysis is done according to the performance of the Kinematic Analysis System (APAS), outputting the required results and values of the kinematic indicator.

STATISTICAL PROCESSING METHODS

The collected data were processed by the statistical analysis software "IBM SPSS 20", and statistical parameters were determined using the methods: arithmetic mean, standard deviation, minimum score, maximum score, skewness, and kurtosis. The confirmation of the mutual influence of the variables was done by the Pearson's correlation coefficients method.

RESULTS AND DISCUSSION

Table 1 presents the results of the basic statistical parameters of the 10 kinematic variables used in the analysis of the ball release phase for the two-point shot in basketball. For the ball release phase of the two-point jump shot, the obtained results

show that there is no obvious deviation from the normal distribution. The results of the arithmetic mean (Mean), standard deviation (Std. Deviation), minimum value (Minimum), and maximum value (Maximum) are within the expected limits. In normal distributions, the indicators of asymmetry (Skewness) and the top of the curve (Kurtosis) are equal to 0 and, according to Peric (2006), the limits of the obtained values are ± 2 . The negative value of the asymmetry test (Skewness) indicates that the distribution of the results is skewed to the right (hypokurtic). The greatest number of results achieved is above the arithmetic mean value. The negative asymmetry was obtained in the following variables: the distance between the centre of gravity and the ball in the final position (DCGFP) with $(120.80 \pm 12.27 \text{ cm})$ and $Sk = -0.43$, the ball release height (HBR) with (252.40 ± 19.120) and $Sk = -0.93$, the trajectory of the ball movement (horizontal displacement) (THD) with (410.00 ± 24.710) and $Sk = -0.94$.

The largest negative value of the asymmetry test (skewness) was obtained in the variable trajectory of the ball movement (horizontal displacement) (THD) with a skewness value of $(Sk = -0.94)$. The positive value of the asymmetry test (Skewness) indicates that the distribution of the results is skewed to the left (epikurtic). Positive asymmetry is obtained in the following variables: distance between the centre of gravity and ball at starting position (DCGSP) with $(65.40 \pm 8.76 \text{ cm})$ and $Sk = 0.11$, the trajectory of the ball movement (vertical displacement) (TVD) with (160.70 ± 31.270) and $Sk = 0.40$, angle of the ball release (ABR) with (37.65 ± 5.960) and $Sk = 0.72$, angle of the ball entrance (ABE) with (41.15 ± 6.660) and $Sk = 0.47$, ball movement speed (BMS) with $(9.78 \pm 0.88 \text{ m/s})$ and $Sk = 0.11$, ball movement time (BMT) with $(1.15 \pm 0.10 \text{ sec})$ and $Sk = 0.07$, and total time (TT) with $(1.52 \pm 0.09 \text{ sec})$ and $Sk = 0.74$. The largest positive value of the asymmetry test (skewness) was obtained in the variable total time (TT) with a skewness value of $(Sk = 0.74)$. This shows the fact that lower numerical values were obtained in this test. Negative values of the kurtosis coefficients (Kurtosis) indicate a normal extension of the distribution (distribution). Negative kurtosis values were obtained for the following variables: the trajectory of the ball movement (vertical displacement) (TVD) with (160.70 ± 31.270) and $Ku = -0.94$ and angle of the ball entrance (ABE) with (41.15 ± 6.660) and $Ku = -0.25$. The largest negative value of kurtosis was obtained for the following variable: the trajectory of the ball movement (vertical displacement) (TVD) with a value of $(Ku = -0.94)$.

Positive values of the kurtosis coefficient were obtained in the following variables: distance between the centre of gravity and ball at starting position (DCGSP) with $(65.40 \pm 8.76 \text{ cm})$ and $Ku = 0.37$, distance between the centre of gravity and ball in final position (DCGFP) with $(120.80 \pm 12.27 \text{ cm})$ and $Ku = 0.28$, height of the ball release (HBR) with (225.40 ± 19.120) and $Ku = 0.19$, the trajectory of the ball movement (horizontal displacement) (THD) with (410.00 ± 24.710) and $Ku = 1.80$, angle of the ball release (ABR) with (37.65 ± 5.960) and $Ku = 1.94$, ball movement time (BMT) with $(1.15 \pm 0.10 \text{ sec})$ and $Ku = 0.06$, and total time (TT) with $(1.52 \pm 0.09 \text{ sec})$ and $Ku = 2.39$, while the highest value of kurtosis was obtained in the variable total time (TT) with

a value of ($Ku = 2.39$). The obtained values show that there is a minimum distribution of the results around the arithmetic mean because they are insignificant in relation to the specified values of the standard deviation.

The findings of this study are similar with the study conducted by authors, such as (Hudson, 1982; Chen & Shiang, 2005; Mohammad, 2014). Tsaroucha et al. (1988) show that the upper extremities are the biggest contributors to a shooter's success, increasing the point of release (the vertical displacement of the ball) and decreasing the distance to the goal. The angle of the release from any distance is positively related to the angle of entry of the ball through the basket (Miller & Bartlett, 1996). The authors (Ranjith & Rajini, 2014) concluded that the accuracy of a shot has a high correlation with the speed of releasing the ball, showing

that these are the variables that have the highest relationship in shooting in basketball. Increasing the release height of the ball allows the player to use a smaller release angle, thus reducing the need for high-speed movement, which is needed to make a successful shot (Hamilton & Reinschmi, 1997). According to Okazaki and Rodacki (2012), the angle of the ball entry into the basket is one of the main factors that determines the success of shots in the basketball game. Ball release height has been found to be important for shooting success in basketball, according to the results of Hudson (1982). The height of the parabolic arc of the basketball is in direct correlation with the angle of entry, which determines precision and probability of placing the ball inside the basket (Jovanović, 1994).

Table 1. Results of the basic statistical parameters of the kinematic analysis of the ball release phase for two-point shot in basketball

| | Minimum | Maximum | Mean | Std. D | Skewness | Kurtosis |
|-------------------|---------|---------|--------|--------|----------|----------|
| DCGSP (cm) | 47.00 | 84.00 | 65.40 | 8.76 | 0.11 | 0.37 |
| DCGFP (cm) | 92.00 | 140.00 | 120.80 | 12.27 | -0.43 | 0.28 |
| HBR (0) | 208.00 | 281.00 | 252.40 | 19.12 | -0.93 | 0.19 |
| THD (0) | 341.00 | 448.00 | 410.00 | 24.71 | -0.94 | 1.80 |
| TVD (0) | 116.00 | 218.00 | 160.70 | 31.27 | 0.40 | -0.94 |
| ABR (0) | 27.00 | 54.00 | 37.65 | 5.96 | 0.72 | 1.94 |
| ABE (0) | 31.00 | 56.00 | 41.15 | 6.66 | 0.47 | -0.25 |
| BMS (m/s) | 8.00 | 11.85 | 9.78 | 0.88 | 0.11 | 0.60 |
| BMT (sec) | 0.95 | 1.32 | 1.15 | 0.10 | 0.07 | 0.06 |
| TT (sec) | 1.33 | 1.75 | 1.52 | 0.09 | 0.74 | 2.39 |

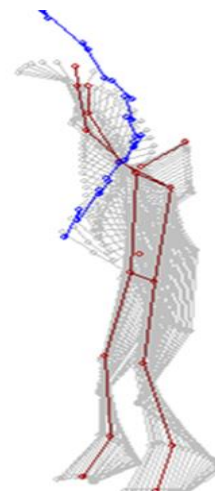
Table 2. Results of the Pearson's correlation coefficients of the ball release phase for two-point shot in basketball

| | DCGSP (cm) | DCGFP (cm) | HBR (0) | THD (0) | TVD (0) | ABR (0) | ABE (0) | BMS (m/s) | BMT (sec) | TT (sec) |
|-----------------------|---------------|---------------|------------|------------|---------|---------|---------|--------------|--------------|-------------|
| DCGSP (cm) | 1.00 | 0.50* | 0.63** | 0.02 | -0.41 | -0.34 | 0.17 | 0.29 | -0.23 | 0.14 |
| DCGFP (cm) | 0.50* | 1.00 | 0.75** | -0.33 | -0.49* | 0.19 | 0.45* | -0.08 | -0.30 | -0.05 |
| HBR (0) | 0.63** | 0.75** | 1.00 | -0.12 | -0.81** | -0.12 | 0.22 | 0.01 | -0.57** | -0.04 |
| THD (0) | 0.02 | -0.33 | -0.12 | 1.00 | 0.23 | -0.55** | -0.48* | 0.07 | 0.31 | 0.38 |
| TVD (0) | -0.41 | -0.49** | -0.81** | 0.23 | 1.00 | 0.00 | -0.27 | 0.01 | 0.78** | 0.40 |
| ABR (0) | -0.34 | 0.19 | -0.12 | -0.55** | 0.00 | 1.00 | 0.40 | -0.42 | 0.11 | -0.23 |
| ABE (0) | 0.17 | 0.45* | 0.22 | -0.48* | -0.27 | 0.40 | 1.00 | -0.56** | -0.37 | -0.04 |
| BMS (m/s) | 0.29 | -0.08 | 0.01 | 0.07 | 0.01 | -0.42 | -0.56** | 1.00 | 0.16 | 0.06 |
| BMT (sec) | -0.23 | -0.30 | -0.57** | 0.31 | 0.78** | 0.11 | -0.37 | 0.16 | 1.00 | 0.54* |
| TT (sec) | 0.14 | -0.05 | -0.04 | 0.38 | 0.40 | -0.23 | -0.04 | 0.06 | 0.54** | 1.00 |

The kinematic variables which have shown high correlation with statistical significance at the level ($p = 0.01$) are: distance between the centre of gravity and ball at starting position (DCGSP) and height of the ball release (HBR) with correlation coefficients in the value of (0.63); distance between the centre of gravity and ball in final position (DCGFP) and height of the ball release (HBR) with correlation coefficients in the value of (0.75); height of the ball release (HBR) and the trajectory of the ball movement (vertical displacement) (TVD) with correlation coefficients in the value of (-0.81); height of the ball release (HBR) and ball movement time (BMT) with correlation coefficients in the value of (-0.57); the trajectory of

the ball movement (horizontal displacement) (THD) and angle of the ball release (ABR) with correlation coefficients in the value of (-0.55); the trajectory of the ball movement (vertical displacement) (TVD) and ball movement time (BMT) with correlation coefficients in the value of (0.78); angle of the ball entrance (ABE) and ball movement speed (BMS) with correlation coefficients in the value of (-0.56).

Contourogram 1. The trajectory of the ball movement (blue line): preparatory phase, ball release and trajectory of the ball movement for two-point shot in basketball



CONCLUSION

As part of biomechanics, kinematics develops every day and is increasingly available as a tool for coaches and scientists working with athletes in developing performance and body positions. For an accurate jump shot, a proper shot pattern plays a very important role for many basketball experts (Varghesea & Shelvam, 2014). The kinematic variables, such as: height of the ball release, the trajectory of the ball movement (vertical displacement), the trajectory of the ball movement

(horizontal displacement), and angle of the ball release, ball movement time, ball movement speed, angle of the ball entrance, distance between the centre of gravity and ball at starting position and final position, provide new knowledge on the optimal trajectory model of the ball from the two-point shot with a jump. Such and similar research have placed the sport of basketball in an activity of high importance in social life.

REFERENCES

1. Ariel, G. (1994). Ariel Performance Analysis System (APAS). Ariel Dynamics - Handbook. San Diego.
2. Brancazio, P. J. (1981). The physics of basketball. American Journal of Physics, 49, 356-365.
3. Diar Mohammad, S. (2014). Comparison some of biomechanics variables to jump shot from a 45° angle from the area of the three points in front of the defender or without for the player and ball in basketball. Analytical Research. International Journal of Advanced Sport Sciences Research. Vol. 2, 137-146. Published online: 1st June 2014.
4. Hamilton, G. R., & Reinschmit, C. (1997). Optimal trajectory for the basketball free throw. Journal of Sport Sciences, 15 (5):491-504.
5. Hay, J. G. (1994). The biomechanics of sports techniques. Englewood Cliffs, NJ: Prentice-Hall.
6. Hudson, J. L. (1982). A biomechanical analysis by skill level of free throw shooting in basketball. Biomechanics in Sports. J. Terauds. Del Mar, CA, Academic Publishers.
7. Jovanović, I. (1994). Košarka teorija i metodika (Basketball theory and methodology). Niš: CIA.
8. Krause, J. V., Meyer, D., & Meyer, A. (1999). Basketball skills and drills. 3rd Ed., Indianapolis, Masters Press.

9. Miller, S., & Bartlett, R. M. (1996). The relationship between basketball shooting kinematics, distance and playing position. *Journal of Sports Science*, 11, 243-253. doi:101080/02640419608727708
10. Okazaki, V. H. A., & Rodacki, A. L. F. (2012). Increased distance of shooting on basketball jump shot. *Journal of Sports Science and Medicine*, 11, 231-237. <http://www.jssm.org>.
11. Ranjith, P., & Rajini Kumar, P. (2014). Biomechanical analysis of set shot in basketball. *Star International Journal*, 11(1), 1-5. ISSN: 2321-676X.
12. Satti, S. (2004). The perfect basketball shot. Physics Department, College of Wooster, Wooster, Ohio 44691; Monograph.
13. Tang, W. T., & Shung, H. M. (2005). Relationship between isokinetic strength and shooting accuracy at different shooting ranges in Taiwanese elite high school basketball players. *Isokinetics and Exercise Science*, 13, 169-174.
14. Tsarouchas, K., Kalamaras, E., Giavroglou, A. (1988). Biomechanical analysis of free shooting in basketball. In E. Kreighbaum and A. McNeil (Eds.), *Biomech. Sports VI* (pp. 551-560). Bozeman, MT: ISBS Publishers.
15. Varghesea, J., & Shelvam, P. V. (2014). Effect of resistance training on shooting performance of basketball players. *International Journal of Physical Education, Fitness and Sport*, 3(4), 133-138.
16. Walters, M., Hudson, J., & Bird, M. (1990). Kinematics adjustments in basketball shooting at three distances, In M. Nosek, et al., (Eds). *Proceedings of the VIII International Symposium of the Society of Biomechanics in Sports*. Prague, Czechoslovakia, Consport Corporation, 219-233.

KINEMATIČKA ANALIZA FAZE PUŠTANJA LOPTE KOD ŠUTA ZA DVA POENA U KOŠARCI

SAŽETAK

Cilj ovog istraživanja je provesti kinematičku analizu faze puštanja lopte kod šuta za dva poena u košarci. Istraživanje je provedeno na dvadeset elitnih košarkaša, igrača sljedećih timova Super lige Kosova: Priština, Kerasan i Lipjani. Metode: Video snimci izvođenja tehnike šuta su napravljeni sa tri Canon HD kamere postavljene pod uglom od 90 stepeni uz mogućnost reprodukcije šezdeset slika u sekundi. 10 varijabli je odabrano za kinematičku analizu. Prikupljeni podaci su obrađeni korištenjem statističkog programa IBM SPSS Statistics 20, a statistički parametri su određeni korištenjem sljedećih metoda: aritmetička sredina, standardna devijacija, minimalni rezultat, maksimalni rezultat, asimetrija i spljoštenost. Rezultati: U rezultatima Pearsonovih koeficijenata korelacije kinematičke analize puštanja lopte kod šuta za dva poena, varijable koje su pokazale visoku korelaciju sa statističkom značajnosti na nivou ($p = 0,01$) su: udaljenost između težišta tijela i lopte u finalnoj poziciji i visine puštanja lopte sa koeficijentima korelacije od (0,75); udaljenost između težišta tijela i lopte u početnoj poziciji i visine puštanja lopte sa koeficijentima korelacije od (0,63). Zaključak: Rezultati ovog istraživanja faze puštanja lopte, putanje horizontalnog, vertikalnog kretanja, visine puštanja lopte, ugla puštanja lopte i ukupnog vremena su veoma značajni indikatori za izvedbu šuta za dva poena i veoma važan vodič za stručnjake u ovom polju.

Ključne riječi: košarka, kinematika, putanja, šut za dva poena, Pearsonova korelacija

Correspondence to: Diellza Kelmendi
Kosovo Olympic Academy, Kosovo Olympic Committee, Pristina, Kosovo
E-mail: diellza.kelmendi@noc-kos.academy

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