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DEAR READER,

Here is the new issue of the Sport Science journal. This issue brings new scientific papers containing new knowledge and values promoted through the research results of our esteemed authors.

A multitude of researchers continue to submit their papers for publishing in our journal, and we are very grateful, since they have recognised its quality and effort to promote new scientific and professional achievements whose results ultimately contribute to the given area of sport science. We are pleased that researchers from Serbia have recognised our journal, with an outpouring of papers being submitted for publication each day.

The world is slowly recovering from the COVID-19 pandemic, but its effects will remain and we will have to find new methods to cope with them. Research on the effects of the COVID-19 pandemic on various aspects of sport science is ongoing, as there is a need to delve deeper into the unknown so as to try and solve new mysteries of the changed world. The new findings on the changes in behaviour and requirements during sports practice shed light on the emergence of new ways in which people engage in sports. The papers exploring these topics bring new findings which will certainly help in understanding the issues we are faced with.

The Editorial Board was responsible and professional in their approach to the selection of papers for the new issue of Sport Science. In doing so, the quality of the work conducted by the authors represented a priority and a requirement for their publishing. We would like to thank them for their effort and endeavour to select the papers which promote scientific thought and contribute to new findings in sport through their results.

We are pleased that our journal represents the setting for the development of scientific thought and creation of new sports systems despite the effects of the COVID-19 pandemic.

Thus, the Sport Science journal remains a platform for presenting new results which will

contribute to the development of sport science. Promoting these results and achievements represents an obligation for our journal to maintain trust and the quality that will satisfy the needs and expectations of our devoted readers.

That is why, we invite you, readers, to become a part of our team and participate in our work so that, together, we could contribute to science and cope with changes imposed by the new movements in the world of sports.

Nihad Selimović, MD, MSc
Editor in chief



DRAGI ČITATELJU,

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

Idalje imamo veliki broj istraživača koji dostavljaju svoje radove za objavu u našem časopisu te smo im zahvalni jer su prepoznali njegov kvalitet i nastojanje da promoviše nova naučna i stručna dostignuća čiji rezultati u konačnici doprinose datoj oblasti nauke o sportu. Drago nam je da su istraživači iz Srbije prepoznali naš časopis uz izniman priliv radova koji pristižu svaki dan.

Svijet se polako oporavlja od pandemije COVID-19, ali će njene posljedice ostati sa nama te ćemo morati pronaći načine da se sa njima nosimo. Istraživanja efekata pandemije COVID-19 na različite aspekte nauke o sportu su i dalje aktuelna obzirom na potrebu dubljeg proučavanja nepoznanica kako bismo pokušali riješiti nove misterije promijenjenog svijeta. Nova saznanja o promjenama u ponašanju i zahtjevima sportske prakse pružaju jasniju sliku novih načina na koje se ljudi bave sportom. Istraživanja koja se bave ovim temama donose nova saznanja koja će zasigurno pomoći u razumijevanju problema sa kojim se suočavamo.

Recenzentski odbor je odgovorno i profesionalno pristupio odabiru radova za novi broj časopisa Sport Science. Pri tome je kvalitet autorskog rada bio prioritet i uslov za njegovu objavu. Zahvaljujemo im se na naporima i nastojanju da odaberu radove koji promovišu naučnu misao i rezultatima doprinose novim saznanjima u sportu.

Sretni smo što naš časopis predstavlja mjesto za unaprjeđenje naučne misli i stvaranje novih sportskih sistema uprkos posljedicama pandemije COVID-19.

Sport Science time ostaje platforma za predstavljanje novih rezultata koji će doprinijeti razvoju nauke o sportu. Promocija tih rezultata i dostignuća predstavlja obavezu našeg časopisa da održi povjerenje i zadrži kvalitet koji će zadovoljiti potrebe i očekivanja naših vjernih čitatelja.

Upravo zato pozivamo Vas, čitatelje, da budete dio našeg tima i učestvujete u našem radu kako bismo zajedno doprinijeli nauci i nosili se sa promjenama koje nam nameću nova kretanja u svijetu sporta.

Mr. sci. dr. Nihad Selimović

Glavni urednik



EMBRACING MODELS-BASED PRACTICE TO TEACH PHYSICAL EDUCATION TO CHILDREN WHO HAVE SPECIAL NEEDS

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ABSTRACT

Background: Models-based practice (MBP) is an innovative concept that has been widely researched since the early 1980s. For example, Siedentop (1982) was an early advocate of MBP which is a pedagogical approach to curriculum planning. There are a range of individual models which are widely regarded to fall within MBP, and they include Teaching Games for Understanding (TGfU), Sport Education and Games Sense. **Aim:** The aim of this study is to use the TGfU model with students who have special needs and attend a special education school to determine whether a one model-based approach can have an impact on a student's engagement and activity levels within Physical Education (PE). **Methods:** Tchoukball was used as the activity of choice, where the students were exposed to the TGfU model, and every student reflected upon their learning journey by completing a questionnaire at the end of the teaching unit. **Problem:** The research problem was whether the TGfU model and its principles could have an impact on the engagement and activity levels of the students ($n = 12$). **Results:** The results show that both the physical activity and engagement levels of the students increased because of experiencing the TGfU model. The results also support the hypothesis that one MBP can be effective when improving outcomes for children who have special needs. **Conclusion:** The main finding is that an experienced teacher can positively impact and implement a single models-based practice approach to teaching PE with children who have special needs.

Keywords: models-based practice, Teaching Games for Understanding, special needs, Physical Education

INTRODUCTION

Models-based practice (MBP) in physical education (PE) focuses on the delivery of a teaching model, such as Cooperative Learning, Sport Education or the Teaching Games for Understanding Model (TGfU). The aim of this study was to provide the rationale for selecting the TGfU model to use with children who have Special Educational Needs (SEN). This includes the planning, engagement levels and lessons that were learned by the teacher-researcher as a result of implementing the TGfU model into the PE lessons of children with special needs.

Casey (2014) stated that "local level modifications are too complex for normal teachers and that the

intricacy of these MBP models is such that only the best of the best can use them". This comment was supported by Haerens et al. (2011), Kirk and Macdonald (2001), and Lund and Tannehill, (2010) who all had researched MBP and come to similar conclusions about how only expert and experienced teachers had the ability to improve student outcomes using a models-based approach. However, very few teacher-researchers have taken on the challenge of planning and implementing this approach when the students have special educational needs. The teacher-researcher is not aware of any other studies which have focussed on selecting one MBP teaching model to enhance student learning.

This TGfU model was described in a different way by Kirk and MacPhail (2002) who defined the essential characteristics of the TGfU model as the transfer of

skills between sports, the adaption of the tasks to suit the student's needs and the addition of tactical elements to increase the difficulty levels within the lesson linking it back to the main game / sport at all times. But in essence, the model has remained very stable since its inception in the early 1980s and this has been researched by many authors, including Goodyear et al. (2016). Both commentaries place tactical play at the centre of the learning, and this was a key point for the teacher-researcher to become aware of and ensure that this was shared with the students during every lesson.

The activity of Tchoukball was chosen because it's a non-contact team sport which was developed in the 1970s by the Swiss Biologist Hermann Brandt. Tchoukball is a mixed activity sport consisting of seven players, played between two teams aiming to throw a ball against a rebound frame to score a goal. The aim of Tchoukball is to throw the ball at a frame so that a ball rebounds and lands over the shooting line within the court. The opposition's role is to catch the ball to prevent their opponents scoring and then shoot it themselves. The teacher-researcher wanted to ensure there was as much playing time as possible for the students, and this was one of the most interactive and interesting activities on the PE curriculum. It was also an activity that the teacher-researcher was familiar with and had taught to a different group of students in previous years. The teacher-researcher was experienced at teaching Tchoukball, and this is a further reason why the activity was chosen to be used in this study.

The teacher-researcher wanted to focus on only one model because this would be a suitable amount of 'change' for students who had been mainly used to learning using a didactic teacher-led approach and whose special educational needs were better suited to knowing that there would only be some small changes to their PE lessons. Several of the variables mentioned above were also highlighted by Metzler (2011) who said changing variables, such as the facilities, lesson times and activities, would negatively impact the results of any future studies. This is an important consideration for students who have ASD for example, since they prefer to follow a structured timetable and the results from the study might not have been as effective if too many of the variables had been changed all at once.

Therefore, the only variable to change was the introduction of the TGfU model to deliver a unit of learning focussed on Tchoukball, and this is supported by Casey et al. (2009) who stated that teaching in a new way is not an easy process as all models had their complications. Curtner-Smith et al. (2006) also agreed that using MBP requires a higher level of subject knowledge because the concept of MBP is not enough to facilitate learning and therefore teachers have to learn by themselves how to apply these ideas into their own lessons over a period of time. In another study conducted

by Koekoek and Knoppers (2015), they focussed on the activity of baseball because it allowed students the opportunity to make tactical decisions which matched their previous experiences. Hastie and Casey (2014) also argued that any paper focussing on MBP research should report on three elements, and these were a description of the curriculum unit, which was Tchoukball in this example; secondly, it was a detailed explanation of the intended model and its implementation, and finally an overview of the previous experiences of both the teacher and students with MBP.

PROBLEM AND AIM

Studies by Dyson, Linehan and Hastie (2010) as well as Barrett and Turner (2000) suggested that 'sustained pedagogical change' requires a teacher to initially learn how to teach through a models-based approach and then engage in a change of thinking of what teaching in physical education becomes. However, these studies both focus on teaching students who were in a mainstream setting and neither study looked beyond the impact of this research with students who have SEN. Therefore, it was the intention of the teacher-researcher to move away from a traditional approach of teaching physical education and adopt a single models-based approach of TGfU with the SEN students. The teacher-researcher wanted to demonstrate the hypothesis that one teaching model could be plentiful to enhance the physical and educational outcomes of the students with special needs.

However, Lund and Tannehill (2010) and Haerens et al. (2011) both highlighted that one model might not be capable of delivering the entire breadth and depth of learning required in the different "national contexts in which physical education curricula operate". Metzler (2011) also stated that there are many important variables in teaching physical education, such as the personnel, learning goals, facilities, content, activities, and the teacher instructions, and that no one model is capable of encapsulating and then delivering them all. Similarly, Kirk and Macdonald (2001) discovered that the expertise of a teacher in their local context was more important than having to worry about the type of activity or the personal teaching style of the staff leading the activities. The teacher-researcher wanted to ensure that the students remained in their normal school setting to help with consistency and to ensure that the students were comfortable with their environment throughout the study.

It was a sub-aim of the teacher-researcher to focus on the activity and engagement levels within the school setting and challenge the views of the authors above to determine whether their findings

are also relevant in a SEN setting with students who specifically have social, emotional, or mental health issues (SEMH) using a single MBP teaching model. O'Leary (2016) also stated that for the TGfU model to demonstrate these outcomes, the stages of the TGfU model should be followed. The original design of the TGfU model was created by Bunker and Thorpe (1982), and since then, there have been a number of authors who have re-developed the stages of the model to give it a very clear and defined structure. For example, O'Leary (2016) identified three key stages which were the playing stage, the tactical stage and then to refine these steps and apply them back into the execution stage where the students would become better games players.

METHODS

PARTICIPANTS

A total of twelve students took part in this study and they all had an Education and Health Care Plan (EHCP) and were in Key Stage 3 (Age 11-14) of a UK Special Secondary School. All of the students were able to take part in a range of physical activities and none of them had any physical disabilities or mobility limitations. The teacher-researcher facilitated a unit of work focussed on the activity of Tchoukball with lessons timetabled for 45 minutes. The unit consisted of ten lessons, taught twice per week over the period of one summer half-term. The students were split into four learning teams, and each team consisted of both boys and girls for the entirety of the unit (Boys = 8 Girls = 4). The reason for doing this was to build up a sense of teamwork and consistency for the students as this would help them to engage in their learning and really focus on improving their activity levels.

Barba-Martín et al. (2021) agreed that PE units which were taught over eight hours were regarded as longer-term interventions, and these interventions were seen as important because using a TGfU approach required the students to have more reflection and thinking time to be fully engaged in the learning process. This would also concur with the view of Stolz and Pill (2014) who recommended longer interventions because TGfU demands that learners engage in tasks that require a higher level of thinking and reflection opportunities. These were important views to consider when planning the study as the teacher-researcher wanted to ensure that the study would be able to provide the most reliable and robust data as possible. The teacher-researcher intended to use a student questionnaire to analyse the outcomes of the lessons.

The data collected in this study was collected through an action learning process. The purpose of action

learning is to bring about change in a person's learning and development using the process of reflection. Action learning was chosen as the main type of study design because the process allowed the students to reflect on their learning and, as a result, the teacher-researcher was able to link these reflections back to the original question about adopting a MBP with children who have special needs and whether the TGfU model could be implemented successfully (Moon, 2013).

The process of action learning started with the teacher-researcher explaining the process to the students and outlining that an adapted questionnaire would be used to collect the data. Action learning is also effective because it does not matter which physical activity was selected, such as Tchoukball or it could have been Badminton or Volleyball, as the same process and principles of action learning could be applied. The main principles of action learning are problem solving, self-development and collaborative enquiry by physically taking part in a familiar activity. It's a way of learning by doing an activity and being able to apply some principles to a practical situation and being open with any findings. These were the main principles which applied to this study and the framework in which the study was based around

PROCEDURES

Each student completed a questionnaire at the end of the learning unit as this allowed them to reflect upon their learning straight after it had happened. The reflections were analysed, and the percentages of results were calculated based upon the type of response to each question from the students. The results from the questionnaires were evaluated and then shared with the students at the end of the investigation. None of the students had any prior experience of either taking part in Tchoukball, and they also had not taken part in any other research studies.

The questionnaires were designed with a five-item Likert Scale that would give a representative cross-section of a student's experience to improve the process of data collection (Gehlbach & Artino Jr, 2018). The teacher-researcher decided upon the Likert Scale as a method of good practice, and this view was supported by the research of Carifio and Perla (2007) who saw the Likert Scale as a way of measuring responses and that the scale is helpful and supportive to provide a quantitative result. The teacher-researcher encouraged the students to answer the questions as honestly as possible which ensured the results were as valid and reliable as possible. The data was then analysed to look for any patterns, themes or relationships, and percentages were drawn up

Permission to undertake the study was gained from the Trust Chief Executive (CEO). The CEO wanted the

reassurance that none of the students from the trust would be named for safeguarding purposes and all of the families of the students were going to be informed about the study and they were all happy to be involved for ethical purposes. The teacher-researcher did the necessary reading about this subject from British Educational Research Association (BERA) and gained full consent from all participating students' parents about the study and that the necessary arrangements were in place before, during and after the study to ensure the health and safety of everyone involved in the research.

Throughout the study, the teacher-researcher was open with the students about his dual role as both a teacher and as a researcher. No distinction or discrimination was made between participants and non-participants in lessons, but data, in the form of questionnaires, were only gathered from students who took an active part in the lessons. The teacher-researcher selected the groups to ensure that each team contained students across the full ability range. Furthermore, they were selected to ensure they contained neither existing friendships nor rivalries. Over the course of the unit, the groups worked through a carousel of practices and activities using modified equipment or rules.

The teacher-researcher used a series of challenges as the main source of information and acted in the role of facilitator (Goodyear & Dudley, 2015). Metzler (2011) highlighted the importance of verifying that any model implemented in physical education led to the intended student outcomes, and the first lesson in the unit was called 'Lesson Zero' (Dyson & Casey, 2016) to explain the model and the unit outcomes to the students. Each lesson which proceeded this first lesson followed the same structure after an initial warm-up which would be undertaken in small learning groups. The teacher-researcher led all of the lessons to ensure there was a level of consistency and reliability in the approach to gathering the data. This also applies to the way in which the students were given the questionnaire at the end of the unit, the amount of time they had to complete the questionnaire and the observation of the teacher-researcher to ensure this part of the data collection was valid and accurate without any external input.

At the time of the study, the teacher-researcher was an experienced teacher of PE and an experienced proponent of MBP, with a specific interest in the TGFU model. The teacher-researcher had taught more than 10 units of work using MBP (across multiple classes and age groups) and had also undertaken several research studies on TGFU. According to Kirk et al. (2021), the experience levels of the teacher can have a significant impact on the findings using a MBP approach to teaching PE. Both Dania et al. (2017) and Hortigüela and Hernando (2017) also agreed with this and found that teachers who had had some form of intervention training using a MBP were more likely to be able to

deliver successful student outcomes.

STATISTICAL ANALYSIS

The teacher-researcher used an adapted version of a questionnaire designed by Cervelló et al. (2007). Originally, the questionnaire consisted of 24 items that measured two areas; firstly the task climate and also the ego climate. All 24 of the questions started in the same way – "In my physical education lessons..." and then moved on to ask the students about how their engagement and physical activity levels had changed because of the introduction of Tchoukball through the implementation of a single TGFU teaching model.

The questionnaire has demonstrated the teacher-researcher has genuinely undertaken the study within a school setting and not within a lab environment. This has enhanced the value of the data as it has come directly from the participants, and there was no need to have a control group because the teacher-researcher wanted to ensure that all of the participants were able to be as open and honest as possible about their experience of learning physical activity in a different way.

The teacher-researcher decided that 24 questions would be too demanding for the SEN students and therefore adapted the questionnaire by removing 12 of the less relevant questions, only focussing on those questions about engagement, physical activity and their enjoyment levels which are the three main factors within MBP research. The reason for this is because all of the students had special needs and their literacy and numeracy skills were all below age-related expectations. The students did not have the cognitive ability to read and answer 24 questions individually, and this could have triggered a range of anxious emotions from the students which the teacher-researcher was sensitive too. Each student answered a total of 12 questions with about each of the key topics, and this was used to inform the teacher-researcher about the reliability of the research. An example of questions includes, "In my PE lessons, I usually take part in all of the activities?" Previous research by Amado et al. (2014) and Arias et al. (2013) has demonstrated the internal reliability of this type of qualitative questionnaire. This is a form of descriptive statistics where the teacher-researcher has taken the number of responses to each question and summarised them as a percentage of the total number of participants.

RESULTS

Overall, the findings show that there is a positive impact on student outcomes using a single MBP with children who have special needs. The use of the TGfU model has demonstrated that students have become more engaged in their learning during the Tchoukball lessons (reported as 75%). The results from the study also show that the students felt more actively engaged in their learning and they had enjoyed the lessons, with 92% of students feeling more positive after PE using the TGfU model. This finding would agree with the research conducted by Miller (2015) who also found that using the TGfU model increased the positive engagement levels of the students in PE.

A further 83% of the students felt that they were more active in their PE lessons as a result of using a MBP. By using this single TGfU model of learning, the students reported that they were more motivated to take part and were physically more active during PE. This is another positive finding which concurs with the views of Barba-Martín et al. (2020) who also reported that the students in that study were more active during PE once they understood the requirements of the lesson and tactics were clear.

The aim of the review was to consider if MBP is worth undertaking specifically in regard to adoption of one model, and specifically whether by selecting one model, this could have a positive impact on student outcomes in a special school. There are a number of important points to emerge from this study, including the improvement in activity and engagement levels of the SEN students and how this was brought about by only using one model of learning. The results show there is a higher positive level of engagement and activity from the raw data, and the students responded to the Likert Scale questions with positive responses about how they felt they were learning Tchoukball.

It was the aim of the teacher-researcher to determine whether the TGfU model was an effective model which could be applied in a special school setting. The setting was also important because, according to Kirk et al. (2020), there have been no TGfU studies to date which have focussed on special school educational settings. Kirk et al. (2020) also went on to highlight that there had been four studies which had focussed on the educational setting, but there were no conclusive results between the study settings and any the impact on student outcomes. The effect of the educational setting is something which could be further investigated in a follow-up study to determine how much of the engagement levels had been improved within school or by taking a group to a local gym, for example.

The results from this study are more promising because teaching Tchoukball in this way has allowed the students to become more active and confident in their physical movements. This has also resulted in more students being active by taking more of an interest in their PE lessons. These results would agree with similar intervention studies, such as the ones conducted by Miller (2015) and Robinson and Foran (2011) who also concluded that results in all game performance and knowledge variables after longer interventions of more than eight hours were the most effective and brought about the most positive results. Using this intervention model has shown that the students have become more self-reliant and have enjoyed taking on a range of different roles during their PE lessons. They have also shown that they can become more resilient, take ownership of their own learning, and have enjoyed working in teams.

DISCUSSION

According to Casey (2014) teachers need support in making the conceptual shift from direct instruction to MBP. He also comments on how teachers discover MBP outside of their teacher training education and the ways in which they are supported to use MBP in their schools. The teacher-researcher has undertaken some previous research into the teaching of MBP, but this is something he has initiated himself, and this is not something which his establishment has prescribed. This research has come about because of his interest in using the TGfU model in PE and not because it has been stipulated by the institution or because the teacher-researcher has attended a specific training course on MBP. The results support this as the study was undertaken by a teacher-researcher who has experience using the TGfU model, and this would have had an impact on the outcome because a highly motivated teacher-researcher could have passionately promoted the TGfU model and there could have been rewards for the students taking part which would have served as another motivational factor.

Barba-Martín et al. (2020) also stated that it is necessary to invest time in teachers' previous preparation, since they must master both the content and the characteristics of a models-based approach to teaching; and specifically, the more time which is invested in learning about MBP to teaching games will only benefit the students on the programme. A study by Hortigüela and Hernando (2017) stated that to be regarded as an experienced practitioner in the teaching of TGfU, the teacher should be trained for at least thirty hours which would include reading and studying any of the MBP models in greater depth with the support of a mentor or from an academic source.

The training themes in this study were focussed on the teaching of Tchoukball and as a result of the teacher-

researcher being experienced and confident in the delivery of a MBP, the students were able to experience a range of opportunities based on altering the game structures, tactical principles of play and the critical elements of the TGfU model which according to Kirk (2017) are 'questioning, expected teacher and learner behaviours and the lesson design'. It was the teacher-researcher's knowledge and experience in teaching these critical elements to solve a range of problems which has probably led to a more successful outcome and the keen interest in teaching through a models-based approach.

This validation of this outcome is possible because the teacher-researcher can confirm that the critical elements of the lessons were in place and the students were taught using the TGfU model. Validation is the student-centred approach to pedagogy using modified games and the setting of problems to be solved according to Kirk (2017). Verification is more difficult to demonstrate because even though the teacher-researcher was demonstrating his usual behaviours when teaching PE, the students all had a range of additional needs and these were often affected by other variables such as the timing of lessons, student interactions, medication, and the enthusiasm of the students towards playing Tchoukball (Butler, 2014).

The qualitative part of the study served to verify the information on the perception of students obtained in quantitative data. The use of action learning provided a central framework for the qualitative part of the study to ensure the reflections were always open, practical and shared between the teacher-researcher and the students involved in the study. This is a strength of the study in that it was very practical and allowed the teacher-researcher to have a pragmatic focus on learning throughout the entire teaching unit. The results are clear, and this is another strength because it shows other teachers that they can be confident in the use of a single models-based approach to learning in PE.

There are still several limitations with this study which could be further explored and reported on. For example, the teacher-researcher could further report on all of the outcomes from the questionnaire and not only focus on the positive comments. The study could also investigate having a control group or randomised groupings and focus on whether another teacher of PE, who is not as experienced as the current teacher-researcher, would be able to teach a unit of Tchoukball and further activities across the PE curriculum with the same levels of success.

There needs to be more research into whether the school setting played a significant part in the results and whether the realities of everyday school life can be balanced with the aspiration of using a models-based approach to learning. For example, one of the realities

is having the time in lessons to be able to set-up this type of MBP study. A statistical program such as IBM SPSS v. 24.0 could have been used to further analyse the data and the in-gender differences in the results, and a further qualitative method, such as interviews, would allow a teacher-researcher to obtain more in-depth insights into the student's thoughts of the TGfU model.

CONCLUSION

The purpose of this paper was to explore whether one model of MBP could impact and enhance the physical education of students with special educational needs, and the findings demonstrate a positive conclusion. The results show that the students were more active and engaged in their learning and that they were able to reflect and respond to a range of problems as the lessons progressed during the course of a teaching unit of Tchoukball. Tchoukball was only ever the medium in which the students were learning, but the paper highlights the importance of the school context along with the experience levels of the teacher and the benefit of following a single TGfU model.

In conclusion, it was clear that the teacher-researcher had a significant amount of experience both using a models-based approach to teaching PE and in the application of the TGfU model which has resulted in a highly positive outcome for the students in special education. This would agree with the views supported by Kirk et al. (2020), who said that for the teacher to have an impact on student outcomes, they would need to have previous experience of using the TGfU model and be trained in how to apply it. Follow-up research should focus on the modification of the games and the process of how the teacher could modify games to make them more specific to tactical situations or focus on a different model of learning to compare the results against the same set of students.

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UKLJUČIVANJE PRAKSE ZASNOVANE NA MODELIMA U PODUČAVANJE FIZIČKOG OBRAZOVANJA KOD DJECE SA POSEBNIM POTREBAMA

Kontekst: Praksa zasnovana na modelima (MBP) je inovativni koncept koji je uvelike istraživana već od ranih 1980-ih. Na primjer, Siedentop (1982) je bio rani zagovornik MBP-a, a koji predstavlja pedagoški pristup planiranju nastavnog plana i programa. Postoji mnoštvo individualnih modela za koje se općenito smatra da pripadaju MBP-u, a oni uključuju učenje igara s razumijevanjem (TGfU), sportsko obrazovanje i smisao igara. **Cilj:** Cilj ove studije je koristiti TGfU model sa učenicima koji imaju posebne potrebe te pohađaju školu za specijalno obrazovanje kako bi utvrdili da li jedan pristup zasnovan na modelima može uticati na učešće i nivoe aktivnosti učenika tokom fizičkog obrazovanja (PE). **Metode:** Tchoukball se koristio kao izabrana aktivnost gdje su učenici izloženi TGfU modelu te se svaki učenik osvrtao na svoj put učenja ispunjavajući upitnik na kraju nastavne jedinice. **Problem:** Problem istraživanja je bio da li TGfU model i njegovi principi mogu uticati na učešće i nivoe aktivnosti učenika (n = 12). **Rezultati:** Rezultati pokazuju da su se fizička aktivnost i nivoi učešća učenika povećali zbog sudjelovanja u TGfU modelu. Rezultati također podržavaju hipotezu da jedan MBP može biti efikasan u poboljšanju ishoda za djecu sa posebnim potrebama. **Zaključak:** Glavni pronalazak je da iskusan učitelj može pozitivno uticati i provoditi jedan pristup prakse zasnovane na modelima u podučavanju fizičkog obrazovanja kod djece sa posebnim potrebama.

Ključne riječi: praksa zasnovana na modelima, učenje igara s razumijevanjem, posebne potrebe, fizičko obrazovanje

DO SPINNERS MATTER IN THE POWERPLAY OF TWENTY20 (T20) CRICKET? EVIDENCE FROM IPL

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ABSTRACT

In limited overs cricket, powerplays provide the batting team an opportunity to maximise their chances of scoring runs. Traditionally, powerplay bowling has been dominated by pace bowlers (pacers). However, with the advent of the Indian Premier League (IPL), powerplays in T20 cricket are witnessing the rise of the introduction of spin bowlers (spinners) even as early as asking them to open the bowling. The same used to be a rarity. This paradigm shift in the captains' thought process to ask the spinners to have a lion's share in the powerplay bowling encourages us to think whether the spinners are in fact contributing better than the pacers during the powerplays. In our work, we have compared the performance of the spinners and the pacers when they bowl during the powerplays. Our analysis revolves around the T20 games played in the Indian Premier League (IPL) from 2008 to 2020. We found that the performance of the spinners is indeed better than the pacers in terms of better Economy Rate. Further, when a team is defending a total, spinners have shown better Bowling Average, Economy Rate, and a combined metric called the Combined Bowling Rate.

Keywords: sports analytics, performance measurement in sports, sports management, cricket, powerplay

INTRODUCTION

Cricket is one of the most popular team sports in the world, with its viewership spanning across the globe. It is evident from the fact that the flagship event of cricket, i.e., the Cricket World Cup (CWC) 2019, had an overall viewership of 1.6 billion viewers (ICC, 2019). International cricket is played in many formats, which include the longer five-day format of Test cricket, the shorter one-day format of One-Day cricket, and the shortest and the most popular format of Twenty20 cricket (T20) (Rediff, 2018). The advent of T20 in the international arena for men's cricket can be traced back to 2005, when Australia played New Zealand (Cricketcountry, 2016). With the initial success of the new format on the international

stage, the International Cricket Council (ICC), the world governing body of cricket, launched the T20 World Cup in 2007

(Times of India, 2021). Following the success of the inaugural T20 cricket World Cup in 2007, the Board of Cricket Control of India (BCCI), the governing body of cricket in India, launched the Indian Premier League (IPL) in 2008. The inaugural season started with eight teams, each representing a geographical location of India, playing in a double round-robin format followed by the knockout stages, including the finals to decide the winner (Espncriinfo, 2008). Soon after its launch, its popularity started increasing with 100 million cumulative viewers in 2008, reaching an excess of 400 million cumulative viewers in 2017, thereby indicating a four-fold increase in viewership within a decade of its

launch (Statista, 2020).

In the limited-overs format of cricket, i.e., One-Day and T20, powerplay rules were introduced to make the games more interesting and popular, whereas powerplay refers to the fielding restrictions imposed on the bowling team that allows only a limited number of fielders outside the 30-yard inner circle, i.e., in the outfield (Silva et al., 2015). The rationale for such restrictions is to encourage the batting team to play more aggressive shots to score runs (Silva et al., 2015). In the T20 games, the powerplay rule is applicable to the first six overs (i.e., 36 balls), where the bowling team can place only two fielders outside the inner circle except in the shortened games, which are affected either by rain or other issues.

Historically, we have seen that the pacers dominate the powerplay overs even though, nowadays, spinners do take centre stage during the powerplays (Cricket, 2021). It was in the 1992 World Cup that the New Zealand off-spinner Dipak Patel took the world by the storm when he opened the bowling as it took the batters by surprise, and the said decision played a pivotal role in New Zealand's run to the semi-finals (Firstpost, 2019). Since the advent of the T20, and especially IPL, we have noticed that spinners have quite often been used during the powerplays, even being asked to open the bowling, which was rarely witnessed in the past (The Analyst, 2021). The introduction of the spinners so early into the game, when the fielding restrictions are on, challenges the conventional wisdom. Whether the spinners are really doing better than the pacers during the powerplays is a matter of interest as more and more spinners get introduced to bowl during the powerplays. Hence, in this work, we wish to study whether the bowling performances of the spinners during the powerplays are better than the pacers using statistical analysis.

The paper is organised as follows: the next section covers the problem statement and the aim of the research. Section three covers the detailed methodology, while section four highlights the results of our study. The last two sections respectively cover the discussions of the results and the final conclusions.

PROBLEM AND AIM

Measuring bowling performance is a well-researched area under the domain of sports analytics. To measure the performance of bowlers, some of the most commonly used metrics include Bowling Average (BA), Bowling Strike Rate (BSR), and Economy Rate (ER). BA is defined as the total number of runs conceded for each wicket, BSR is defined as the total number of balls bowled for each wicket, and ER is defined as the number of runs conceded in every over, i.e., per six balls bowled. If the number of balls is denoted by B, the

number of wickets denoted by W, and the number of runs conceded is denoted by R, then the said metrics can be mathematically expressed as:

$$BA = \frac{R}{W}, BSR = \frac{B}{W}, \text{ and } ER = \frac{6R}{B} \quad \dots(1)$$

These metrics capture different aspects of bowling performances. However, the extant literature lacked a comprehensive bowling performance metric that will incorporate all the above metrics together (Bhattacharjee & Chakraborty, 2018). Lemmer (2002) has introduced the Combined Bowling Rate (CBR) which combines BA, BSR and ER and is defined as:

$$CBR = \frac{3}{\frac{1}{BA} + \frac{1}{BSR} + \frac{1}{ER}} \quad \dots(2)$$

Barr and Kantor (2004) used a metric, which is a weighted average of BA and BSR, as a balance between bowling average and bowling strike rate. They expressed their metric as:

$$BK = BA^{1-\alpha} BSR^{\alpha} \text{ where } 0 \leq \alpha \leq 1 \quad \dots(3)$$

The choice for α , however, is subjective. Lemmer (2005) further modified the metric CBR by introducing different weights for the wickets taken, which will depend upon the batting position of the batters dismissed when the number of matches is small. He defined the metric as:

$$CBR^* = \frac{3R}{W^* + 6B + W^* \frac{R}{B}} \quad \dots(4)$$

In principle, CBR^* is similar to CBR with the exception of different weights being used for different batting positions. Basevi and Binoy (2007) introduced a performance metric called Calc and expressed it as:

$$Calc = \frac{R^2}{W.B} = \frac{BA.ER}{6} \quad \dots(5)$$

The requirement for Calc is that the bowler must have delivered 200 balls (Lemmer, 2008). Out of all the metrics discussed, CBR and CBR^* are the most commonly used metrics due to their ease of interpretation. Since our analysis is focused on the powerplays when the batters in the batting order will bat, CBR and CBR^* will give almost similar results. Further, the number of matches that we have considered is also large. Hence, we have used CBR for our analysis.

In this work, we study whether it is a correct move to introduce spinners during the powerplays. To test the same, we have used the T20 games played during the IPL. We compared the commonly used metrics like Bowling Average, Bowling Strike Rate and Economy Rate. We have also used a comprehensive metric called the Combined Bowling Rate (CBR) for our analysis.

Additionally, we have split the data into parts innings-wise to check whether any significant differences arise in terms of CBR due to either bowling first or defending a total. Further, we have also ranked the various bowlers in terms of their performances during the powerplays. Our analysis shows that the spinners perform better than the pacers during the run chases in terms of CBR, Economy Rate and Bowling Average. Further, spinners have a better Economy Rate than the pacers during the powerplays, irrespective of the innings in which they are bowling.

METHODS

We collected the ball-by-ball data of all the T20 games played in the IPL from the beginning of the IPL, i.e., the year 2008 to 2020. The data was accessed from Kaggle¹. The data comprises two .csv files, one having the match details and the other having the ball-by-ball data. The data fields include innings no., over no., the ball no., bowler, runs off the bat, extra runs, total runs, and whether the wicket has fallen, including the type of dismissal, among certain other non-relevant fields. We aggregated and organised the bowlers' specific data, i.e., bowlers' names, bowlers' type (pacer or spinner), innings, runs conceded, balls bowled, and wickets. We then reduced our dataset by eliminating all those bowlers who had bowled less than 100 balls during the powerplay. The classification of bowlers' types was carried out manually by going through each of the bowlers' profiles present on www.cricinfo.com. For the innings-specific analysis, we considered only those entries where the bowlers have at least bowled 60 balls while bowling first or while defending a total. That led to two separate datasets for carrying out our bowlers' type and innings-specific analyses. We then computed the different bowlers' performance metrics, i.e., CBR, BA, BSR, and ER, for the pacers and spinners separately, both innings-wise and aggregated for innings. The computations are done using equations (1) and (2). We then carried out the statistical tests comparing the bowling performances of the pacers and spinners separately for the bowlers' performance metrics, i.e., CBR, BA, BSR, and ER.

¹ <https://www.kaggle.com/datasets/patrickb1912/ipl-complete-data-set-20082020>

RESULTS

For the statistical analysis where we need to compare the bowlers' performance metrics, i.e., ER, BA, BSR, and CBR of two populations of pacers and spinners, we state the following hypotheses:

H0(1a): There is no difference between the ER of pacers and spinners

H0(1b): There is no difference between the BA of pacers and spinners

H0(1c): There is no difference between the BSR of pacers and spinners

H0(1d): There is no difference between the CBR of pacers and spinners

Then, for the analysis specific to innings, we state the following hypotheses:

H0(2a): There is no difference between the ER of pacers and spinners in the first innings

H0(2b): There is no difference between the BA of pacers and spinners in the first innings

H0(2c): There is no difference between the BSR of pacers and spinners in the first innings

H0(2d): There is no difference between the CBR of pacers and spinners in the first innings

H0(3a): There is no difference between the ER of pacers and spinners in the second innings

H0(3b): There is no difference between the BA of pacers and spinners in the second innings

H0(3c): There is no difference between the BSR of pacers and spinners in the second innings

H0(3d): There is no difference between the CBR of pacers and spinners in the second innings

The analysis is carried out by the Mann-Whitney U test, also known as the Wilcoxon Rank Sum Test. Since t-tests compare the means of two populations, the mean of ER or other performance metrics for pacers or spinners across players could be erroneous due to different denominators. Hence, we considered the Mann-Whitney U test which deals with the median of two populations. The Mann-Whitney U test is a non-parametric test and can be considered as a non-parametric equivalent of the two-sample t-test. This test compares differences between two independent populations, where the independent variable is either continuous or ordinal. However, the independent variable need not be normally distributed. We ran these tests on the R software (<https://www.r-project.org/>).

The final results of the statistical tests are presented in the following table:

Hypotheses	Test statistic	p-value	Rejection of Null
H0(1a)	2002	0.0324	Yes
H0(1b)	1629	0.8628	No
H0(1c)	1494	0.5922	No
H0(1d)	1741	0.4474	No
H0(2a)	1754	0.0347	Yes
H0(2b)	1374	0.9062	No
H0(2c)	1256	0.4146	No
H0(2d)	1488	0.5859	No
H0(3a)	1594	0.0691	Weak
H0(3b)	1592	0.0710	Weak
H0(3c)	1485	0.2481	No
H0(3d)	1678.5	0.0196	Yes

DISCUSSION

It is evident from the above table that if we do not take the innings-specific performance into account, then, out of the four bowlers' performance metrics considered here, only the ER is significantly different for the pacers and spinners during the powerplay. For the remaining three hypotheses, we could not get sufficient evidence to reject the Null Hypothesis. Hence, without the innings-specific performance, the pacers and spinners are similar in terms of BSR, BA and CBR. However, the moment we bring the innings-specific performance into account, we also find that during the first innings, once again the pacers and spinners have performed similarly in terms of BSR, BA and CBR, while

differing significantly in terms of ER. On the contrary, for the second innings, we do get weak evidence of ER and BA differing for pacers and spinners, while strong evidence of CBR differing for pacers and spinners although, in terms of BSR, the performance is similar. In order to make further conclusions, we took the average ranks of pacers and spinners for each Null hypothesis that we rejected and found the following results:

(I) Spinners have a significantly lower Economy Rate than the pacers during the powerplays (both innings combined as well as first, and innings taken separately).

(II) When it comes to defending any total, spinners have a significantly better Bowling Average and Combined Bowling Rate than pacers during the powerplays.

CONCLUSIONS

During run chases, the batting team always wants to maximise the opportunities to score runs in order to chase down the target. For high-scoring chases, the batters aim to maximise the scores during the powerplays when the fielding restrictions are there. It is easier for them to target the spinners who can be lofted outside the inner circle to maximise the chances of scoring runs. In their pursuit of maximising the outcome during the powerplays, batters often throw their wickets, and that eventually builds pressure on the new batters and slows down the run rate. That is why the spinners, during the run chases perform better than the pacers. Hence with the rise of IPL, when the performances of spinners started producing desired results, more and more spinners are being brought into the powerplays, something which in the past used to be witnessed rarely.

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DA LI SU BACAČI KOJI KORISTE TEHNIKU ZAVRTANJA LOPTE BITNI U OGRANIČENOM TWENTY20 (T20) KRIKETU? DOKAZI IZ IPL-A

Tokom jednodnevnog kriketa ograničenja pružaju mogućnost da udarački tim poveća šanse za osvajanje poena. U igri sa ograničenjima obično dominiraju brzi bacači. Međutim, sa pojavom Indijske premijer lige (IPL) igra sa ograničenjima u T20 kriketu svjedoči porastu uvođenja bacača koji koriste tehniku zavrtnja lopte pa čak i na početku bacanja. To je nekada bilo rijetkost. Ovaj pomak u razmišljanju kapetana da zatraže od bacača koji koriste tehniku zavrtnja lopte da na sebe preuzmu odgovornost za najveći doprinos u igri sa ograničenjima nas potiče na razmišljanje da li ti bacači zaista doprinose više od brzih bacača tokom igre sa ograničenjima. U radu smo poredili izvedbu bacača koji koriste tehniku zavrtnja lopte i izvedbu brzih bacača kada bacaju u igri sa ograničenjima. Naša analiza se tiče T20 igara koje su se provodile u Indijskoj premijer ligi (IPL) od 2008. do 2020. godine. Otkrili smo da je izvedba bacača koji koriste tehniku zavrtnja lopte zaista bolja od one koju imaju brzi bacači po pitanju boljeg prosječnog broj bodova po bacanju 6 lopti. Nadalje, kada tim vrši odbranu, bacači koji koriste tehniku zavrtnja lopte imaju bolji prosjek bacanja, bolji prosječni broj bodova po bacanju 6 lopti te bolju kombinaciju mjerenja naziva kombinovana stopa bacanja.

Ključne riječi: sportska analitika, mjerenje uspješnosti u sportu, sportski menadžment, kriket

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DIAGONAL AGILITY TEST INNOVATION IN GYMNASTIC PERFORMANCE FOR CHILDREN: A CONSTRUCT OF THE CONTENT VALIDITY AND RELIABILITY APPROACH

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ABSTRACT

Background: The agility test is important in identifying and developing talent in gymnastics. **Purpose:** This study aimed to test the content validity and reliability of the diagonal agility test on junior gymnasts. **Design/methodology/approach:** The research used both qualitative and quantitative approaches. Data collection was carried out using the Delphi technique involving seven experts. Questionnaires with a scale of 1-5 (very relevant, relevant, quite relevant, less relevant, and irrelevant) were used as instruments. The data was analysed using Aiken's formula to test content validity and Cronbach's alpha and intraclass correlation coefficients (ICC) to test the reliability between raters from the diagonal agility test. **Result:** The findings showed that the Aiken's coefficient value of all aspects was above 0.71; aspect 1 showed the Aiken's V coefficient value of 0.750, aspect 2 showed the Aiken's V coefficient value of 0.750, aspect 3 showed Aiken's V coefficient value of 0.821, aspect 4 showed the Aiken's V coefficient value of 1.000, aspect 5 showed the Aiken's V coefficient value of 0.750, and aspect 6 showed the Aiken's V coefficient value of 0.857. Therefore, it can be concluded that all items were valid. In addition, Cronbach's alpha value of 0.880 and ICC of 0.880 was also obtained with a consistency of 0.512 for each rater, suggesting that the instrument was very reliable. **Conclusion:** Gymnastics' agility measurement test for children has good validity and reliability, so this instrument can be used to measure the agility ability of junior gymnasts. For future research, testing the effectiveness and design of assessment norms is recommended.

Keywords: agility test, gymnastics, children, measurement

INTRODUCTION

Many studies focus on the anthropometric and physiological characteristics of high-level performance and the identification of talent in sports (Alp & Gorur, 2020) (Marinšek & Pavletič, 2020) (Sánchez-Muñoz et al., 2020). However, the success of any talent detection and development programme

depends entirely on a clear understanding of the specific performance requirements in different sports. According to Marefat et al. (2021), the elements of anthropometric, physiological and physical measurements must be considered when it comes to the specific performance of various types of sports. These elements play a significant role in all sports, including gymnastics, especially those involving agility components (Bayraktar et al., 2021).

Agility is the key to success in high performance in gymnastics (Kaur & Koley, 2019) (Santos et al., 2015).

Agility is one component of physical condition that is essential in several sports (Garcia-Gil et al., 2018; Dragos Florin, 2018; Azmi & Kusnanik, 2018; Yudhistira & Tomoliyus, 2020). It is also an important element as a parameter for performance in gymnastics (Dallas et al., 2019; Trajković et al., 2016). It is defined as a person's ability to move, stop and then start again quickly, or fast whole body movements with rapid changes in direction in response to stimuli (Bompa & Buzzichelli, 2015). With good agility, an athlete can move quickly, hence helping them to win a race or competition. According to Paul et al. (2016), agility is a skill possessed by an athlete that is carried out continuously to unexpected stimuli, decision making, and the ability to react to changes in place quickly and precisely. Therefore, a gymnastics coach must modify agility training in different ways to improve the athletes' agility.

Gymnastics is a body exercise chosen and constructed intentionally, carried out consciously, planned and systematically arranged to increase physical fitness, develop skills and instil mental and spiritual values (Gymnastics, 2011). According to FIG (Federation Internationale de Gymnastique), gymnastics is divided into six groups, namely: artistic gymnastics, sports rhythmic gymnastics, acrobatic gymnastics, aerobic sports gymnastics, trampoline gymnastics, and general gymnastics. Gymnastics can be defined as a form of body exercise on the floor or on equipment designed to increase endurance, strength, flexibility, agility, coordination, and body control. (Abdollahipour et al., 2015). Therefore, gymnastics focuses on the body, not the tools, or the patterns of movement because whatever motion is used, the main goal is to improve physical quality and mastery of control.

All types of gymnastics have the characteristics of movements that suddenly change direction quickly and explosively (Marefat et al., 2021). Therefore, agility, the physical aspect that supports sudden and fast movements, is necessary. Agility is something that all gymnasts must possess. Agility is needed to make changes in motion quickly, technically and tactically perfectly while maintaining speed and coordination. Many agility test instruments have been created, but these field-based tests only measure general agility and do not focus on gymnastics. A sport has its own characteristics, so a test model with specificity is needed based on the sport. Not only specialisation in sports, specialisation for users of the test model must also be considered; for example, instruments for children, adolescents and even adults must be distinguished based on actual characteristics and conditions. In the previous research conducted by Yudhistira and Tomoliyus (2020), which examines the

biomotor physical condition of agility, the test was only devoted to the sport of karate, not yet specifically based on the user, and hence cannot be used for gymnasts. In another study, Sant' Ana et al. (2019) also designed a test instrument in taekwondo for elite athletes. In her research, the instrument was designed for elite athletes but was specific for taekwondo athletes. So far, gymnastic agility tests, especially for children, have not been designed.

Content validity is a measure where content is an instrument in construction or can be described as a measuring tool for measuring sports activities (Terwee et al., 2017). The construction of measuring instruments must be properly designed by considering the relevance, completeness, goals, and objectives for designing (Hong et al., 2019). Therefore, it is crucial to know the validity of the test instrument so that it can be used properly to measure the agility in gymnastics, especially for children. Due to the lack of research that focuses on gymnastics agility tests, especially in children, this study aims to develop a measuring instrument for gymnastics agility tests in children and determine the validity of its contents. This research is expected to be useful for measuring the agility of junior gymnasts, improving their performance and motivation, and helping coaches and sports academics to identify talents.

MATERIALS AND METHODS

This research was a mixed study combining qualitative and quantitative approaches to obtain more comprehensive and valid data. The researchers used a combination of qualitative and quantitative research methods with one concept. The study was carried out sequentially or simultaneously to examine the research in depth (Edmonds & Kennedy, 2016). Seven experts were involved in this study as participants. The seven experts had the following qualifications: three experts with the title of professor in the field of gymnastics and sports evaluation, three experts in the field of gymnastics with a bachelor's degree and one expert with a master's degree. This research was carried out in three stages as follows:

The first stage was a qualitative approach using the literature reviews method with the type of narrative review (Sarmiento et al., 2018; Widodo & Nahimana, 2021; Yudhistira & Tomoliyus, 2020). It involved articles, journals and textbooks related to existing agility measurement instruments to develop conceptual and operational definitions of agility and design agility measurement instruments in gymnastics.

The second stage was conducting a content validity test using the Delphi technique (Terwee et al., 2017), where every expert judgment did not meet in assessing the design of agility tests in gymnastics. The third stage was a qualitative analysis of input from expert judgement.

Finally, the results were analysed to be revised and then returned to the expert until they received no revision in the construction of the gymnastics agility instrument in children by giving a score. This study used questionnaires with a scale of 1 to 5, with 1 being very relevant and 5 being irrelevant.

Content validity was tested using Aiken's V with a 5% confidence level, where, to be valid, the V count must be greater than the V table, where the V table is 0.71 (Aiken, 1985). Meanwhile, to measure the reliability of the developed agility test, the author used Cronbach's alpha (Bonett & Wright, 2015) and intraclass correlation coefficients (ICC) (Portney & Watkins, 2009) with the help of SPSS version 25. To draw conclusions for the reliability test, Cronbach's alpha with $n = 7$ was used, and the value of the r table at a significant level of 5% was 0.754. Meanwhile, the values of ICC were categorised as follows (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

Qualitative Analysis Results:

Agility in gymnastics is the speed of the footstep and the displacement of the direction by considering the speed of the foot and the speed of turning. In addition, the running distance was adjusted to the ability of the junior gymnasts from the field analysis results. The construction of the gymnastics agility test for children is shown in Figure 1.

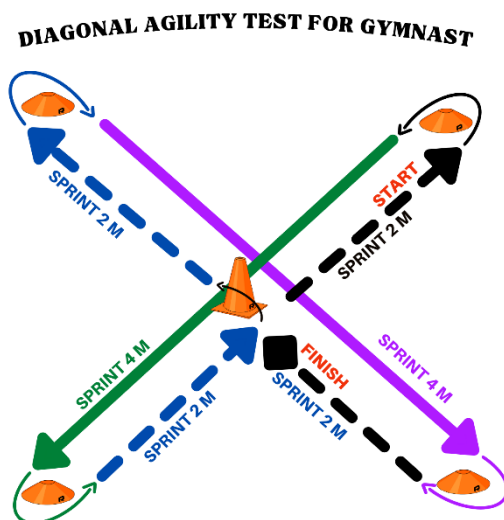


Figure 1. Diagonal agility test

The field size for the test:

The size of the field used for the test is similar to Figure 1, which is drawn in 4 colours, green and purple, at a distance of 4 metres, while the blue and black lines are 2 metres apart.

The equipment used for testing is as follows:

- 1) Stopwatch
- 2) Whistle
- 3) Cones
- 4) Field
- 5) Plan
- 6) Measuring tape
- 7) Chalk/duct tape

Number of Examiners:

- a) One examiner to give instruction
- b) One examiner to watch the stopwatch
- c) One examiner to record the results

The Test Procedures:

- 1) The starting point of the test is the cone in the middle.
- 2) After the signal/whistle, the children run as fast as possible. They run a distance of two metres from the cone to the marker following the direction of the black line as shown in Figure 1, then turn around and sprint with a distance of four metres following the direction of the green line.
- 3) They then run to the cone again for two metres, following the blue line.
- 4) Next, the children run to the marker, following the direction of the blue line with a distance of two metres, then turn around and sprint with a distance of four metres to the marker, following the direction of the purple line.
- 5) Lastly, they run from the marker to the cone by following the direction of the black line as far as two metres. The examiner then stops the stopwatch to see their time in the diagonal agility test.

Quantitative Analysis Results:

Content Validity

Table 2 presents Aiken's V coefficient values for all aspects. For example, aspect 1 shows the Aiken's V coefficient value of 0.750, aspect 2 shows Aiken's V coefficient value of 0.750, aspect 3 shows the Aiken's V coefficient value of 0.821, aspect 4 shows the Aiken's V coefficient value of 1.000, aspect 5 shows the Aiken's V coefficient value of 0.750, and aspect 6 shows the Aiken's V coefficient value of 0.857. Thus, the agility test construction is valid because the V count is greater than the V table (0.71) in all aspects.

Table 2. Content validity test results with Aiken's V

Jury	Aspect 1		Aspect 2		Aspect 3		Aspect 4		Aspect 5		Aspect 6	
	Score	s	Score	s	Score	s	Score	s	Score	s	Score	s
A	4	3	4	3	4	3	5	4	4	3	4	3
B	4	3	4	3	4	3	5	4	4	3	5	4
C	4	3	4	3	4	3	5	4	4	3	4	3
D	4	3	4	3	3	2	5	4	4	3	4	3
E	4	3	4	3	5	4	5	4	4	3	5	4
F	4	3	4	3	5	4	5	4	4	3	5	4
G	4	3	4	3	5	4	5	4	4	3	4	3
Σ s	21		21		23		28		21		24	
V	0.750		0.750		0.821		1.000		0.750		0.857	

Reliability

The results of the reliability test between raters using Cronbach's alpha are presented in Table 3 as follows:

Table 3. Cronbach's alpha analysis result

N	R-table (5%)	Cronbach's alpha	Status
7	0.754	0.880	Reliable

Based on the reliability test using Cronbach's alpha, the r-table was 0.754, while the Cronbach's alpha value was 0.880. So, because the Cronbach's alpha value is greater than the r-table, this agility test instrument is considered reliable.

The test results of interrater agreement or interrater reliability using intraclass correlation coefficients (ICC) are presented in the following table:

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	.512 ^a	.201	.879	8.341	5	30	.000
Average Measures	.880 ^c	.637	.981	8.341	5	30	.000

Based on the table above, the average interrater agreement was 0.880, while for one rater, the consistency was 0.512. According to Portney and Watkins (2009), these results are in the category of good reliability. Thus, it can be concluded that the agreement between raters was strong, and each rater had a fairly good consistency.

DISCUSSION

This study focused on a test instrument developed for junior gymnasts aged 9-11 years old. The test instrument was adjusted based on the characteristics of the sport and the characteristics of children aged 9-11 years so that it can be used to measure the agility of the gymnasts.

The physical component is one of the most important

elements for gymnasts that are useful for achieving maximum performance (Mariana & Orlando, 2014). Gymnasts are individuals who are required to have the excellent physical condition to win competitions. One's success in winning a competition is not solely derived from innate talent, as one must train hard with a proper programme. Gymnasts have different characteristics, from gymnasts at the level of children, teenagers, and adults, to professional gymnasts

Gymnastics for children is characterised by basic movements, easy to understand and fun. Gymnastics has the characteristics of moving in all directions, moving forwards, backwards, and sideways with good acceleration and rapid change of direction (Mkaouer et al., 2018; Trajković et al., 2016). Gymnasts need biomotor agility because it allows them to change direction quickly and accelerate while maintaining body control when moving forwards, sideways and backwards as a reflex to stimuli without causing injury. In addition,

having good agility will lead to an increase in balance and reaction time. Therefore, agility is an important point in gymnastics. This is supported by some literature which states that performing movements quickly, flexibly and agilely is a necessary multifactor movement that serves to improve motor skills and posture stability, prevent injuries, and contribute to improving gymnastics performance (Skelton, 2001) (Vernetta et al., 2020) (Kaur & Koley, 2019).

In the results of research with a qualitative approach using the literature review method with the type of narrative by Sarmento et al. (2018); Widodo and Nahimana (2021); Yudhistira and Tomoliyus (2020), conceptual and operational definitions of agility in gymnastics and the construction of agility measurement instruments have been arranged. In addition, the content validity (Aiken) was also obtained as follows: the aspect of the conceptual definition suitability shows the value of $V = 0.750$, the aspect of the suitability of the stimulus for the respondent shows the value of $V = 0.750$, the aspect of the distance suitability shows the value of $V = 0.821$, the aspect of movement suitability shows the value of $V = 1.00$, the clarity aspect of the test procedure shows 0.750 , and the aspect of clarity of the test design image shows the value of $V = 0.857$. These V values, when compared to the value of the standard table compiled by Aiken (1985), using a rating scale of 1-5 and 7 raters, show that the minimum standard of Aiken's V for this study is 0.71 . Therefore, it can be concluded that content-wise, all aspects of the diagonal agility test are highly valid. In other words, the instrument for measuring diagonal agility for children in gymnastics has a high expert agreement.

The reliability of each aspect of the agility test instrument was measured using Cronbach's alpha. The analysis result of Cronbach's alpha agility test instruments was 0.880 . Cronbach's alpha is a reliability measure that has a value ranging from 0 to 100 . According to Tavakol and Dennick (2011), the value of the minimum reliability level of Cronbach's alpha is 0.70 . Since the Cronbach's alpha value in this research is greater than 0.7 , the aspects of the agility test instrument are very reliable. The level of reliability can also be seen from the r -table value in which Cronbach's alpha value must be greater than the r -table value. In this study, the Cronbach's alpha value was 0.880 , while the r -table was 0.754 . Because the value of Cronbach's alpha is greater than the r -table, the instrument can be considered very reliable.

Meanwhile, to test the reliability between raters (interrater agreement) and the consistency of each rater, an analysis of intraclass correlation coefficients (ICC) was used, as seven raters were involved in the study. In other words, they were assigned to assess the construction of agility test instruments for aerobic gymnastics through rating instruments. The ICC analysis shows that the average agreement between raters was 0.880 , while for one rater, the consistency was 0.512 .

According to Portney & Watkins (2009), values between 0.00 - 0.50 indicate poor agreement, values between 0.51 - 0.75 indicate moderate agreement, values between 0.76 - 0.90 indicate good agreement, and values between 0.91 - 1.00 indicate excellent agreement. Based on the results of the ICC analysis in this study, it can be concluded that the agreement between raters was strong/good, and each rater had fairly good consistency (moderate reliability). Therefore, the designed test is considered feasible to measure the agility in gymnastics because it is adapted or specified with techniques in gymnastics.

Thus, based on the results of qualitative and quantitative data analyses, it can be concluded that the agility test instrument in gymnastics has high content validity and a good average agreement between raters, and the consistency of each rater is quite good.

CONCLUSION

Based on the results of this study, it can be concluded that the agility test instrument for junior gymnastics is considered valid and reliable. Therefore, this instrument can be used or tested to measure the agility ability of junior gymnasts. It is recommended for future research to test the effectiveness and design of assessment norms.

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Conflict of Interests

All authors state that there is no conflict of interest in this study.

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INOVATIVNI TEST DIJAGONALNE AGILNOSTI U GIMNASTIČKOJ IZVEDBI KOD DJECE: KONCEPT PRISTUPA VALJANOSTI I POUZDANOSTI SADRŽAJA

Kontekst: Test agilnosti je značajan za identifikaciju i razvoj talenta u gimnastici. **Svrha:** Ova studija je nastojala ispitati valjanost i pouzdanost sadržaja testa dijagonalne agilnosti kod juniorskih gimnastičara. **Dizajn/metodologija/pristup:** U istraživanju su se koristili kvalitativni i kvantitativni pristupi. Podaci su prikupljeni korištenjem Delphi tehnike sa sedam stručnjaka. Upitnici sa skalom od 1 do 5 (iznimno važno, važno, prilično važno, manje važno i nevažno) su korišteni u vidu instrumenata. Podaci su analizirani korištenjem Aikenove formule za testiranje valjanosti sadržaja, a Cronbach's alpha koeficijent i intraklasni koeficijent korelacije (ICC) su korišteni za testiranje pouzdanosti između ocjenjivača testa dijagonalne agilnosti. **Rezultat:** Pronalasci su pokazali da je Aikenov koeficijent veći od 0,71 za sve aspekte; aspekt 1 je pokazao Aikenov V koeficijent od 0,750, aspekt 2 je pokazao Aikenov V koeficijent od 0,750, aspekt 3 je pokazao Aikenov V koeficijent od 0,821, aspekt 4 je pokazao Aikenov V koeficijent od 1,000, aspekt 5 je pokazao Aikenov V koeficijent od 0,750, a aspekt 6 je pokazao Aikenov V koeficijent od 0,857. Prema tome, može se zaključiti da su sve stavke bile valjane. Nadalje, Cronbach's alpha koeficijent od 0,880 i ICC od 0,880 su također dobiveni uz konzistentnost od 0,512 za svakog ocjenjivača, a što ukazuje da je instrument bio iznimno pouzdan. **Zaključak:** Test mjerenja agilnosti u gimnastici kod djece ima dobru valjanost i pouzdanost pa se ovaj instrument može koristiti za mjerenje agilnosti juniorskih gimnastičara. U budućim istraživanjima se preporučuje testiranje efektivnosti i dizajna normi procjene

Ključne riječi: test agilnosti, gimnastika, djeca, mjerenje

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VIEWS AND PERCEPTIONS OF GYM MEMBERS ON LIVE-STREAM FITNESS CLASSES

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ABSTRACT

In Greece, as in many other countries, gyms were forced to temporarily close due to the COVID-19 pandemic. Responding to this new reality, some gyms and exercise trainers provided free online classes through social media platforms. The aim of the present research was to explore the views and perceptions of gym members on live-stream fitness classes. The research comprised 191 gym members who participated in online fitness classes that were broadcast in real-time through social media platforms during the Greek gyms' closure, and the instructor was not able to see the participants in question. As it was documented, live-stream fitness classes have a broad spectrum of attendants. Most of them were highly satisfied with the internet-based programmes, and although digital exercise classes lacked face-to-face communication, they did offer a feeling of interaction. On the other hand, there were various positive and negative comments on the feedback/instructions provided by the trainers, on the content/design of the exercise sessions and on the expertise/credentials of the fitness instructors. Since online exercise classes continue to be popular among exercisers, the opinions of gym members form a valuable source of knowledge that could be effectively used by fitness instructors in order to update their way of delivering internet-based classes.

Keywords: online exercise programmes, digital fitness, internet-based workouts, live-stream fitness classes

INTRODUCTION

Gyms have been described as "one of the most pursued leisure places in Western societies" (Doğan, 2015), and in 2011, there were around 40,000 fitness centres and 34.7 million fitness members in Europe alone (Ruseva & Ruskov, 2015). Gyms offer structured forms of exercise, and gym members have characteristics that differentiate them from other types of exercisers (e.g., "green exercisers", i.e., persons that prefer to do unsupervised physical activity in the nature) (Calogiuri & Elliott, 2017). The notion of supervision has indeed been found to be a facilitator to exercise adherence, while the lack of it was seen as a barrier in active gym members (Morgan et al., 2016). Additionally, although gyms are predominately places for exercising, for some exercisers they also fulfil other functions, i.e., socialising and interacting with other people (Morgan et al., 2016; Rojas, 2016), and it has been shown that

social interactions during group exercise classes serve as a motivator to ongoing participation (Laverie, 1998). For these reasons, the closure of the gyms during the COVID-19 pandemic has certainly created a problem for gym members.

During the quarantine, gyms worldwide have provided internet-based exercise classes (Sahu & Naqvi, 2020). Such programmes were also provided by fitness instructors through their personal accounts on social media. In the research conducted by Daskalaki, Gioftsidou, Beneka, and Malliou (2021), it was shown that a notable percentage of exercisers were not only participating in online fitness classes during the quarantine, but were intending to continue doing so even after the opening of the gyms. And interestingly, now, many gyms continue to offer online classes for their members, proving that these kinds of programmes are here to stay. Taking into account that online exercise programmes flourished during the extreme situation of social isolation, being the only option for supervised exercise, it could be suggested that this

period also offered a unique opportunity to understand their full potential. The aim of the present research was to investigate the views and perceptions of Greek gym members on internet-based live-stream fitness classes during the quarantine.

MATERIAL AND METHODS

Instruments

An online questionnaire was created containing closed- and open-ended questions in relation to demographic and anthropometric characteristics, previous gym-based exercise experience (e.g., the number of years spent as a gym member, exercise frequency, types of programmes attended, etc.), current internet-based exercise experience (e.g., exercise frequency, platform used, etc.), criteria and reasons for choosing/attending the specific classes, positive/negative elements of the programmes, overall satisfaction with the programmes, etc. The survey was launched on the internet using Google Forms, and the data were collected from 6th to 31st May 2020 (during the first period that Greek gyms were closed).

Inclusion criteria

It was clarified to the visitors that they could take part in the research if: a) Immediately before the suspension of gyms due to the pandemic (March 13th, 2020), they were enrolled in a gym and physically participated in exercise programmes in the gym, and b) they had attended at least one live-stream online exercise programme during gym lockdown. Live-stream exercise programmes were defined as programmes with the following features:

1. They were available on the internet through platforms such as Instagram, Facebook, etc.

2. They were broadcast live and were NOT pre-recorded.

3. The trainer and the trainees were connected to the website at the same time.

4. In those programmes, the trainees were able to see the trainers, but the trainer could not see the trainees.

Analysis

The responses given at the open-ended questions were organised into representative categories which were then labelled accordingly (Hausenblas et al., 1999). For the analysis of the data, the method used was the analysis of frequencies from SPSS.

Participants

191 gym members participated in the research, with 80.6% of females (n = 154) and 19.4% of males (n = 37) aged from 17 to 66 (mean \pm SD: 38.33 \pm 11.99 years) of all BMI types (range: 16.53 - 40.82 kg/m²; mean \pm SD: 23.14 \pm 3.55 kg/m²).

RESULTS

The respondents exercised from 1 month to 43 years at a gym (median: 5 years), 1 to 7 times/week (median: 3 times/week), and from 1 hour to 14 hours weekly (mean \pm SD: 4.63 \pm 2.81 hours). They were practicing a variety of exercise programmes at the gyms, and during the quarantine, they continued exercising online. The types of programmes in both situations and the percentages of attendants are presented in Table 1.

Table 1: Gym-based and internet-based programmes attended by the participants

Programmes	Gym-based	Internet-based
Pilates	55%	58.6%
Muscle Strengthening Programmes (e.g., Body Sculpt/Total Body/Hips & Abs)	41.4%	57.6%
Aerobic machines (e.g., treadmill, bicycle and elliptical)	37.2%	-
Weight Training	36.6%	-
Suspension Training	26.2%	-
Cross Fit/Cross Training	22%	1.05%
Yoga	20.4%	28.8%
Team Combat Programmes (e.g., Fight Bo/Tae Bo)	13.6%	8.9%
Aerobics/Dance Aerobics	12%	9.9%
Zumba	11%	5.8%
Step	8.4%	1.05%
Tai Chi	7.3%	9.4%
Other	5.8%	8.9%

The respondents exercised mainly through platforms like Instagram (51.3%), YouTube (44%), Facebook (27.2%), and Zoom (13.1%). The number of times that each one of them participated in an online programme varied from 1 to 100 times (mean \pm SD: 15.28 ± 19.07 times).

In the open-ended question: "Based on which criteria did you decide to attend the specific exercise programmes?", the most frequent criteria were: the fitness instructor (41.9%) who was defined as a fitness instructor they previously knew in 19.6% of the cases, the type/content of the programme (18.8%), the fact that the programme was offered by the gym (3.7%), the popularity of the programme (3.1%), and the hour the lesson was taking place (3.1%).

In the open-ended question: "What were the reasons you attended an online exercise programme (what were your expectations)?", the most common reasons were: to continue exercising (34.6%), to maintain/improve physical condition (27.2%), for psychological reasons (15.7%), from curiosity/as a new experience/to learn something new (including new exercises) (13.6%), to stay fit/maintain or decrease body weight (12.6%), to remain healthy (5.8%), and as a form of entertainment (5.8%).

In the open-ended question: "What are the elements that you appreciated/appreciate as positive, satisfactory and that you think make a successful online exercise programme?", the most common answers were: high-quality feedback/sufficient instructions provided by the trainers (e.g., visual and verbal feedback on the correct and safe execution of the exercises) (27.7%), satisfactory content/design of the exercise session (e.g., proper structure of the programme, variety) (27.2%), the comfort/safety of the home environment and saving time (25.1%), strong motivational skills of the instructors (e.g., positive mood, encouragement) (15.2%), and the feeling of interaction (e.g., communication through chat messages) (8.9%). Additional points that were mentioned as positive were: the effective handling of technical problems (3.7%), expertise/credentials of the instructor (3.5%), the perceived effectiveness of the programme (3.14%), and the use of music (2.6%).

In the open-ended question: "What are the elements that you regard/regarded as negative, unsatisfactory and you consider that they do not contribute to the success of an online programme", the most common answers were: lack of direct supervision and individual feedback (e.g., the trainer could not see the exercisers) (35.1%), lack of human contact (24.2%), technical problems (e.g., bad/slow internet connection) (17.8%), inappropriateness of the home environment (e.g., restricted space, lack of fitness equipment) (12%), unsatisfactory content/design of

the exercise session (e.g., inadequate/inexistent warm up/cool down/rest periods, lack of variety) (9.4%), low-quality feedback/insufficient instructions provided by the trainers (e.g., bad technique, insufficient verbal explanation of the exercises) (7.9%), lack of different programmes for different needs (5.2%), non-existent expertise/lack of credentials of the instructor (e.g., not a University graduate) (4.2%), lack of motivational skills of the instructors (e.g., bad mood, boredom) (2.1%), and the absence of music (2.09%).

In the open-ended question: "What else would you like to suggest to the trainers who launch online exercise programmes so that their programmes become even more satisfactory?", the most common answers included suggestions about: the content/design of the exercise session (28.8%), the kind of feedback/instructions provided by the trainers (e.g., detailed, analytical instructions, anticipated corrections) (21.6%), handling technical problems (6.8%), the motivational skills of the instructor (e.g., energy, encouragement, good mood) (5.3%), the availability of a bigger variety of programmes according to individual level/needs (3.7%), lessons in two-sided platforms (e.g., where the instructor can see the exercisers) (3.1%), and the use of music (e.g., loud music) (2.09%).

29.3% ($n = 56$) of the exercisers reported musculoskeletal issues. 85.7% of them responded that there were instructions for modifications. 44.6% ($n = 25$) felt insecurity in relation to their musculoskeletal issue, while 55.4% ($n = 31$) did not. The most frequent reasons reported to be causing insecurity were the lack of direct supervision and individual feedback (32%) and the uncertainty about the correct execution of the exercise (44%). 28% of them ($n = 7$) stated that there were sufficient instructions given, as well as modifications of the exercises. 20% ($n = 5$) experienced aggravation of their symptoms, reporting that the programmes which caused such an aggravation were dynamic ($n = 1$), with a fast rhythm ($n = 1$) or intense programmes ($n = 1$). The exercisers who reported that they did not feel insecurity explained that this was mainly due to their past experience in the field of exercise/ability to control themselves (38.7%), and due to the fact that the modifications and instructions provided were sufficient (41.9%). None of these 31 exercisers felt insecurity regarding the execution of the exercise. 6.5% of them ($n = 2$) experienced an increase of their symptoms, and according to one of them, this was due to a programme with free weights.

The majority of the participants (84.3%) reported to be satisfied with the online exercise programmes, and 15.7% stated that they were not satisfied. In the question: "On a scale from 1 to 7, where 1 = not at all satisfied and 7 = completely satisfied, how much do your online exercise programmes satisfy you?", the majority of the respondents (72.8%) gave a score of 5 and more. 75.4% ($n = 144$) of the participants stated

they will continue exercising through live-stream programmes, while 24.6% ($n = 47$) of them said they will stop engaging in this form of exercise. The reasons why they stopped were: they decided to work out alone, either outdoors (running, walking and cycling) or to create their own programme according to their needs ($n = 11$), they were bored/the programmes were boring ($n = 10$), they did not have the time due to other obligations ($n = 6$), and the programmes were impersonal/lacking live interaction and human contact ($n = 5$).

DISCUSSION

According to the results of the present research, live-stream fitness classes have a broad spectrum of attendants, i.e., novel and experienced gym members, high and low frequency exercisers of both genders, various ages and of all BMI types with or without musculoskeletal disorders. Although this same population is encountered at gyms, the major difference is that, in a live-stream situation of this kind, the trainer is not able to see the exercisers and correct their individual mistakes. This was a major concern for many exercisers who, in a great percentage, pinpointed the "lack of direct supervision and individual feedback" as a negative element of these programmes and felt insecurity about the correct execution of the exercises. This finding is in line with other research that have documented that the lack of direct supervision/uncertainty of the way of executing the exercises is a common concern even among exercisers that are working out at the gym (Morgan et al., 2016) but also of persons with musculoskeletal issues that work out at home (Escolar-Reina et al., 2010).

On the other hand, many participants positively commented on the feedback/instructions provided by the trainers, stating that the instructors were providing appropriate, detailed and constant feedback regarding the correct performance of the exercises and the avoidance of possible mistakes, while they were also physically demonstrating the exercises with precision. However, there was a smaller number of participants that criticised the trainers' feedback/instructions as insufficient, commenting that some trainers were merely executing the exercises (sometimes even rapidly or with incorrect technique) without providing sufficient instructions. Apart from the fact that, in order for a programme to be as safe as possible, the fulfilment of the exercisers' observations is a prerequisite in every class (gym or internet-based), the technical-pedagogical quality of the trainers is also one of the basic elements that contribute to the satisfaction of the gym members (Campos et al., 2015).

Another issue that emerged was the design/content of the exercise session, which was most of the times positively criticised, but it sometimes received negative comments. The programmes that were characterised

as successful were the ones properly structured (e.g., contained a sufficient warm up/main part/cool down, rest periods), included a variety of exercises, as well as variations of those exercises that would serve the specific needs of exercisers of different levels and of various musculoskeletal profiles. Programmes that lacked these features were perceived as unsuccessful. Undoubtedly, the views of the exercisers about the structure of the programme are in line with scientific principles (Malliou, Rokka, Beneka, Mavridis, & Godolias, 2007; Woods et al., 2007). For this reason, it is recommended that online programmes are held by graduated professionals with adequate teaching skills (Eickhoff-Shemek & Topalian, 2022) who are able to design their sessions according to scientific evidence (Consejo Colef, 2020), and as it appeared, there were exercisers who made positive or negative comments about the expertise and/or the credentials of the instructors. On the other hand, free of charge massive programmes provided through social media, even if designed by the most experienced instructor, cannot possibly fulfil the needs of all (and most importantly not visible) exercisers.

Expanding the discussion in relation to the previous point, a negative element mentioned was the lack of different programmes for different individual needs (e.g., some of the exercisers reported that they preferred easy exercises, while others preferred intense and demanding exercises). Therefore, availability of a bigger variety of programmes was suggested according to the individual level/needs of the different exercisers. In relation to this proposal, it should be noted that, as suggested by the different comments on the programmes' intensity and from Table 1, there is already a big variety of programmes offered. Taking into account that a group exercise session in not individually tailored, the potential participants would be advised to firstly watch some programmes without actively participating in them and then decide which one of them is meets their needs (DeSimone, 2020). Also, considering that in the present research a small (but existent) percentage of participants with musculoskeletal disorders experienced aggravation of the symptoms (mainly after dynamic/fast or intense programmes), a useful guideline for exercising with safety in the digital environment would be (for all) to follow what WHO has recommended for inexperienced exercisers, i.e., to be cautious and aware of their own limitations when working out through online exercise programmes (WHO, 2020). Finally, although not all instructors deliver free for all internet-based programmes, in the case that an exerciser previously knows (and appreciates) a fitness instructor leading a programme, it might be better to continue working out under that instructor's guidance.

Another element recorded as negative by many exercisers was that in live-stream programmes, there is "absence of human contact", e.g., lack of direct communication/live interaction/socialisation with and between the trainer and the co-exercisers. On the other hand, some exercisers stated that live-stream programmes offered a feeling of interaction (e.g., communication of the fitness instructor with the exercisers via chat messages and feeling that friends and other persons watch the same programme). As it appears, live-stream classes cannot substitute the social environment of a gym, but they may offer the feeling of a team experience commonly shared in the digital environment. Additionally, in such a context, the motivational skills of the instructor seem even more crucial, as indeed comments were made by a number of exercisers regarding the motivational skills of the trainers (i.e., how the instructor interacts and communicates with the exercisers) (Moustakas et al., 2020). Elements such as positive mood, elevated energy, humour, and capability to inspire, motivate, support and encourage the exercisers, were all mentioned as positive, while boredom, bad mood, low energy, and lack of communication skills were considered negative. The social skills and motivating capabilities of the instructors is a theme that has already been discussed thoroughly in the literature and it correlates with exercise experience, intension and commitment (Brown & Fry, 2013; Szumilewicz, 2011).

As for working out at home, this was judged from different respondents either positively or negatively. Specifically, the fact that they could work out from the individuality of the house was considered by some respondents to be a positive element, i.e., a safe, calm and clean space, without being in danger (due to the pandemic) and without losing time for transportation. On the other hand, comments were made by other respondents on the inappropriateness of the home environment (limited/not adequate space, e.g., lack of shock absorbent floors and lack of fitness equipment), and that, as reported, also had an impact on the choices made from the part of the instructor. Indeed, it is a fact that a house cannot substitute the gym: working out at home restricts the exercisers to make adjustments on the space or even to avoid some exercises if the space is not adequate (DeSimone, 2020). Additionally, given the fact that these programmes, apart from being home-based, were also internet-based, many respondents commented negatively about experiencing frequent technical problems such as bad/slow internet connection and bad quality of picture/sound that was causing bad visibility/audibility of the trainer and disrupted the flow and the rhythm of the programme. Although a good Wi-Fi connection is suggested in order to ensure a good experience (DeSimone, 2020), it should be also noted that both sides (instructor and trainees) should have such a connection. However,

it cannot be ensured that this recommendation could be easily applied considering the considerably higher costs this type of connection requires.

Finally, it should be mentioned that, despite the problems reported, many elements of the online programmes were positively evaluated, and the majority of the participants were highly satisfied with them. The majority of the respondents reported their intention to continue participating in online sessions during the closure of the gyms which reveals that these programmes offered a significant alternative to the gym members in Greece, similarly to other countries where online programmes were followed by a big percentage of active exercisers (Sowier-Kasprzyk & Widawska-Stanisiz, 2020). Taking into account that these kinds of programmes will probably continue to be popular (Eickhoff-Shemek & Topalian, 2022), fitness professionals who aim to continue delivering these kinds of programmes should be aware of the particularities of the digital environment in order to build them in the most professional way (Daskalaki, Beneka, & Malliou, 2021).

CONCLUSION

Although online exercise programmes cannot substitute the gym experience, they were much appreciated by gym members as a temporary alternative during the quarantine. While a digital exercise class is deprived of face-to-face communication, it may offer a feeling of interaction. The fact that there were both positive and negative comments on the feedback/instructions provided by the trainers, on the content/design of the exercise sessions and on the expertise/credentials of the fitness instructors indicates that exercisers appreciate particular qualities of the online exercise programmes. Since online workouts continue to be popular among exercisers, the opinions of gym members form a valuable source of knowledge that could be effectively used by fitness instructors in order to update their way of delivering internet-based classes.

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MIŠLJENJA I ZAPAŽANJA ČLANOVA FITNESS CENTARA O ONLINE TRENINZIMA

Kao i u mnogim drugim zemljama, u Grčkoj su fitness centri bili primorani na privremeno zatvaranje usljed pandemije COVID-19. Neki su fitness centri i treneri odgovorili na novo stanje organizovanjem besplatnih online časova putem platformi društvenih mreža. Cilj ovog istraživanja je istražiti mišljenja i zapažanja članova fitness centara o online treninzima. Istraživanje je obuhvatilo 191 člana fitness centara koji su učestvovali u online treninzima emitovanim u stvarnom vremenu putem platformi društvenih mreža tokom perioda zatvaranja fitness centara u Grčkoj gdje trener nije mogao vidjeti navedene učesnike. Online treninzima prisustvuje široki spektar učesnika, a što je prethodno dokumentovano. Većina njih je iznimno zadovoljna sa online programima te, bez obzira što su digitalni treninzi imali nedostatak lične komunikacije, zaista su davali osjećaj interakcije. Međutim, dati su različiti pozitivni i negativni komentari o informacijama/uputama trenera, sadržaju/dizajnu vježbi te stručnosti/kredibilitetu trenera. Obzirom da su online časovi i dalje popularni kod vježbača, mišljenja članova fitness centara čine vrijedan izvor znanja koje treneri mogu efikasno koristiti kako bi dopunili svoj način održavanja treninga.

Ključne riječi: online programi vježbanja, digitalno vježbanje, vježbanje putem interneta, online treninzi

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THE EFFECT OF SURGICAL MASKS ON OXYGEN SATURATION AND PERCEIVED EXERTION DURING RESISTANCE TRAINING

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ABSTRACT

Objective: This investigation aimed to evaluate SpO_2 and the rate of perceived exertion (RPE) derived from a strength training session in two distinct scenarios: normal condition versus the usage of surgical masks for COVID-19 prevention. **Methods:** Fifteen trained men (81.66 ± 8.37 kg; 177.66 ± 6.31 cm; 26.88 ± 5.55 years of age; 12.17 ± 5.98 % fat; 1.15 ± 0.19 kg/kg bench press relative strength/body weight) were selected, and they performed two test sessions to determine 10-RM loads for all exercises adjusted for 80%. The SpO_2 measurement was verified immediately after each set for every exercise, and, concomitantly, the participants were asked to identify their RPE to provide a subjective measure of fatigue. In the first session, subjects performed the training routine using the SARS-CoV-2 protection surgical mask with a passive rest interval of 2 minutes, but the second was performed without wearing a surgical mask. **Results:** The SpO_2 showed a difference ($p = 0.03$) under the condition curve with the mask (481.33 ± 3.04) versus without the mask (484.46 ± 5.96), with increments in SpO_2 for the condition without the mask at different verification times ($p = 0.039$). Regarding the initial sets and exercises, there were no significant differences between the RPE values between the different conditions, that is, regardless of the mask use ($p = 0.052$). However, for the final exercises, significant differences were observed in the second set (PD, $p = 0.01$; LC, $p = 0.02$) and in the three sets of the TE exercise ($p = 0.006$). **Conclusion:** Overall, we found that the use of surgical masks reduces SpO_2 and increases RPE in a strength training session.

Keywords: weight lifting, COVID-19, surgical mask, physical fitness

INTRODUCTION

In 2019, the Chinese city of Wuhan, capital of Hubei province, was the epicentre of an explosion of cases of a new pneumonia, classified as a severe

acute respiratory syndrome of coronavirus 2 (COVID-19), with SARS-CoV-2 being classified as a type of coronavirus which was the causative agent of the disease as officially identified by the World Health Organisation (Lu, Stratton, & Tang, 2020). The main symptoms observed include fever, fatigue, dry

cough, upper airway congestion, sputum production, myalgia or arthralgia, lymphopenia, prolonged prothrombin production, and shortness of breath (Ramanathan et al., 2020).

The transmissibility of COVID-19 is exceptionally high, and it occurs specifically between humans, mainly between family members, including relatives and friends who have come into close contact with patients or asymptomatic incubation carriers (Guo et al., 2020). With the increase in COVID-19 worldwide, simple prevention strategies were adopted globally, intending to reduce the virus spread. However, there is still controversy over the use of face masks as an effective physical barrier against disease transmission (Wang et al., 2020).

In this sense, as required by government public health entities, the use of masks was mandatory during the majority of interpersonal contact, including places of physical exercise performance, like clubs and fitness centres. Recently, an experiment compared three types of masks commonly used for training during the SARS-CoV-2 pandemic: (a) traditional surgical mask, (b) cotton, and (c) filter (Kim, 2020). Although it seems highly relevant, little evidence observed the physiological effects of artificial physical barriers to breathing during strength training (ST).

For instance, Jagim et al. (2017) analysed the acute effects of the altitude simulated training mask on the performance of recreational weightlifters. As the manufacturer stated, the mask was set at 2743 metres above sea level, which appears to be more restrictive than the masks commonly used in the COVID-19 pandemic. According to Jagim et al. (2017), using this specific apparatus neither reduced the ST volume nor increased physical discomfort and negatively impacted subjective effort assessments. In another study, André et al. (2018) examined the effects of using a simulated training mask for elevation on muscle performance, hemodynamic variables and perceived stress in response to a single ST session. The mask of 3657 metres, as stated by the manufacturer, was used in comparison with the sea level to adjust the mask. The results showed a significant reduction in the performance of multi-joint exercises, increased heart rate and higher perceived exertion (RPE), in addition to a significant reduction in oxygen saturation (SpO_2).

Despite its mass use today, little is known about the influence of the mask used in the COVID-19 pandemic on different ST variables. In fact, to the authors' knowledge, no study has focused on investigating the influence of masks for the prevention of COVID-19 on SpO_2 and the rate of perceived exertion (RPE) in a ST session. Therefore, the present study aims to evaluate SpO_2 and RPE when performing a ST session in situations when the mask is used and

when it is not in use.

METHODS

Participants

Fifteen trained men were selected (81.66 ± 8.37 kg; 177.66 ± 6.31 cm; 26.88 ± 5.55 years of age; $12.17 \pm 5.98\%$ of fat; 1.15 ± 0.19 kg/kg bench press relative strength/body weight). The following inclusion criteria were adopted: (a) individuals with previous experience in ST (minimum of six months); (b) non-smokers; (c) with no performance-enhancing drug use; (d) without joint or bone injuries that could compromise the training session; (e) with no use of medications that could alter blood pressure and breathing during the research; (f) no alcohol, coffee or any other stimulant consumption for more than 24 hours prior to the first visit. The sample size calculation was made with the G*Power software, version 3.1 (Kiel University, 2014). The following variables were adopted: a) ANOVA for repeated measures; b) alpha error = 0.05; c) 1-beta error = 0.95; different number of conditions (2) and sets (5). According to the variables previously described, the minimum number of participants was 12 for a 0.98 power. Subjects were informed of the possible risks of carrying out the training session. The study was submitted to the Ethics Committee of the Catholic University of Petrópolis under the protocol: CAAE: 37333920.0.0000.5281 and report: 4.296.177. Written informed consent was obtained from all participants following the Declaration of Helsinki. In addition, all participants responded to the PAR-Q (Shephard, 1988).

Strength Training Protocol

After two familiarisation sessions, tests of 10 repetitions maximum (10-RM) were performed in the following exercise sequence as previously described (Senna et al., 2009): leg press (LP); bench press (BP); leg extension (LE); pec deck (PD); leg curl (LC); and triceps extension (TE). Briefly, during each test, each subject performed three attempts of 10-RM for each exercise, with 5 minutes of rest interval between attempts and 10 minutes between exercises. Standardised exercise techniques were followed, and after 48 hours, the tests were repeated to determine their reproducibility ($r > 0.94$). The 10-RM test protocol was performed as previously described (Senna et al., 2011). Moreover, in order to minimise errors, the following strategies were adopted: a) standardised instructions regarding the test were given to the participants before the test; b) the participants received standardised instructions regarding each exercise technique; c) observations for maintenance of posture were provided during exercise; d) standardised verbal motivation was provided to the participants; e) measurement of all bars and free weights used by a precision scale.

Rate of Perceived Exertion Protocol

For RPE collection, subjects followed the adult resistance exercise OMNI scale (Lagally & Robertson, 2006). Participants were instructed to implement the scale in their regular training routine for one week before the experiment to familiarise themselves with the rating values. The subjects were oriented to choose a number based on their perceived exertion or subjective intensity, tension, discomfort, or fatigue experienced during each exercise (Lagally & Robertson, 2006). Before the tests, the participants were invited to perform a familiarisation session consisting of three sets of 15 repetitions with three minutes of rest between sets and estimated loads for each subject (similar to daily training routines). Immediately after each set of exercises, participants were asked to identify their RPE in order to provide a subjective measure of the level of effort (Scudese et al., 2015; Senna et al., 2016).

Oxygen Saturation Measurements

The oxygen saturation measurement (SpO_2) was performed immediately after each set of each exercise with the CONTEC® brand oximeter.

Experimental Procedures

Forty-eight hours after the 10-RM loads' determination, the subjects performed two training sessions, with an inter-session interval of at least 48 hours. The participants performed the first session using the surgical mask, performing the described exercises (in the same order) with a passive interval of 2 minutes. The second session was performed using the same procedures as the initial session but without a surgical mask. Participants performed three sets per exercise with loads of 80% of 10-RM for ten repetitions. Before performing the first exercise, the individuals performed a warm-up of two sets, consisting of 12 repetitions with 40% of the 10-RM load, with an interval of two minutes. No attempts were made to control the speed of repetitions; however, instructions were given for controlled and well-performed executions (Senna et al., 2009). All sessions were supervised by a physical education professional with practical experience.

Statistical Analysis

To determine the reliability of the 10-RM tests, we performed the Pearson correlation test. To determine normality and uniformity, the Kolmogorov-Smirnov test was performed. All inter-value data were considered normal and uniform, and so they were presented according to their mean and standard deviation, while ordinal data (RPE) were presented according to their median. To determine the significance in the SpO_2 data, a two-way ANOVA was conducted. Subsequently, if significant differences occurred, the Tukey's post-hoc

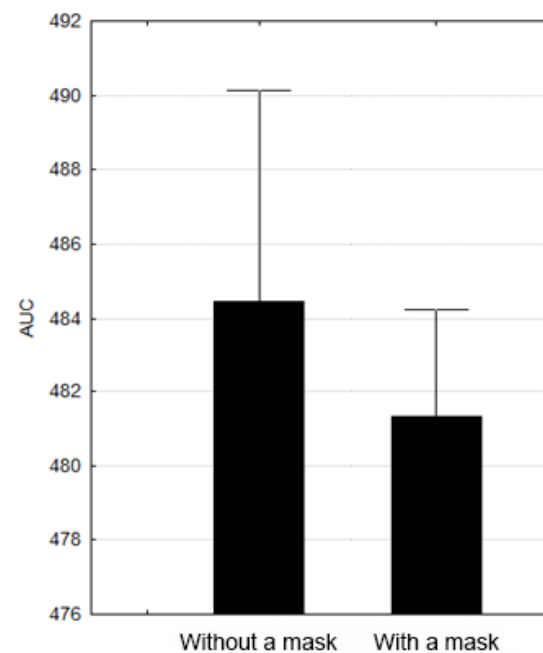
test was applied. For the RPE values, we've applied the Friedman and Wilcoxon tests for intra- and inter-conditions, respectively. The confidence interval of $p \leq 0.05$ was used to establish significant differences in the comparisons. To perform the statistical analysis, we used the SPSS software version 21.0 (IBM, Inc).

RESULTS

Oxygen Saturation (SpO_2)

According to the SpO_2 data, a significant difference ($p = 0.03$) was observed for the AUC for the condition with the mask (481.33 ± 3.04) versus the normal condition (484.46 ± 5.96). Additionally, at different time-points, SpO_2 concentration was significantly higher in the condition without the mask ($p < 0.039$). Figure 1 presents the SpO_2 data.

Figure 1. Area under the curve for data representing the conditions with and without the mask



* Significant difference between conditions.

Table 1: Oxygen saturation during a resistance training routine in both conditions with and without the mask

Exercise	Set	With the mask	Without the mask	P value between conditions
Leg press	1 st set	96.13 ± 0.56	96.78 ± 0.94	0.039 ^a
	2 nd set	96.33 ± 0.48	96.80 ± 1.03	0.288
	3 rd set	96.47 ± 0.91	96.79 ± 0.88	0.262
Bench press	1 st set	94.60 ± 1.18	96.80 ± 1.09	0.0001 ^a
	2 nd set	95.33 ± 2.38	96.65 ± 1.17	0.023 ^a
	3 rd set	96.33 ± 1.95*	96.75 ± 1.03	0.304
Leg extension	1 st set	96.67 ± 0.89	96.80 ± 0.70	0.792
	2 nd set	96.73 ± 0.88	96.79 ± 1.27	0.998
	3 rd set	96.07 ± 0.79	96.79 ± 1.06	0.0003 ^a
Pec deck	1 st set	96.20 ± 0.86	96.81 ± 1.18	0.1108
	2 nd set	95.67 ± 1.34	96.84 ± 1.35	0.0009 ^a
	3 rd set	94.93 ± 1.66	96.79 ± 0.89	0.001 ^a
Leg Curl	1 st set	95.67 ± 0.81	96.62 ± 1.27	0.001 ^a
	2 nd set	96.13 ± 1.18	96.64 ± 1.84	0.430
	3 rd set	96.33 ± 0.89	96.86 ± 0.70	0.0001 ^a
Triceps extension	1 st set	96.20 ± 1.56	96.79 ± 1.03	0.014 ^a
	2 nd set	94.67 ± 1.75*	96.73 ± 0.96	0.022 ^a
	3 rd set	96.27 ± 1.38	96.80 ± 1.20	0.149

Data presented according to its mean and standard deviation; *significant difference for the first set; ^a significant difference between the conditions.

Rate of Perceived Effort

Regarding the initial sets and exercises (LP, BP and LE), there were no differences between the RPE values between the different conditions ($p > 0.052$). However, for the final routine exercises (PD, LC and TE), significant differences were observed in the

second for PD ($p = 0.01$) and LC ($p = 0.02$) and in the third set for the TE exercise ($p < 0.006$). Regardless of respiratory deprivation, we observed RPE increase throughout the routine, except for the LC performed with masks ($p = 0.356$) and the TE for the condition without the mask ($p = 0.280$). Table 2 presents the RPE for both conditions.

Table 2: Rate of perceived effort during a resistance training routine in both conditions with and without the mask

Exercise	Set	With the mask	Without the mask	P value between conditions
Leg press	1 st set	7	7	0.734
	2 nd set	7*	8*	0.059
	3 rd set	8	8*	0.052
Bench press	1 st set	6	7	0.095
	2 nd set	8*	7	0.601
	3 rd set	8*	8*#	0.234
Leg extension	1 st set	6	6	0.546
	2 nd set	7	7	0.891
	3 rd set	8*#	7*	0.235
Pec deck	1 st set	6	5	0.15
	2 nd set	6*	6	0.012 ^a
	3 rd set	7*	6*	0.556
Leg curl	1 st set	6	6	0.66
	2 nd set	6	6*	0.029 ^a
	3 rd set	7	7*	0.366
Triceps extension	1 st set	6	6	0.005 ^a
	2 nd set	7	6	0.002 ^a
	3 rd set	8*	6	0.006 ^a

Data presented according to its median. *Significant difference for the 1st set; # significant difference for the 2nd set.

DISCUSSION

The main findings of the present study were the significant reduction in SpO_2 verified by the AUC at different moments during the training session for the condition without the mask and the increase in RPE during the final part of the training routine. These findings add to the growing body of knowledge since the Wuhan 2019 events that created the necessity for a safer environment, leading to global and local regulations regarding surgical mask use (Hui et al., 2020). This pioneering study focused on fatigue and discomfort related to the use of masks, commonly recommended in the COVID-19 pandemic. However, other experiments have already used physical barriers that restricted the airflow (Andre et al., 2018; Jagim et al., 2018).

For instance, in a previous experiment (Jagim et al., 2018) during a training session performed with the use of a training mask with elevation simulation, it was observed that the number of complete repetitions in bench press decreased significantly. Additionally, the execution speed decreased in both exercises performed (squat and bench press), the execution speed was higher during the condition without the mask, and these differences occurred from the fifth repetition onwards. In the research conducted by André et al. (2018), TF sessions were carried out with ten men, consisting of 12 repetitions with the intensity of 70% of 1-RM, with and without using the lifting mask. In the result, it was observed that there was a significant reduction in the total number of repetitions in multi-joint exercises (squats and leg press) between the session and exercises, while no difference was found in the execution of single-joint exercises (knee extension). For the perceived exertion rate, significant increases were found in the pre- and post-effort conditions; additionally, there was a significant reduction in SpO_2 with the elevation simulation mask.

When comparing these studies (Andre et al., 2018; Jagim et al., 2018), the RPE with the use of the elevation simulation mask was higher, demonstrating an additional discomfort when performing an exercise. This only occurred in our experiment at the end of the training session and single-joint exercises. RPE elevations followed by performance reduction influenced by ergogenic resources have been previously documented (Fontanella et al., 2020). More specifically, in tests conducted by Jagim et al. (2018), the squat had higher RPE values than the bench press; in the experiment by André et al. (2018), the perceptions of effort remained higher in the squat and leg press exercises than in the knee extension. In the present experiment, the RPE had significantly higher values in the execution of the leg press and bench press, and it turned out that the multi-joint exercises presented the highest level of effort in the training sessions when comparing the studies.

Observing the SpO_2 data in the tests performed by Jagim et al. (2018), the measurement of the SpO_2 level was reduced (but not significantly) with the use of the elevation simulation mask regardless of the type of exercise performed (squat, bench press and running sprint test), when the three were observed. Subsequent minutes of the exercises, with the greatest decrease in the first minute after execution. In the study conducted by André et al. (2018), a significant reduction in SpO_2 was observed for lower limbs, consisting of three exercises (squat, leg press, and leg extension).

In both studies presented, saturation levels have shown a reduction with training masks simulating elevation (Andre et al., 2018; Jagim et al., 2018), corroborating our findings. Our experiment does not aim to observe the relationship of a type of ergogenic resource during training but to understand how the protective mask for COVID-19 influences the performance of ST. In this sense, the most common model of surgical mask was used for COVID-19.

Even knowing that the mask use was previously recommended (Kim, 2020), in our experiment, both SpO_2 reductions and RPE elevations were observed. It seems that with the accumulation of training fatigue, especially with the condition of respiratory restriction (with the mask), we can assume an emphasis of anaerobic glycolysis in greater magnitude to compensate for the incomplete phosphocreatine resynthesis (Maughan, Gleeson, & Greenhaff, 2000). The greater dependence of anaerobic glycolysis is associated with the accumulation of H^+ that reduces the pH of the intracellular fluid. The effect is the afferent feedback of the chemoreceptors and nociceptors muscle associated with an increase in the perceived exertion (Lagally, Mccaw, Young, & Medema, 2004). The central nervous system responds to increased RPE by increasing pulmonary ventilation and recruitment of motor units (Lagally & Robertson, 2006). However, in our study, as there is a reduction in oxygen uptake, as observed in SpO_2 , a significant increase in RPE can be observed at the end of the training.

We strongly recommend the necessity of more work involving this theme, such as longer training sessions, or even with additional intensifying factors, such as reduced interval time (Senna et al., 2009), higher intensities (Senna et al., 2019a), additional multi-joint exercises (Senna et al., 2012), and distinct exercise orders (Senna et al., 2019b) in order to explore further ST mask use implications.

CONCLUSION

In general, the results found in the present study demonstrate that the surgical mask use in a ST

session causes a reduction in the SpO₂ concentrations and an increase in RPE. For practical application, the data from this study may help trainers comprehend ST prescription when clients were wearing masks during the COVID-19 pandemic.

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UTICAJ HIRURŠKIH MASKI NA ZASIĆENJE KISIKOM I PERCIPIRANI NAPOR TOKOM TRENINGA SNAGE

Cilj: Ovo istraživanje je nastojalo procijeniti SpO_2 i stopu percipiranog napora (RPE) kao rezultat treninga snage provedenog u dva različita scenarija: normalna situacija naspram korištenja hirurških maski za prevenciju COVID-19. **Metode:** Odabrano je petnaest obučanih muškaraca ($81,66 \pm 8,37$ kg; $177,66 \pm 6,31$ cm; $26,88 \pm 5,55$ godina starosti; $12,17 \pm 5,98$ % masti; $1,15 \pm 0,19$ kg/kg relativne snage potiska sa klupe/tjelesne težine) koji su izvodili dva testna treninga kako bi utvrdili napor za 10 maksimalnih ponavljanja za sve vježbe koje su prilagođene na 80%. Mjerenje SpO_2 je verifikovano odmah nakon svake serije za svaku vježbu, a od učesnika je istovremeno zatraženo da identifikuju svoj RPE kako bi se dobila subjektivna mjera zamora. Ispitanici su tokom prvog treninga izvodili vježbe sa SARS-CoV-2 zaštitnim hirurškim maskama uz pasivni interval odmora od 2 minute, ali su tokom drugog treninga vježbe izvodili bez hirurških maski. **Rezultati:** SpO_2 je pokazao razliku ($p = 0,03$) u situaciji gdje su korištene maske ($481,33 \pm 3,04$) naspram odsustva maski ($484,46 \pm 5,96$) uz povećanje SpO_2 u situaciji sa odsustvom maski tokom različitih perioda verifikacije ($p = 0,039$). Kada su u pitanju početne serije i vježbe, nisu uočene značajne razlike između vrijednosti RPE-a u različitim situacijama, tj. neovisno od upotrebe maski ($p = 0,052$). Međutim, kod završnih vježbi su uočene značajne razlike u drugoj seriji (razvlačenje na trenažeru (PD), $p = 0,01$; nožni pregib (LC), $p = 0,02$) te u tri serije triceps ekstenzija (TE) ($p = 0,006$). **Zaključak:** Otkrili smo da korištenje hirurških maski smanjuje SpO_2 i povećava RPE tokom treninga snage.

Ključne riječi: dizanje tegova, COVID-19, hirurška maska, kondicija

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MUSCULOSKELETAL DISORDERS AMONG ELITE JUNIOR MALAYSIAN BADMINTON PLAYERS

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ABSTRACT

The study investigated the prevalence of musculoskeletal disorders in elite Malaysian junior badminton players. A descriptive cross-sectional study included 73 players (43 boys and 30 girls) aged from 13 to 18 years old, who were all members of Malaysian National Junior squads with a mean playing experience of 7.7 years. Using the Nordic Musculoskeletal Questionnaire, players were asked to recall the injuries sustained in the previous 12 months that had prevented them from completing standard badminton practices, specifically during the last 7 days. The collected injury information included the anatomical site of injury (neck, shoulders, elbows, wrist, hands, back, hips, thighs, knees, and ankles) and pain ranking. The most prevalent anatomical site of injury was the lower back (62%), followed by hips/thighs (44%) and dominant shoulder (40%); this was mirrored in pain experienced in the previous 7 days: lower back (42%), hips/thighs (26%) and shoulders (22%). According to this study's findings, most players experienced musculoskeletal disorders in the lower back, followed by hips/thighs and shoulders. Shoulder, elbow and wrist/hand pain were most reported on the dominant side.

Keywords: athletic injuries, badminton injuries, musculoskeletal injuries, racquet sports, sports injuries

INTRODUCTION

After soccer, badminton is the second most popular sport in the world (Li et al., 2017). Badminton is a racquet sport in which a shuttlecock is struck across a net using a badminton racquet as a weapon. Badminton is a non-contact, individual sport that requires jumps, lunges, quick changes of direction, and rapid arm movements (Manrique & Gonzalez-Badillo, 2003), as well as gripping the racquet for long lengths of time (Muttalib et al., 2009). Badminton has the greatest overhead strokes of any racquet sport (more than 30%). As a result, it is critical to improve shoulder strength, mobility and stability to avoid injuries (Miyake et al., 2016).

It was discovered that most of the injuries suffered

by the best badminton players resulted from overuse (Fahlström et al., 2006). It was also proven that this is relevant to players of all ages (Miyake et al., 2016). According to another research, traumatic (acute) injuries in elite junior players exceeded overuse-related injuries by as much as three times in the usual junior player's case (Goh et al., 2013). This finding contradicts the findings of the first research. Further analysis found that (98.5%) of injuries in the upper limbs resulted from overuse. In comparison, the percentage for injuries to the knee was (26.5%), injuries to the ankles accounted for (17.5%), and injuries to the back made up (79.5%) of the total. During an ongoing competition, Fahlström et al. (2006) surveyed the top badminton players on the world circuit. They found that shoulder discomfort

was a prevalent complaint among badminton players of both genders (52%), and the athletes reported having previous shoulder pain and (20%) experienced ongoing pain.

A badminton injury results is pain, swelling, stiffness, or numbness during or after a game (Muttalib et al., 2009). According to Marchena-Rodriguez et al. (2020), badminton is a very low-risk activity, and the most linked injuries are overuse injuries. Muttalib et al. (2009) and Shariff et al. (2009) claimed that most injuries sustained by badminton players resulted from overuse, namely knee ailments. The damage resulting from badminton may be classified based on the nature, severity and location on the body.

A typical screening method for detecting disparities in muscular strength between the dominant and non-dominant sides of the body is side-to-side strength asymmetry screening (Chia et al., 2016; Ruas et al., 2018). Side-to-side asymmetry is linked to greater injury risk (Ellenbecker & Davies, 2000), postural issues and a higher frequency of lower back pain episodes (Nadler et al., 2001). Findings from the systematic review showed that there are limited studies that focus on the non-dominant side; therefore, further research should focus on muscle imbalance in non-dominant upper limbs and its connection to overhead sports injuries, providing essential programmes and exercises that can stabilise muscles in the non-dominant side (Kamalden et al., 2021; Gasibat & Kamalden, 2021).

It is vital to comprehend the occurrence of injuries, forecast risk factors and implement preventative actions to avoid injuries. According to earlier studies, badminton players have sustained a variety of injuries (Jørgensen & Winge, 1987; Jørgensen & Winge, 1990). That report, however, was outdated. Furthermore, changes have been made to the badminton rules. This study's objective is to provide an update on badminton players' injuries. Moreover, this study will provide objective data and information to build a better training plan for players, minimising the risk of injury and improving performance.

METHODS

Study Design

This is a descriptive cross-sectional study which included 73 badminton players attending practice at the National training centre (Akademi Badminton Malaysia, Bukit Kiara). Approval from the Ethical Committee for Research Involving Human Subjects of the University Putra Malaysia (JKEUPM;0072022) was obtained to conduct the research.

Study Setting

Akademi Badminton Malaysia, Bukit Kiara is a training facility specifically designed for elite badminton players.

Sample Size

This study recruited 73 players between the ages of 13 and 18, comprising 43 boys and 30 girls. Participants averaged 7.6 years of playing experience (Mean = 7.69, SD = 1.99), and 17 hours per week of regular training (Mean = 17.28, SD = 2.11) (Table 1).

Procedure

The players were initially informed of the study's purpose. As part of our research, we questioned players to ascertain their health and athletic background using the Nordic Musculoskeletal Questionnaire. According to the standard questions, we sought information on age and sex, years of badminton experience, frequency of badminton play, active participation in other sports, and handedness (whether right or left). Badminton injuries were defined as any episode or history of pain or numbness during or after the game. Each component of the Nordic Musculoskeletal Questionnaire was explained to each player. Players were asked to recall their injuries in the last 12 months when they were prevented from doing their standard badminton practices, and specifically in the previous 7 days. Injury information was collected for the anatomical site of injury and pain (neck, shoulders, elbows, wrists/hands, back, hips, thighs, knees, and ankles). The information obtained from the scale was analysed using graphs and pie charts. Descriptive analysis was performed using the Statistical Package for Social Sciences version 15.0 (SPSS Inc, Chicago, IL, USA).

Table 1: Age Distribution of Badminton Players

	N	Minimum	Maximum	Mean	Std. Deviation
Body mass (kg)	73	31.5	80	56.18	8.655
Height (cm)	73	145	180	165.08	8.291
How long did you play Badminton?	73	1	13	7.69	1.99
On average, how many hours do you play each week?	73	7	21	17.28	2.11

RESULTS

Anatomical Site of Injury

The prevalence of musculoskeletal problems in badminton players is displayed in Figure 1. The

anatomical sites of injury seen in the players were reported in the lower back (62%), followed by hips/thighs (44%), shoulders (50%), upper back (36%), ankles (32%), knees (26%), neck (19%), wrists/hands (38%), and elbows (9%), respectively.

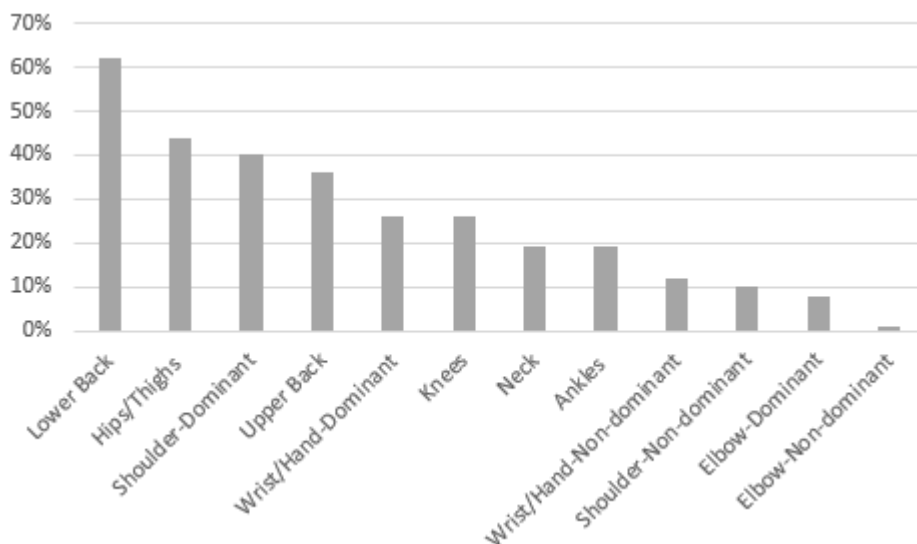


Figure 1: Anatomical site of injury

Anatomical Site of Pain in the Previous 7 Days

The number of players having pain at the anatomical sites in the previous 7 days is displayed in Figure 1.1. The sites of pain seen in the players were reported

in the lower back (42%), hip/thighs (26%), shoulders (22%), upper back (15%), knees (14%), ankles (13%), wrists (10%), neck (5%), and players' elbows (3%), respectively.

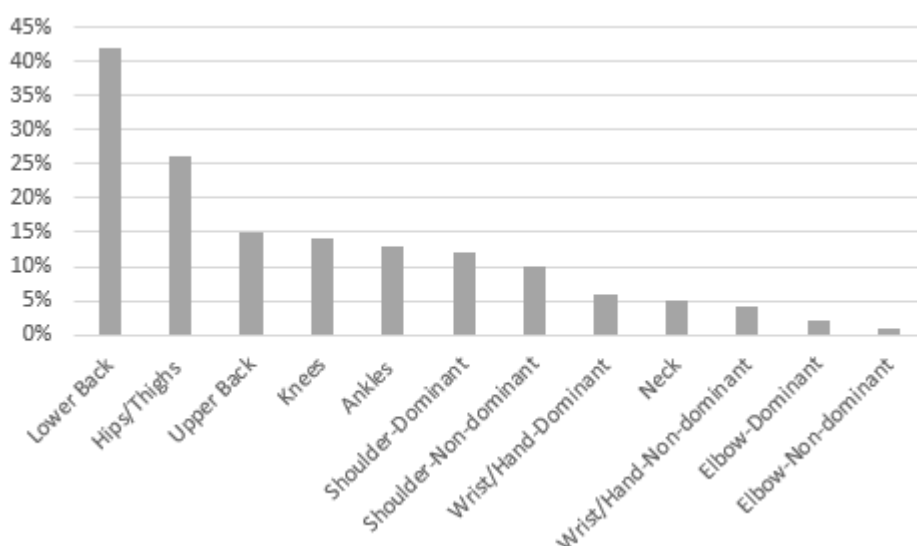


Figure 1.1: Players having pain at the anatomical sites in the last 7 days

Anatomical Site of Pain in the Previous 12 Months

The number of players having pain at the anatomical sites in the last 12 months is displayed in Figure

1.2. The sites of pain seen in the players were lower back (15%), hips/ thighs (10%), knees (7%), ankles (6%), wrists (5%), shoulders (3%), upper back (3%), neck (2%), and elbows (1%), respectively.

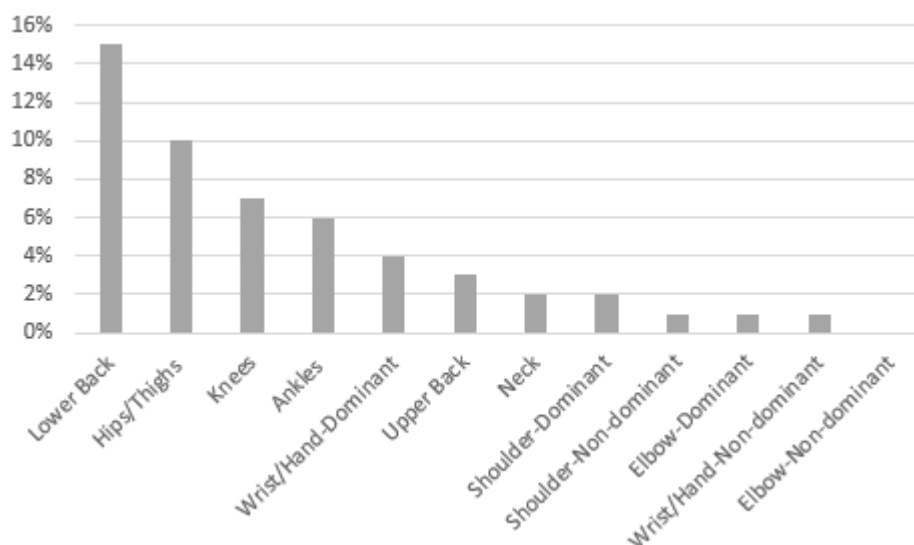


Figure 1.2: Players having pain at the anatomical sites in the last 12 months

Anatomical Site of Pain on the Dominant/Non-dominant and Both Sides

The number of players having pain at the anatomical sites on the dominant, non-dominant and both sides (shoulders, elbows and wrists/hands) is displayed in Figure 1.3. (40%) of players have pain in the dominant shoulder, (10%) of players in the non-dominant shoulder, (7%) of players in both shoulders; (26%) of

players have pain in the dominant wrist/hand, (12%) in the non-dominant wrist/hand and (3%) of players in both wrists/hands; (8%) of players have pain in the dominant elbow, (1%) of players in the non-dominant elbow and (2%) of players in both elbows.

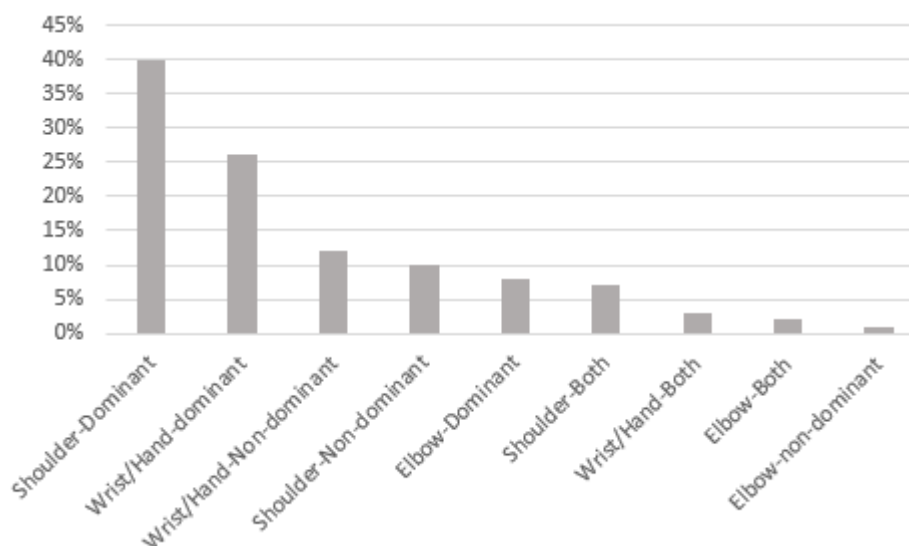


Figure 1.3: Players having pain at the anatomical sites on the dominant side, non-dominant side and both sides

DISCUSSION

The study's main goal was to determine the frequency of musculoskeletal injuries among badminton players. According to this study, among the badminton players who were examined, the most prevalent injured areas were the lower back (62%), followed by hips/thighs (44%), shoulders (50%), upper back (36%), ankles (32%), knees (26%), neck (19%), wrists/hands (38%), and elbows (9%), respectively. These injuries occurred between the last 7 days and the past 12 months.

The injuries suffered by badminton players are poorly understood. Four experienced sports physicians documented a total of 469 musculoskeletal injuries, as described by Shariff et al. (2009). The most diagnosed ailments were mild overuse injuries requiring up to seven days of rest. This result was consistent with previous research (Jørgensen & Winge, 1990; Krøner et al., 1990). Only ten (2.1%) instances were deemed severe enough to warrant referral to a tertiary care hospital.

According to Hoy et al. (1994), researchers noticed a greater injury incidence among athletes between the ages of 18 and 25. (45 per 1,000 per year). The lack of experience among younger players and potentially a more aggressive style of play are both viable hypotheses to explain this data. Another possibility is that the younger players are simply more aggressive. Most injuries did not occur during actual competition but rather in the context of training or practise. Even earlier research has found similar results (Jørgensen & Winge, 1990). On the other hand, Hoy et al. (1994) discovered a higher rate of injury among recreational badminton players with less experience, but their sample size was smaller. The elite players' training schedule, in which they spent most of their time preparing for competition and trained 3–4 times a day for 1–3 hours per session, could explain this variation in observation. Training sessions could also include more strenuous exercises that a recreational athlete would never do (Witvrouw et al., 2001).

In elite badminton players, Jørgensen & Winge (1987) discovered (58%) of injuries were lower extremity injuries. Krøner et al. (1990) found a higher rate of lower extremity injuries (82.9%), but only among recreational badminton players. In our study, hips/thighs (44%), ankles (32%) and knees (26%) were affected. This is less than what we reported in our study. Peers and Lysens (2005) believed that knee difficulties were connected to the quickly shifting eccentric/concentric work of the quadriceps in knee flexion and rotation, which puts a significant force load on the patellar tendon. Witvrouw et al. (2001) found that decreased quadriceps and hamstring flexibility is linked to patellar tendinitis in athletes.

Elite senior athletes were shown to have a greater prevalence of recurring injuries than elite junior and prospective athletes. (64%) of all new injuries were strains, with the most common locations for the damage being the back, shoulder, thigh, and knee (Yung et al., 2007).

When executing a badminton stroke, one must move energy from the legs and trunk to the upper limb and racquet (Witvrouw et al., 2001). A lack of coordination can harm the performance at any point in the kinetic chain (Nhan et al., 2018). Research showed (25%) of upper limb injuries among 44 badminton players (Nhan et al., 2018). There was a high incidence of upper limb injuries among 469 elite badminton players studied (18.1%) (Pardiwala et al., 2020).

According to an epidemiological survey by Nhan et al. (2018), most upper limb injuries were caused by overuse. While overuse has been connected to (98.5%) of all upper-limb injuries, it is only responsible for (26%) of knee injuries and (17%) of ankle injuries. In most research, non-competitive training-related injuries surpass competitive match-related injuries (Lees, 2003).

Our study reported injuries in the lower back (62%), upper back (36%) and shoulders (50%). However, injuries in the shoulder and back are reported less frequently by Shariff et al. (2009). It is reported that 16–19% of elite players compete with ongoing pain in the Achilles and/or patellar tendon and/or the shoulder (Boesen et al., 2011). It is unknown whether the training and tournament loads, as well as physical development disparities, encountered by young elite players are equivalent to those experienced by adult players. Upper extremity pain was also strongly associated with lower back pain in prior research Jonasson et al. (2011) conducted on basketball players between elementary and middle school. In a previous investigation of overhead motion sports, shoulder discomfort was found to have a substantial connection with back pain (Matsuura et al., 2017), which included a relatively small sample size of 95 badminton players. Both Arab and Nourbakhsh (2010) and Nadler et al. (2001) reported no statistically significant difference between low back pain sufferers with and without iliotibial tightness, which is connected to and common during lower back pain, in hip strength levels. In our study, (40%) of players have pain in the dominant shoulder, (26%) of players have pain in the dominant wrist/hand and (8%) of players have pain in the dominant elbow. Such data may help generate novel badminton injury hypotheses. More prospective studies on injury processes are needed to improve injury management and prevention.

CONCLUSION

Even though badminton is a non-contact sport, there is a substantial danger of injury. Most badminton injuries are caused by overuse and high cumulative loads. These observations should be noted by badminton coaches and trainers, who should then consider modifying the training load of badminton players to allow the body to

recuperate and break the recurrent cycle that leads to overuse problems. A "safe" and low risk playing style should be instilled in young, passionate players by

coaches, as research shows that younger badminton players are more prone to acute traumatic injuries.

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MIŠIČNO-KOŠTANI POREMEĆAJI KOD ELITNIH JUNIORSKIH IGRAČA BADMINTONA IZ MALEZIJE

Ova studija je ispitala učestalost mišićno-koštanih poremećaja kod elitnih juniorskih igrača badminton iz Malezije. Deskriptivna transverzalna studija je uključila 73 igrača (43 dječaka i 30 djevojčica) uzrasta 13-18 godina koji su članovi Malezijskih nacionalnih juniorskih timova te igraju 7,7 godina. Putem Standardiziranog nordijskog upitnika za analizu mišićno-koštanih simptoma od igrača je zatraženo da se prisjete povreda zadobijenih u proteklih 12 mjeseci koje su ih spriječile da se uobičajeno bave badmintonom, a posebno onih koje su zadobili u proteklih 7 dana. Prikupljene informacije o povredama su obuhvatile anatomsku lokaciju povrede (vrat, ramena, laktovi, ručni zglob, ruke, leđa, kukovi, bedra, koljena i skočni zglobovi) i procjenu boli. Najčešća anatomska lokacija povrede je bila donji dio leđa (62%), nakon kojih slijede kukovi/bedra (44%) te dominantno rame (40%). Lokacija povrede je praćena bolom u proteklih 7 dana: donji dio leđa (42%), kukovi/bedra (26%) i ramena (22%). Prema pronalascima studije, mnogi su igrači zadobili mišićno-koštane poremećaje u donjem dijelu leđa, nakon koji slijede kukovi/bedra i ramena. Bolovi u ramenu, laktu i ručnom zglobu/ruci su najčešće bili prisutni na dominantnoj strani.

Ključne riječi: sportske povrede, povrede prilikom bavljenja badmintonom, mišićno-koštane povrede, sportovi sa reketom, povrede zadobijene tokom bavljenja sportom

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VARIATIONS OF MORPHOLOGICAL INDICATORS AND BMI IN PRESCHOOL CHILDREN

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ABSTRACT

The aim of this research was to determine variations of the selected morphological indicators and BMI in boys and girls aged 3-6. The research included 1804 children (boys n = 902, girls n = 902) aged 3-6, divided into four subgroups (Three years old n = 360; Four years old n = 534; Five years old n = 480; Six years old n = 430). Four morphological measurements were used: body height (BH), body weight (BW), head circumference (HC), chest circumference (CC), and body mass index (BMI). The Student's t-test for independent samples was used to determine the variations. Body mass showed differences in the 3- and 4-years-old subgroups in favour of boys. Body height is statistically significant in children aged 4-6, also in favour of boys. The differences, i.e., variations in body mass index were seen in children aged 3 in favour of boys. At this age, we can observe certain differences between boys and girls concerning the morphological measurements and BMI, studied in this research, but these differences are minimal despite being statistically significant.

Keywords: morphology, gender difference, preschool age, body mass index

INTRODUCTION

Children of the same age show significant differences in physical and psychological maturity, that is, the speed of their development is diverse (Cikojević, 2020; Majer, 2015). If we seek answers to the question why do these differences occur, we will obtain two explanations. The first, traditional explanation stems from the inherent conditionality of the speed and level of development, in addition to the environmental factors, and second, where new research points to the transfer of an entire series of psychomotor and morphological dimensions which are affected by the movement stimulation of the programmed work (Antolović, 2017; Matušan, 2018). The growth and development of preschool children do not occur at a steady rate. Differences in the

growth and development of children vary since birth between boys and girls (Majdandžić, 2018; Kapo et al., 2018; Šalković, 2019; Marić, 2020). Certain endocrine glands affect the growth and development of preschool children. The thymus is particularly active during the age of 3 and 4, with prevalence of the pituitary, thyroid and gonad from the age of 4 to the age of 7 (Bošnjaković, 2018; Fruk, 2019). The preschool period is marked by a more stable increase in body height in relation to the previous period, and the child's body mass increases with the increase of body height (Grbeša, 2016; Kotarski, 2018). Numerous factors affect the growth and increase of body weight, such as: the child's health, the natural environment in which the child lives, organisation of the child's daily regime, nutrition, etc. (Blažević, Božić, & Dragičević, 2012; Poljak, 2016; Ćirić, Čaušević, & Bejdić, 2015). The aim of this paper

is to investigate the differences between the selected morphological indicators and BMI in preschool boys and girls aged 3-6.

MATERIAL AND METHODS

Participants

The research was conducted on a sample of 1804 children from BiH, out of which there were 902 boys and 902 girls aged 3-6, divided into four subgroups according to age ± 0.5 years, namely: 3 years old – 360 children (boys = 180, girls = 180); 4 years old – 534 children (boys = 267, girls = 267); 5 years old – 480 children (boys = 240, girls = 240), and 6 years old – 430 children (boys = 215, girls = 215). The subjects had to satisfy the following criteria: that they are medically fit and that they have no physical disabilities; the research did not include children who were ill or with limited abilities during the measurements; that they had parental agreement for conducting measurements.

Experimental Approach to the Problem

When choosing the variables, we opted for the variables satisfying the basic metric characteristics (validity, reliability, objectivity, sensitivity, etc.) which were also appropriate in relation to the subject's age, all of which was done according to the instructions of the International Biological Programme – IBP, as well as the variables which reliably represent biological growth and development concerning the children of this age: body height – BH; body weight – BW; chest circumference – CC; head circumference – HC and body mass index – BMI. In order to satisfy the fundamental requirements so as to eliminate errors and provide optimal conditions for measuring morphological characteristics, we undertook the following activities: the measurements used in this research were described according to the method recommended by the International Biological Programme (IBP); the entire measurement of anthropometric dimensions was conducted in the afternoon, from 8 to 10, so as to avoid variations

of certain body parts, that is, parameters, especially the body height and mass; the measurements were conducted in spacious, well-lit and clean facilities with the temperature of 18 to 24 °C; all measurements were conducted using the same standard-issue, calibrated anthropometric instrumentation. Prior to using the instruments, we calibrated them and verified the accuracy of measurements. The results of anthropometric measurements are grouped according to gender and age per decimal years.

Statistical analyses

Variations of anthropometric means in boys and girls for each variable were tested using the Student's t-test for independent samples, and the level of significance was set at $p = .01$ and $p = .05$. When applying the analysis of variance, we calculated the arithmetic means for each observed morphological measurement, which was followed by variability among the subjects between the groups and variability among the subjects within groups. The analysis designated the F-test as a ratio of variability between groups and variability within groups, as well as the degrees of freedom (df).

RESULTS

The results of the analysis for determining the basic result distribution parameters of measuring anthropometric characteristics and BMI in boys and girls are shown in tables for the corresponding age (Tables 1 and 2). In children aged 3, we observed statistically significant variations (of arithmetic means between boys and girls) in the largest number of anthropometric characteristics. Statistically significant differences were not present in the average body height ($p = .411$). Statistically significant variations at the level of statistical significance of .001 in the age of 3 were shown in the variable body weight ($p = .002$), head circumference ($p = .001$) and body mass index ($p = .001$), while at the statistically significant level of .05, the variation was shown in the variable chest circumference ($p = .40$) in favour of boys (Table 1.).

Table 1. Central and dispersion parameters and variations between the genders for morphological measurements in preschool boys and girls – 3 and 4 years old

Age groups								
	3 y (n = 360)				4 y (n = 534)			
	Boys (n = 180)	Girls (n = 180)	T-test		Boys (n = 267)	Girls (n = 267)	T-test	
	AS \pm SD	AS \pm SD	t	Sig	AS \pm SD	AS \pm SD	t	Sig
BH	17.37 \pm 2.73	16.39 \pm 3.15	3.13	.002	19.85 \pm 3.32	19.15 \pm 4.30	2.11	.035
BW	100.86 \pm 5.61	100.35 \pm 6.02	1.41	.411	108.37 \pm 6.41	107.01 \pm 6.44	2.44	.015
HC	50.79 \pm 1.80	50.14 \pm 1.54	1.00	.000	51.98 \pm 1.51	51.07 \pm 1.59	6.74	.000

CC	53.65 ± 2.99	52.94 ± 3.57	3.74	.040	55.46 ± 3.30	54.56 ± 4.55	2.59	.010
BMI	17.10 ± 265	16.21 ± 2.27	4.04	.001	16.87 ± 2.18	16.61 ± 2.76	1.21	.226

Table 1 also shows statistically significant variations in all four morphological measurements (4 years old), namely: body weight ($p = .035$), body height ($p = .015$), head circumference ($p = .001$), and chest circumference ($p = .010$) in favour of boys, while the variable body mass index ($p = .226$) did not show a statistically significant difference.

An analysis of the results in Table 2 shows statistically significant differences in the variables: body height ($p = .014$), head circumference ($p = .001$) and chest circumference ($p = .006$). The variables body weight ($p = .078$) and body mass index ($p = .554$) did not show any statistically significant differences.

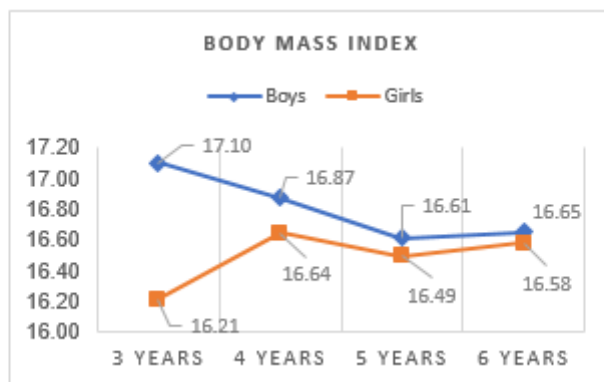
Table 2. Central and dispersion parameters and variations between the genders for morphological measurements in preschool boys and girls – 5 and 6 years old

Age groups								
	5 y (n = 480)				6 y (n = 430)			
	Boys (n = 240)		Girls (n = 240)		Boys (n = 215)		Girls (n = 215)	
	AS ± SD	AS ± SD	T-test		AS ± SD	AS ± SD	T-test	
BH	22.22 ± 4.19	21.52 ± 4.46	1.76	.078	24.50 ± 4.11	23.86 ± 4.56	1.54	.123
BW	115.32 ± 6.58	113.84 ± 6.60	2.45	.014	121.05 ± 6.43	119.55 ± 6.79	2.36	.019
HC	52.53 ± 1.50	51.69 ± 1.40	6.32	.000	53.24 ± 1.51	52.54 ± 1.70	4.52	.000
CC	57.68 ± 4.32	56.55 ± 4.65	2.75	.006	58.79 ± 3.99	57.59 ± 4.61	2.88	.004
BMI	16.61 ± 2.03	16.49 ± 2.38	.592	.554	16.65 ± 1.89	16.58 ± 2.13	.335	.738

By examining the results in Table 2 for the age of 6, the statistically significant variations were shown in the variables: body height ($p = .019$), head circumference ($p = .001$) and chest circumference ($p = .004$) in favour of

boys. The variables body weight ($p = .123$) and body mass index ($p = .738$) did not show any statistically significant variations.





Graph 1. Differences between boys and girls (3-6 year old)

DISCUSSION

Growth and development are dynamic processes which cannot be independently observed. Growth represents a consequence of an increase and multiplication in the organism cells (Pelemiš, 2016). Development signifies changes in tissue leading to the functional improvement of organs and organic systems, as well as the organism as a whole. As the most striking indicators of physical growth, child height growth and an increase in body mass do not occur simultaneously. The height growth most frequently occurs at the expense of the skeletal system, while the weight growth (and the increase of body mass) is partially a consequence of the growth in the skeletal system and the muscular system, etc. It can be pointed out that the preschool period is characterised by a stable and not so turbulent development of the child's organism, making it an ideal period for the formation and perfection of diverse motor skills (Kosinac, 1999; Bala, Jakšić, & Katić, 2009; Jakić & Popović, 2009). The age period of 3 to 6 is characterised by an increase in body mass of around 2 kg and body height of 5-8 cm. At this age, we can observe certain differences between boys and girls concerning the morphological measurements studied in this research, but these differences are minimal despite being statistically significant. The physical appearance of boys and girls aged 3-6 is highly similar when observed from the back, where boys are somewhat taller and heavier. The chest circumference has an average growth of 1-2 cm per year. Physical proportions change in the sense that the chest gradually becomes larger than the abdomen, and the stomach is less protuberant (Pelemiš, 2016; Fratrić & Rubin, 2006; Trajkovski-Visić, 2004; Trajkovski, Misigoj-Duraković, & Plavec, 2014). Proper growth and development of children is the prerequisite for preserving their psychophysical health which is manifested at a later stage in life. The growth and development rate in children is highly diverse. The complex functional transformation of a developing individual does not occur regularly and

equally in different parts of the organism, but according to the rhythmic flow marked by the so-called "growth crises" (Martinović et al., 2012; Krneta et al., 2014; Stupar et al., 2017; Kotarski, 2018; Šekeljčić et al., 2019). Children aged 3-6 grow faster in height than physical weight (Graph 1.). Measurements prove that the child grows around 12 cm on average from the age of 3 to the age of 4, and around 8 cm from the age of 4 to the age of 5, with the average of 6 cm from the age of 5 to the age of 6. An increase in the child's body weight amounts to between 3 and 4 kg. At the age of three, the head circumference amounts to 49 cm, at the ages of four and five, it is 51 cm, and at the age of six, it amounts to 52 cm. The chest circumference amounts to 50.5 at the age of three, at the age of four, it increases by 3 cm, with a 3-cm increase at the age of five, and it amounts to 60.5 cm at the age of six (Dumić & Mardešić, 2000; Pereša, 2020; Šalković, 2019). The growth and development depend upon several factors divided into endogenous and exogenous. Endogenous factors relate to the genotype and functioning of the endocrine glands as well as the gender and race. The exogenous factors relate to the climate and geographical conditions, temperature variations, seasons, economic and social living conditions, nutrition, physical activities, disease, etc. (Bajrić, Srdić, Puljić, & Jahić, 2017; Đukić, 2013; Matijašić, 2019; Petrović, 2018). Growth signifies a quantitative increase of an organism or its parts, as well as the changes in size representing the result of cell multiplication or an increase in the existing ones. On the other hand, development signifies a maturation of organs and its systems, acquisition of abilities, faster adaptation to stress, i.e., it signifies qualitative changes of an organism or system (Tomažin, 2015; Kotarski, 2018; Matušan, 2018). Anthropometric measurements of children belong to the group of fundamental anthropological data concerning a population. In the available literature, anthropometric measurements of adults for both genders are relatively well investigated, while they practically do not exist for children. The first step in the dynamic anthropometry of children was determining the two main anthropologically significant functions of canonical and harmonic dependence; standing height and current weight (Baksa, 2007).

Canonisation was implemented in the same way as for adults with the eight head count canon, but is not the same as the one used in adults, and it is closely dependent upon the child's age. For example, an infant has a proportionally large head, short limbs and long body which accounts for 70% of its total length (Akinbami, Kit, Carroll, Fakhouri, & Ogden, 2017; Méio, Moreira, & Preedy, 2012). During the development of the organism, physical dimensions also change along with their proportional ratio so that an adult subject's body accounts for around 50% of the entire length. It is clear how, during child development, anthropometric canons change with age. Genetic factors primarily affect the development of the human body, with environmental factors being second. The very course of the human organism development is not continuous; it varies, e.g., sudden increase in body height during puberty, the so-called height spurt. It is important to note that the relevant anthropometric units are not equal for both genders during the growth period (Zekić, Car Mohač, & Matrljan, 2016).

CONCLUSION

It is best to observe a child as a being in development, i.e., it should be understood as an individual in development and monitor both the dynamics and the differences in its growth and development. The preschool period is marked by a more stable increase in body height in relation to the previous period, and the child's body mass increases with the increase of body height so that, during the period of 3-6 years, the increase of body mass amounts to 1.5 - 2.5 kg. Numerous factors affect the growth and increase of body weight, such as: the child's health, the natural environment in which the child lives, organisation of the child's daily regime, nutrition, etc. In order to understand the very ontogenesis process, it is necessary to be familiar with the norms and standards concerning the growth and development of children of this age primarily because, in practice, it is often very hard to draw the line between normal variation and pathological deviation.

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VARIJACIJE MORFOLOŠKIH INDIKATORA I BMI-JA KOD PREDŠKOLSKJE DJECE

Cilj ovog istraživanja je utvrditi varijacije odabranih morfoloških indikatora i BMI-ja kod dječaka i djevojčica uzrasta 3-6 godina. Istraživanjem je obuhvaćeno 1804 djece (dječaka $n = 902$, djevojčica $n = 902$) uzrasta 3-6 godina, podijeljenih u četiri podgrupe (Tri godine starosti $n = 360$; Četiri godine starosti $n = 534$; Pet godina starosti $n = 480$; Šest godina starosti $n = 430$). Korištena su četiri morfološka mjerenja: tjelesna visina (BH), tjelesna težina (BW), obim glave (HC), obim prsnog koša (CC) i indeks tjelesne mase (BMI). Za utvrđivanje varijacija korišten je Studentov t-test za nezavisne uzorke. Tjelesna masa je ukazala na razlike u podgrupama uzrasta 3 i 4 godine, a u korist dječaka. Tjelesna visina je statistički značajna kod djece uzrasta 4-6 godina, također u korist dječaka. Razlike, tj. varijacije u indeksu tjelesne mase su uočene kod djece uzrasta 3 godine u korist dječaka. U ovom uzrastu možemo uočiti određene razlike između dječaka i djevojčica u pogledu morfoloških mjerenja i BMI-ja, proučavanih u ovom istraživanju, ali te su razlike minimalne iako su statistički značajne.

Ključne riječi: morfologija, rodne razlike, predškolsko doba, indeks tjelesne mase

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THE ROLE OF ANODAL GALVANISM IN THE TREATMENT OF RETROCALCANEAL BURSITIS: A COMPARATIVE STUDY

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ABSTRACT

Background: Retrocalcaneal bursitis (RCB) is highly prevalent, with resultant disability in over 50% of those affected. RCB can result from repetitive impingement from biomechanical alterations or an increase in workout without proper conditioning. Literature focusing on conservative management of RCB is highly scarce. This study focuses on investigating the efficacy of anodal galvanism (AG) in improving pain and function for RCB patients.

Methods: Clinically diagnosed RCB subjects (N = 135) were randomly assigned to either of the three intervention groups: AG, Ultrasound Therapy (UST) and Laser Therapy (LT) for a 2-week long treatment in this retrospective study. All subjects additionally received the conventional treatment. After a drop-out of 28 subjects, follow-up and analysis was done for 107 subjects (57 male and 50 female). The difference in the baseline characteristics and variables (age, gender, BMI, average symptoms duration, VAS, and AOFAS) among 3 independent groups of treatment populations (AG, LT and UST) was tested using one-way ANOVA. Testing for outcome measures (VAS and AOFAS) was done at day 0, 15 and 90. Timeline differences of the dependent variables within a group were analysed by a paired t-test. Mixed-design multivariate analysis of variance (MANOVA) was used to compare the dependent variables among independent variables at different time points.

Results: A mean percentage decline in VAS score was significantly higher ($p < 0.001$) in AG (74.73% and 83.92% at day 15 and 90, respectively) compared to the LT (42.77% and 53.81% at day 15 and 90, respectively) and UST groups (25.06% and 32.82% at day 15 and 90, respectively). AG group depicted a significantly higher percentage increase in AOFAS at the end of the treatment on day 15 (50.51%) compared to the LT and UST groups (22.50% and 13.55%, respectively) ($p < 0.001$), which rose to 67.72%, 31.81% and 20.59%, respectively, at day 90. Tukey's post hoc revealed that improvements in VAS and AOFAS scores between the three groups were significant ($p < 0.05$). The correlation between symptom duration in AG group and the difference in scores for VAS ($r = 0.075$, $p = 0.648$) and AOFAS ($r = 0.187$, $p = 0.255$) was non-significant.

Conclusion: All three treatment alternatives showed statistically significant improvement in reducing VAS and AOFAS. Anodal galvanism had the best efficacy in improving pain and function in subjects with retrocalcaneal bursitis, relative to laser and ultrasound therapy. The authors recommend the use of AG for managing the RCB at all stages of chronicity.

Keywords: retrocalcaneal bursitis, conservative management, anodal galvanism, laser therapy, ultrasound therapy

INTRODUCTION

Posterior heel (retrocalcaneal) pain is highly prevalent, affecting 1 in 8 of the general population, making it disabling in over 50% of those affected [1]. It can result from common conditions like insertional Achilles tendinopathy or degeneration, Haglund's deformity, as a symptom of many systemic/inflammatory arthritic conditions, or retrocalcaneal or Achilles bursitis [2]. Retrocalcaneal bursa, being located directly anterior to the Achilles tendon insertion, allows smooth gliding of the tendon during ankle dorsiflexion. The repetitive impingement of this bursa can be due to lower extremity biomechanical alterations [3, 4], an increase in workout without proper conditioning, or pressure from the shoe counter. It can result in the bursa becoming inflamed, hypertrophied, and adherent to the underlying tendon [5]. This is common in general as well as athletic population, with a resultant break from training in the latter [6].

Often, the thickened/inflamed retrocalcaneal bursa is found to co-exist with Achilles tendon disorders [7, 8]. Also, the Achilles tendinopathy symptoms can easily mask the presence of an inflamed bursa underneath. So, distinguishing it from retrocalcaneal bursitis (RCB) can be difficult in clinical practice. It is common for RCB to cause posterior ankle pain with compression over the medial and lateral edges of the distal tendoachilles, with a tender thickening. Whereas, insertional Achilles tendinitis causes tenderness more distal to the point of attachment at the posterior calcaneus [9, 10].

The majority of patients respond well to the conservative management of RCB, which includes a multitude of options ranging from anti-inflammatory drugs, corticosteroid injections, physical therapy (ice application in the acute stage, electrical modalities, stretching and strengthening exercises, and activity modification) to orthotics (Ankle-Foot Orthosis and footwear modification with a heel raise) [11, 12]. If recalcitrant, open or endoscopic decompression surgery may be required for excision of the inflamed bursa, or resection of calcaneal tuberosity [13]. Literature on the surgical outcomes of RCB treatment is extensive, while studies on conservative management are highly scarce. The earlier textbooks have mentioned the use of anodal galvanism (AG) in different areas of musculoskeletal practice, including bursitis [14], with effects more pronounced in acute stages owing to its depletive effect helping to move the fluid [15]. So, in this study, we tried to explore the association of AG treatment effect with respect to the duration of symptoms. Additionally, to evaluate the efficacy of conservative non-invasive management approaches, we compared the outcomes of AG with other widely used electro-therapeutic agents, like laser [16, 17] and ultrasound therapy, in the management of RCB, with a 3-month follow-up.

METHODOLOGY

This is a retrospective clinical study of patients who reported to the Physiotherapy outpatient department of our institute, from October 2019 to September 2022, with pain at the back of the heel and were diagnosed with retrocalcaneal bursitis on the basis of patient-reported symptoms, clinical history and physical examination (including range of motion, swelling, and tenderness over the tendoachilles insertion). Subjects were recruited after obtaining an informed consent. The study was conducted in accordance with Declaration of Helsinki guidelines. Patients (above 18 years of age) with pain intensity as on the Visual Analogue Scale (VAS) > 3/10, positive two-finger squeeze test and a complete AOFAS (American Orthopaedic Foot and Ankle Society) Ankle-Hindfoot Scale were included. The patients with Achilles tendinitis, plantar fasciitis, calcaneal spur, any previous foot or ankle surgery, pregnancy, neuromuscular disorders, and connective tissue disorders were excluded.

Using simple randomisation, the patients were recruited into three groups: group 1 (AG) received anodal galvanism, group 2 (LT) received low-level laser therapy (LLLT), group 3 (UST) received ultrasound therapy - all three for 12 sessions (6 sessions/week) for a period of 2 weeks. All three groups additionally received the conventional treatment which included strengthening exercises for intrinsic muscles of foot, contrast bath, and instructions on footwear and activity modification. VAS and AOFAS were quantified prior to the treatment (pre-treatment, day 0). The patients were then re-assessed for VAS and AOFAS, once at the completion of treatment on day 15 (PTD 15) and then after 3 months during a follow-up visit (PTD 90). VAS and AOFAS were scored by the therapist blinded to the treatment identity. The demographics of age, gender, BMI, and history of physical activity were recorded at the initial visit.

Interventions

Anodal Galvanism: Low intensity direct current of 0.5-2 mA for 30 minutes duration was employed with the neuromuscular electrical stimulator (Pro Stim LCD (Dual Channel Stimulator), IEMCO, India). A smaller-sized active carbon electrode was placed over the tender area at the posterior heel, and the larger indifferent electrode was placed at the mid-posterior calf. The therapist checked with the patient every 5 minutes for any discomfort/erythema at the stimulation site due to galvanic current. The treatment was given for 6 sessions weekly in the period of two weeks.

Laser Therapy: Each patient received a low-level laser therapy (LLLT) dose of 3 J/cm² in prone lying, single pillow placed at the dorsum of the ankle. The laser energy was irradiated over the tender area onto three points of the heel, at 3 J per point. The total dose was 9 J per session and we used previously calibrated equipment (HPL 7.0. Class IV. Electronica Pagani, Italy). The pen's semi-conductor consisted of gallium arsenide with the wavelength of 808 nm, frequency of 200 Hz, average power of 60 mW, and pulse duration 4.3 ms, 50 seconds per point (area 0.5 cm²). The treatment was given for 6 sessions weekly in the period of two weeks.

Ultrasound Therapy: UST (Enraf Nonius, Netherlands) with transducer head size 0.8 cm² was used with patients in prone lying. The frequency of 3 MHz in continuous mode and intensity of about 0.8 W/cm² was employed. The duration of treatment was 6 min for each session. The treatment was given for 6 sessions weekly in the period of two weeks.

Statistical Analysis

The results were categorised on days post-treatment in which 0 refers to pre-treatment and 15 and 90 refers to post-treatment days (PTD). The difference in the baseline characteristics and variables (age, gender, BMI, average symptoms duration, VAS, and AOFAS) among 3 independent groups of treatment populations (AG, LT and UST) was tested using one-way ANOVA. Timeline differences of the dependent variables (VAS and AOFAS) within a group were analysed by a paired t-test. Mixed-design multivariate analysis of variance (MANOVA) was used to compare the dependent variables among independent variables at different time points. The association of symptom duration and effectiveness of treatment (differences in VAS and AOFAS scores after 90 days) in AG group was established using the Pearson correlation coefficient. Statistical analyses were performed using GraphPad Prism 9.4.1 (San Diego, CA), with a statistical significance defined as a $p < 0.05$.

RESULTS

This study included the initial recruitment of 135 adult patients diagnosed with retrocalcaneal bursitis (unilateral) and met all inclusion criteria. Out of 135 enrolled, 13 patients failed to continue the entire treatment protocol or were treated for bilateral bursitis, and therefore excluded from the study. Six patients did not show for follow-up testing after three months, and 8 were excluded owing to unavailable/incomplete AOFAS. Finally, 107 patients (57 male and 50 female) were included for data analysis. The patients were categorised into 3 groups, namely

AG (N = 39), LT (N = 33) and UST (N = 35), matched for demographics and pre-treatment VAS, AOFAS and symptom duration (Table 1). Demographic and baseline parameters were not statistically different ($p > 0.05$)

VAS score

Patients with RCB had a VAS score of 6.73 ± 1.5 prior to the treatment, demonstrating moderate-severe pain. No significant correlation was established between baseline VAS and age, gender or BMI, suggesting the VAS is a variable independent of patient's demography. Irrespective of the type of treatment received, the pain was reduced to minimum on day 15 (3.45 ± 1.76) and day 90 (2.80 ± 1.72) post-treatment. However, the mean percentage decline in VAS score was significantly higher ($p < 0.001$) in patients receiving AG (74.73% at PTD 15 and 83.92% at PTD 90) compared to those receiving LT (42.77% at PTD 15 and 53.81% at PTD 90). UST group had the least mean percentage decrease in VAS (25.06% at PTD 15 and 32.82% at PTD 90). On follow-up visit at day 90 (PTD 90), the VAS score further declined (Figure 1A), with the score being least in AG group.

AOFAS

As a whole, patients had an average pre-treatment AOFAS score of 50.71 ± 16.44 . This value rose to 62.91 ± 14.76 at PTD 15 and 66.93 ± 13.76 at PTD 90. Notably, among the three treatment groups, AG group depicted the significantly higher percentage increase in AOFAS at the end of treatment on day 15 (50.51%) compared to the LT and UST groups (22.50% and 13.55%, respectively) ($p < 0.001$). The carry-over effect was further checked at Day 90 post-treatment at a follow-up visit, which revealed the percentage increase in AOFAS scores for AG, LT and UST groups to be 67.72%, 31.81% and 20.59%, respectively (Figure 1B).

The paired t-test represented a statistically significant improvement with time (at the end of treatment and at the 3-month follow-up) in all three groups (Table 2), but improvement in the AG group was greater than in LT and UST groups. The mixed design MANOVA for between and within groups indicated significant effects for group, time and group*time interaction for both VAS and AOFAS (Table 3).

Tukey's post hoc analysis for multiple comparisons between groups revealed that improvement in VAS scores between AG and LT groups (mean diff. = 2.552, 95% CI = 1.766 to 3.339), between AG and UST groups (mean diff. = 3.842, 95% CI = 3.068 to 4.617), and between LT and UST groups (mean diff. = 1.290, 95% CI = 0.4829 to 2.097) were all statistically significant ($p < 0.001$) (Table 4). Likewise, improvements in AOFAS scores between AG and LT groups (mean diff. = 13.69,

95% CI = 8.808 to 18.58), and between AG and UST groups (mean diff. = 19.56, 95% CI = 14.75 to 24.37) were significant at $p < 0.001$, while between LT and UST groups (mean diff. = 5.866, 95% CI = 0.8533 to 10.88), it was significant at $p = 0.017$ (Table 5).

Further, the correlation between symptom duration in the AG group and the difference in VAS ($r = 0.075$, $p = 0.648$) and AOFAS scores ($r = 0.187$, $p = 0.255$) was not significant.

Table 1. Baseline (pre-treatment) parameters and demographic characteristics

	Total (n = 107)	AG (n = 39)	LT (n = 33)	UST (n = 35)	f	p
Mean Age (Range) (years)	38.78 ± 11.97	37.95 ± 11.63 (21-61)	39.52 ± 12.05 (21-60)	39.03 ± 12.54 (19-63)	0.16	0.85
Gender ratio (M:F)	57:50	23:16	18:15	16:19	0.66	0.52
BMI (kg/m²)	23.95 ± 3.85	23.59 ± 2.89	24.51 ± 3.32	24.37 ± 5.11	0.85	0.43
VAS at day 0 (Range 0-10)	6.73 ± 1.5	7.28 ± 1.38	6.63 ± 1.47	6.68 ± 1.52	2.58	0.08
AOFAS at day 0 (Range 0-100)	50.71 ± 16.44	47.05 ± 15.36	54.70 ± 16.35	51.03 ± 17.22	1.98	0.14
Symptom Duration (months)	5.06 ± 2.67	5.34 ± 2.54	4.88 ± 2.8	4.88 ± 2.68	0.37	0.69
Acute : Chronic	29:78	9:30	9:24	11:24	0.32	0.73

Table 2: Paired t-test for within-group differences for VAS and AOFAS

	VAS difference Day 0-15		VAS difference Day 15-90		AOFAS difference Day 15-0		AOFAS difference Day 90-15	
	t	p	t	p	t	p	t	p
AG	22.71	< 0.0001	4.793	< 0.0001	12.80	< 0.0001	9.656	< 0.0001
LT	12.57	< 0.0001	5.488	< 0.0001	15.76	< 0.0001	3.158	0.0035
UST	8.799	< 0.0001	3.625	0.0009	8.413	< 0.0001	2.998	0.0051

Table 3: Mixed-effects MANOVA for a) AOFAS and b) VAS

Table 3a) AOFAS

	DF	MS	F (DFn, DFd)	P value
Interaction	4	1024	F (4, 312) = 5.006	P = 0.0006
Time	2	7173	F (2, 312) = 35.06	P < 0.0001
Group	2	1934	F (2, 312) = 9.452	P = 0.0001
Residual	312	204.6		

Table 3b) VAS

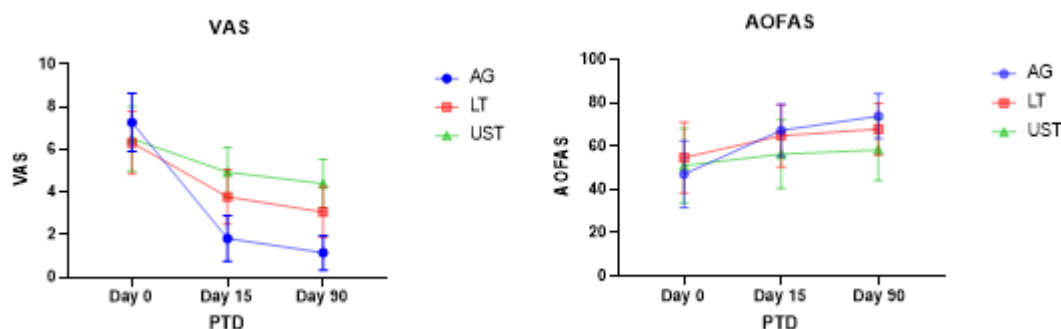
	DF	MS	F (DFn, DFd)	P value
Interaction	4	52.08	F (4, 312) = 5.006	P < 0.0001
Time	2	449.6	F (2, 312) = 35.06	P < 0.0001
Group	2	96.69	F (2, 312) = 9.452	P < 0.0001
Residual	312	1.526		

Table 4: Tukey's multiple comparison test for difference in VAS scores

	Mean Diff.	95% CI of diff.	Below Threshold?	Summary	Adjusted p value			
AG vs LT	2.552	1.766 to 3.339	Yes	***	< 0.001			
AG vs UST	3.842	3.068 to 4.617	Yes	***	< 0.001			
LT vs UST	1.290	0.4829 to 2.097	Yes	***	< 0.001			
	Mean 1	Mean 2	Mean Diff.	SE of diff.	n1	n2	q	DF
AG vs LT	6.128	3.576	2.552	0.3309	39	33	10.91	104
AG vs UST	6.128	2.286	3.842	0.3257	39	35	16.68	104
LT vs UST	3.576	2.286	1.290	0.3395	33	35	5.374	104

Table 5: Tukey's multiple comparison test for difference in AOFAS scores

	Mean Diff.	95% CI of diff.	Below Threshold?	Summary	Adjusted p value			
AG vs LT	13.69	8.808 to 18.58	Yes	****	< 0.0001			
AG vs UST	19.56	14.75 to 24.37	Yes	****	< 0.0001			
LT vs UST	5.866	0.8533 to 10.88	Yes	*	0.0175			
	Mean 1	Mean 2	Mean Diff.	SE of diff.	n1	n2	q	DF
AG vs LT	26.85	13.15	13.69	2.055	39	33	9.424	104
AG vs UST	26.85	7.286	19.56	2.023	39	35	13.67	104
LT vs UST	13.15	7.286	5.866	2.108	33	35	3.935	104

**Figure 1:** Within-group difference in a) VAS and b) AOFAS

DISCUSSION

As we have compared the three interventions for RCB, our results will help to choose the best conservative treatment option for RCB patients. According to our study, all of the three electrotherapeutic modalities (anodal galvanism, laser and ultrasound therapy) are effective in patients with RCB. Our results have shown improvement in both pain and functional ability, with AG depicting best results in the form of pain reduction (74.73% at PTD 15 and 83.92% at PTD 90) and improvement of functional ability in comparison to the other two treatment procedures. AG is known to facilitate the resolution of inflammation and reduction of interstitial oedema through electro osmosis [18]. In their study, Hillman and Delforge (1985) discussed the physiological

efficiency of AG and its vasomotor effect to increase circulation [19]. Inflammation of the bursa produces chemical changes which stimulate the sensory nerve endings, thus causing pain produced by diminution of blood flow. Thus, the AG-induced hyperaemia under the positive anode helps to relieve the pain. The relief could also be attributed to the physiological changes brought about by AG, i.e., it produces acidic reaction, hardens the tissue and reduces the nerve irritability [20]. There is no direct study till date, investigating the role of AG and its effects on RCB. Though Marino et al. (1986) explained the mechanism of AG, wherein using a steady flow of current, AG causes the skin to accumulate ions under the electrode, which produce reflex vasodilation in response to a physiological stimulus to the sensory nerve endings, which washes out pain producing substances to reduce pain [21]. Galvanic current also inhibits the pain by stimulating the A beta fibre and blocking the unpleasant sensation carried by A delta

and C fibres, as described in the pain gate theory.

The pain reduced by 42.77% at PTD 15 and 53.81% at PTD 90 in patients who received laser therapy owing to its effects on reducing oedema [22] and hampering the nutrient exchange in inflamed tissues which indirectly helps to decrease patients' discomfort, and thus explains the improvement in function as depicted by AOFAS scores. There is evidence that it is possible for laser therapy to have a direct impact on nerve conduction and thereby result in a reduction of pain [23]. Our results are in consensus with those of Cotler et al. [24] in patients with musculoskeletal conditions for the improvement in pain. After 90 days of follow-up, the patients showed consistent improvement (53.81%) in pain. This can be explained as the reduction of inflammation in the target pathology. LLLT increases the macrophage and neutrophil activity, favourably enhancing the output of inflammatory mediators. A reduction of neutrophil influx into inflamed tissues or fluid-filled spaces is attributed to LLLT, coupled with an increase in anti-inflammatory metabolites release, such as the cyclooxygenase 1 (COX 1) and COX 2 [25, 26].

There is also a positive effect of UST in patients with RCB, and our study contradicts the interpretation of Downing et al. [27]. The reduction in pain and the resulting improvement in function (AOFAS) in the UST group support the non-thermal effects of the ultrasound: the cavitation in which the microstreaming causes the increase in flow of surrounding fluid. This kind of effect will reduce the swelling [28]. But the application of UST during the inflammatory, proliferative and tissue repair stages is known to stimulate or enhance the normal events and thus increase the efficiency in the healing stages [29]. Maxwell also supported the similar stimulating effect on the mast cells, platelets, white

cells with phagocytic roles, and macrophages [30].

Additionally, this study did not find any correlation between efficacy of AG treatment and the chronicity of the condition, which implies that anodal galvanism is effective during all stages of retrocalcaneal bursitis (acute as well as chronic).

This study had certain limitations. The study focussed on the clinical assessment and outcomes only; the radiographic findings were not considered. Also, there was a lack of literature support both for the experimental treatment per se (anodal galvanism) and for the conservative management of retrocalcaneal bursitis. Only a few published reports and books are available for these, which have been discussed in our paper. So, this study was a step in this direction to add to the existing literature the effects of an obsolete conservative treatment option (anodal galvanism) for a rather common condition of RCB.

CONCLUSION

Anodal galvanism provided the best results in the conservative management of retrocalcaneal bursitis, irrespective of the stage at which the patient was included. Laser and ultrasound therapy also yielded significant results in improving the pain and function scores for RCB, but the between-groups comparisons revealed significantly higher effects for AG. So, the authors recommend the implementation of an obsolete treatment option (anodal galvanism) in the management of retrocalcaneal bursitis before terming it recalcitrant and opting for surgical intervention.

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ULOGA ANODNE GALVANIZACIJE U LIJEČENJU RETROKALKANEARNOG BURZITISA: KOMPARATIVNA STUDIJA

Kontekst: Retrokalkanearni burzitis (RCB) je veoma rasprostranjen te uzrokuje invaliditet kod preko 50% osoba koje su njim pogođene. RCB može nastati ponavljajućim uklještenjem usljed biomehaničkih promjena ili povećanjem obima vježbi uz izostanak odgovarajuće kondicije. Vrlo je malo literature koja se bavi konzervativnim liječenjem RCB-a. Ova studija se fokusira na ispitivanje efikasnosti anodne galvanizacije (AG) u ublažavanju boli i poboljšanju funkcije kod pacijenata koji pate od RCB-a.

Metode: Pacijenti kojima je RCB klinički dijagnosticiran (N = 135) su nasumično podijeljeni u jednu od tri interventne grupe: AG, Ultrazvučna terapija (UST) i Laserska terapija (LT) te su podvrgnuti liječenju u trajanju od dvije sedmice u ovoj retrospektivnoj studiji. Svi su pacijenti dodatno dobili uobičajenu terapiju. Nakon što je 28 pacijenata odustalo, provedena je kontrola i analiza 107 pacijenata (57 muškog i 50 ženskog spola). Razlika u početnim karakteristikama i varijablama (dob, spol, BMI, prosječno trajanje simptoma, VAS i AOFAS) kod 3 nezavisne grupe populacije koja se tretira (AG, LT i UST) je testirana korištenjem jednosmjerne ANOVA-e. Mjerenje rezultata (VAS i AOFAS) je provedeno na dan 0, 15 i 90. Vremenske razlike zavisnih varijabli unutar grupe su analizirane uparenim t-testom. Mješoviti model multivarijantne analize varijacije (MANOVA) je korišten za poređenje zavisnih varijabli koje se nalaze među nezavisnim varijablama, a u različitim trenucima.

Rezultati: Srednji postotak pada VAS rezultata je bio značajno viši ($p < 0,001$) kod AG (74,73% i 83,92% pojedinačno za 15. i 90. dan) u poređenju sa LT (42,77% i 53,81% pojedinačno za 15. i 90. dan) i UST grupama (25,06% i 32,82% pojedinačno za 15. i 90. dan). AG grupa je pokazala značajno viši postotak povećanja AOFAS-a na kraju liječenja 15. dana (50,51%) u poređenju sa LT i UST grupama (22,50% i 13,55%) ($p < 0,001$), a on se u svakoj od njih povećao na 67,72%, 31,81% i 20,59% na 90. dan. Tukey post hoc test je pokazao da je poboljšanje VAS i AOFAS rezultata između tri grupe bilo značajno ($p < 0,05$). Povezanost između trajanja simptoma u AG grupi i razlika u rezultatima za VAS ($r = 0,075$, $p = 0,648$) i AOFAS ($r = 0,187$, $p = 0,255$) nisu bili značajni.

Zaključak: Sve tri metode liječenja su pokazale statistički značajno poboljšanje u smanjenju VAS i AOFAS rezultata. Anodna galvanizacija je bila najefikasnija u ublažavanju boli i poboljšanju funkcije kod pacijenata sa retrokalkanearnim burzitisom u odnosu na lasersku i ultrazvučnu terapiju. Autori preporučuju korištenje AG-a za tretiranje RCB-a u svim stadijima hroničnog oboljenja.

Ključne riječi: retrokalkanearni burzitis, konzervativno liječenje, anodna galvanizacija, laserska terapija, ultrazvučna terapija

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ANALYSIS OF THE EFFECTS OF ANAEROBIC LACTATE TRAINING ON THE ANAEROBIC STATUS OF ELITE TEAM HANDBALL PLAYERS

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ABSTRACT

The aim of this study is to evaluate the effects of a specially designed anaerobic lactate training on the anaerobic status of elite team handball players who have already reached a high competitive level of anaerobic abilities. The hypothesis was that the training will lead to an improvement in anaerobic characteristics for elite team handball players regardless of the high level of abilities they already reached. The research was conducted on a sample of 16 elite team handball players. From the analysis of the results, it can be clearly seen that this training leads to a significant increase in anaerobic characteristics, thus confirming the hypothesis. The mean of an extremely high effect of the training on the increase in all anaerobic characteristics was detected. Enormously large increases in running distances and running speeds in the anaerobic lactate mode cause an enormously high competitive level. Such results were achieved, among other things, owing to a very large increase in the force created and an increase in muscle efficiency, which was also due to an enormous increase in the maximum rate of oxygen consumption ($\text{VO}_{2\text{max}}$). The presented and analysed training showed numerous positive features which is why further research is recommended alongside its application in training practice.

Keywords: anaerobic training, $\text{VO}_{2\text{debt}}$, glycogen, lactic acid, muscle efficiency, team handball

INTRODUCTION

The modern team handball game requires players to have the ability to alternately endure the effort of intensive anaerobic and aerobic work (with the largest share of the glycolytic-lactate process of energy generation), partially interrupted by shorter

and longer breaks, with frequent, sudden and rapid changes in intensity and direction of movement, and with permanent execution of jumps (Bangsbo & Michalsik, 2018; Florin, Rizescu, & Georgescu, 2012; Michalsik, Madsen, & Aagaard, 2015; Michalsik & Aagaard, 2015; Milošević & Milošević 2010; Milošević & Milošević, 2020).

Statistically speaking, for top handball teams, the total average effective playing time in a match is from 48 to 50 minutes (Bernath, 2013; Šibila et al., 2004). During that time, players run an average of 5 to 6.8 km, out of which 1 to 2% is run with the ball. Out of the total game time, 15% is played at maximum intensity during which 900 m is run. (Bernath, 2013; Šibila et al., 2004). Then, out of the total game time, 51.35% is played with submaximal intensity during which 3060 m is run, and 33.65% is played with moderate intensity during which 2040 m is run. (Bernath, 2013; Šibila et al., 2004).

In these conditions, handball players consume 187 litres of oxygen (935 kcal) on average per match, out of which 40 litres is consumed in aerobic work, and 147 litres of oxygen debt is created in anaerobic lactate work (and about 22 L \cdot min⁻¹ of oxygen debt) (Bernath, 2013; Florin et al., 2012; Milošević, 2010; Milošević & Milošević, 2010, 2020). The average production of lactic acid in handball players during a match is 1029 grams, where about 1 kg and 29 grams of glycogen are consumed (about 98 gr \cdot min⁻¹) (Bernath, 2013; Florin et al. 2012; Milošević, 2010; Milošević & Milošević, 2010, 2020). At the same time, their average muscle efficiency is 23% (Bernath, 2013; Böning, Maassen, & Steinach, 2017; Malacko & Rado, 2004; MecLaren & Morton, 2012; Milošević & Milošević, 2010). During the game, the pulse of top handball players constantly varies in the range of 150 to 210 beats per minute (Bernath, 2013; Šibila et al., 2004).

Analyses indicate that top handball players must have an extremely developed lactate status (lactate power, capacity and muscle efficiency) as well as aerobic status (aerobic capacity and strength), which enables them to utilise and speed the production of energy and force (Bernath, 2013; Milošević & Milošević, 2010; Milošević et al., 2014; Milošević, et al., 2014; Šibila et al., 2004). Then, they must be able to function well in conditions of a large amount of oxygen debt, i.e., in conditions of a high concentration of lactic acid in the body (muscles, brain), observe the ball, time, space, their own and the opponent's players well, which enables them to play precise and fast (Bernath, 2013; Milošević & Milošević, 2010; Šibila et al., 2004).

Considering the intensity, character and duration of the described movements in top handball, it is especially necessary to develop the anaerobic and aerobic status, the speed of muscle force generation and the speed of establishing all handball movements (Boraczyński & Urniaż, 2008; Dello Iacono, Eliakim, & Meckel, 2015; Dello Iacono, Karcher, Michalsik, Laver, et al., 2018; Florin et al. 2012; Milošević et al., 2014; Milošević et al., 2014; Nemec, Milošević, Nemec, & Milošević, 2016). The problem of increasing the efficiency of the training process for handball players arises every time they reach new, higher competitive levels. In this paper, we will investigate the effects of a specially designed anaerobic lactate training on the anaerobic status of top handball players (Milošević & Milošević, 2020; Milošević,

Rado, & Milošević, 2021). The design is different from the previously used types of anaerobic lactate training (Bangsbo & Michalsik, 2018; Michalsik et al., 2015; Michalsik & Aagaard, 2015). Given that the sample consists of top handball players, the question arises whether their anaerobic status can be significantly improved by specially designed training, given that they have already reached a high anaerobic level through years of training.

The aim of this study is to evaluate the effects of a specially designed anaerobic lactate training on the anaerobic status of elite team handball players who have already reached a high competitive level of anaerobic abilities. The hypothesis was that the training will lead to an improvement in anaerobic characteristics for elite team handball players regardless of the high level of abilities they already reached. The results of this study may initiate significant alterations of anaerobic training programming practice as well as a significant increase in anaerobic status of elite handball players.

MATERIALS AND METHODS

Participants

Sixteen professional team handball players competing in the first national handball league participated in the study. Their average age was 23.8 ± 3.6 , with the height of 188.2 ± 6.3 cm, weight of 92.4 ± 10.2 kg, and body mass index of 26.4 ± 2.8 . At the beginning of the study the team was in the preparatory period and have already achieved a high level of competition form (Table 1).

The sample size was determined after performing a statistical power analysis. For ANOVA repeated measure, within factors, with an effect size $f = 0.25$, probability of making a type I error $\alpha = 0.05$, power $1 - \beta = 0.90$, 1 group, 3 measurements and high expected correlation among measures $r = 0.8$, the sample size should include at least 12 subjects (Faul, Erdfelder, Lang, & Buchner, 2007).

All the subjects were informed about the study aims and procedures, and they provided written consent for their volunteer participation. The study was conducted in accordance with the European Commission's General Data Protection Regulation - GDPR, and the APA-prescribed Ethical Principles and Code of Conduct.

Experimental design

The experiment was conducted during a season period without matches. Before starting the software programming (VAC Bioengineering hardware

and software system) of anaerobic training and analysing its effects, measurements (times, speeds, distances, age, body weight and height) and software evaluations (equations 1 – 15) of aerobic and anaerobic test values were done for each handball player. Then, for each handball player, according to the measured and estimated values, the current and cumulative effects are simulated for several training variants (Milošević & Milošević 2010; Milošević, Jourkesh, & Milošević, 2020; Milošević & Milošević, 2020) such as the amount of oxygen debt and lactic acid, the amount of consumed and resynthesised glycogen, usefully expended energy, the number of sets, distances run, running speeds and times, breaks, and force (Table 1). All the obtained effects are compared to match requirements (Bangsbo, 2018; Bernath, 2013; Milošević & Milošević, 2010; Milošević et al., 2014; Milošević et al., 2014; Šibila et al., 2004). Based on the analysed effects and the degree of agreement with the requirements of the matches, the most effective training is chosen for each player. Then, daily, seven-day and monthly effects and changes are calculated for the selected training. All calculations are printed or displayed in the form of reports on condition, capacities, development functions, individual position in relation to match requirements, training goals, and individual, seven-day, ten-day, monthly, and annual training work with an assessment of progress for the same time periods (Milošević & Milošević, 2010; Milošević et al., 2020; Milošević & Milošević, 2020). After the implementation of 6 to 8 trainings, the diagnostic analytical procedure is repeated because the applied training no longer provides any improvements. It changes in accordance with the resulting increases in the monitored variables and the pace of growth of the results.

Experimental Procedures

Standard procedures and equipment were used in this research (Margaria, Edwards, & Dill, 1933; Milošević & Milošević, 2010; Milošević & Milošević, 2020; Milošević et al., 2021) for measuring and calculating the values of the variables on the basis of which the training process is programmed. Standardisation and validation of the variables on the basis of which the training process is programmed and managed was done on 1000 top athletes, medal winners at the Olympic Games, World, European and Balkan championships (Milošević & Milošević, 2010; Milošević et al., 2020; Milošević & Milošević, 2020; Milošević et al., 2021). External validation was done with the same athletes based on medals won at the Olympic Games, World, European and Balkan championships (Milošević & Milošević, 2010). This training process is described in detail in several previously published studies (Milošević, 2010; Milošević et al., 2014; Milošević et al., 2014; Milošević et al., 2016; Nemec et al., 2016; Milošević,

Nemec, Nemec, & Milošević, 2017; Milošević, Nemec, Nemec, & Milošević, 2018; Milošević & Milošević, 2020; Milošević et al., 2021; Milošević, Rado, Selimović, & Milošević, 2022).

The mathematical procedures for estimating the variables are:

Maximum oxygen uptake is calculated according to the following equation:

$$\text{VO}_2\text{max} = [(3.134304 \cdot 10^{-7} \cdot K^2 + 0.02077344 \cdot K - 9.03125) \cdot \text{BW}] \cdot 1000^{-1} (1)$$

where VO_2max is the maximum oxygen uptake expressed in litres per minute ($\text{L} \cdot \text{min}^{-1}$), K – the value of the Cooper's 12-minute running test expressed in metres (m), and BW – body weight expressed in kilograms (kg).

The velocity of running at maximal oxygen uptake was calculated according to the following formula:

$$v\text{VO}_2\text{max} = 0.0014 \cdot K + 0.1786 (2)$$

where $v\text{VO}_2\text{max}$ is the velocity of running at VO_2max in metres in a second (ms^{-1}), and K is the value of Cooper's 12 minute running test in metres (m).

Estimating the speed on the distance in which the one-time oxygen debt is being created

Estimating the maximal amount of oxygen debt (the capacity of the oxygen debt) in the work of each individual athlete is carried out according to the following function:

$$\text{VO}_2\text{debt} = [(T/60) / v\text{VO}_2\text{max}]^3 \cdot \text{VO}_2\text{max} (3)$$

where VO_2debt – maximal amount of oxygen debt expressed in litres (L), $T/60$ – speed of running distance in 1 minute expressed in metres per second, $v\text{VO}_2\text{max}$ – the speed at which the maximal amount of oxygen is consumed, expressed in metres per second (ms^{-1}), VO_2max – the maximal consumed oxygen expressed in litres per minute ($\text{L} \cdot \text{min}^{-1}$).

Calculating the maximal amount of oxygen debt (the capacity of the oxygen debt) in the work of each individual athlete is carried out according to the following function:

$$\text{VO}_2\text{debt90} = (\text{Td}/60)/v\text{VO}_2\text{max}]^3 \cdot \text{VO}_2\text{max} (4)$$

where VO_2debt – maximal amount of oxygen debt expressed in litres (L), $\text{Td}/60$ – speed of running distance in 1 minute expressed in metres per second, $v\text{VO}_2\text{max}$ – the speed at which the maximal amount of oxygen is consumed, expressed in metres per second (ms^{-1}), VO_2max – the maximal consumed oxygen expressed in litres per minute ($\text{L} \cdot \text{min}^{-1}$).

$\text{VO}_2\text{debt90.NR}$ - Total oxygen debt after 16 repeated runs of 1 minute in a set expressed in litres (L).

(5)

$$\text{Gly} = (\text{VO}_2\text{debt}_{90} - 2.5) \cdot \text{NR} \cdot 7 \quad (6)$$

where Gly – amount of glycogen expressed in grams (g), $\text{VO}_2\text{debt}_{90}$ oxygen debt created by running 90% of the maximum expressed in litres (L), NR – the number of running repetitions in a set expressed in metres (m). Estimating the maximal amount of lactic acid created in the study of each individual athlete is carried out according to the following function (Jakovlev, 1979; Li et al., 2009; Milošević, 2010; Milošević & Milošević, 2010, 2014; Nédélec, 2012; Volkov et al., 2000):

$$\text{LA} = [(a_1 \cdot e^{k_1 \cdot v} + a_2 \cdot e^{k_2 \cdot v}) - \text{VO}_2\text{max}] \cdot 7 \quad (7)$$

where LA – is the amount of lactic acid expressed in grams (g), VO_2max – is the maximal oxygen spent expressed in litres per minute ($\text{L} \cdot \text{min}^{-1}$), v – is the speed expressed in ms^{-1} , e – is the base of the natural logarithm, while k is the constant which depends on the weight of the athlete and the degree to which he masters his moves.

Estimating amount of energy created in the study of each individual athlete is carried out according to the following function:

$$E = (\text{VO}_2\text{debt}_{90} \cdot 5) \cdot \text{NR} + (\text{VO}_2\text{max} \cdot \text{NR}) \quad (8)$$

where E – energy expressed in kilocalories (kcal), NR – the number of running repetitions in a set, expressed in metres (m)

Consuming one litre of oxygen is the equivalent of releasing the energy of 5 kilocalories.

Estimating the muscle efficiency created in the study of each individual athlete is carried out according to the following function:

$$\eta = [(\text{VO}_2\text{debt}_{90} \cdot \text{NR} \cdot 5) + \text{VO}_2\text{max} \cdot \text{NR}] / [(\text{VO}_2\text{debt}_{90} - 2.5) \cdot \text{NR} \cdot 7 \cdot 3.8] \quad (9)$$

where η is the muscle efficiency expressed as a percentage (%), $\text{VO}_2\text{debt}_{90}$ is the one-time oxygen debt expressed in litres per minute $\text{L} \cdot \text{min}^{-1}$, NR is the number of running repetitions in a set expressed in metres, and VO_2max is the maximum oxygen uptake expressed in litres per minute ($\text{L} \cdot \text{min}^{-1}$),

The force in running is calculated according to the following function (Milošević, 2010; Milošević & Milošević, 2010):

$$F = 2 G d / t^2 \quad (10)$$

where F – is the force expressed in Newtons (N), G – is the body weight multiplied by 9.81, d – is the distance ran in metres (m), and t – is the time in seconds (sec).

$$V_1 = \text{Td} / 60 \quad (11)$$

where V_1 – is the speed on the distance run in one minute, Td – is the distance expressed in metres (m), 60 – is the

time in seconds (s).

Calculating the speed on the distance in which the one-time oxygen debt is being created

$$V_2 = 0.90 \cdot (\text{Td} / 60) \quad (12)$$

where V_2 – is the speed of the one-time distance expressed in metres per second (ms^{-1}), $\text{Td} / 60$ – is the speed of running the distance for 1 minute expressed in metres per second (ms^{-1}).

Td – Distance run in one minute expressed in metres (m) (13)

$\text{Td}_{90\text{1minut}}$ – Working distance run in 1 minute expressed in metres (m) (14)

$\text{Td}_{90\text{NR}}$ – Working distance run in 1 minute expressed in metres (m), Working distance run from 16 repetitions performed in 1 minute, expressed in metres (m) (15)

Exercise Protocol

The exercise training protocol was carried out twice a week, on Wednesday and Saturday, beginning at 11 o'clock (Milošević & Milošević, 2020; Milošević et al., 2021). The training consisted of 4 sets of 4 repetitions in the set (Milošević, 2010). The speed at which the distance was run each minute over the course of repetitions in the sets was determined for each individual with the help of equations (12), and it was 90% of the maximum running speed in 1 minute. The number of sets and the number of repetitions was determined according to the energy power of each individual. The unmitigated time of work per training without breaks was 16 minutes. The breaks in the sets between the first and second repetition lasted 3 minutes, those between the second and third repetition lasted 2.5 minutes, and the ones between the third and fourth lasted 2 minutes. The pauses between the repetitions lasted the amount of time needed so that, from repetition to repetition, the distances, the oxygen debt and the amount of lactic acid increased in a controlled manner (Milošević, 2010). Throughout the pause in the sets, the participant was unable to resynthesise the expended glycogen (Milošević, 2010). By using such programmed breaks, after the fourth repetition in the set, we bring the handball player to an almost capacity value of oxygen debt and an almost capacity value of lactic acid, which is one of the training goals. After completing the work in the set, there is a 10-minute break between the two sets during which there is supercompensation in the formation of glycogen in the time from the fifth to the tenth minute of the break. The break is implemented as an active rest in which low-intensity work on improving individual and collective technique and tactics is

represented. After the end of the 4 sets, light jogging, loosening and stretching exercises are started for 10 minutes, which completes the training. Each workout begins with a 15-minute warm-up.

Statistical Analysis

The effects of anaerobic lactic training on the anaerobic characteristics of elite team handball players was determined by comparing the training changes obtained from the measurements at various time points. For that purpose, a one-way ANOVA repeated measure, within-subjects factors, comparing Pre-test (Initial), Intermediate (Transitive) and Post-test (Terminal) measurements of the variables of anaerobic status, was used with a chosen level of significance of $p \leq 0.001$. Before applying ANOVA normality (Kolmogorov-Smirnov) and sphericity (Mauchly), tests were conducted for all dependent variables. The criterion for the evaluation of the effect size was: $\eta^2 (0.001) = \text{very small}$, $\eta^2 (0.01) = \text{small}$, $\eta^2 (0.06) = \text{medium}$, $\eta^2 (0.14) = \text{large}$, $\eta^2 (.26) = \text{very large}$, and $\eta^2 (.5) = \text{huge}$ (Sawilowsky, 2009). All results of the measurement were analysed with the help of the JAMovi 1.2.27.0 software package.

RESULTS AND DISCUSSION

Lactate training is described by the intensity of lactate power engagement and the capacity of the lactate system in elite handball players who have already reached a high competitive level. Descriptive indicators of lactate power (Table 1) on which the training was programmed are such that for 1 training, handball players are at the average working speed of running (V_2) at the initial level of 5.67 ms^{-1} , transitive 5.97 ms^{-1} , and final 6.11 ms^{-1} ; on average, at the initial level they ran a distance (TdNR) of 5442 m, the transitive 5732 m and final 5857 m. In order to overcome the given distance, at the initial level, handball players have to create an average oxygen debt (VO_2debt) of 196 L, the transitive 198 L and final 205 L. At the initial level, they spend an average of 1107 g, the transitive 1108 g and final 1152 g of glycogen (Gly). For this, they need to spend 1059 kcal at the initial level, 1078 kcal at the transitive level and 1112 kcal at the final level and produce an average of 1107 g at the initial level, 1108 g at the transitive level and 1152 g of lactic acid (LA) at the final level. In order to run the given distances in 16 minutes, the handball players had to generate 27316 N at the initial level, 28774 N at the transitive level, and 28118 N at the final level, while their muscle efficiency (η) at the initial level was 25.4%, at the transitive level, it was 26.6%, and at the final level, it was 26.5% of the total energy used. The training designed and implemented in this way made it possible for the capacity of the lactate

system to look like this. The running speed (V_1) for one minute increased on average from 6.29 ms^{-1} to 6.78 ms^{-1} . The distance run (Td1min) went from 378 m to 407 m. Maximum oxygen consumption ($\text{VO}_{2\text{max}}$) increased from 4.85 L to 5.52 L, and the speed at which the maximum amount of oxygen is consumed ($\text{vVO}_{2\text{max}}$) went from 4.17 ms^{-1} to 4.67 ms^{-1} . The average VO_2debt increased from 17 L to 17.5 L. And finally, the average energy used increased from 1059 kcal to 1112 kcal. The results of partial eta (η^2p) show that the effects of training at the three-month level range from average to very large, which confirmed the hypothesis.

From the analysis, it can be seen that training designed in this way leads to a significant increase in the effects of anaerobic and aerobic strength, capacity, muscle efficiency and strength in handball players who have already reached a high competitive level. Medium increase was achieved in VO_2debt and $\text{VO}_2\text{debt90}$. A large increase was achieved in $\text{VO}_2\text{debt90}$, 16, Gly, LA, and kcal. From this, it can be concluded that a large increase in supercompensation is taking place. A very large increase was noted in η and F. The training caused an enormous increase in running for 1 minute (Test), $\text{VO}_{2\text{max}}$, $\text{vVO}_{2\text{max}}$, V_1 , V_2 , $T_{d1\text{min}}$, and TdNR. Although handball players have already reached a high competitive level, their physiological response to this training is great. In addition to the physiological response of the handball player's body, the effects of increasing the distances and speed of running in the anaerobic lactate regime are enormous. Such results were achieved, among other things, owing to a very large increase in the generated force and an increase in muscle efficiency, which was also due to an enormous increase in $\text{VO}_{2\text{max}}$.

Table 1. Descriptive statistic and ANOVA

Variables	Initial				Transitive				Final				F (2.30)	η^2p
	M	St.D	Min	Max	M	St.D	Min	Max	M	St.D	Min	Max		
Test	378	24.7	320	411	398	21	340	421	407	12.6	370	421	50.9** *	0.7 7
VO ₂ max	4.85	0.48 6	4.03	5.83	5.4	0.46 1	4.55	6.44	5.52	0.43 9	4.71	6.54	290** *	0.9 5
vVO ₂ max	4.17	0.31 2	3.49	4.47	4.56	0.30 3	3.88	4.9	4.67	0.31 4	4	5.1	273** *	0.9 5
V1	6.29	0.40 6	5.3	6.8	6.63	0.34 9	5.67	7.02	6.78	0.20 8	6.17	7.02	56***	0.7 9
V2	5.67	0.36 6	4.8	6.17	5.97	0.31 1	5.1	6.3	6.11	0.18 1	5.6	6.3	54.6** *	0.7 8
Td1min	340	21.9	288	370	358	18.8	306	379	366	11.2	333	379	52.8** *	0.7 8
VO ₂ debt	17	2.52	12.2	21.3	17.2	2.85	13.8	25	17.5	2.78	14.3	23	0.36	0.0 2
VO ₂ debt90	12.4	1.83	8.89	15.5	12.6	2.08	10.1	18.2	12.8	1.99	10.5	16.8	0.51	0.0 3
TdNR	5442	350	4608	5920	5732	302	4896	6064	5857	180	5328	6064	52.9** *	0.7 8
VO ₂ debt90.16	196	28.4	142	248	198	26.9	161	251	205	31.8	167	268	1.21	0.0 7
LA	1107	205	716	1457	1108	190	850	1480	1152	223	892	1598	0.95	0.0 6
Gly	1107	205	716	1457	1108	190	850	1480	1152	223	892	1598	0.95	0.0 6
E	1059	143	794	1313	1078	138	892	1342	1112	161	922	1425	1.9	0.1 1
η	25.4	1.67	21.6	29.2	26.6	1.25	24.5	29.3	26.5	1.62	24	30.7	3.54*	0.1 9
F	2731 6	2551	2387 4	3305 6	2877 4	2492	2482 6	3437 4	2811 8	2774	2457 4	3362 6	6.19**	0.2 9

*p < 0.05, **p < 0.01, ***p < 0.001

The obtained results allow a comparison of the anaerobic status developed under the influence of a specially designed and conducted training for handball players with the requirements of matches (Bernath, 2013; Šibila et al., 2004). In an anaerobic lactate training designed in a special way, handball players run an average of 39% more than for the whole match. The production of anaerobic energy in 1 training session is higher by 16 5% (Bernath, 2013; Florin et al., 2012; Milošević, 2010; Malacko & Rađo, 2004; Milošević & Milošević, 2010, 2020). 28% more oxygen debt is created than for the whole match. On average, muscle efficiency increases by 14.5% (Bernath, 2013; Florin et al., 2012; Milošević, 2010; Malacko & Rađo, 2004; Milošević & Milošević, 2010, 2020; Milošević et al., 2020; 2021). In one training session, 11% more glycogen is consumed, and the same amount of lactic acid is made as during the entire matches (Bernath, 2013; Florin et al., 2012; Milošević, 2010; Malacko & Rađo, 2004; Milošević & Milošević, 2010, 2020; Milošević et al., 2020; 2021). Therefore, it is possible to significantly increase the results of anaerobic lactate status in handball players who have reached a high competitive level with this designed and implemented lactate training.

The logic of the new approach to training is that, from the beginning, handball players who have already reached a high competitive level prepare for the anaerobic lactate efforts that await them in matches (Milošević, 2010; Malacko & Rađo, 2004; Milošević & Milošević, 2010, 2020; Milošević et al., 2020; 2021). This paper deals with the period without matches. Anaerobic lactate training was done twice a week, for three months, on Wednesdays and Saturdays in the morning hours (Malacko & Rađo, 2004; Milošević, 2010). Monthly effects and changes are calculated by multiplying the effects of one training session (Table 1) by 4, and for three months by multiplying the monthly effects by 3.

Training on Wednesdays conditions anaerobic supercompensation and a very strong physiological response of handball players on Saturdays, and training on Saturdays, which falls at the time of supercompensation and a strong physiological response of the body, causes the following even greater anaerobic supercompensation and an even stronger physiological response on Wednesdays, when normally one or two games are played per week (Wednesday, Saturday) (Malacko & Rađo, 2004;

Milošević, 2010). The period between two anaerobic training sessions is sufficient for players to recover and for their recovery to coincide with anaerobic supercompensation. Increased physiological response of the handball player's body (Table 1) and supercompensation occur month after month. Due to the very large effects caused by this training, we recommend it for use in conditions where handball players have already reached a high competitive level.

CONCLUSION

In this study we provided evidence that a significant increase in the results of anaerobic lactate status in handball players, who reached a high competitive level by applying a specially designed anaerobic lactate training, is possible. Analysis of the results indicates significant increases in training effects. A moderate increase was achieved in oxygen debt ($VO_{2\text{debt}}$ and $VO_{2\text{debt}90}$). A large increase was achieved in the sum of oxygen debt, the amount

of glycogen and energy consumed, and lactic acid produced ($VO_{2\text{debt}90.16}$, Gly, kcal, and LA). Although handball players have already reached a high competitive level, the physiological response of their body to this training is great. A very large increase was noted in muscle efficiency and force (η and F). Training caused enormous increases in 1-minute running, maximal oxygen consumption, maximal oxygen consumption speed, and running distances for various times (Test, $VO_{2\text{max}}$, $vVO_{2\text{max}}$, V_1 , V_2 , $Td1\text{min}$, and $TdNR$). The achieved enormously high competitive level is reflected in the enormously large effects of increasing the distances run and running speed in the anaerobic lactate regime. Such results were achieved, among other things, owing to a very large increase in the force created and an increase in muscle efficiency, which was also due to an enormous increase in the maximum oxygen consumption ($VO_{2\text{max}}$). Finally, the obtained results confirmed the assumption that a specially designed anaerobic lactate training leads to a significant increase in training effects (anaerobic and aerobic strength, capacity, muscle efficiency, and force).

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ANALIZA EFEKATA ANAEROBNOG LAKTATNOG TRENINGA NA ANAEROBNI STATUS RUKOMETASA ELITNIH EKIPA

Cilj ove studije je ispitati efekte posebno dizajniranog anaerobnog laktatnog treninga na anaerobni status rukometaša elitnih ekipa koji su već dostigli visok takmičarski nivo anaerobnih sposobnosti. Hipoteza je da će trening dovesti do poboljšanja anaerobnih karakteristika kod rukometaša elitnih ekipa neovisno o visokom nivou sposobnosti koji su već dostigli. Istraživanje je provedeno na uzorku od 16 rukometaša elitnih ekipa. Analizom rezultata se jasno može vidjeti da ovaj trening dovodi do značajnog poboljšanja anaerobnih karakteristika, čime se potvrđuje hipoteza. Utvrđena je aritmetička sredina ekstremno visokog efekata treninga na poboljšanje svih anaerobnih karakteristika. Iznimno visoko povećanje predene udaljenosti i brzine trčanja u anaerobnom laktatnom režimu prouzrokuje iznimno visok takmičarski nivo. Takvi rezultati su, između ostalog, postignuti zahvaljujući velikom povećanju sile koja je nastala i povećanju efikasnosti mišića, a što je također prouzrokovano iznimno visokim povećanjem maksimalne stope potrošnje kisika (VO_{2max}). Predstavljene i analizirane trening je pokazao brojne pozitivne karakteristike zbog čega se preporučuje provođenje dodanih istraživanja uz njegovu primjenu u trenažnoj praksi.

Ključne riječi: anaerobni trening, VO_{2debt} , glikogen, mliječna kiselina, efikasnost mišića, ekipni rukomet

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MOTOR PROFILE OF YOUNG TAEKWONDO ATHLETES

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ABSTRACT

Taekwondo is a combat sport with significant advances being made in the past two decades in organisation, competitive systems, the number of active practitioners as well as rules, and especially tactics. However, there is a significant lack of anthropometric and motor reference values. This research is trying to illuminate this particular part of great value for sports science, not examined yet. The sample for this research comprises $n = 98$ young taekwondo athletes out of which $n = 68$ are competitors and $n = 30$ are regular practitioners, separated within age categories into four groups: C - children ($n = 24$), YC - young cadets ($n = 38$), OC - older cadets ($n = 21$), and J - juniors ($n = 15$). They were initially tested using basic anthropometric tests (body height, body weight and BMI), followed by seven motor tests (foot tapping, standing long jump, 2x15m sprint, side steps, 1-minute abdominal flexion, 1-minute squats/sit-ups, and the flamingo test) previously proven to have a correlation with success in younger taekwondo categories according to Babić, 2022. The results suggest there are linear development tendencies towards speed and strength-related latent motor abilities throughout all the observed categories. These presented reference value tables are highly utilised in practical applications, serving both as a training evaluation tool and as athlete/talent monitoring in taekwondo.

Keywords: motor abilities, youth taekwondo, reference values, combat sports

INTRODUCTION

Speaking of Taekwondo, it is a native Korean fighting art that originated thousands of years ago and has become a popular sport with over 120 million children and adults actively participating worldwide (Birrer, 1996). Along with this increased popularity, coaches and federations are in need of evidence-based talent identification and development programmes (Wazir et al., 2019). Still, there is limited scientific literature about the effects of short- and long-term participation in regular taekwondo classes. Moreover, little evidence is published about the effects of taekwondo on children. As taekwondo is characterised by specific fast, high and spinning kicks with a movement structure which is highly demanding for most muscle groups of the athletes (Čular et al., 2010), motor and functional abilities are capabilities to generate such movement

structures. It is therefore important that coaches and sports scientists collect objective information about their players' physical performance capabilities to substantiate the objectives of training, establish short-term and long-term training programmes, provide objective feedback, and motivate athletes during training (Bridge et al., 2014). The precondition for qualitative evaluation of motor abilities is a hierarchical, systematic scheme of previously collected results on equal samples.

PROBLEM AND AIM

Motor abilities present one of the key elements within the overall anthropological status and are crucial in the development of children. The effect of exercise on the motor development of children

is an increasingly more prevalent topic (Katanić et al., 2022), and numerous studies have determined that physical exercise has a positive effect on motor skills of preschool children (Dobrila et al., 2003; De Privitellio et al., 2007; Alwasif, 2013; Krneta et al., 2015; Bellows et al., 2017; Birnbaum et al., 2017; Jaksic et al., 2020). Motor profiling is, unfortunately, a rarely researched topic within taekwondo, with only several published open-source papers (Marković et al., 2005; Suzana & Pieter, 2009; Bridge et al., 2014). Profiling is method for standardisation of motor ability (reference) values, and such values represent valuable data for further evaluations and comparisons of the next generation of taekwondo fighters. In accordance with the previous statement, the authors defined the aim of this research. The main goal of this research is to define a motor profile and reference values within the sample of underage children, young cadet, cadet and junior taekwondo fighters and practitioners.

METHODS

Sample of participants and variables

The overall sample comprises $n = 98$ young taekwondo athletes out of which $n = 68$ are competitors and $n = 30$ are regular practitioners. Ethical approval for this research was obtained within the Croatian Science Foundation Project No. [IP-2020-02-3366]. The examinees were separated according to their age categories into four groups: C - children ($n = 24$), YC - young cadets ($n = 38$), OC - older cadets ($n = 21$), and J - juniors ($n = 15$).

For the sample of variables, the authors used a battery of tests for the evaluation of motor profiles

among young taekwondo practitioners (Babić, 2022). The mentioned battery is composed of seven simple motor tests which are suitable for practical application in field/sports club. The applied tests are: foot taping (TAP FOOT) for movement frequency speed, standing long jump (LOJUMP) for explosive power, 2x15m sprint (SPRINT30) for maximal whole body speed, side steps (SS) for agility, 1-minute abdominal flexion (ABS1MIN) for repetitive abdominal strength, 1-minute squats/sit-ups (SQ1MIN) for repetitive leg strength, and the flamingo test (FLAMINGO) for balance.

Experimental approach and statistical analysis

The authors initially measured anthropometric parameters. Body weight was measured with a TANITA diagnostic scale (BC 418), while body height was measured using the Martin anthropometer with scalar precision of 0.01 cm. Body mass index (BMI) was calculated via a suitable formula (Himes & Dietz, 1994). Motor variables were measured according to the protocol of the selected test battery (Babić, 2022). All participants were barefoot, dressed in dobok bottoms and t-shirt. The measurements were conducted on tatami (25 mm) puzzle mats, with a temperature of 20 °C and air humidity of 60% at the Taekwondo club Dubrava, in Zagreb, Croatia. All participants are healthy and of Caucasian origins. Due to Croatian laws, all participants remained anonymous, and their identities were protected with code names.

Descriptive anthropometric parameters for the overall sample, subsamples and age categories were calculated in the first step. The second step contains an analysis of the results obtained through the motor tests according to age and sex categories, while in the third step, the authors investigated the results of motor tests within the subsample of competitors. All analyses were conducted using Statistica 14, TIBCO Software Inc.

RESULTS AND DISCUSSION

Table 1. Descriptive statistics of the examined competitors' anthropometric characteristics ($n = 98$)

	Competitors	Regular practitioners	C	YC	OC	J
	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD
BY	2010 ± 2.79	2011 ± 2.22	2014 ± 0.34	2012 ± 0.81	2009 ± 0.8	2006 ± 0.69
BH	148.98 ± 17.63	141.28 ± 12.88	130.13 ± 6.15	140.23 ± 8.29	158.14 ± 11.79	170.85 ± 7.06
BW	40.72 ± 12.50	38.60 ± 14.05	29.83 ± 8.19	35.38 ± 9.07	47.93 ± 10.45	58.15 ± 8.01
BMI	17.92 ± 2.49	18.77 ± 3.90	17.38 ± 3.17	17.81 ± 3.18	19.06 ± 2.89	19.95 ± 2.80

Note: BY - birth year, BH - body height, BW - body weight, BMI - body mass index, M - mean, SD - standard deviation, C - children, YC - younger cadets, OC - older cadets, J - juniors

The results presented in Table 1 suggest that there is a natural distribution within the overall sample, with all the observed values growing proportionally with the age category. BMI values are below 20 in every category (column from Table 1), which represents a typical lean taekwondo phenotype, already observed in younger

categories (Čular et al., 2017). However, mean body height values are not as great as expected, but among individual heights, there are higher values, with the tallest male (junior) having the height of 188 cm, and the tallest female (junior) having the height of 177 cm.

Table 2 . The overall results of motor testing separated by age and sex category (n = 98)

	TAP FOOT M ± SD	LOJUMP M ± SD	SPRINT 30 M ± SD	SS M ± SD	ABS 1MIN M ± SD	SQ 1MIN M ± SD	FLAMINGO M ± SD
C male (n = 10)	43 ± 6	137.8 ± 18.06	8.60 ± 0.71	11.87 ± 1.07	31 ± 5	52 ± 9	4.91 ± 2.56
C female (n = 14)	46 ± 9	140.29 ± 18.73	8.28 ± 0.70	11.14 ± 1.11	34 ± 8	52 ± 12	8.69 ± 6.5
YC male (n = 11)	54 ± 11	151.92 ± 25.14	7.73 ± 0.72	10.65 ± 0.77	35 ± 8	51 ± 6	8.55 ± 4.67
YC female (n = 27)	56 ± 10	149.63 ± 19.39	8.02 ± 0.58	10.58 ± 0.74	35 ± 8	53 ± 8	11.95 ± 10.43
OC male (n = 11)	64 ± 12	196.25 ± 30.63	7.34 ± 0.65	9.12 ± 1.25	40 ± 9	59 ± 11	11.61 ± 7.04
OC female (n = 10)	65 ± 16	162.3 ± 22.30	7.55 ± 0.54	9.92 ± 1.59	36 ± 5	52 ± 9	11.95 ± 8.66
J male (n = 5)	75 ± 10	221.13 ± 12.77	6.46 ± 0.27	8.14 ± 0.66	44 ± 10	61 ± 7	4.99 ± 1.86
J female (n = 10)	79 ± 12	194.67 ± 19.41	6.86 ± 0.51	8.18 ± 0.90	55 ± 12	60 ± 9	15.65 ± 11.88

Note: TAP FOOT - foot tapping, LOJUMP - standing long jump, SPRINT30 - 2x15 m sprint, SS - side steps, ABS 1MIN - 1-minute abdominal flexion, SQ 1MIN - 1-minute squats, FLAMINGO - flamingo test for balance.

The first impression from Table 2 is that the obtained results are similar in the same age categories, regardless of sex. As we know, in comparison with females, males usually have around 30-40% more strength (Miller et al., 1993) and different mechanical properties within muscles (Miller et al., 1993; Jeon et al., 2019). The results in Table 2 actually present the fact that females enter puberty a few years earlier, and so their results are still matching those of males until senior age. Speaking of motor tests, in the children category, female examinees tend to be more successful than males. A similar comparison is visible within young

cadets too, with males being slightly more dominant only in LOJUMP and SPRINT30 where absolute power plays a significant role. Within the older cadets' category, there is an evident impact of puberty on agility, strength, explosive power, and speed (except movement frequency speed - TAP FOOT) among male examinees in regard to females. Junior female examinees seem to be in the peak of puberty, with relatively great values even for adult females, while males are becoming stronger and faster year after year until their peak of puberty in younger seniors.

Table 3. Results of motor testing on the subsample of competitors separated by age and sex (n = 68)

	TAP FOOT M ± SD	LOJUMP M ± SD	SPRINT 30 M ± SD	SS M ± SD	ABS 1MIN M ± SD	SQ 1MIN M ± SD	FLAMINGO M ± SD
C male (n = 7)	43 ± 3	139.57 ± 12.92	8.64 ± 0.73	11.55 ± 1.01	30 ± 4	53 ± 7	5.10 ± 3.10
C female (n = 12)	46 ± 8	140.75 ± 18.14	8.39 ± 0.68	11.06 ± 1.01	33 ± 8	52 ± 13	9.20 ± 6.92
YC male (n = 9)	53 ± 12	154.89 ± 27.66	7.63 ± 0.80	10.64 ± 0.87	37 ± 8	52 ± 5	9.47 ± 10.20

YC							
female		158.31 ±	7.89 ±	10.30 ±			
(n = 13)	57 ± 12	19.72	0.59	0.76	34 ± 8	56 ± 9	13.50 ± 9.20
OC male		198.80 ±	7.23 ±		41 ±	61 ±	12.89 ±
(n = 10)	64 ± 13	32.60	0.64	9.03 ± 1.36	10	10	14.01
OC							
female		171.17 ±	7.31 ±				14.93 ±
(n = 6)	69 ± 17	20.24	0.30	9.23 ± 1.11	38 ± 5	55 ± 9	10.25
J male		221.50 ±	6.42 ±				
(n = 3)	76 ± 11	15.61	0.32	8.19 ± 0.79	48 ± 6	63 ± 8	5.76 ± 1.27
J female		195.38 ±	6.80 ±		56 ±		16.96 ±
(n = 8)	80 ± 13	20.63	0.51	8.12 ± 0.95	12	62 ± 8	12.00

The observed results in Table 3 revealed a lack of significant difference between the overall sample and the subsample of competitors. It could be explained by a significant proportion of competitors within the whole sample. However, it can be concluded that motor abilities of young taekwondo practitioners tend to develop continuously and almost linearly, as their results become greater every (training) year. Their bodies are continuously adapting to the demands of contemporary competitive taekwondo, where speed, explosiveness and accuracy lead to success. The presented data can be a useful instrument for development tracking of young athletes in taekwondo.

CONCLUSION

This paper represents the first reference value table for motor abilities of young taekwondo practitioners. In other words, it is a motor profile of young taekwondo examinees, composed of scores achieved through testing the abilities previously proven to be associated with competitive success in taekwondo (Babić, 2022). Within this particular research, it is easy to notice a lean body phenotype represented within all categories. Second, there are linear development tendencies towards speed and

strength-related latent motor abilities. And third, there is slight difference in motor abilities between competitors and practitioners, probably due to the greater number of competitors and their similar training programmes focused on competitive taekwondo. The conclusion of the presented paper could be summarised within a cognition that motor abilities of younger age categories in taekwondo depend on pubertal status up to a certain extent. The impact of pubertal status could be measured through the relative age effect (RAE), but individual and precise values can be determined only individually through talent identification processes. The observed results should be further compared with other athletes of the same age categories from different martial sports. Motor profiles should also be collected within every sport so that they can be utilised in training programme evaluations and monitoring of young talents' fitness progress.

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MOTORIČKI PROFIL MLADIH TAEKWONDO SPORTISTA

Taekwondo je borilački sport sa značajnim naprecima u posljednje dvije decenije po pitanju organizacije, takmičarskih sistema, broja aktivnih učesnika, pravila, a posebno taktike. Međutim, postoji značajan nedostatak antropometrijskih i motoričkih referentnih vrijednosti. Ovo istraživanje nastoji rasvijetliti upravo ovaj dio koji je iznimno značajan za sportsku nauku, a još uvijek nije ispitan. Uzorak ovog istraživanja obuhvata $n = 98$ mladih taekwondo sportista od kojih su $n = 68$ takmičari, a $n = 30$ rekreativci, podijeljenih u četiri dobne kategorije: D - djeca ($n = 24$), MK - mlađi kadeti ($n = 38$), SK - stariji kadeti ($n = 21$) i J - juniori ($n = 15$). Prvo su testirani pomoću antropometrijskih testova (tjelesna visina, tjelesna težina i BMI), a nakon toga su izvodili sedam motoričkih testova (taping nogom, skok u dalj iz mjesta, sprint 2x15m, koraci u stranu, pregibi trupa u 1 minuti, čučnjevi/trbušnjaci u 1 minuti i flamingo test) za koje je, prema Babiću (2022.), prethodno dokazano da su povezani sa uspjehom kod mladih taekwondo kategorija. Rezultati ukazuju na postojanje linearnog trenda razvoja brzine i latentnih motoričkih sposobnosti povezanih sa snagom u svim posmatranim kategorijama. Predstavljene tabele referentnih vrijednost su iznimno korisne u praktičnoj primjeni te mogu poslužiti kao alat za procjenu treninga i monitoring sportiste/talenta u taekwondou.

Ključne riječi: motoričke sposobnosti, omladinski taekwondo, referentne vrijednosti, borilački sportovi

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DIFFERENCES IN MOTOR ABILITIES AMONG STUDENTS FROM THREE PRIMARY SCHOOLS AFTER ONE YEAR OF PHYSICAL EDUCATION CLASSES

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ABSTRACT

The growth and development of children has an important place in the study of their entire anthropological status, both from the point of view of biological anthropology and from the point of view of medical sciences, physiology, psychology, and especially from the aspect of kinesiology. Although students are considered to be the most physically active population, there is a reasonable suspicion that in the context of the modern way of life, the level of students' physical activity is not sufficient. The research was conducted on a sample of 386 male students. The students are enrolled in the 7th, 8th and 9th grade, aged 12 to 14 years \pm 6 months, and regularly attend physical education classes. The measuring instruments for this research consist of a set of 14 variables for the assessment of motor abilities, i.e., for the assessment of the four mechanisms responsible for human movements. The main goal is to determine the differences that occur in the motor abilities of students from three schools after one year of attending physical education classes. At the multivariate level, a statistically significant difference was determined between the groups at the level of Sig. = .000, while at the univariate level, statistically significant differences were found in seven variables of the motor space.

Based on the results of the research, it is recommended to review the Physical Education curricula and introduce new methods for motivating students to actively engage in the Physical Education class.

Keywords: motor abilities, students, schools, education

INTRODUCTION

The population of students in the upper grades of primary schools is one of the links in the chain of complex educational and systematic social influences in physical and health education (Mikic et al., 2001). One of the priority tasks in working with children undoubtedly refers to caring for their optimal growth and development. A particularly sensitive period for the development of children is the school age period. The growth and development of children has an important place in the study of their entire anthropological status, both from the point of view of biological anthropology and from the point of view of medical sciences, physiology, psychology, and especially from the aspect of kinesiology. Anthropology is a science that studies the physical nature of the human, his characteristics, i.e., the structure of the human. In other words, it studies the origin and development of a human in space and time (Mikic, 2000). Although students are considered to be the most physically active population, there is a reasonable suspicion that in the context of the modern way of life, the level of students' physical activity is not sufficient. Lack of active movement in students can adversely affect the development and growth of children which, with improper eating habits, prolonged sitting and the help of other factors, creates a good basis for health disorders. From this, it can be concluded that the value of physical education is not only seen in meeting the basic needs of the student in physical activity, but it also plays an important role in the transformation of various characteristics in the anthropological status of students.

Numerous factors are important for the optimal development of the child, especially proper nutrition and physical activity. Childhood is a critical period for the development of lifelong habits and healthy behaviours (CDC, 2019). Physical fitness has become a key prognosis for adolescent health (Ruiz et al., 2016) and significantly associated with health measures such as cardiovascular health (Andersen et al., 2015), cognitive ability, and psychological well-being (Pontifex et al., 2014). Relevant studies show that physical inactivity is not only an independent risk factor for chronic diseases, such as hypertension (Borjesson et al., 2016), heart disease (Schnohr et al., 2017) and type 2 diabetes mellitus (Awad et al., 2017), but there are serious negative impacts on physical fitness, leading to mass social issues (Ding et al., 2016). Globally, 80% of adolescents do not engage in physical activity; "low physical activity - high sedentary period" has become a widely used descriptor of current physical inactivity in adolescents. The latest WHO guidelines recommend that children and adolescents engage in an average of 60 minutes of moderate to high intensity exercise

(mainly aerobic exercise) daily and limit their sitting time, especially screen time (WHO, 2020).

PROBLEM AND PURPOSE

Information on the growth and development of children can be obtained based on the measurement and testing of relevant anthropological features. The problem of this research is the identification of the measurement of motor abilities in children from three schools after one year of regular attendance of physical education and health education.

Motor abilities have been the subject of research conducted by many researchers, so it makes perfect sense to have different definitions of the term. In essence, what is called motor ability may have the most appropriate definition provided by Zaciorski (1969), who considers motor abilities as those aspects of motor activity that occur in moving structures, and which can be described by the same parametric system, measured by an identical set of standards and performance of analogue physiological, biochemical, cognitive, and conative mechanisms. By designing this type of research, the main goal is to determine the differences that occur in the motor abilities of students from three schools after one year of regular attendance of physical education classes.

METHODS

The research includes a sample of 386 male students from the following three primary schools in Pristina: Nazim Gafuri Primary School with 142 students, Elena Zika Primary School with 158 students and Zelena Shkola Primary School with 88 students. The students are enrolled in the 7th, 8th and 9th grade, aged 12 to 14 years \pm 6 months, and regularly attend physical education classes. The measuring instruments for this research consist of a set of 14 variables for the assessment of motor abilities, i.e., for the assessment of the four mechanisms responsible for human movements, and they are:

I. Synergy regulation and tone regulation mechanism

1. Hand tapping (MTAR) 2. Foot tapping (MTAN) 3. Deep forward bend on a bench (MDPK) 4. Stick rotation (MISP) 5. Bend, twist and touch (MBFPZD)

II. Mechanism for regulating the intensity of excitation

6. Long jump (MSDM) 7. High jump (MSVM) 8. Medicine ball throw (MFML) 9. 20m running (MFE20V)

III. Mechanism for regulating the duration of excitation

10. 30cm torso lift (MDTR) 11. Knee push-ups (MSKL) 12. Lying torso lift (MRCZTL)

IV. Mechanism for structuring the movements

13. Side steps (MCVS) 14. Running in a rectangle (MTVP)

Motor abilities were assessed according to the methodology of Metikoš, Prot, Hofman, Pintar, and Oreb (1989) as well as Kurelić, Momirović, Stojanović, Šturm, Radojević, Štalec-Viskić (1975). Quantitative differences between the groups were determined using a t-test for large dependent samples. The method of multivariate analysis of variance (MANOVA) determined the significance of the differences between the groups of respondents, while the individual differences in each variable were determined by a univariate analysis of variance (ANOVA), according to the given characteristics. The level of significance of the differences between the

groups in each variable was determined by applying the LSD test post hoc analysis.

RESULTS

Analysing the obtained results (Table 1), which present the values from the multivariate analysis of variance in the variables for the assessment of motor abilities in the three groups of students obtained after attending one year of physical education classes, it can be seen that there is a statistically significant difference in the arithmetic means between the groups of respondents.

Table 1. Multivariate Analysis of Variance (MANOVA)

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Wilks' lambda	.679	5.455 ^a	28.000	714.00 0	.000	.176

The difference is determined on the basis of Wilks' lambda values and reads .679, which in relation to the Rao's approximation $F = 5.45$, the degrees of freedom $df = 28$ which are related to the errors of the model Error df 714, is significant at the level of $Sig. = .000$.

Based on these data, it can be said that, after one year of regular attendance of physical education classes, the three groups of students statistically significantly differ in motor abilities.

The obtained results from the univariate space of motor abilities between the groups of respondents in the sample are presented in Table No. 2. From the same table, it can be noticed that there is a statistically significant difference in most of the applied variables, i.e., from a total of fourteen applied variables, a significant difference was obtained in nine of them at the level of $Sig = .000$ to $Sig = .027$. The difference is evident in the variables:

In the Mechanism for Synergy Regulation and Tone Regulation, statistically significant differences appear in three variables that contribute to the differences in the groups: Foot tapping (MTAN), Deep forward bend on a bench (MDPK) and Bend, twist and touch (MBFPZD). The mechanism for regulating the intensity of excitation participates with two variables in the creation of intergroup differences: Long jump (MSDM) and 20m running (MFE20V). In the Mechanism for Regulation of the Excitation Duration, statistically significant differences appear in three variables that contribute to the differences in the groups, namely: Trunk lifting in 30 s (MDTR), Knee push-ups (MSKL) and 020 Lying torso lift (MRCZTL). The mechanism for structuring movements participates with one variable in creating intergroup differences: Side steps (MCVS). The variables in which no significant difference was obtained have the values that do not significantly contribute to the creation of differences between the groups of respondents from the three schools.

Table 2. Univariate Analysis of Variance (ANOVA)

Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
MTAR	.903	2	.452	.057	.945	.000
MTAN	22.934	2	11.467	3.777	.024	.020
MDPK	211.586	2	105.793	3.635	.027	.019
MISP	10.826	2	5.413	.064	.938	.000
MBFPZD	42.357	2	21.179	4.587	.011	.024
MSDM	.298	2	.149	8.166	.000	.042
MSVM	114.085	2	57.043	2.573	.078	.014
MFML	.417	2	.209	.429	.652	.002
MFE20V	2.623	2	1.311	19.158	.000	.094
MDTR	110.237	2	55.118	4.801	.009	.025
MSKL	68.781	2	34.390	3.959	.020	.021
MRCZTL	110.239	2	55.120	20.351	.000	.099
MCVS	6.185	2	3.092	3.764	.024	.020
MTVP	1.870	2	.935	.455	.635	.002

DISCUSSION

The ontogenetic development of a human chronologically goes through certain periods. There are several divisions of childhood according to anatomical and physiological characteristics, as well as the division that takes into account the education system. According to this division, children are usually divided into three age categories of adolescents: younger, middle-aged and older. This research was conducted with students from 7th to 9th grade from three primary schools, aged 12-14 years. At this age, children are characterised by the completion of ossification of the bones at the root of the hand and the beginning of the ossification of the sesamoid bones (13-14 years). The ossification

of the skeleton of the hand in girls takes place faster than in boys, and the difference is about 2 years. As children move from lower to higher levels, intellectual demands increase, so children spend more time sitting. Numerous studies show that children spend 85% of their waking time in a static position, mostly sitting. As a result, there is a deterioration of health, vision loss, general atrophy, poor posture, and many other aesthetic defects that result from it.

From the point of view of sports and physical education, the most important thing is to determine the so-called biological age, which often differs from the morphological age, and even more than chronological age. Knowledge of the growth and formation of the organism, and functional capabilities characteristic of the development of each age phase, allow determining such an optimal complex of exercises and the size of the

impact (load) that will enable successful sports training. During this period, there are significant changes in physical appearance, full maturation and acquisition of pollen, physical and personal identity, social and moral norms in behaviour, independence and responsibility.

The biological growth and development of children, their motor, intellectual and emotional development, their behaviour, socialisation, physical and other activities, need to be measured, assessed, monitored, controlled, and through the process of teaching physical education, they need to be corrected (Kostovski & Georgiev, 2009). This is especially important when children are at a lower school age, when their body is very susceptible to various influences and whose effects are manifested in the later period. Growth and development are dynamic processes that cannot be seen in isolation. There is a certain legality of child growth that is important to know when dealing with children. In this regard, it can be said that the growth intensity of individual organs is not always the same; the growth trend is not linear and the organs during growth not only increase their mass but also change their structure (Medved et al., 1989).

Determining the current state of the students' motor status and comparing it with other students from other schools provide a clear picture of the situation, which directly controls the implementation of physical education and also implements or realises the set goals. In order to implement these activities, it is necessary to determine the factual situation of students in schools, i.e., students who regularly attend physical education classes and those who do not attend it regularly, in order to identify the impact of teaching on anthropological characteristics (Findak et al., 1992). In this way, by determining the condition at the beginning of the school year and at the end of it, information is obtained for accurate determination of the condition of the students during the analysed period (Mraković, 1992).

Muscle strength largely depends on muscle mass. In males, strength increases especially at the end of puberty. The age of 13-14 is a sensitive zone for the development of strength. Students of this age should use exercises with or without external load, which they can perform relatively easily, with mandatory maintenance of proper body position. Speed implies the ability to perform movement at the highest possible speed for the given conditions, where it is assumed that the external resistance is not large and that the activity does not last long in order not to cause fatigue (Zaciorski, 1969). It largely depends on the genetic factor. The widest opportunities for speed improvement are in childhood and adolescence, when it is necessary to pay close attention to the development of this ability.

The stages of development in which significant changes in physical development and physical abilities occur are called critical periods of development of the organism. The critical periods in the "phases of the greatest

realisation of the organism's potential in ontogeny" or "the period in which the specific action of the organism causes a certain increased reaction", where the phase in which optimal results of such action can be achieved are "sensitive periods" (Karsaevskaja, 1970). When it comes to the "sensitive phase", it is a time interval, and is characterised by greater convenience for the action of external stimuli than in other developmental intervals. "Critical period" is the interval in which stimulation must occur if we want to achieve the desired developmental changes.

During pre-adolescent childhood, selective attention is crucial because it involves prolonged attention and control of one's actions (Zhu, et al., 2019; Carson et al., 2017), which are appropriate for school success. In their research, some authors point out that lower fitness can affect general impairments in cognitive control and overall brain health. In particular, increased aerobic fitness is associated with improved performance of working conditions that require regulation of inhibitory control (i.e., mismatched movements), suggesting that fitness may have specific benefits for this aspect of cognition.

Regarding the frequency of physical activity, studies derived from previous studies have shown that girls generally have lower levels of physical activity than boys (Ortega, Ruiz, Castillo, & Sjostrom, 2008), and 27.9% of girls were sedentary, compared with 10.6% of boys (Lacy et al., 2012). This study showed that 36.36% of boys and 44.46% of girls had little physical activity. Girls' sitting in front of a screen can be longer than boys, so strategies to increase physical activity in adolescents need to focus more on girls. Previous studies have shown that physical activity is key to improving cardiopulmonary endurance, muscle strength, and endurance in adolescents (Poitras et al., 2016; Landry et al., 2012). Upper limb muscle strength and endurance in boys and abdominal muscle endurance in girls are significantly related to physical activity (Chen, Hammond-Bennett, Hypnar, & Mason, 2018), which is consistent with the results shown in this study that boys and girls with high levels of physical activity had better upper extremities, muscle strength and endurance, and better strength and endurance of abdominal muscles. It is worth noting that the relationship between the components of physical fitness and physical activity is recognised as gender specific (Belcher, Berrigan, Dodd, Emken, Chou, & Spruijt-Metz, 2010) and that girls are more likely to engage in low- to moderate-intensity exercise, while boys are prone to high-intensity exercise (Lacy et al., 2012).

CONCLUSION

By designing this type of research, the intention was to determine the differences that occur in motor abilities after one year of physical education in male students aged 12 to 14 years (from 7th to 9th grade) from three various primary schools. The transition from one adult period to another is usually marked as a step forward in individual development. Quantitative and qualitative age changes occur at the age of 12 to 14 years. At each transitional stage, genetic conditional maturation of those structures is carried out, which should provide new features of the physiological functions and reactions that should exist in the appropriate adult period. From the point of view of sports and physical culture, the most important thing is to determine the so-called biological age, which often differs from the morphological age, and even more than the chronological age. Knowledge of the growth and formation of the organism, and functional capabilities characteristic of the development of each age phase, allow determining such an optimal complex of exercises and the size of the impact (load) that will enable successful sports training. During this period there are significant changes in physical appearance, full maturity, physical and personal identity, social and moral norms in behaviour,

independence, and responsibility. This period of the child's development corresponds to the period of early adolescence (from 12/13 to 15 years). Previous research on the characteristics of the chronological age in which the respondents are indicates that this age period is characterised by improved motor abilities at the expense of body growth, explosive strength and increased muscle strength.

The strength of this study is that it is the first in the Republic of Kosovo that uses a large number of students of this age to analyse the implementation of physical education. The results of this study revealed the current difficult situation of physical fitness of adolescents in Pristina, which will result in proposals to the Ministry of Education and schools in order to find strategies to improve the physical fitness of Kosovo adolescents such as: 1. Review of the Physical Education curricula, 2. Introduction of methods for motivating students to actively engage in the Physical Education class. 3. Based on research and experiences from surrounding countries, it is necessary to introduce a third class in physical education so as to improve the development of children. The limitation of this study that may affect the generalisation of the results is reflected in the fact that the research was conducted only in Pristina, which on the other hand opens space for conducting this type of research in all schools in the territory of the Republic of Kosovo.

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RAZLIKE U MOTORIČKIM SPOSOBNOSTIMA KOD UČENIKA IZ TRI OSNOVNE ŠKOLE NAKON JEDNOGODIŠNJE NASTAVE FIZIČKOG OBRAZOVANJA

Rast i razvoj djece ima značajno mjesto u proučavanju njihovog cjelokupnog antropološkog statusa, kako sa stanovišta biološke antropologije, tako i sa stanovišta medicinskih nauka, fiziologije, psihologije, a posebno sa aspekta kineziologije. Iako se učenici smatraju fizički najaktivnijom populacijom, postoji osnovana sumnja da u kontekstu savremenog načina života nivo fizičke aktivnosti učenika nije dovoljan. Istraživanje je provedeno na uzorku od 386 učenika. Učenici pohađaju 7., 8. i 9. razred, uzrasta su od 12 do 14 godina \pm 6 mjeseci, te redovno pohađaju nastavu fizičkog obrazovanja. Mjerni instrumenti za ovo istraživanje čine skup od 14 varijabli za procjenu motoričkih sposobnosti, odnosno za procjenu četiri mehanizma odgovorna za kretanje čovjeka. Osnovni cilj je utvrditi razlike koje se javljaju u motoričkim sposobnostima učenika iz tri škole nakon godinu dana pohađanja nastave fizičkog obrazovanja. Na multivarijantnom nivou utvrđena je statistički značajna razlika između grupa na nivou Sig. = ,000, dok su na univarijantnom nivou statistički značajne razlike utvrđene kod sedam varijabli motoričkog prostora.

Na osnovu rezultata istraživanja preporučuje se revidiranje nastavnih planova i programa fizičkog obrazovanja i uvođenje novih metoda za motivisanje učenika za aktivno angažovanje na času fizičkog obrazovanja.

Ključne riječi: motoričke sposobnosti, učenici, škole, obrazovanje

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IS THERE A DIFFERENCE IN BALL DISTRIBUTION BETWEEN TOP-LEVEL FOOTBALL GOALKEEPERS?

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ABSTRACT

Given the extremely important role of goalkeepers and their ball distribution competence in modern football, the subject of this paper is a detailed analysis of technical and tactical characteristics in relation to the ball distribution of the three goalkeepers who play at the highest world level. In order to determinate the differences in ball distribution, the data were collected on the basis of 30 matches in which the analysed goalkeepers performed. For the purposes of this paper, ball distribution is divided according to the structure into short, medium and long passes. The results of this research showed that there is a general statistically significant difference between the observed goalkeepers in all observed indicators of ball distribution ($X^2 = 58.735$, $p = 0.000$). Additionally, the existence of statistically significant differences for the examined subspaces in relation to the observed subsample of the goalkeepers was determined. There are two factors that determine the style of ball distribution; the first is the technical-tactical competence of the goalkeeper, and the second is the tactics of the team. These two factors are interrelated and greatly influence each other. The lack of technical or tactical preparation in goalkeeper ball distribution can completely change the play tactics for the entire team.

Keywords: ball distribution, football, goalkeeper, tactics, technique

INTRODUCTION

In the football game, the goalkeeper (GK) represents one of the most important positions. His main role is to prevent opponents from scoring. However, in modern football, GKs are no longer used only at the goal; moreover, the number of their actions on goal is much smaller in relation to the number of their actions in distributing the ball by kicking. The GK must be technically and tactically trained and be the eleventh player in the game. He must always be a safe solution for the return ball when the opponent puts pressure, have the ability to break the pressure of the opposing team with an excellent pass, employ his teammates with long passes whenever possible, and launch a

quick attack. The problem of distributing the ball by kicking at a GK position is demanding because every mistake, incorrect pass or bad decision will end badly for his team. At all times, the GK must be able to cope with pressure and the large amount of risk that comes with the position of a modern GK. If any GK characteristic can be taken as the most important, then it is certainly the ball distribution performed by kicking. In modern football, the GK represents the first attacking player and the last defensive player. In every attack, when starting from the GK, he must recognise and use certain patterns of play that his team uses. A GK can be an extremely good "weapon" for his team, representing good build-up play from the back, and breaking the opponent's pressure will leave his attackers a lot of space to successfully finish the attack. In a surprisingly small number of previous studies that have dealt with the technical

and tactical characteristics of football GKs (Janković & Leontijević, 2009; Hrnčiarik & Peraček, 2011; Seaton & Campos, 2011; Janković, Leontijević, Cvijanović, & Mićanović, 2016; Peraček, Varga, Gregora, & Mikulić, 2017), it can be said that the expert analysis from the aspect of the competences that GKs have in relation to ball distribution performed by kicking is practically neglected (Seaton & Campos, 2011). In addition, previous research has mainly studied the ball distribution in relation to GKs of different competitive levels and age categories (Hrnčiarik & Peraček, 2011; Seaton & Campos, 2011).

Due to all of the above, the primary goal of this research is to use the empirical non-experimental method to determine whether there are differences in ball distribution performed by kicking in three GKs who play at the highest world level and are regular participants in the most prestigious club football competition UEFA Champions League.

MATERIALS AND METHODS

Participants

The sample of participants consisted of three GKs who play at the highest world level as regular participants in the UEFA Champions League. GKs 1 and 2 are members of clubs that play in the Spanish La Liga, while GK 3 is a member of a club that plays in the English Premier League.

Procedures

The empirical non-experimental method was used as the basic research method. In order to classify the research method in relation to the goals and type, the observation technique was used. Data for this work were collected on the basis of 30 matches in which the three selected GKs participated, often against each other. When watching the match, each action of the GK was entered in a specially prepared observation sheet. In this way, faster access to the detailed data needed to create this research was provided. For the purposes of achieving the defined goal of the research, the following variables of ball distribution performed by kicking were used in the paper: short passes - maximum 10m long (SP10m), medium passes - from 10 to 40m long (MP10-40m) and long passes - over 40m long (LP40+m).

Statistical Analysis

The data obtained in the conducted research were processed by applying descriptive and comparative statistical analysis. Within the descriptive statistics for all variables, arithmetic mean (Mean), standard

deviation (SD), coefficient of variation (cV%), and cut-off values of the total range (Min and Max) were calculated. Within comparative statistics, a chi-square (X^2) test was used. Statistical significance for all analyses was defined by $p < 0.001$. All statistical analyses were performed using the SPSS 20.0 program (SPSS Inc, Chicago, IL, USA) and Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA, USA).

RESULTS

The results of descriptive statistics for the observed indicators of ball distribution are shown in Table 1.

Table 1: Descriptive statistics of the observed ball distribution indicators

		Mean	SD	cV%	Min	Max
GK 1	SP10m	16.2	5.3	32.8	12	29
	MP10-40m	6.8	4.8	70.3	2	18
	LP40+m	4.5	2.6	57.6	1	8
GK 2	SP10m	3	2.0	66.7	0	7
	MP10-40m	1	0.8	81.6	0	2
	LP40+m	16.7	6.9	41.1	9	31
GK 3	SP10m	13.7	5.5	40.3	7	25
	MP10-40m	4	2.7	66.7	1	8
	LP40+m	3.3	3.3	101.1	0	11

Applying non-parametric statistical analysis, it was determined that there is a general statistically significant difference between all the observed indicators of ball distribution performed by kicking at the level of $X^2 = 58.735$, $p = 0.000$. Additionally, the existence of statistically significant differences for all the examined subspaces in relation to the observed GK subsample was determined as follows: at SP10m, $X^2 = 19.963$, $p = 0.000$; at MP10-40m, $X^2 = 16.198$, $p = 0.000$; and at LP40+m, $X^2 = 19.753$, $p = 0.000$. The results of the partial difference between the observed indicators of ball distribution in the observed GKs are shown in Table 2.

Table 2: Partial differences of the observed indicators

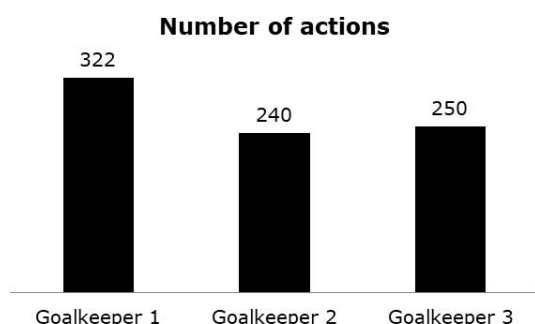
	I - II subsample		differences (number of attempts)	Sig.
SP10m	GK 3	GK 2	10.7	0.000
	GK 1	GK 2	13.2	0.000
MP10-40m	GK 1	GK 2	5.8	0.001
LP40+m	GK 2	GK 3	13.4	0.000
		GK 1	12.2	0.000

DISCUSSION

In this paper, significant differences in the observed indicators of ball distribution performed by kicking were found in a sample of three top GKs (Table 1 and 2). Previous research has found differences in ball distribution indicators in relation to the competitive level (Seaton & Campos, 2011; Liu, Gomez, & Lago-Pegas, 2015) and in relation to the age categories of GKs (Hrnčiarik & Peraček, 2011). GKs who play at a higher competitive level have been found to have more successful passes to the attacking third of the field leading to a goal opportunity, while those in lower leagues have more ball passes where there are fewer players and where the environment is safer to pass (Seaton & Campos, 2011). Seaton and Campos (2011) also found that all GKs demonstrated a tendency to play to more central zones when distributing the ball during matches, and this was surmised as a way to avoid the ball going straight out of play from the GKs throw or kick. In addition, differences were found in the success of offensive actions where senior GKs were more successful than juniors (Hrnčiarik & Peraček, 2011). Besides, based on the obtained results, we can assume that differences between the GKs performances exist due to individual GK characteristics, which also confirmed the results of some other research (Ihsan, 2006; Seaton & Campos, 2011). As the available papers did not study the differences in the ball distribution performed by kicking in relation to GKs of the same competitive level, it is difficult to discuss the results obtained at the level of comparison; so, the differences determined by this research can be most easily explained on the basis of the analysed relations between ball distribution performed by kicking in ten games played for each GK and the analysis of technical-tactical characteristics of the three selected GKs.

Figure 1 shows the total number of actions in ball distribution performed by kicking in the 10 games played. It can be noticed that GK 1 has far more actions than the other two GKs. This data shows that the ball distribution in GK 1 is very frequent and that this is its very pronounced characteristic (Figure 1).

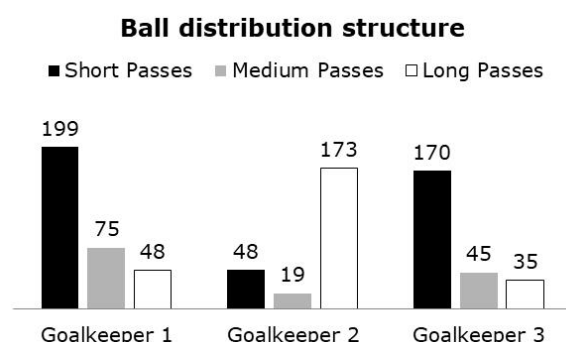
Figure 1: The number of ball distribution actions performed by kicking in 10 games



However, for conclusions about the ball distribution of each GK, the structure of those actions is much more important than the total number of actions. Ball distribution structure represents a number of short, medium and long passes for each GK.

Figure 2 shows the number of actions in which GKs used short, medium and long passes. The results have shown a big difference between GK 2 and the other two GKs.

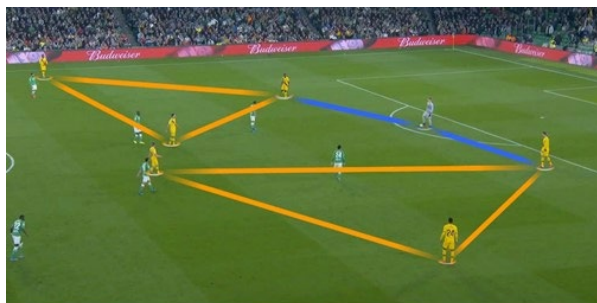
Figure 2: Ball distribution structure



It is obvious that GK 2 uses long passes in a large number of actions. The reasons for the identified differences will be explained in more detail below, but at the general level, there are two possible reasons. The first is the poor technical training of GK 2 in ball distribution performed by kicking. The second reason is that the club he plays for plays defensive football with a lot of physical duels, and they insist on direct football. They use fast actions without much possession of the ball. This tactic and philosophy of the game requires the GKs to use long passes and play without much risk. Indirectly, this is further supported by the findings of Seaton and Campos (2011) which determined that top-level GK performances are largely due to individual characteristics and/or are tactically predetermined.

The determined differences between GK 1 and the other two analysed GKs are the easiest to explain, starting from the explanation of the basic patterns of the play used by the GK 1's club. The basic idea is to make a large number of triangular formations between players on the field. The pattern used by the GK 1's club consists of a line with two centre-backs and a GK between them, as well as a formation of two triangles (Figure 3).

Figure 3: An example of a pattern in which GK 1 uses short passes



GK 1 waits for the reaction of the opposing attackers and, based on their movements, throws the ball into one of the two triangles. GK 1's characteristic is excellent play under the pressure of the opponent's attackers. As a result, it was much easier for his team to solve and break through the opponent's pressure. When they succeed, they left a lot of space for their attackers who are very dangerous in such situations. He has another great characteristic that brings good results. As soon as he catches the ball, he quickly passes it to his teammates who launch a quick counterattack, and in this way, he does not give the opponent's attackers time to create a good pressing formation. His team is extremely dangerous in situations like this, when they have a lot of space for a counterattack. In case the opponent successfully closes this pattern of play, GK 1 uses his excellent individual quality of medium passes. In order for the opposing team to close this pattern, the opponent must move its midfield high, and then GK 1 distributes the ball over the midfield with extremely precise medium passes and the ball goes into the "hole" between the defence and the midfield line. His attackers are positioned there and waiting for the ball. After winning the ball, they start a quick attack and have a lot of space again (Figure 4).

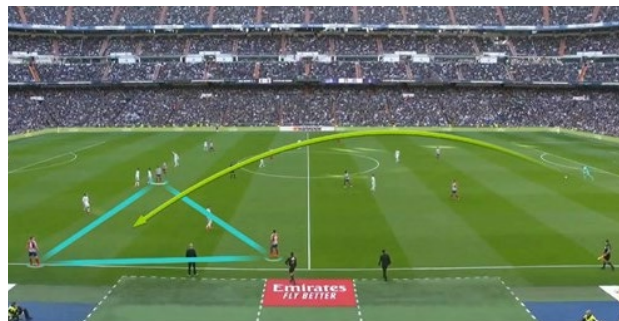
Figure 4: An example of a pattern in which GK 1 uses medium passes



Long passes are used by GK 1 as another "weapon" to surprise opponents and starts a quick and direct attack for his team. His long passes are extremely precise and often create a lot of problems for the opponent's defences. In some cases, he directly

assists his teammates to score a goal. It should be emphasised that he often assists with his left, non-dominant foot, which confirms his ability to play with both feet. When it comes to GK 1, it can be concluded that his excellent ball distribution is the main characteristic. His team created their tactics based on his technical-tactical and mental abilities to implement patterns of play, solve the opponent's pressing and allow his attackers a lot of space to attack. Based on GK 2's technical-tactical analysis of the ball distribution performed by kicking, we can conclude that he mainly uses long passes. Short and medium passes are very rare, and in many cases, they are ordinary passes to a free player when he starts the game from a goal kick or after a foul. For this reason, short and medium actions have not been analysed in detail for GK 2. In the previous part of the paper (Figure 2), it is shown that GK 2 uses long passes in a large number of actions. During the analysis of the matches, it was noticed that his team uses only one pattern of play. His attackers make a triangle on the left side of the field in which GK 2 tries to distribute the ball with a long pass (Figure 5). They are an extremely physically prepared team and play with a lot of physical aerial duels. They play without much risk and try to reach the opponent's goal with direct football with as few passes as possible.

Figure 5: An example of a pattern in which GK 1 uses long passes



However, the analysis of GK 2 noticed a big problem with the arc of the ball, and his lack of technical qualities in the ball distribution badly affects his team attack. This analysis shows that his attackers are in a subordinate position in relation to the opposing teams defenders when the ball has a high arc. On the other hand, when he manages to hit the ball so that it flies closer to the ground, the advantage in the jump of his attackers comes to the fore and his team has much more success. The analysis established that, during long passes, GK 2 very often hits the ball at its lowest point, and it travels very long and with a very high arc. In order to shorten the travel time of the ball through the air, the ball must be hit at a higher point, and in that way, it will not travel that long and the arc will be lower. However, in order to achieve this, the position of the feet, knees and hips plays a very important role in precision. The toes, heel, knee, and hip must be as flat

as possible (Figure 6). If this is not the case, the shot will move either vertically or horizontally, and the ball will be inaccurate.

Figure 6: An example of a side volley



In Figure 6, we can see how the hip, knee, heel, and toes are practically flat. In that way, the GK puts himself in an unstable position and can often fall after the shot, but the ball will reach the attacker very quickly. This kicking technique is one of the characteristics of a modern GK and can be very effective. It can be said that this kind of kick on the ball is similar to a hit with the baseball bat.

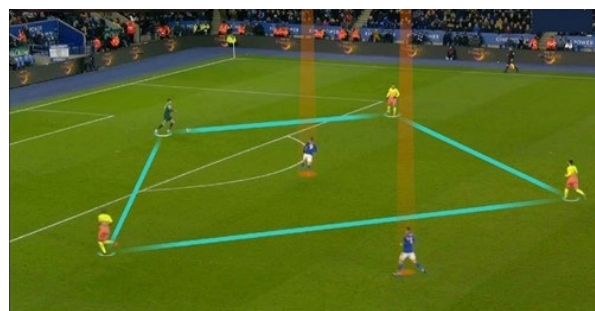
During the analysis of GK 2's ball distribution, a big problem with return balls was noticed. It is difficult to determine the exact reason for such a thing, but his weak abilities in playing with his feet probably affect his self-confidence in such situations. The result is that, although in many situations his teammates make the basic patterns of triangles and squares, he does not want to play a short pass to them, but sends the ball far away from his teammates for no reason and his team often loses possession of the ball. It is interesting to mention the data of a research which found that GKs playing at the higher levels tended to be consistent with their distribution pattern regardless of the game outcome (Liu et al., 2015).

When it comes to GK 2, it can be concluded that his poor technical preparation in the ball distribution performed with his foot very badly affects the tactics of his team. They are forced to play with long passes because GK 2 does not have the ability to break the opponent's pressing through short passes, as is the case with the other two analysed GKs.

In the team for which the GK 3 plays, the philosophy of football is based on keeping the ball in possession and playing short passes. They move the opponent's team with short passes from one side to another until they make a "hole" in the opponent's defence, and at that moment, they try to use the free space and speed of their players with quick passes to create chances for a goal.

The role of GK 3 is of great importance for his team. They use a basic square pattern of play (Figure 7). They use this pattern very well, and it is very difficult for opponents to take the ball from them. After successfully breaking the pressure of the opponent with the help of this pattern, a large space opens up for his attackers who are among the fastest in the world and very dangerous in situations like that.

Figure 7: An example of a pattern of play in which GK 3 uses short passes



In situations when the opponent block this pattern of play, GK 3 uses his individual quality and excellent medium passes, which are one of his main characteristic, and he passes the ball to his left- or right-back. His medium passes are extremely precise. These tactical variants can be used only thanks to the great technical and tactical preparations of the GK 3.

In order for the opposing team to close this pattern of middle passes to the left or right side, they have to come out high with a large number of players. This leaves a "hole" between the midfield and the defence line, so similarly to GK 1, GK 3 passes the ball between lines and allows a quick attack for his team (Figure 4).

If the opponent wants to close that "hole" as well, they have to move their defensive line high, which leaves a lot of space between the opponent's GK and the defence. GK 3 uses this space whenever the opportunity arises. His long passes are among the best in modern football. He has the ability to pass a precise long ball up to 80 meters. In addition, the passes are very fast and have a low arc, which makes it easier for his attackers to receive the ball. Often, his long passes are at a distance from his to the opponent's penalty area and create a lot of problems for the opponent's defences.

When it comes to GK 3, it can be concluded that his excellent technical and tactical preparation in the ball distribution is of great importance for his team. He breaks pressing with short, medium and long passes, which allows a lot of space for his attackers and often makes a difference in favour of his team.

CONCLUSION

In this paper, significant differences in the observed indicators of ball distribution performed by kicking were determined on a sample of three top GKs. Applying non-parametric statistical analysis, it was determined that there is a general statistically significant difference between all observed indicators of ball distribution at the level of $X^2 = 58.735$, $p = 0.000$. Additionally, the existence of statistically significant differences for the following examined subspaces in relation to the observed GK subsample was determined as follows: at SP10m, $X^2 = 19.963$, $p = 0.000$; at MP10-40m, $X^2 = 16.198$, $p = 0.000$; and at LP40+m, $X^2 = 19.753$, $p = 0.000$.

By presenting the analysis of the competitive activity and technical and tactical characteristics of the observed top GKs, it can be concluded that their role is of great importance for the tactics of the team. The lack of technical or tactical preparation in GK ball distribution performed by kicking can completely change the play tactics for the entire team. On the other hand, good technical and tactical preparation in the ball distribution can open many tactical possibilities for the team and enable the implementation of well-played patterns of play. The analysis of competitive activity for GKs is very rare, and that is why this type of paper initiates new ideas in the approach to analysing the GKs position, making it very important. In future research, it would be very useful to analyse a larger number of GKs from different clubs who play at the highest world level.

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POSTOJE LI RAZLIKE U DISTRIBUCIJI LOPTE KOD VRHUNSKIH FUDBALSKIH GOLMANA?

S obzirom na izuzetno značajnu ulogu golmana i njihove kompetencije prilikom distribucije lopte u modernom fudbalu, predmet ovog rada je detaljna analiza tehničko-taktičkih karakteristika u odnosu na distribuciju lopte kod tri golmana koja nastupaju na najvećem svjetskom nivou. U cilju utvrđivanja razlika u distribuciji lopte, podaci su prikupljeni na osnovu 30 utakmica u kojima su nastupali analizirani golmani. Za potrebe ovog rada distribucija lopte je podijeljena prema strukturi na kratka, srednja i duga dodavanja. Rezultati ovog istraživanja su pokazali da između posmatranih golmana postoji generalna statistički značajna razlika svih posmatranih pokazatelja distribucije lopte na nivou $X^2 = 58,735$, $p = 0,000$. Također, utvrđeno je postojanje statistički značajnih razlika ispitivanih potprostora u odnosu na posmatrani poduzorak golmana. Dva su faktora koja određuju način distribucije lopte; prvi je tehničko-taktička obučenost golmana, a drugi je taktika ekipe. Ova dva faktora su uzajamno povezana i veoma utiču jedan na drugi. Nedostatak tehničke ili taktičke pripremljenosti u distribuciji lopte kod golmana može potpuno da promijeni taktiku igre cjelokupne ekipe.

Ključne riječi: distribucija lopte, fudbal, golman, taktika, tehnika

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DYNAMIC BALANCE IS NOT RELATED TO THE VERTICAL JUMP PERFORMANCE OF FEMALE INDOOR VOLLEYBALL ATHLETES

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ABSTRACT

This study aimed to evaluate the association of dynamic balance with the performance of female volleyball athletes in the countermovement vertical jump. For this, anthropometric measurements (body mass, height and right lower limb measurements), a dynamic balance test, and countermovement vertical jump test were performed on 27 female indoor volleyball amateur athletes. One-way analysis of variance (ANOVA) was used to verify differences between groups, with Tukey's test being used for post hoc analysis. Pearson's correlation was used to verify the association between the variables of interest in the study. After the evaluations, the athletes were divided into three groups based on the median terciles of their results in the dynamic balance test: G1 (n = 9) athletes with the lowest balance score; G2 (n = 9) athletes with average balance score; G3 (n = 9) athletes with the highest balance score. In the dynamic balance composite score, the three groups differed from each other ($p < 0.05$). However, no differences were observed in the vertical jumping performance of volleyball athletes due to different balance classifications ($p > 0.05$). Therefore, the dynamic balance was not associated with vertical jump performance. In addition, the low level of the dynamic balance did not interfere with the height of the vertical jump among the volleyball athletes.

Keywords: vertical jump, dynamic balance, volleyball, athletes

INTRODUCTION

The practice of volleyball occurs simultaneously with individual and collective actions, being organised in attack and defence systems (Vuorinen, 2017). In this way, the physical demand of athletes includes a vast set of motor skills and physical capabilities to perform the fundamentals and technical gestures required by the sport (Gabbett, 2008; Bara Filho et al., 2013).

Thus, the vertical jump becomes a crucial skill for

volleyball players (Lidor & Ziv, 2010), especially in the terminal actions of the rally, which generate points for the team (Drikos & Vagenas, 2011). The performance of the vertical jump is influenced by the power of the lower limbs (Sheppard et al., 2008), specific physical training (Ugrinowitsch et al., 2007), flexibility (Hunter & Marshall, 2002), kinetic parameters (Dal Pupo, Detanico, & Santos, 2012), anthropometric parameters (Fattahi et al., 2012), and the type of warm-up performed (Solon Junior & Silva Neto, 2021). In addition, other factors may be the determinants for vertical jump performance, such as balance, which is related to basic locomotor skills, as well as performance in different sports (Hrysomallis,

2011).

The use of dynamic balance as a parameter to determine the risk of injury in the lower limbs of athletes is not new (Plisky et al., 2006). The skill has also been used to analyse sports performance and specific motor gestures in basketball, soccer and gymnastics athletes (Bressel et al., 2007). However, the association of dynamic balance with performance in vertical jumps among volleyball athletes is still little explored in the literature.

PROBLEM AND AIM

Considering the dynamic characteristic of the volleyball game and the importance of muscle power for athletes, little is known about the relationship between dynamic balance and vertical jump performance, which may elucidate an issue not yet explored in the literature.

Therefore, this study aimed to evaluate the association of dynamic balance with the countermovement vertical jump in female volleyball athletes. Our initial hypothesis is that there will be a positive association between dynamic balance scores and vertical jump performance in volleyball athletes.

METHODS

Sample

Twenty-seven females participated in this study (21.6 ± 4.5 years, 19.5 ± 11.8 months of experience, 7.4 ± 1.3 hours of weekly training, 63.1 ± 11 kg, 1.68 ± 0.07 m, 22.3 ± 3.2 kg/m²) of indoor volleyball amateur athletes competing at the regional level. The study included athletes over 18 years of age who have had regular training for at least three months and a weekly training load of 6 h or more. Athletes who presented injuries or limitations in the required movements and the use of ergogenic substances were considered as exclusion criteria. This is a cross-sectional study using non-probability sampling. The study was approved by the local ethics committee (number 3416611) according to the standards required by the Declaration of Helsinki.

Initial procedures

The athletes were evaluated in their respective training places and by the same evaluator. The assessment followed updated recommendations (Bogataj et al., 2020) and consisted of measuring body mass, height and measurements of the right lower limb in three different positions: a) distance from the anterior superior iliac spine to the ipsilateral medial malleolus; b) distance from the anterior superior iliac spine to the tip of the foot in plantar flexion; c) distance from the anterior superior iliac spine to the ground, with the knees flexed

at approximately 90°. After the evaluations, the athletes were divided into three groups according to their performance in the dynamic balance test. Group 1 (G1, $n = 9$) was composed of athletes with the lowest balance score, followed by group 2 (G2, $n = 9$) with an average score and, finally, group 3 (G3, $n = 9$) with the highest balance score. The division was performed by terciles, based on the median of the results. The characteristics of the participants are shown in Table 1.

Dynamic balance test

Dynamic balance was assessed by the modified Star Excursion Balance Test (mSEBT) (Picot et al., 2021), with measurement of reach in three directions: anterior, posteromedial (135° from the anterior line) and posterolateral (135° from the anterior line). Each direction was indicated on the ground with a wide adhesive tape, marked with a tape measure at 1 cm intervals. To perform the test, the athlete was barefoot and used the opposite side of the dominant arm as a support foot in the attacking actions in volleyball games according to the biomechanical standard of this modality (Marques Junior, 2019). The positioning of the support foot followed the recommendations of Cug (2017) to eliminate the possibility of the results being influenced by the size of each athlete's foot. Thus, in the anterior reach movement, the hallux was placed at the zero point (junction of the three directions), while in the posteromedial and posterolateral movements, the heel was positioned at the zero point. Hands were kept on the waist throughout the test. The reaching limb (opposite to the support foot) gently touched (without generating support on the ground) the adhesive tape with the most distal part of the big toe, at the farthest possible point from the support foot, in each of the three directions. The range of distances was recorded in raw value (cm) and later normalised to the length of the lower limb of each individual (%) (Gribble & Hertel, 2012). The athletes performed three attempts in each direction, with 30 s intervals between them, as a way of adapting to the test movements. Subsequently, they performed three valid attempts, with an interval of 30 s between them, and the best result for each direction was recorded.

Vertical jump assessment

Vertical jump performance was evaluated using the My Jump 2® application, with the athletes performing the countermovement vertical jump without the aid of the arms (Balsalobre-Fernández, Glaister & Lockey, 2015). The performance of each athlete was recorded by the height of the jump (cm). To perform the test, each athlete wore the shoes used in training/games. Starting from the initial standing

position, with the trunk straight, the knees fully extended and the feet shoulder-width apart, the athlete performed a quick downward movement, forming an angle of approximately 90° in the knees, and then a quick upwards movement, jumping as high as possible. Hands were kept on the waist throughout the jump. There was a recommendation for take-off from the ground to occur with extended knees and ankles and for landing to be similar. Each athlete performed three attempts at submaximal intensity, with 30 s intervals between them, to adapt to the test movements. Then they performed a valid attempt, which was recorded by the smartphone camera attached to a tripod 50 cm from the ground and positioned frontally and 1.5 metres away from the evaluated athlete. The adopted procedures follow previously described studies (Hernández-Preciado et al., 2018; Brooks, Benson, & Bruce, 2018; Yingling et al., 2018; Seyhan, 2019).

Statistical analysis

Results are expressed as mean and standard deviation. One-way analysis of variance (ANOVA) was

used in the present study to verify differences between groups. In addition, the Tukey test was used as a post hoc test. Pearson's correlation was used to verify the association between the variables of interest in the study. The significance level was set at 5%. All analyses were performed using the GraphPad Prism 8 software for Mac.

RESULTS

Initially, the present study found no correlation between jump height and composite dynamic balance ($r = 0.13$, $p = 0.51$). Furthermore, no differences were observed between the general characteristics of the athletes when divided into groups related to dynamic balance performance (Table 1). In addition, as expected, the groups showed significant differences among themselves for the dynamic balance test.

Table 1. General characteristics of the sample

	Age (years old)	Experience (months)	Training (hours/weekly)	Body Mass (kg)	Height (m)	BMI (kg/m ²)
G1 (n = 9)	20.9 ± 4.0	18.7 ± 11.8	7.9 ± 1.4	66.6 ± 13.8	1.69 ± 0.07	23.3 ± 4.4
G2 (n = 9)	22.2 ± 5.9	22.7 ± 9.4	7.8 ± 0.8	60.9 ± 8.7	1.66 ± 0.04	22.1 ± 2.5
G3 (n = 9)	21.8 ± 3.7	17.2 ± 14.3	6.4 ± 1.3	61.8 ± 10.5	1.70 ± 0.08	21.3 ± 2.3

Regarding balance, in the range of the previous movement, G1 ($69.6 \pm 4.9\%$) showed a significant difference, compared to G2 ($73.8 \pm 2.7\%$) and G3 ($77.5 \pm 2.3\%$). However, groups G2 and G3 showed no difference between them (Figure 1A, $p < 0.05$). In the range of posterolateral movement, the three groups differed: G1 ($69.7 \pm 6.8\%$), G2 ($77.7 \pm 2.6\%$) and G3

($85 \pm 3.7\%$) (Figure 1B, $p < 0.05$). In the range of the posteromedial movement, the groups presented the same behaviour observed in the range of the anterior movement. G1 ($74.8 \pm 3.3\%$) showed a significant difference, compared to G2 ($85.9 \pm 4.1\%$) and G3 ($89.3 \pm 4.7\%$), while groups G2 and G3 showed no difference between them (Figure 1C, $p < 0.05$).

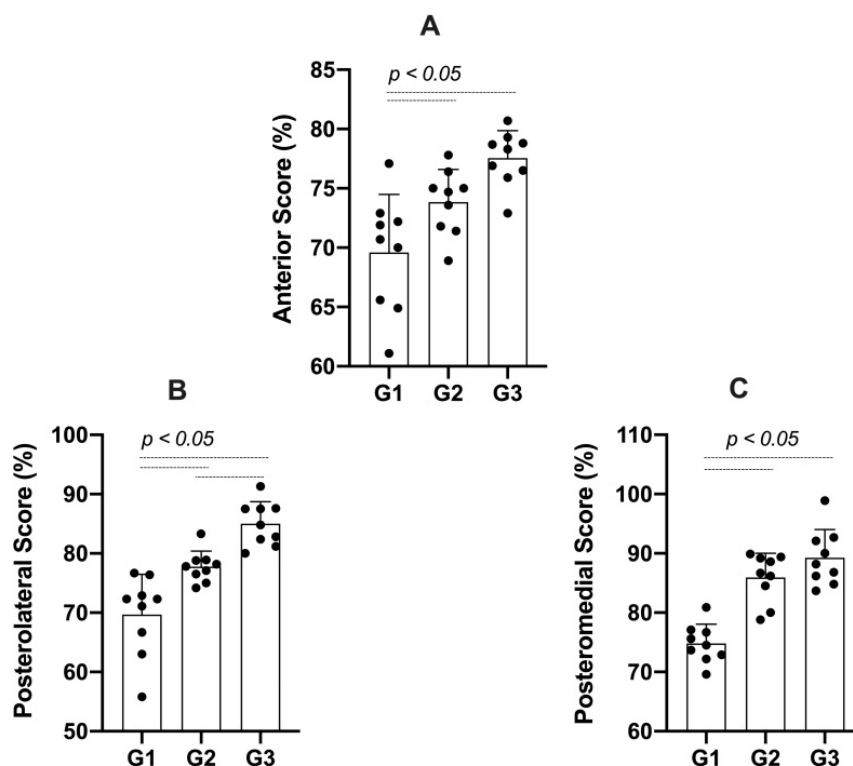


Figure 1. Dynamic balance of female indoor volleyball amateur athletes according to the range of motion in three directions

In the composite score (%) of dynamic balance, the three groups differed from each other: G1 ($71.4 \pm 4.3\%$), G2 ($79.2 \pm 0.9\%$) and G3 ($83.9 \pm 2.5\%$) (Figure 2A, $p < 0.05$). Finally, no differences were observed in vertical jump

performance among volleyball athletes of different balance classifications: G1 (22 ± 4.8 cm), G2 (26.3 ± 4.0 cm) and G3 (23.4 ± 3.5 cm) ($p > 0.05$) (Figure 2B).

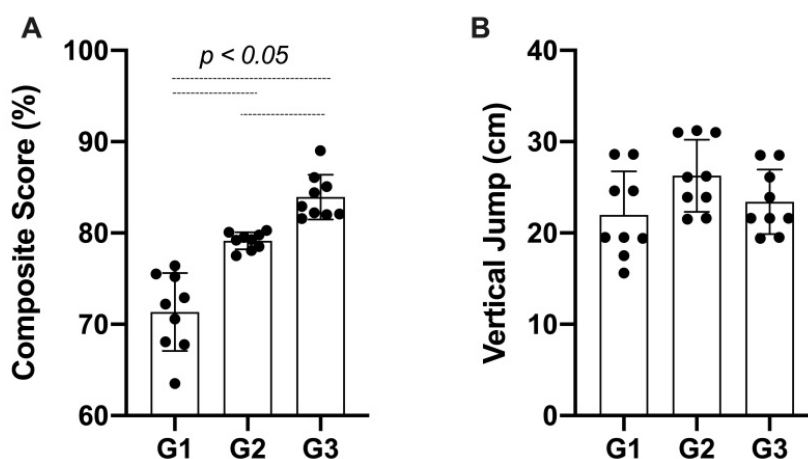


Figure 2. Composite score of dynamic balance and vertical jump height of female indoor volleyball amateur athletes

DISCUSSION

The findings of the present study reject the initial hypothesis. That is, dynamic balance showed no association with performance in the vertical jump. Furthermore, even different balance levels (low, medium and high) did not impact vertical jump height. To the best of our knowledge, this is the first study that investigated vertical jump performance in indoor volleyball amateur athletes according to the level of dynamic balance.

The possible relationship between balance and vertical jump in athletes was initially supported by the fact that systematic physical training causes positive effects on both physical capacities. Evidence regarding the increase in performance of these variables proved to be significant in young volleyball players (Sahin & Ozdal, 2020). However, Sahin and Ozdal (2020) did not perform measurements of association between balance and vertical jump, further supporting the initial hypothesis of the present study.

On the other hand, even recognising that balance and vertical jump are important components for the performance of athletes in several sports, the responses that muscle training provokes in these variables are different. In this sense, Vitale et al. (2018) found that eight weeks of neuromuscular training before skier training increased performance in dynamic balance but did not find positive changes for countermovement jump or drop jump. Thus, the existence of additional and still little explored factors, in addition to neuromuscular training, becomes evident in the understanding of the combination

between dynamic balance and vertical jump.

It is possible that the lack of correlation between dynamic balance and vertical jump, observed in the present study, is related to physiological elements of the neuromuscular structures involved in the execution of the practical actions of these two variables. The vertical jump depends directly on the explosive strength of the lower limb muscles and the activation of fast-twitch muscle fibres, while actions that define dynamic balance are related to the activation of slow-twitch muscle fibres to sustain the movement for a relatively longer period than the duration of the jump (Ozmen, 2016). Even so, the evidence presented in the literature is still not conclusive and, sometimes, divergent regarding the relationship between performance tests and body stability (Nesser & Lee, 2009; Sharrock et al., 2011). Thus, at the moment, it is possible to affirm that dynamic balance is important for sports practice and, even so, volleyball athletes, with different dynamic balance classifications presenting similar performance in the vertical jump.

CONCLUSION

Dynamic balance was not associated with vertical jump performance. In addition, the low level of the dynamic balance does not interfere with the height of the vertical jump. Additionally, as volleyball is a sport with wide participation around the world, future studies must further investigate the relationship between dynamic balance and other variables involved in this sport. In this sense, we suggest to verify the differences between the types of volleyball and the performance variables that can influence the game.

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DINAMIČKA RAVNOTEŽA NIJE POVEZANA SA IZVEDBOM SKOKA U VIS KOD ODBOJKAŠICA KOJE IGRAJU U ZATVORENOM PROSTORU

Ova studija je nastojala ispitati povezanost dinamičke ravnoteže i izvedbe skoka iz čučnja sa pripremom kod odbojkašica. Za to su izvršena antropometrijska mjerenja (tjelesna masa, visina, mjerenja desnog donjeg ekstremiteta), test dinamičke ravnoteže i test skoka iz čučnja sa pripremom kod 27 odbojkašica koje igraju u zatvorenom prostoru. Jednostruka analiza varijanse (ANOVA) je korištena za provjeru razlika između grupa uz Tukey test koji je korišten u vidu post hoc analize. Pearsonova korelacija je korištena za provjeru povezanosti između varijabli koje se ispituju u studiji. Sportašice su nakon evaluacija podijeljene u tri grupe na osnovu trećina medijana njihovih rezultata testa dinamičke ravnoteže: G1 (n = 9) sportašice sa najnižom ocjenom ravnoteže; G2 (n = 9) sportašice sa prosječnom ocjenom ravnoteže; G3 (n = 9) sportašice sa najvišom ocjenom ravnoteže. Ove tri grupe su se razlikovale jedna od druge u zbirnoj ocjeni dinamičke ravnoteže ($p < 0,05$). Međutim, razlike nisu uočene u izvedbi skoka u vis kod odbojkašica zbog različitih klasifikacija ravnoteže ($p > 0,05$). Prema tome, dinamička ravnoteža nije bila povezana sa izvedbom skoka u vis. Nadalje, nizak nivo dinamičke ravnoteže nije uticao na visinu skoka u vis kod odbojkašica.

Ključne riječi: skok u vis, dinamička ravnoteža, odbojka, sportašice

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GENDER AS A DETERMINANT OF STUDENTS' LIFE HABITS RELATED TO THEIR PHYSICAL ACTIVITY

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ABSTRACT

Positive lifestyle habits, especially those aimed at health, are acquired throughout life. In this sense, the life habits of the student population are determined by the foundations set through successive developmental stages during life and within the framework of the educational system in which they study. One of the factors of a healthy lifestyle is regular physical activity. Accepting a certain way of life and, implicitly, a lifestyle, can essentially be treated as a kind of shaping of their personal and social identity. The research, which was carried out in the form of an empirical transversal study, had as its goal the identification of certain factors of students' life habits related to physical exercise. The sample of respondents consisted of a total of 140 students of the University of Bihać, both sexes. For the collection of empirical data, a questionnaire was used, specially created for this research, whose item construct is based on the instruments used in a number of previous studies. The results indicate that the respondents, in general, perceive themselves as people who recognise the importance of physical activities, but they generally do not have healthy lifestyle habits, which is not in agreement with the elements of the health doctrine model upon which this research approach is based. In two of the three sets of variables, it was determined that there are lifestyle habits that could be characterised as bad. Generally, in this research, the gender of the respondents did not prove to be a significant determinant of students' lifestyle habits.

Keywords: life habits, physical activities, students

INTRODUCTION

The general context of a healthy lifestyle can be viewed through the prism of the adopted lifestyle, especially the so-called active lifestyle that is determined by a set of certain habits, procedures and behaviours. If the determinants of life habits and lifestyle are treated partially (each for themselves), then they can lead to a situation where their projections can be made relatively inconsistent when their explicit connection with health is observed. However, if a certain pattern of individual human behaviour is viewed in the light of a synthesis

of correct actions, healthy habits and adequate behaviour and the relationship "towards oneself and others", then a completely different perspective of the synergism of life habits and lifestyle is obtained. The lifestyle habits of young people are determined by the foundations laid in the earliest stages of their lives. Positive lifestyle habits, especially those aimed at health (proper nutrition, regular physical activity, etc.) are acquired during life. Early school age and youth are considered the most important periods for the formation of healthy lifestyle habits. Regular physical activity is one of the important factors of a healthy

lifestyle. It generally includes those movement activities that increase energy consumption (which is above the consumption in the resting state of the human organism). Insufficient physical activity, measured through functional abilities, has a negative effect on body structure and triglycerides, which significantly affects the deterioration of students' health (Skender, Cakar, Kurtović, & Šabić, 2022). This mainly includes everyday activities (walking, climbing stairs, working in the house, shopping, going to work, etc.). Physical form largely depends on the level of physical activity, and so different exercise programmes are implemented with the goal of improving certain attributes of form (Ostojić et al., 2009). So far, in several studies (Myint et al., 2007; Oellingrath et al., 2019), it has been concluded that the level of physical and working abilities of the population is increasingly unfavourable, which, in the long run, can have a negative impact on overall health, both on a personal/individual level and on the population as a whole. The promotion of the acceptance of healthy lifestyle habits is increasingly seen as an important social task aimed at preserving public health. The recommendations of health and kinesiology institutions are directed towards the constant affirmation of increasing the level of physical activities and the adoption of proper nutritional habits among the population, and these are the two most frequently emphasised population tasks (Nešić et al., 2014). Morphological characteristics of students, in addition to affecting the more successful manifestation of functional abilities, should be one of the conditions for the appearance of students in physical activities (Skender, Šabić, Selimović, Kurtović, & Karalić, 2022). Insufficient physical activity of students affects the morphological characteristics, and it clearly shows us that the reduction of aerobic capacity causes a lower level of student movement. If we also mention that the research was conducted during the COVID-19 pandemic, we can assume that it probably affected the level of student movement and had a negative impact on the physical activity and morphological characteristics of students, which the research confirmed (Šabić, Skender et al., 2021). Recent circumstances that have drastically changed people's lives on a global level are related to the emergence of the COVID-19 pandemic, and one of the areas that has "felt" these changes more intensively is physical activity, especially physical exercise. So, the trend of a constant decline in physical activity has been clearly observed at all ages in recent decades, and living under a pandemic has intensified this problem even more (Šabić, 2018; Šabić, Skender, Kurtović, & Nešić, 2021). So far, a relatively small number of more complex studies have been conducted in Bosnia and Herzegovina, which focused on the lifestyle habits of the student population. Some of the studies warn of a relatively unfavourable relationship between regular physical activity and some health parameters (Đurić et al.,

2017), as well as the young people's tendency towards a sedentary lifestyle, which can be seen in the often unfavourable relationship between body composition and its connection with physical activity (lack of activity) (Nešić et al., 2011). When it comes to the lifestyles of young people in BiH that can be linked to healthy lifestyle habits, one study showed (Turčilo et al., 2019) that they have a declaratively positive attitude about this topic, but that in everyday life, they often behave the opposite (e.g., about 49% of young people very rarely or only occasionally engage in sports or sports-recreational activities; they mostly spend their free time on social networks; etc.). In addition, the habits of young people in terms of eating habits warn of the trend that, although they are aware of the usefulness of physical activity and proper nutrition, they often choose patterns of behaviour that can damage their health (Škutor, 2018). The population of students of all age groups is affected by hypokinesia, regardless of their place of residence, and because of this, the consequences of such an inappropriate attitude towards physical exercise, as a measure to prevent the occurrence of painful conditions of lumbar syndrome, are noticeable (Nešić, Šabić, & Skender, 2020).

METHOD

The research was carried out as a transversal empirical study. The goal was to identify certain aspects of students' lives (habits) related to physical exercise. The sample of respondents consisted of a total of 140 students of the University of Bihać, both genders (M = 61/43.6%; F = 79/56.4%). The average age of the respondents was 24 years. A questionnaire, specially created for this research, was used to collect empirical data. The item construct was based on instruments that were used in a number of previous studies (Nešić, 2016), with appropriate adaptation and harmonisation with the population in which the survey procedure was implemented. The research variables were arranged in the form of item indicators whose construct referred to nominal scalar values (self-assessment scales). In the field of independent variables, the sex and age of the respondents were identified, while the system of independent variables consisted of a total of 16 indicator items (daily physical activity; playing sports before enrolling in college; perception of self-attitude; forms of physical activities they practice; regularity of physical exercise; level of daily activities outside the home that are performed on foot; staying in nature; self-assessment of physical condition; regularity of taking daily meals; quality of daily meals; regularity of breakfast consumption; consumption of water as a basic means of hydration; regularity of preventive medical examinations; blood pressure control; vaccination against seasonal diseases; and vaccination against COVID-19). The empirical material was processed using the appropriate procedures of

descriptive statistics. Since most of the variables were arranged in the form of nominal item indicators, the central tendency parameters (frequency distribution) were calculated, and contingency analysis (chi-square test) was used to compare the data. The collected data were processed using the SPSS.21 application program, and all statistical conclusions were made with a significance level of 0.05 ($p < .05$).

RESULTS

The information provided by the processed empirical material shows that the context of the respondents' individual life habits can be interpreted through the following aspects:

In terms of the way in which students carry out daily life activities related to daily existential factors (work, departures and returns from college, etc.), it can be seen that the way of life "on the move" prevails. The largest percentage of respondents declare that during daily activities, movement prevails (60.7%), while a smaller percentage of them is oriented towards a sedentary way of performing daily duties (20.7%). In terms of gender, no statistically significant differences were identified (Table 1).

Table 1: Dominant way of conducting daily activities

Spends the day	Gender		Total
	Men	Women	
mostly sitting	21 15.0%	29 20.7%	50 35.7%
mostly standing	2 1.4%	3 2.1%	5 3.6%
mostly in motion	38 27.1%	47 33.6%	85 60.7%
Total	61 43.6%	79 56.4%	140 100.0%
	<i>Chi = 0.121</i>	<i>df = 2</i>	<i>Sig. = .941</i>

Playing sports as one of the important factors of good life habits was one of the indicators that focused on the identification of earlier engagement in sports (before enrolling in college). The data show that only about 1/3 of respondents were actively involved in sports before college (30%), with male respondents dominating (M = 21.4%; W = 8.6%). The largest percentage of respondents perceive their previous sports as sporadic recreation, since 40.7% of them declare that they did it occasionally. In addition to those who played sports 2-3 times a week (17.1%), it can be concluded that among the respondents,

there are those who did not incorporate sports into their lifestyle during the high school period. In this context, it can be observed that gender can represent a more significant determinant, given that the number of those who did not play sports at all or did so only occasionally significantly dominates among women (M = 12.1%; W = 40.7%). This is confirmed by the established statistical significance of the differences between the subsamples (Sig. = 0.000) (Table 2).

Table 2: Playing sports before enrolling in college

Playing sports before enrolling in college	Gender		Total
	Men	Women	
no	1 0.7%	16 11.4%	17 12.1%
periodically	16 11.4%	41 29.3%	57 40.7%
2-3 times a week	14 10.0%	10 7.1%	24 17.1%
every day	30 21.4%	12 8.6%	42 30.0%
Total	61 43.6%	79 56.4%	140 100.0%
	<i>Chi = 33.626</i>	<i>df = 3</i>	<i>Sig. = .000</i>

One of the indicators related to the perception of lifestyle, which can be implicitly linked to life habits, referred to the identification of the respondents' self-assessment in the context of their attitude about themselves (when it comes to physical exercise). The data show that the majority perceives themselves as a person who, in the environment of the academic community, recognises the importance of physical exercise and considers themselves an active

recreational player (50%), out of which 34.3% consider themselves to be moderate recreational players in solid physical shape, while 15.7% perceive themselves as active and regular recreational exercisers in excellent physical shape. However, it can be observed that there is a very small number of active athletes-competitors in the research entity (11.4%). Statistically significant differences (Sig. = 0.000) were found for this indicator as well (Table 3).

Table 3: Perception of the attitude about oneself in the context of physical exercise

In terms of physical exercise, they perceive themselves as:	Gender		Total
	Men	Women	
anti-athlete	0 0.0%	8 5.7%	8 5.7%
a passive sports fan	7 5.0%	15 10.7%	22 15.7%
athletic type, but only in words and style of clothing	9 6.4%	15 10.7%	24 17.1%
a moderate recreational player in solid physical condition	19 13.6%	29 20.7%	48 34.3%
a strong recreational athlete in excellent physical shape	17 12.1%	5 3.6%	22 15.7%
an active athlete-competitor	9 6.4%	7 5.0%	16 11.4%
Total	61 43.6%	79 56.4%	140 100.0%

Chi = 22.528 *df* = 5 *Sig.* = .000

The research also focused on a set of indicators that can be linked to healthy lifestyle habits and were based on the concept of the health doctrine (Sharkey & Gaskill, 2006). The item indicators included three sets of variables from the space of the mentioned model: physical activity, nutrition and health habits, with four item indicators each. The physical activity variable produced five item indicators.

When it comes to personal attitude towards physical exercise, it is evident that the majority of respondents have an active attitude towards physical activities that can be considered regular physical recreation. More than two-thirds of them declare that they do it every day (77.1%), while there is 16.4% of those who do it 2-3 times a week (which can be considered a continuity of exercise). In the context of gender differentiation, no statistically significant differences were found (Table 4).

Table 4: Regularity of engaging in sports and recreational activities

Regularity of engaging in sports and recreational activities	Gender		Total
	Men	Women	
periodically	5 3.6%	4 2.9%	9 6.4%
2-3 times a week	10 7.1%	13 9.3%	23 16.4%
regularly, every day	46 32.9%	62 44.3%	108 77.1%
Total	61 43.6%	79 56.4%	140 100.0%

Chi = 0.562 *df* = 2 *Sig.* = .755

With regard to the dominant type of recreational activities that the respondents practice as a form of physical exercise, it was determined that about 1/3 use the facilities and programmes of fitness clubs (39.3%), while about 1/3 of the respondents are also engaged

in walking (as a recreational activity) (37.9%). No statistically significant differences between the subsamples were observed for this indicator either (Table 5).

Table 5: Regularity of engaging in sports and recreational activities

Forms of sports and recreational activities	Gender		Total
	Men	Women	
I don't exercise at all	2 1.4%	2 1.4%	4 2.9%
I go to the gym/fitness club	28 20.0%	27 19.3%	55 39.3%
I mostly walk	18 12.9%	31 22.1%	49 35.0%
I only do walking	0 0.0%	4 2.9%	4 2.9%
I exercise at home	13 9.3%	15 10.7%	28 20.0%
Total	61 43.6%	79 56.4%	140 100.0%

Chi = 6.876 df = 2 Sig. = .143

In the context of the previous one, one can also observe the respondents' answers that are related to the indicator of performing daily life activities without using the means of transport (on foot). The largest percentage of respondents do this regularly (48.6%), that is, mostly (32.9%), which indicates the dominance of this way of

daily life functioning (81.5%). Even with this indicator, gender did not prove to be a significant determinant, given that no statistically significant differences between the subsamples were found (Table 6).

Table 6: Carrying out daily activities on foot as part of life habits

Carrying out daily activities outside the home - on foot	Gender		Total
	Men	Women	
rarely	12 8.6%	14 10.0%	26 18.6%
mostly	17 12.1%	29 20.7%	46 32.9%
often	32 22.9%	36 25.7%	68 48.6%
Total	61 43.6%	79 56.4%	140 100.0%

Chi = 1.236 df = 2 Sig. = .539

When analysing the respondents' answers to the indicator that sought to identify the part of the lifestyle habits related to spending free time during the weekend, it is noticeable that more than half of the respondents declare that they often use their free time to spend time in nature (54.3%). This can be interpreted as a generally developed awareness of healthy lifestyle habits.

However, in terms of gender, it can be observed that this tendency is somewhat more pronounced among male respondents (28.6%), while among female respondents, there are significantly more people who do this very rarely (16.4%). These differences were determined at the level of statistical significance (Sig. = 0.044) (Table 7).

Table 7: Staying in nature during the weekend

Staying in nature (on a trip) during the weekend	Gender		Total
	Men	Women	
very rarely	9 6.4%	23 16.4%	32 22.9%
mostly	12 8.6%	20 14.3%	32 22.9%
often	40 28.6%	36 25.7%	76 54.3%
Total	61 43.6%	79 56.4%	140 100.0%

Chi = 6.248 df = 2 Sig. = .044

The set space of the nutrition variable was structured with four item indicators. By selecting the most dominant factors that structure the framework of healthy nutritional habits (regularity of taking at least three daily meals, regularity of eating breakfast as the recommended most important daily meal, quality of nutritional inputs and water consumption as the basic source of the daily hydration level), it is observed that the respondents do not have a consistent approach to this segment related to the quality of life. Although they individually assess that

they mostly eat quality food and that they try to eat at least three meals a day, it is evident that the largest percentage of respondents almost regularly skips breakfast (85.7%). There is also a very small number of those for whom water is the dominant source of daily hydration (12.9%). As a whole, this can be characterised as the dominance of bad eating habits. In this context, gender is not an important determinant. No statistically significant differences between male and female respondents were recorded for most of the item indicators (Table 8).

Table 8: Eating habits in relation to the respondents' gender

Regularity of taking daily meals (at least three)	Gender		Total
	Men	Women	
hardly ever	10 7.1%	18 12.9%	28 20.0%
usually consumed three times a day	19 13.6%	23 16.4%	42 30.0%
regularly	32 22.9%	38 27.1%	70 50.0%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 0.894 df = 2 Sig. = .640</i>			

Quality of daily meals	Gender		Total
	Men	Women	
average	5 3.6%	18 12.9%	23 16.4%
good	16 11.4%	29 20.7%	45 32.1%
very good	40 28.6%	32 22.9%	72 51.4%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 9.841 df = 2 Sig. = .007</i>			

Regularity of breakfast consumption	Gender		Total
	Men	Women	
hardly ever	43 30.7%	49 35.0%	92 65.7%
occasionally, when I can	13 9.3%	15 10.7%	28 20.0%
regularly	5 3.6%	15 10.7%	20 14.3%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 3.446 <u>df</u> = 2 Sig. = .178</i>			

Consuming water as the basic daily drink	Gender		Total
	Men	Women	
mostly	39 27.9%	57 40.7%	96 68.6%
I try to make water my main source of hydration	14 10.0%	12 8.6%	26 18.6%
water is my dominant source of hydration during the day	8 5.7%	10 7.1%	18 12.9%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 1.451 <u>df</u> = 2 Sig. = .484</i>			

The structure of the health habit variable set also consisted of four item indicators. As a whole, the structure of the analysed empirical data indicates that even in this segment of life habits, we cannot speak of the respondents' self-responsible approach to the quality of life. Most of them (65.7%) never go for regular preventive medical examinations, that is, they do so only when a visible health problem appears (20%). Additionally, as one of the health doctrine measures related to healthy lifestyle habits, blood pressure control is not applied by the majority of respondents (71.4%) in their lifestyle habits. 15.7% of them occasionally do this, while only 12.9% of respondents included in the research do it on a regular basis. The attitude towards vaccination against

seasonal diseases also has a negative connotation when considered in the context of healthy lifestyle habits. The largest number of them are never vaccinated (65.7%), and only a smaller percentage do so in situations where the realisation of a right in the immediate living and working environment depends on vaccination (11.4%). Corresponding to this is the attitude towards the recommended vaccination during the COVID-19 pandemic period, where it is observed that the majority of respondents did not do so (67.1%). In relation to gender, no statistically significant differences were found in this set of variables (Table 9).

Table 9: Health habits in relation to the respondents' gender

Regularity of going to preventive medical examinations	Gender		Total
	Men	Women	
never	42 30.0%	50 35.7%	92 65.7%
only when the need arises	12 8.6%	16 11.4%	28 20.0%
I try to make it once a year	7 5.0%	13 9.3%	20 14.3%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 0.777 <u>df</u> = 2 Sig. = .678</i>			

Regular blood pressure control	Gender		Total
	Men	Women	
no	41 29.3%	59 42.1%	100 71.4%
periodically	12 8.6%	10 7.1%	22 15.7%
regularly	8 5.7%	10 7.1%	18 12.9%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 1.342 df = 2 Sig. = .511</i>			

Regularity of vaccination against seasonal diseases	Gender		Total
	Men	Women	
never	44 31.4%	48 34.3%	92 65.7%
only if I have to	8 5.7%	8 5.7%	16 11.4%
I get vaccinated regularly	9 6.4%	23 16.4%	32 22.9%
Total	61 43.6%	79 56.4%	140 100.0%
<i>Chi = 4.190 df = 2 Sig. = .123</i>			

Vaccination against COVID-19	Gender		Total
	Men	Women	
yes	20 14.3%	26 18.6%	46 32.9%
no	41 29.3%	53 37.9%	94 67.1%
Total	61 43.6%	79 56.4%	140 100.0%

DISCUSSION

Analysing the research results must be based on the settings of the healthy lifestyle model, which is based on the health doctrine of an active lifestyle (Sharkey & Gaskill, 2008). Care essentially consists of five dimensions: physical activity, healthy and proper nutrition, weight control, stress control, and safety habits. In our research, the focus contextually referred to three segments: (a) physical activity, with a dominant focus on physical exercise (respecting the conceptual distinction: physical activity includes all movements that increase the energy consumption of the human organism above the consumption at rest, while physical exercise is planned and purposeful physical activity, the primary goal of which is to improve health and physical condition/form), (b) eating habits, as an important segment of a healthy lifestyle (should be such that it enables unhindered physical activity along with work and other daily activities; optimal nutrition, as well as the optimal level of physical activity, which is individually determined; an increase in the daily level of physical activity must be accompanied by adequate nutrition) and (c) safety habits, as a factor in accepting a

healthy lifestyle, it is necessary that they be individually adopted and continuously implemented (habits that have a preventive health character which are based on the sentence that each individual, not his doctor, is responsible for personal health).

The basis of life habits among young people, where the student population occupies a special place (lives and creates in an environment that is oriented towards the future through academicism and striving for the highest competences), is represented by the way in which they satisfy their needs. Accepting a certain way of life and, implicitly, a lifestyle, can essentially be treated as a kind of shaping of their personal and social identity. Health, vitality and long life are the dominant desires of most people. The results of recent research (Grasdalsmoen et al., 2019; Zhao et al., 2019; Lepeš & Halaši, 2021; Bunčić et al., 2021) have shown that people who exercise regularly (with properly organised and individually dosed physical activity) take care of a balanced and proper diet (which is in accordance with the individual character of life and work) and undergo regular periodic health checks are less susceptible to

cardiovascular and psycho-somatic diseases (Banožić et al., 2015; Milošević-Georgiev & Krajnović, 2016; Ruegsegger & Booth, 2017; Fletcher et al., 2018). The lack of regular physical activity and inadequate nutrition in the last few years are among the leading risk factors for diseases in the spectrum of the so-called mass non-communicable diseases (Nešić et al., 2014a). Some studies on the student population (Malčić & Marić-Jurišin, 2018; Obradović, 2020) have shown that a sedentary lifestyle prevails in their behaviour patterns, especially among female students, and that older students are more aware of the importance of physical activity. Additionally, students who are more physically active show tendencies towards healthier eating habits (Karnai et al., 2020). Other studies (Skead & Rogers, 2016; Voinea, 2018) provide information about the fact that some lifestyle habits of students (engagement in physical activities, proper nutrition, etc.) are interconnected and constitute an individual's lifestyle, which can have a correlative relationship with healthy lifestyle habits.

CONCLUSION

It is known that the adopted life habits form the basis for determining the way of satisfying individual needs. In this regard, healthy lifestyle habits can be emphasised through the context of how they are satisfied, and one can talk about the need to adopt and accept them as a kind of shaping of the personal and social identity of a young person. It is considered that the students' way of life (lifestyle) is dominantly imposed by the demands that come from individuals in search of activities that represent socially acceptable models of interpersonal connection. Sport, that is, purposeful and regular physical exercise, is a desirable activity that can intensely affect all aspects of interpersonal relationships and communication. It has an extremely positive impact on health, and thus on the formation of healthy lifestyle habits. The problem of the presence of healthy lifestyle habits among young people today is one of the most frequently asked questions when looking at their living and working conditions. Research shows that there is a growing trend in the number of young people, especially among the student population, who are dominated by lifestyle habits characterised as unhealthy. Among the health risk phenomena, the following are particularly present: improper and irregular diet, lack of physical activity, sedentary lifestyle, indolent attitude towards health prevention, etc. As a general conclusion of the research conducted on a sample of 140 students of the University of Bihać, which aimed to identify certain aspects of life (habits) related to physical exercise, the statement that the respondents perceive themselves as people who recognise the importance of physical activity is imposed. They are mostly physically active, to a degree that can be considered average, as with

most people in this population niche. However, the structure of physical activity does not indicate habits that can be considered an adopted pattern of an active lifestyle. There are very few who are actively involved in sports. The majority of respondents are directed towards recreational activities, which are reflected in the two most common forms: exercising in fitness clubs/gyms and/or hiking/walking. What is directly related to the characteristics of their age (the need for intensive communication with the social environment, interaction with peer groups, economic dependence, professional instability, not owning their own means of transport, etc.), is that daily physical activity, as a way of performing daily duties, despite being primarily dependent upon the imposed economic factors of life, represents an active awareness of the importance of regular physical exercise. On the other hand, in terms of attitudes towards nutritional habits and preventive health domains of life, respondents show a trend towards unhealthy lifestyle habits. The daily rhythm of the diet, for the majority, does not include the regular consumption of breakfast (according to the recommendations of health science - the most important daily meal), while only half of the respondents consume three regular meals a day. In the same context is the attitude towards proper daily hydration, where it was determined that a very small percentage of respondents consume water as the main source of daily hydration. When it comes to preventive health habits that provide prerequisites for the quality of life, it was determined that the majority of respondents have an indolent attitude towards health prevention. Most of them do not carry out regular periodic medical examinations, and with regard to their attitude towards vaccination against infectious diseases, they express a negative attitude.

In the light of these findings, it is possible to recognise frameworks that indicate that healthy lifestyle habits do not exist in the examined population at all, which is in disagreement with the factors of the health doctrine model on which this research approach is based. In two of the three sets of variables, it was determined that there are lifestyle habits that could be characterised as bad. Generally, in this research, the gender of the respondents did not prove to be a significant determinant of students' lifestyle habits. One of the causes of this situation can certainly be found in the student population's lack of knowledge about the values and essential determinants of health, and in this context, the influence of appropriate models of physical exercise, primarily physical activities of an aerobic nature, but also food patterns, daily rhythm of life, appropriate safety habits, etc. The results of this study can be consistently dimensioned in three directions: (1) as recommendations to academic practice to focus on social activation which would be based on permanent education of students about the impact and values of physical exercise on health

and the development of healthy lifestyle habits; (2) establishment of a purposeful and developmentally sustainable system of sports at the University conceived in the form of regular physical exercise of the widest student population (and not only as

an occasional/ad hoc competitive activity in which only young active athletes who are currently students of a certain faculty participate; and (3)) as a basis for further similar research on the student population.

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SPOL KAO DETERMINANTA ŽIVOTNIH NAVIKA STUDENATA POVEZANIH SA NJIHOVOM FIZIČKOM AKTIVNOSTI

Pozitivne životne navike, posebno one koje su usmjerene na zdravlje, stiču se cijeli život. U tom smislu, životne navike studentske populacije određuju se temeljima postavljenim kroz uzastopne razvojne faze tokom života i u okviru obrazovnog sistema u kojem se školuju. Jedan od faktora zdravog načina života je redovna fizička aktivnost. Prihvatanje određenog načina života i, implicitno, stila života, suštinski se može tretirati kao svojevrsno oblikovanje njihovog ličnog i društvenog identiteta. Istraživanje koje je provedeno u formi empirijske transverzalne studije, imalo je za cilj identifikaciju određenih faktora životnih navika studenata u vezi sa tjelevoježbom. Uzorak ispitanika činilo je ukupno 140 studenata Univerziteta u Bihaću, oba pola. Za prikupljanje empirijskih podataka korišten je upitnik, posebno kreiran za ovo istraživanje, čija je konstrukcija elemenata zasnovana na instrumentima koji su korišteni u nizu prethodnih studija. Rezultati pokazuju da ispitanici sebe općenito doživljavaju kao osobe koje prepoznaju značaj fizičkih aktivnosti, ali da generalno nemaju zdrave životne navike, što nije u skladu sa elementima modela doktrine zdravlja na osnovu kojih je ovaj istraživački pristup i zasnovan. U dva od tri skupa varijabli utvrđeno je da postoje životne navike koje se mogu okarakterisati kao loše. Općenito se u ovom istraživanju spol ispitanika nije pokazao kao značajna determinanta životnih navika studenata.

Ključne riječi: životne navike, fizičke aktivnosti, studenti

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COMPARING THE EFFECT OF TWO RESISTANCE TRAINING MODELS ON FOOTBALL PLAYER PERFORMANCE

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ABSTRACT

The purpose of this research was to compare the effect of two resistance training methods on football players' performance. In recent years, technology and data science has come to the aid of coaches in various sports, such as football, to evaluate the players and training methods. In the meantime, GPS sensors have quickly found their place among sports conditioning coaches and enabled them to evaluate the performance of their athletes with greater accuracy. In this research, two different methods of resistance exercises (linear and non-linear resistance training systems) were performed, and the performance of the athletes was evaluated in terms of distance covered in the real game, maximum speed and the rate of perceived exertion (RPE). The results of the research showed that the non-linear training method had caused more improvement and less loss in football players when it comes to the variables of distance covered and the rate of perceived exertion. Of course, more research is needed to find the best way.

Keywords: data science, football, GPS training, monitoring, resistance training

INTRODUCTION

In recent years, with the development and growth of sports technology, everyone has also developed in different sectors (Ratten, 2020). One of the most important applications of technology in sports is receiving accurate data and conducting a reliable analysis. In fact, this is part of data science. By receiving accurate data and performing analysis on the data, researchers can get better results from training methods and other effective variables in training programmes (O'Donoghue & Holmes, 2014). In recent years, GPS tracking systems have been used in football. This system provides coaches

with various data on players' physiological or tactical performance. By using this data, it is easier to make decisions about the performance of players or the effectiveness of training systems and other related variables (Rago et al., 2020).

Applying technology alongside data science has given researchers in the field of training (Sports Conditioning) and exercise physiology the opportunity to make the best decisions by receiving more accurate information and analysing data with more up-to-date methods. Of course, access to some of the data that is available to us today was not possible until a few years ago, and data science, alongside technology in sports, has established a suitable path for the development and

progress in this field (Muhammad et al., 2021).

The total distance covered during the game, maximum running speed and the rate of perceived exertion in the game are the determining factors in the success of football teams, which can be strengthened by weight training, monitored by a GPS-based system, and finally, analysed with data science methods.

Resistance exercises are one of the most important parts of preparation programmes for football players. By improving muscles and joints, weight training increases explosive power, strength and muscle endurance in football players, and in addition to improving their performance on the soccer field, it makes athletes in this field less likely to be injured. Today, there have been many discussions about the methods of resistance exercises in football, as well as the timing of these exercises (Hoffman & Kang, 2003).

Resistance exercises are included in three main phases of preparing a football team, and in each period, these exercises should be designed with a different system and based on needs. Resistance exercises in the pre-season and preparation phase should linearly and gradually increase the strength and general fitness of the football players and gradually reach the level of maximum power and strength. In the second phase, which is the competition season, the exercise programmes are designed more on maintaining fitness, and the system is selected on the same basis, while finally, at the end of the season or the transition phase, they aim to recover and prevent the loss of acquired abilities (Bompa & Buzzichelli, 2015).

During the resistance training stages in the competition season, the most important concern is the negative effects of weight exercises on the performance of football players, and different training systems are designed to reduce these negative effects. In recent years, scientists in sports science have done a lot of research in this field in order to reduce some of the negative effects of weight training during the competition season. Changing training systems has been one of the best ways for this purpose (Amani et al., 2018). Several resistance training systems are applied to resistance training programmes based on the purpose they are looking for (Hasani et al., 2018).

The two main systems that are currently used in resistance training in various sports, and especially in football, are linear and non-linear training systems (Simão et al., 2012). These training systems are designed with different goals and are among the most popular systems of weight training among athletes in the world. In the method of a linear system, the athlete gradually enters from the stage of general preparation to the stage of hypertrophy and then the stage of strength and power, but in non-linear programmes, this order does not exist, and during one week of training, it is possible

for the athlete to perform hypertrophy, power and strength exercises (Harries et al., 2015). It seems that it is recommended to carry out exercises based on the linear system before the season (Preparation phase) because it can have a negative effect on the performance of the players during the games. Therefore, most coaches prefer to use uniform exercises with high repetitions and light to medium weights at this stage (in-season), and some coaches who are more risk-taking use non-linear exercises in the competition stage (Smith et al., 2014).

In this study, the researcher intends to perform a comparison between the linear and non-linear training systems, examining their effect on the important functional factors of football players using GPS technology to check the results more accurately based on the previously mentioned problems.

METHODS

The present research was experimental and field-based. In this research, two measurement stages were done before and after the implementation of training programmes. The participants of this research were the players of the Premier Football League of Iran. 22 players participated in this research, and data was collected from 20 players (except goalkeepers).

In this research, 2 groups of 10 football players were selected. The two teams played twice. The interval between the two matches was 7 days. Between the two competitions, one group did exercises with uniform weights, and one group did exercises with weights based on a non-linear system. GPS data was received in two matches, and the rate of perceived exertion (RPE) was also determined by the players at the end of the match using a standard method.

The important performance factors of the distance covered and the maximum speed of the players were measured based on the GPS system. Currently, there are various commercial systems for monitoring the performance of soccer players in the world, and in this research, we used GPSports to receive detailed information from the players during the game. Positional variables (distance and speed) were registered at a sampling frequency of 15 Hz (Sánchez-Sáez et al., 2021). The validity and reliability of this system have been previously reported in other studies (Coutts & Duffield, 2010).

The 15-point Borg scale was applied to determine the rate of perceived exertion (RPE) (Whaley et al., 1997).

Two systems of resistance training were used in this research. A uniform training programme with 15 repetitions in 3 sets that took place three times a week and a non-linear training programme of three sessions with hypertrophy, strength and power exercises were implemented in two groups.

The IBM-SPSS version 23 has been applied for the statistical data processing. A one-way ANOVA has been applied to compare the results of two groups.

RESULTS

The descriptive data is provided in Table 1. Data from all players, except goalkeepers, were recorded. The result of this study has shown that there was a significant effect of non-linear resistance training on the distance covered at the $p < 0.05$ level for the 2 conditions [$F(1,18) = 41.867, p = 0.000$]

Table 1. Distance covered, maximum speed and RPE descriptive data

Groups	Variables and Test	Mean	Standard Deviation
Linear System Group	Distance Covered Pre-Test (m/min)	99.9	24.15
	Distance Covered Post-Test (m/min)	94.4	23.86
	Maximum speed Pre-Test (km/h)	26.1	2.92
	Maximum speed Post-Test (km/h)	26.4	3.33
	RPE Pre-Test	16.7	1.33
	RPE Post-Test	17.7	0.94
Non-linear System Group	Distance Covered Pre-Test (m/min)	96.1	22.02
	Distance Covered Post-Test (m/min)	103.7	21.16
	Maximum speed Pre-Test (km/h)	26.1	2.99
	Maximum speed Post-Test (km/h)	26.5	2.63
	RPE Pre-Test	17.3	1.25
	RPE Post-Test	15.9	1.52

Additionally, the researcher found a significant effect of non-linear resistance training on the rate of perceived exertion (RPE) covered at the $p < 0.05$ level for the 2 conditions [$F(1,18) = 31.610, p = 0.000$].

This study has also shown that there is no significant effect of non-linear resistance training on the maximum speed at the $p < 0.05$ level for the 2 conditions [$F(1,18) = 0.037, p = 0.850$]. The descriptive data are available in Table 1.

DISCUSSION

The distance covered during a football game has been proven as a very important variable in the success of football teams in various research. One of the important physiological conditions for sports teams to achieve success in various competitions, including the World Cup, is the ability to run and the distance covered per player (Amani, 2018).

In recent years, it has not been possible to evaluate the amount of distance covered in competitions, and therefore the effect of different training methods has not been evaluated. Therefore, with the popularisation of the use of various technologies that play a role in data science, researchers faced special conditions. Various sensors, along with computer programming such as Python, have come to the aid of this scientific field, and now very accurate and reliable data is available to researchers (Deshpande & Rasal, 2021).

Based on the detailed data obtained from the GPS system in this research, it was found that resistance exercises do not have a negative effect on the distance covered in the game if the principles are followed, and it can even be improved with some training methods. The distance covered improved as a result of non-linear resistance training in this study. The results of this research show that the distance covered in the football game remained unchanged in the group with traditional and linear exercises.

The maximum speed that players can achieve in a football game has been shown as an important

and critical factor in the success of football teams in previous research (Little & Williams, 2003). In the present study, two types of training systems did not have a negative effect on the performance of football players at maximum speed. In addition, no significant improvement and increase in maximum speed have been observed in any of the groups. Since this data is reliably recorded through a GPS system, it can be used as a useful result for future research. Perhaps by adding some training methods, it is possible to improve the maximum speed of football players.

As an influencing variable in football games, the rate of perceived exertion (RPE) has been implicated (Coutts et al., 2003). Athletes who understand less pressure in equal intensity can always show the ability to perform better techniques and tactics in the game. In this research, which was implemented based on the Borg system, the rate of perceived exertion in players with a non-linear training system has decreased significantly, which can be very important data for future research. Today, researchers are trying to reduce the perception of the rate of perceived exertion in equal intensity by using different methods such as the use of dietary supplements and different training methods. Since the recording of data related to the rate of perceived exertion was implemented based on a qualitative system, there is a need for research with a larger number of participants to have valid data.

The present research has investigated the performance of professional football players in different conditions of physical training. The results of this research can be a basis for another research. There are various methods in weight training today that we cannot have the same judgment about them everywhere. A training system can be very useful and effective in one place and may not be useful and even negative in another place. This research is one of the dozens of research studies that are carried out today to check the effectiveness of different training methods on players in different conditions.

Having reliable data and using reliable methods for data analysis in some training variables has not been possible until recent years. Today, technological hardware, alongside high-level computer languages such as Python, has come to the aid of researchers in various fields in data science. Not so long ago, it was impossible to have important data, such as the distance covered or the maximum speed of the players in a game, while today these data are easily available. It seems that a revolution in sports science research is emerging, and if scientists ignore the emerging field, it can cause backwardness. It also seems that with the introduction of technology in sports science, various books and courses should be included in this field in universities, and this is how we can expect more growth in sports science.

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POREĐENJE EFEKTA DVA MODELA TRENINGA SNAGE NA UČINAK FUDBALERA

Svrha ovog istraživanja je bila poređenje efekta dvije metode treninga snage na učinak fudbalera. Tehnologija i nauka o podacima su posljednjih godina priskočile u pomoć trenerima raznih sportova, kao što je fudbal, za procjenu igrača i metoda treninga. U međuvremenu su GPS senzori brzo pronašli svoje mjesto kod kondicionih trenera te im omogućili da preciznije procijene učinak svojih sportista. U ovom istraživanju su provedene dvije metode treninga snage (linearni i nelinearni sistemi treninga snage), a učinak sportista je procijenjen u pogledu udaljenosti koju pređu tokom stvarne igre, maksimalne brzine i stope percipiranog napora (RPE). Rezultati istraživanja su pokazali da je nelinearni metod treninga prouzrokovao veće poboljšanje i manji gubitak kod fudbalera kada su u pitanju varijable predene udaljenosti i stope percipiranog napora. Više je istraživanja svakako potrebno kako bi se pronašao najbolji način.

Ključne riječi: nauka o podacima, fudbal, GPS trening, monitoring, trening snage

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TEAM COHESION AMONG FEMALE BASKETBALL AND VOLLEYBALL PLAYERS OF THE UNIVERSITIES FROM CROATIA

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ABSTRACT

Group cohesion in a sport context is often the subject of scientific research and is oftentimes defined in a different way. In sports psychology, Carron, Brawley, and Widmeyer (1998) suggested that cohesion is "a dynamic process reflected in striving for a group to stick together and stay united in pursuit of its instrumental goals and/or to meet members' affective needs." Ramzaninezhad, Keshtan, Shahamat, and Kordshooli (2009) emphasise that team success is not equal to the sum of individually invested effort, but a complex interaction of interpersonal and situational factors. Sindik and Ćubela Andorić (2014) believe that many factors affect the development of group cohesion, while the most important consequences are the results and achievements of the group. The aim of the research was to determine the differences in team cohesion between female basketball and volleyball players and the differences in their cohesion with regard to the rank of the competition. The sample of respondents includes forty-six basketball and sixty-six volleyball players who were participants of the Final student championship in Croatia. Respondents voluntarily and anonymously completed the Croatian version of the team cohesiveness assessment questionnaire. A t-test for independent samples was used to analyse the data.

The results of the cohesiveness assessment concerning the type of sport indicate that female basketball players have, on average, higher results in individual attractions to the group TASK ($AS = 4.19$), compared with female volleyball players, and female volleyball players have, on average, higher results in individual attractions to the group - SOCIAL ($AS = 3.56$) in comparison with female basketball players. In other aspects of cohesiveness, there are no statistically significant differences between female basketball and volleyball players. The results of the cohesiveness assessment with regard to the ranking of female athletes indicate that female athletes competing in a higher rank have, on average, higher results in individual attractions to the group TASK ($AS = 4.1$), while in other aspects of cohesiveness, there are no statistically significant differences.

Since team cohesion is desirable in team sports and can contribute to better success in competitions, future research should examine which factors could influence the increase of team cohesion in sport.

Keywords: cohesion, differences, teammates, student sport

INTRODUCTION

Carron, Widmeyer, and Brawley (1985) describe group cohesion as “a dynamic process that is reflected in the tendency to hold a group together and maintain unity in the pursuit of sport goals. Carron et al. (2003), in a newer version of the definition, emphasise the tendency of members to be and remain connected in order to meet both affective needs and goals. Since a sports team is a group of people, describing cohesion in this way can equally be applied to sports teams. Cox (2005) considers understanding of dynamics to be fundamental to the study of sports team cohesion and also points out that, from the founding of the sports team to the dissolution of the group, the members interact with each other. In sport, it is known that individuals who act as a group are more successful than those who act independently in a group (Cox, 2005). Thus, the division of mutual roles and group structures are key factors for athletic success (Cox, 2005). Ramzaninezhad et al. (2009) emphasise that team performance is not equal to the sum of individually invested effort, but a complex interaction of interpersonal and situational factors. That is the reason why team cohesion is important in sport settings. Carron, Bray, and Eys (2002) emphasise some factors that determine cohesiveness, such as psychological factors like satisfaction and similarity of members' experiences, as well as past success, communication, existence of team goals, and group size. Thus, there are many factors that influence the development of cohesion itself, but there are also many consequences. However, the most important consequence is the results of the group, more precisely its achievements. Carless and de Paola (2000) suggest the immediacy of the relationship between cohesiveness and success, especially in sports teams. A meta-analysis conducted by Carron, Colman, Wheeler, and Stevens (2002) found that the effect of cohesion on performance was greater in coactive activities (e.g., team sports) and higher in women than in men.

There are two distinctions important for understanding sports cohesiveness. The first distinction in the field of cohesiveness is made between task cohesiveness and social cohesiveness. Task cohesiveness refers to motivation and focuses on achieving team goals, while social cohesion refers to motivation and focus on developing and maintaining relationships within a sports team. The second distinction is the distinction between the individual and the group aspect of the construct. The individual aspect is the individual attraction to the group by an individual as a member of the group who wants to become and remain a member, and the group aspect is the attraction related to the perception of the group as a unity - degree of closeness, connection, etc. (Sindik &

Čubela Adorić, 2014). The two beliefs (group integration and attraction to the group) and the two contexts for cohesion (task and social) interact to create four dimensions of cohesion by which researchers can examine sports teams (Eys, Coleman, & Crickard, 2022).

It is also, important to establish that there are four categories of cohesion correlates; Situational factors (Level of competition, Team size and Proximity), Personal factors (Gender, Adherence, Satisfaction, Anxiety, Depression, and Motivation), Team factors (Group roles, Group norms, and Starting status), and Leadership factors (Coach behaviour and Coach decision style) (Martin, Paradis, Eys, & Blair Evans, 2013); and all of them can affect the increase or decrease of sports team cohesion.

The aim of the research is to determine the differences of all aspects of cohesion with regard to the type of sport and the rank of female athletes.

METHODS

Forty-six basketball players and sixty-six volleyball players from Croatian universities, colleges and polytechnics, participated in the research. During the measurement, all participants took part in the UNISPORT qualifying or final competition. Some of the participants play basketball and volleyball professionally.

To assess the cohesiveness of the sports team, the adapted Perceived Cohesion of the Sports Team Questionnaire (Sindik & Čubela Adorić, 2014) was used, which is an adapted version of the Group Environment Questionnaire (Carron, Brawley, & Widmeyer, 1985). The questionnaire contains 18 items related to four aspects of group or team cohesion: Group Integration - Task (GI-T; e.g., “Our team is united in trying to reach its goals for performance” or “We all take responsibility for any loss or poor performance by our team”), Group Integration - Social (GI-S; e.g., “Our team would like to spend time together in the off season” or “Members of our team would rather go out on their own than get together as a team” - item is reverse scored), Individual Attraction to the Group - Task (IAG-T; e.g., “I am not happy with the amount of playing time I get” or “This team does not give me enough opportunities to improve my personal performance” - both items are reverse scored), and Individual Attraction to the Group - Social (IAG-S; e.g., “Some of my best friends are on this team” or “For me, this team is one of the most important social groups to which I belong”). The items are assessed on a 5-point scale (1 - strongly disagree, 5 - strongly agree). The total score can be calculated separately for the subscales as the average of the estimates on the items, and a higher value indicates greater team cohesiveness. The data was analysed using the Statistics for Windows no. 13.0.

Questionnaires were completed during the UNISPORT qualifying and final tournaments over a period of several months. The researchers first asked the trainer or the person in charge for permission that participants of the survey can complete the questionnaire, and then the questionnaire was distributed to the participants. After completing it, the participants received feedback on the purpose of the research and asked questions if they had any. Questionnaires were completed under the supervision of the researchers.

RESULTS AND DISCUSSION

According to the results of arithmetic means (Table 1), the basketball players indicate the greatest cohesion on the subscale Individual Attractions to the Group - TASK ($AS = 4.19$), which reflects what the individual (player) as a member of a sports team thinks and feels about personal engagement in group tasks. Since the advantage of task cohesion is ensuring that the basketball player will do exactly what it takes to achieve their goals (Eys, Hardy, Carron, & Beauchamp, 2003), high values on this subscale are desirable. Moreover, task cohesion could possibly benefit the basketball team due to the reason that each player within the sports team can feel free to let other players understand how they are feeling. Volleyball players indicate the greatest cohesion on the subscale Group integration - SOCIAL ($AS = 3.89$), which reflects the perceived closeness and connection in the social activities of the group. For both groups of players (basketball and volleyball), the lowest values of arithmetic means were obtained for the subscale Individual Attractions to the Group - SOCIAL ($AS_b = 3.32$; $AS_v = 3.56$), which is reflected in what an individual player as a member of a sports team thinks or feels about personal participation in social interaction between teammates in his/her sports group. The lower scores on this scale are in line with the results of previous research, where it was found that the cohesion among team members is lower for the components of individual attractions (Carron et al., 2003). The most effective way to increase individual attractions to the group - SOCIAL is through team building (Bloom, Stevens, & Wickwire, 2003). Through team building, a player could learn how to increase the sense of closeness and connection in the social activities of their sports team. Also, coaches should have high social support and positive feedback which will lead to increased cohesion in this dimension. Increased social cohesion is very important, since it is well known that social cohesion lifts up the atmosphere of the players by creating a positive energy in the team (Eys et al., 2015). Additionally, positive atmosphere will discourage negativity and players will be focused on playing, which will furthermore prevent their achievements to worsen/decline (Eys, Hardy, Carron, & Beauchamp, 2003). The results of arithmetic means pertaining to the basketball

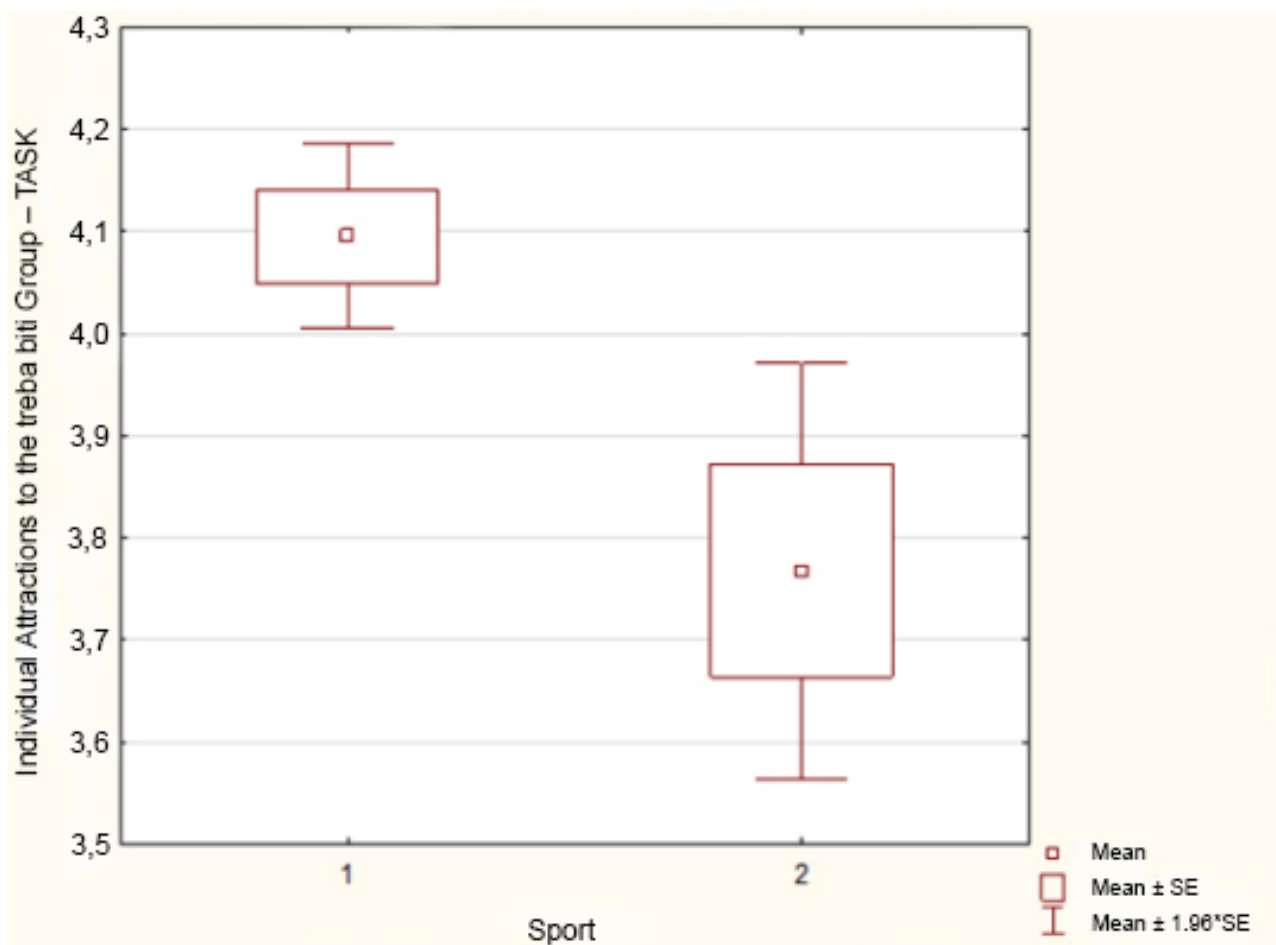
and volleyball players, obtained on the subscales of team cohesiveness, indicate that team cohesion is high, which is positive, since motivation and focus on achieving team goals is very important in achieving success in sports competitions.

Table 1 shows the results of differences on the cohesiveness subscales between female basketball and volleyball players. It was found that there are statistically significant differences in the two subscales: Individual Attractions to the Group - TASK ($p = 0.00$) (Figure 1) and Individual Attractions to the Group - SOCIAL ($p = 0.05$) (Figure 2), and that there are no statistically significant differences in two subscales: Group integration - TASK ($p = 0.46$) and Group integration - SOCIAL ($p = 0.09$) (Table 1). Basketball players have higher results in individual attractions to the group - TASK compared to volleyball players, which means that they are more happy with the amount of playing time they get during the match, more satisfied with their teams' level of desire to win, the team gives them enough opportunities to improve their personal performance, and they like their teams' style of play in comparison with volleyball players. This result in favour of the basketball players can be explained if we take into account the fact that if the team has fewer players in the team, the cohesion is more emphasised (Carron & Eys, 2012), and basketball, compared to volleyball, has fewer players on the field during the game. Volleyball players have higher results in individual attractions to the group - SOCIAL compared to basketball players, which means that they are enjoying being a part of social activities of their team, they will miss the members of their team when the season ends, they have some of the best friends on their team, they enjoy team parties rather than other parties, and for them, the team is one of the most important social groups to which they belong. The obtained results in the research conducted in 2018 (Sujan & Vileep, 2018) indicated that volleyball players have higher individual attraction to the group - SOCIAL compared to basketball players, which is the same as the results obtained on the Croatian sample of players. Basketball and volleyball are team sports that require a lot of coordination and joint contribution, and team performance is linked to levels and changes in social and task cohesion.

Table 1. Differences in team cohesion between basketball and volleyball players

Subscale	Mean _b (SD)	Mean _v (SD)	t	df	p	N _b	N _v
Group integration - TASK	3.87 (0.27)	3.79 (0.72)	0.73	108	0.46	46	64
Group integration - SOCIAL	4.07 (0.33)	3.89 (0.66)	1.69	108	0.09	46	64
Individual Attractions to the Group - TASK	4.19 (0.31)	3.81 (0.60)	3.89	108	0.00*	46	64
Individual Attractions to the Group - SOCIAL	3.32 (0.34)	3.56 (0.75)	-2.01	108	0.05*	46	64

Legend: Mean_b: mean of the upper rank of the competition, Mean_v: mean of the lower rank of the competition, t: t-test results, df: degree of freedom, p: significance level, N_b: number of upper rank players of the competition, N_v: number of lower rank players of the competition, *statistically significant difference (p < 0.01)

**Figure 1.** Individual Attractions to the Group - TASK concerning the type of sport (1 = basketball; 2 = volleyball)

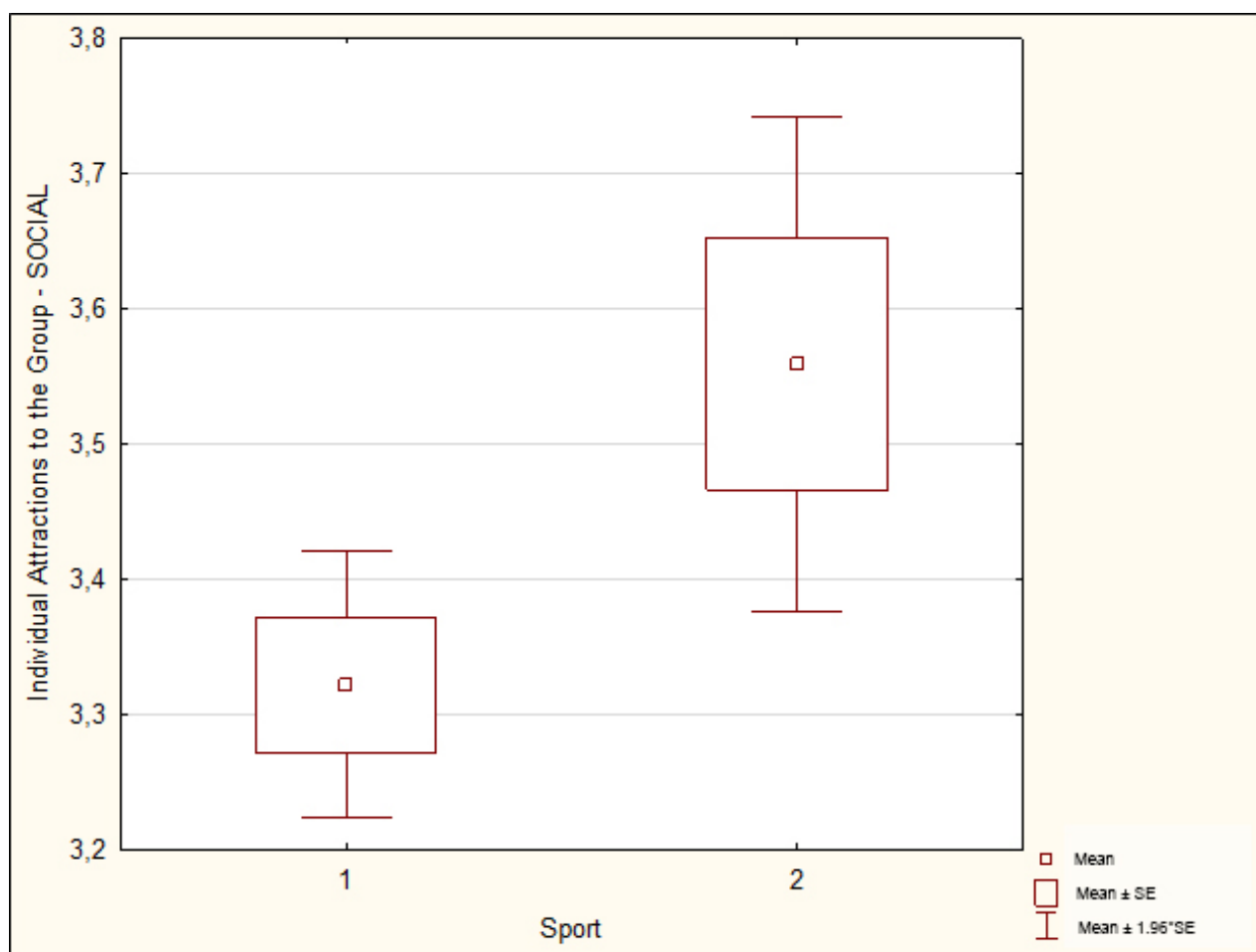


Figure 2. Individual Attractions to the Group - SOCIAL concerning the type of sport (1 = basketball; 2 = volleyball)

Table 2 shows the results of differences on the cohesiveness subscales between female basketball and volleyball players of upper and lower competition rank. It was found that there are statistically significant differences in favour of the player of the upper competition rank in one subscale: Individual Attractions

to the Group - TASK ($p = 0.01$) (Figure 3), and that there are no statistically significant differences in other three subscales: Group integration - TASK ($p = 0.44$), Group integration - SOCIAL ($p = 0.37$) and Individual Attractions to the Group - SOCIAL ($p = 0.45$) (Table 2).

Table 2. Differences in team cohesion between upper and lower rank of the competition

Subscale	Mean ₁ (SD)	Mean ₂ (SD)	t	df	p	N ₁	N ₂
Group integration - TASK	3.78 (0.50)	3.87 (0.67)	-0.77	108	0.44	61	49
Group integration - SOCIAL	4.00 (0.50)	3.91 (0.61)	0.90	108	0.37	61	49
Individual Attractions to the Group - TASK	4.09 (0.39)	3.82 (0.64)	2.70	108	0.01*	61	49
Individual Attractions to the Group - SOCIAL	3.42 (0.61)	3.51 (0.63)	-0.76	108	0.45	61	49

Legend: Mean₁: mean of the upper rank of the competition, Mean₂: mean of the lower rank of the competition, t: t-test results, df: degree of freedom, p: significance level, N₁: number of upper rank players of the competition, N₂: number of lower rank players of the competition, *statistically significant difference ($p < 0.01$)

The results are in line with the previous research according to which the researchers found that there was a moderate, positive, and significant relationship between cohesion and performance (Carron, Colman, Wheeler, & Stevens, 2002). Better results on the player's cohesiveness of the upper level competition rank can be explained by the fact that players of a higher competitive rank have better individual and team performance, and there is evidence that cohesion is associated with better individual and team performance. To improve lower competition rank players, Individual Attraction to the group - TASK coaches should influence the formation of task goal orientation and task motivation climate,

since players who are directed to acquire and improve their motor tasks, and not only to achieve good results, will still further enhance motivation in sport contexts (Alić, 2017) and increased motivation increases team cohesion (Carron & Eys, 2012). Nevertheless, many studies (Carron et al., 2002; Huang, 2004; Murray, 2006) confirm that the higher performance (i.e., better score) teams have higher levels of cohesiveness. Moreover, Grieve (2000) concludes that success has a greater impact on cohesion than the opposite. Brown (2006) states that defeated groups are more likely to show reduced morale and cohesion, and winners may be even happier with their group.

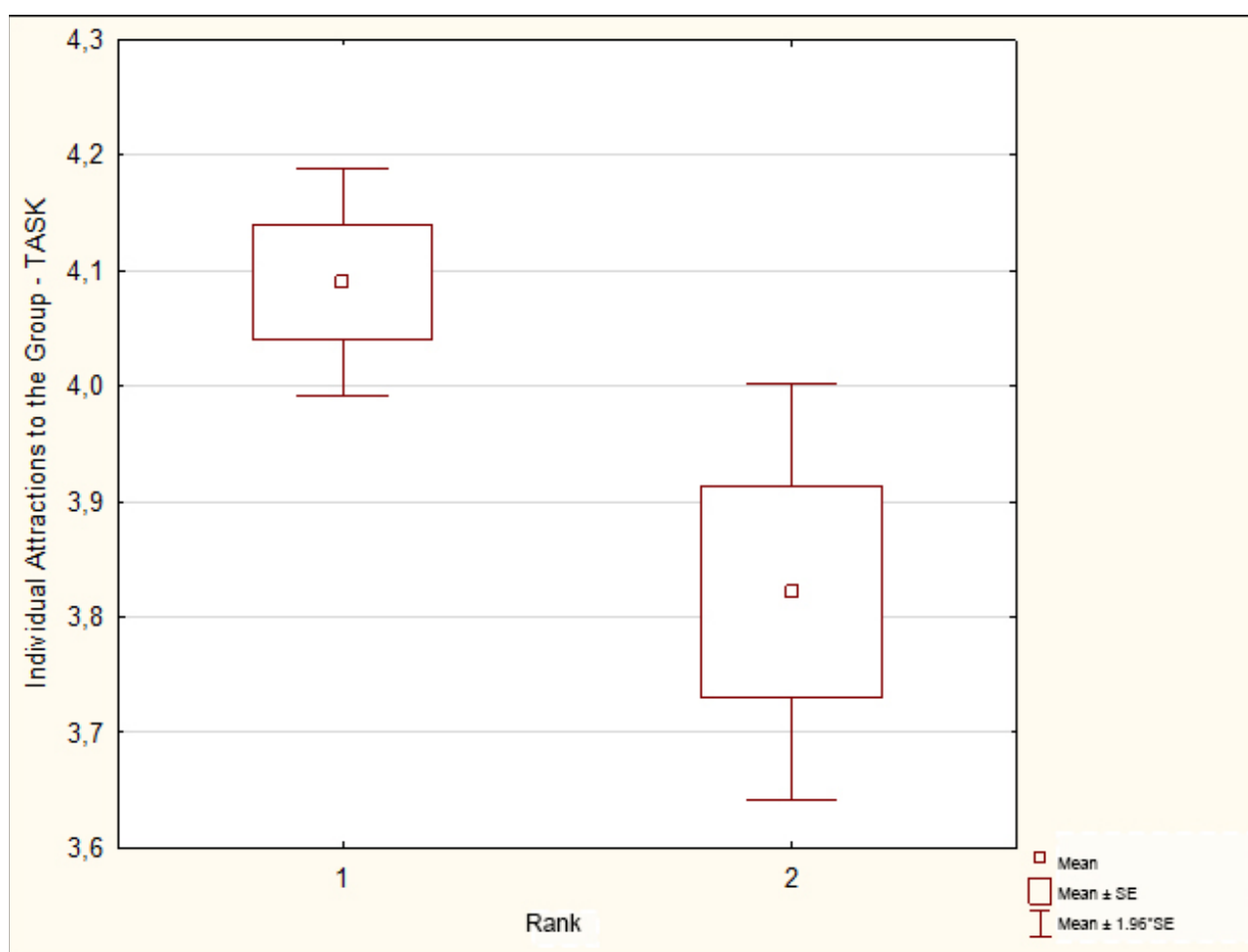


Figure 3. Individual Attractions to the Group - TASK concerning the rank of the competition (1 = upper rank of the competition; 2 = lower rank of the competition)

CONCLUSION

Analysing the differences, between female basketball and volleyball players, of the cohesion subscales, the results showed that there is no statistically significant difference in the group integration - TASK and group integration - SOCIAL subscales, and there

are statistically significant differences in subscales: individual attractions to the group - TASK and individual attractions to the group - SOCIAL.

Basketball players have higher values on the subscale individual attractions to the group -TASK and are assumed to be more motivated and task-oriented than

female volleyball players. In contrast, volleyball players have higher results in Individual attractions to the group - SOCIAL, which means they are more focused on maintaining relationships within the team, compared to basketball players. When assessing cohesiveness in relation to the competition rank, statistically significant higher average results were achieved by athletes of the higher competition rank only in the subscale individual

attractions to the group - TASK, while in other aspects of cohesiveness, there were no significant differences. Since cohesiveness within a team in a sports context is a very important factor in future research, it would be interesting to explore which factors contribute to increasing cohesiveness and what actions coaches can use to maintain or increase cohesiveness within their team.

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EKIPNA KOHEZIJA MEĐU KOŠARKAŠICAMA I ODOJKAŠICAMA UNIVERZITETA IZ HRVATSKE

Grupna kohezija u sportskom kontekstu često je predmet naučnih istraživanja i često se definira na drugačiji način. U sportskoj psihologiji, Carron, Brawley i Widmeyer (1998.) sugerirali su da je kohezija "dinamičan proces koji se ogleda u težnji da se grupa drži zajedno i ostane ujedinjena u postizanju svojih instrumentalnih ciljeva i/ili ispunjavanju afektivnih potreba članova". Ramzaninezhad, Keshtan, Shahamat i Kordshooli (2009.) naglašavaju da timski uspjeh nije jednak zbroju individualno uložene truda, već složenoj interakciji međuljudskih i situacijskih faktora. Sindik i Ćubela Andorić (2014) smatraju da na razvoj grupne kohezije utječu mnogi faktori, a najvažnije posljedice su rezultati i postignuća grupe. Cilj istraživanja bio je utvrditi razlike u timskoj koheziji između košarkašica i odbojkašica te razlike u njihovoj koheziji s obzirom na rang natjecanja. Uzorak ispitanika uključivao je četrdeset šest košarkašica i šezdeset i šest odbojkašica koje su bile sudionici Završnog studentskog prvenstva Hrvatske. Ispitanici su dobrovoljno i anonimno ispunili hrvatsku verziju upitnika za procjenu kohezivnosti tima. Za analizu podataka korišten je t-test za nezavisne uzorke.

Rezultati procjene kohezivnosti s obzirom na vrstu sporta pokazuju da košarkašice imaju u prosjeku veće rezultate u individualnoj privlačnosti grupnog zadatka ($AS = 4,19$) u odnosu na odbojkašice, a odbojkašice imaju u prosjeku veće rezultate u individualnoj privlačnosti grupe u socijalnom pogledu ($AS = 3,56$) u odnosu na košarkašice. U ostalim aspektima kohezivnosti nema statistički značajnih razlika između košarkašica i odbojkašica. Rezultati procjene kohezivnosti s obzirom na rang sportašica pokazuju da sportašice koje se takmiče u višem rangu imaju u prosjeku veće rezultate u individualnoj privlačnosti grupnog zadatka ($AS = 4,1$), dok u ostalim aspektima kohezivnosti nema statistički značajnih razlika.

Obzirom da je timska kohezija poželjna u timskim sportovima i može doprinijeti boljem uspjehu na takmičenjima, buduća istraživanja trebala bi ispitati koji faktori mogu uticati na povećanje timske kohezije u sportu.

Ključne riječi: kohezija, razlike, suigrači, studentski sport

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ESTIMATING THE LEVEL OF PHYSICAL ACTIVITY AND QUALITY OF LIFE AMONG STUDENTS OF THE COLLEGE OF HEALTH SCIENCES IN BELGRADE

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ABSTRACT

This research aims to identify the level of physical activity based on self-assessment and to detect the perception of the general quality of life among students. The research has been conducted as an empirical non-experimental study. The sample of respondents was stratified by the students of the College of Health Sciences in Belgrade, a total of 391, both genders, with the average age 20.3 years. The research sample is dominated by persons who do not engage in physical activity at all (34.5%) or engage in physical activity occasionally (44%), while regular recreational athletes, those who exercise every day or almost every day for at least 60 minutes continuously, make 17.1% of all respondents. The results indicate a trend of pronounced physical inactivity, i.e., the dominant presence of a sedentary lifestyle. In more than half of the sample, the presence of very weak (53.4%) and weak (27.7%) physical activity was found. One of the causes of this condition can certainly be found in the student population's lack of knowledge about the impact of appropriate models of physical exercise, especially physical activities related with aerobic workout, on health and quality of life. The majority of students (87.9%) are oriented towards high satisfaction with the quality of life, which indicates that practicing some other content, which is current in today's student population, is a more important determinant of the perception of the quality of life than physical exercise.

Keywords: hypokinesia, index of physical activity, students' quality of life

INTRODUCTION

Students represent one of the most important segments of social dynamics. In that sense, they are perhaps the most affected by current life phenomena. Recent research more often indicates an increasing

trend of risky life habits in students' life - lack of interest in regular physical exercise and/or sports, improper and irregular diet, sedentary lifestyle, etc. Although the WHO recommendations on the necessary daily minimum of physical activity are very precise, their acceptance among young people is still very problematic. Research indicates a decrease in

physical activity in the student population (Vuillemin et al., 2005; De Vahl et al., 2005; Fogelholm et al., 2006). Additionally, the available data indicate that the level of physical activity decreases during adolescence, as well as during younger adulthood, while the prevalence of inactivity increases (Leslie, Fotheringham, Owen, & Bauman, 2001). In this sense, it is clearly recognised that the level of physical activity in young people decreases significantly, starting from the final grades of high school to the beginning of their studies, and this decline continues during the studies (Small, Bailey-Davis, Morgan, & Maggs, 2013). Some research done in Serbia (Nešić & Kovačević, 2011; Međedović, Perić, & Ahmetović, 2013; Ahmetović et al., 2014) indicate underrepresentation of physical exercise in youth, which in turn induces a low level of values for indicators of their functional abilities (Nešić et al., 2015), but also a very low level of knowledge about healthy living habits that are recommended for their generation. Such tendencies are "helped" by a problem that has been present in Serbia for several decades, and refers to the non-existence of systems and obligations of physical education at higher education institutions. In that context, some studies (Stepanović, Videnović, & Plut, 2009; Grandić & Letić, 2009; Nešić et al., 2014) pointed to the trend of increasing risk-healthy life habits of students, lack of interest in regular physical exercise and/or sports, improper and irregular diet, sedentary lifestyle, smoking, alcohol consumption, drug use, etc., which implies the conclusion that healthy lifestyles are not sufficiently represented among young people, especially students (Nešić, Perić, Srdić, & Muhi, 2019).

The connection between physical activity and health, and therefore the quality of life, is unquestionable and proven today. Numerous scientific research in the last decades of the XX century, which has continued today, has studied the determinants of the connection between physical activity and health. They have unequivocally proven the positive impact on almost all systems of the human body (Stojiljković, Živković, & Stošić, 2011), as well as the positive effects of regular physical activity in the direction of correlation with the reduction of certain diseases: coronary heart disease, diabetes, hypertension, arthritis, depression, osteoporosis, etc. (Macera, Hootman, & Snizek, 2003; Međedović et al., 2015).

Although all forms of physical activity have a beneficial effect on human health, the importance of physical exercise has a more dominant context. In that sense, it is necessary to keep in mind the distinction between these two terminological determinants. Physical activity is any human activity that takes place through the locomotor system, while physical exercise is a methodically organised, time-limited, and physiologically and motorically articulated process dominated by

kinesiology operators. Physical, kinesiological exercise is a process of forming motor skills that are in the function of developing the ability to efficiently perform a motor task (Gojković, 2016). In that sense, one can find an increasingly widespread attitude about the phenomenon of recreation as a form of physical exercise, which includes leisure and strengthening, or in the broadest sense as psychophysical refreshment, prevention and preservation of health, entertainment, leisure, and relaxation (Gojković, 2016). Therefore, the advocacy of a healthy lifestyle by serious scientists and researchers quickly found its place, both in the medical and kinesiological, and the general professional public for the simple reason that it has proven a positive, effective link between exercise and health (Lake et al., 2001).

The WHO recommendations (WHO, 2010) on physical activity as a factor in health prevention speak of the necessary daily minimum activity for adults. In terms of frequency, duration and intensity of physical activity for the average adult population, the daily minimum is 30 minutes of moderate-intensity. The recommendations of the AHA (AHA, 2014) apply to the following: at least 30 minutes of moderate-intensity physical activity of aerobic character five days a week or 25 minutes of aerobic activity of a more energetic nature three days a week.

Therefore, insisting on healthy living habits, in which regular physical exercise should have an important place, with its permanent public affirmation, as well as scientific valorisation, is set as a long-term focus of research interest for the kinesiology profession. Such interests should be especially insisted upon among the student population, which was the focus of this study as well. Therefore, this research aims to identify the level of physical activity based on self-assessment and to detect the perception of the general quality of life among students.

METHOD

The research was conducted as an empirical non-experimental study.

The sample consisted of a total of 391 respondents, students of the College of Health Sciences in Belgrade. It was noticed that in terms of gender representation, females predominate (N = 348; 89%) compared to male respondents (M = 43; 11%), which is under the characteristics of the higher education institution where the research was conducted. In terms of age structure, they belong to the typical student population, the average age of the respondents is 20.3 (min. = 19; max. = 22).

In the process of collecting empirical data, a

questionnaire was created for this research. In addition to the questions related to respondents' characteristics (gender and age) and a set of independent variables, the space of dependent variables consisted of two: (a) self-assessment of the general quality of life (arranged as a nominal scale of attributes) and (b) physical activity self-assessment (PA) for the detection of the physical activity index (Sharkey & Gaskill, 2008). This questionnaire assesses three aspects of physical activity: (1) intensity, (2) duration and (3) frequency. Respondents (self) assess for each of the three aspects of physical activity by selecting a numerical graded value, according to the following criteria:

(1) Intensity of PA (continuous strong and rapid breathing (shortness of breath) and sweating) - 5; strong shortness of breath and sweating (as in tennis) - 4; moderate shortness of breath (as for recreation or cycling) - 3; mild shortness of breath (as in volleyball) - 2; light shortness of breath or no shortness of breath (as when walking) - 1;
 (2) Duration of PA (longer than 60 min. - 4; 30-60 min. - 3; 20-30 min. - 2; less than 20 min. - 1);
 (3) Frequency of PA (every day or almost every day - 5; three to five times a week - 4; once or twice a week - 3; several times a month - 2; less than once a month - 1). The result of the assessment is determined by multiplying the obtained values of all three aspects of physical activity, and it is the Index of physical activity. Results are evaluated through five levels: (a) below 20 - very low physical activity (sedentary lifestyle), 21-40 - low physical activity (insufficient), 41-60 average physical activity (acceptable), 61-80 - good physical activity (active), 81-100 very good physical activity (active lifestyle).

Empirical data were processed using descriptive and comparative statistical procedures. Using descriptive statistics, the distribution of frequencies as well as central/dispersion parameters were calculated (Mean, Std. Deviation and Std. Error). From comparative statistics, contingency analysis (chi square test) was applied. All statistical conclusions were derived with a significance level of 0.05 (Sig. < .05). IBM SPSS software for Windows version 21.0 was used for complete statistical analysis.

RESULTS

In terms of gender representation, female students dominate (N = 348; 89%), while there are significantly fewer male respondents (M = 43; 11%), which is in line with the gender structure of the student population at the higher education institution where the research was conducted. It is a college where it is usual for the student corps to be mostly female students.

In the context of socio-economic determination of the basic existential affiliation, it was determined that the majority of respondents are not employed (N = 308; 78.8%), i.e., their basic current life orientation is studying, and they achieve economic and social support within the primary family. Only a small number of them are employed (N = 83; 21.2%) who, alongside their studies, also achieve some of the types of business engagement.

One part of the research focus was aimed at detecting the perception of the general quality of life. In this regard, more than one-third of the respondents (37.6%) say that they live well, while the number of those who perceive their life as very good is even more significant (42.4%). If respondents who think they live at the highest standard of living (much better than the majority - 7.9%) are included in these frequencies, it is noticeable that the absolute majority of students are oriented towards high satisfaction with the quality of life (87.9%). The gender of the respondents did not prove to be a significant determinant of differentiation in the sample, which is supported by the fact that no statistical significance was identified (Sig. = 0.449) (Table 1).

Table 1. Perception of general life quality

Perception of general life quality	Gender		Σ
	Men	Women	
Low	0 0.0%	1 0.3%	1 0.3%
Average	2 0.5%	44 11.3%	46 11.8%
Well	19 4.9%	128 32.7%	147 37.6%
Very good	17 4.3%	149 38.1%	166 42.4%
Much better than the majority	5 1.3%	26 6.6%	31 7.9%
Σ	43 11.0%	348 89.0%	391 100.0%

Chi = 3.691 *df* = 4 *Sig.* = 0.449

The central part of the detection in the research sample was related to the determination of the physical activity index. The results of the empirical material clearly indicate a trend of pronounced physical inactivity, i.e., they indicate the dominant presence of a sedentary lifestyle. In more than half of the sample, the presence of very weak (53.4%) and weak (27.7%) physical activity was found. Only 4.6% of the respondents have good physical activity that can be considered a factor of an active lifestyle, while only 0.8% of students surveyed can "boast" with a

high level of activity, which indicates the dominant presence of sports content in everyday life (Table 2).

Table 2. The level of physical activity - total sample

Level (Index PA)	f	%	St. dev.
Very Low (0-20)	208	53.4	
Low (21-40)	108	27.7	
Average (41-60)	54	13.8	
Good (60-80)	18	4.6	
Very good (80-100)	3	0.8	
Σ	391	100.0	19.448

The mean value of the total score obtained for the research sample (25.23) is an indicator that, in this case, it is an entity that is physically very inactive.

Correspondence with the previous statements is also identified in the respondents' choice according to the contents of sports and/or sports recreation, i.e., regular physical exercise. The results indicate that the research sample is dominated by persons who do not do sports at all (34.5%), i.e., any physical activity that would have the characteristics of regular physical exercise of at least three times a week for 60 minutes continuously. Along with them, there is a significant number of those who only occasionally have contact with recreational exercise (44%), which cannot be considered regular physical activity because they practice it once or twice a week for less than 30 minutes. There are 17.1% of regular recreational athletes, those who exercise every day or almost every day for at least 60 minutes in a row, while there are only 17 active athletes (4.4%). This distribution in the sample also determined the statistical significance of the differences (Sig. = 0.000) (Table 3).

Table 3. The level of physical activity and playing sports/physical exercise

Level (Index PA)	Playing sports/physical exercise				
	Active athletes	Regular recreation	Occasional recreation	No	Total
Very low (0-20)	1 0.3%	11 3.0%	85 21.6%	111 28.2%	208 53.4%
Low (21-40)	7 1.8%	22 5.7%	63 16.0%	16 4.2%	108 27.7%
Average (41-60)	7 1.8%	23 5.9%	18 4.6%	6 1.6%	54 13.8%
Good (60-80)	2 0.5%	9 2.3%	5 1.3%	2 0.5%	18 4.6%
Very good (80-100)	0 0.0%	2 0.5%	1 0.3%	0 0.0%	3 0.8%
Σ	17 4.4%	67 17.1%	172 44.0%	135 34.5%	391 100%
Chi = 213.553 df = 75 Sig. = 0.000					

What is interesting is that, among the respondents who declared themselves as active athletes, there is a certain (minimum) percentage of those whose level of physical activity is weak, that is, average. As the research did not identify in depth which sports students are specifically involved in, this finding can be interpreted from three angles: (1) that respondents may engage in a particular sport that does not require training/competitive activity of extremely high intensity, (2) that they are only members of a sports club without serious competitive and training potentials, perceive themselves as active athletes, but they are not, or (3) that they are "active" in the increasingly popular virtual (internet) sport, and thus perceive themselves as "athletes". In any case, the data show and warn that the significant majority of students included in the research (81.1%) belong to the corpus of insufficiently physically active persons.

DISCUSSION

The student population is a specific social group that is in a period of social transition. Since the study period is generally associated with a reduced level of physical activity, it is necessary to frequently draw attention to this problem (Mandić, 2020). In particular, the context of physical (non)exercise and/or (non)sports among students is even more drastically present (Nešić, Srdić, & Jezdimirović, 2016).

Current research confirms the generally accepted view on the benefits of regular physical activity, and especially physical exercise, i.e., recreation (Haskell, Blair, & Fill, 2009; Pratt, Epping, & Dietz 2009; Lavie, Ozemek, & Kachur, 2019). Special emphasis is placed on activities that have an aerobic and cyclic character - walking, cycling, running, swimming, etc. - and are based on natural forms of movement (Guthold et al., 2018). In addition to them, a significant recommendation applies to other contents of recreational exercise such as dance, aerobics, tennis, sports games, etc.

Students belong to a section of the population that is potentially at long-term health risk due to reduced levels of physical activity and a dominant sedentary lifestyle. In this regard, some research shows (Lewis, Jacobs, & McCretah, 2000; Bonevski et al., 2014) that young people in this period of life gain weight, with a significant reduction in physical activity, especially physical exercise, where most of them have been involved in sports during primary and secondary school, but ended active sports engagement during college (Keating et al., 2005; Deliens et al., 2014), with a tendency to no longer engage in sports even as a recreation (Nešić et al., 2015; Nešić & Nešić, 2020). This is in complete agreement with the research that dealt with the health issues of the population in Serbia, where it was stated that regular physical activity is less and less represented among the population in all population groups (Group of authors, 2014). It has also been identified that females are significantly less physically active and that a sedentary lifestyle dominates. In this sense, the data on the physical activity of students are also corresponding, which speaks in favour of the tendency to reduce physical activity among the student population, especially females. (Obradović et al., 2020).

The presence of (un)healthy living habits among young people today is one of the most frequently asked questions when considering the living and working conditions, especially of the student population. Available data show that life habits characterised as unhealthy dominate among the student population. Among the phenomena that are risky for health, the following are especially present: lack of physical activity, improper/irregular diet, sedentary lifestyle, etc. (Nešić et al., 2015).

The way of life led by young people, i.e., their adopted lifestyle, is an integral factor in the development of the modern student environment. It is an important driver of the search for the individual identity of young academics and an important determinant of their social connection, preferences, pretensions, and distance. (Tomić-Koludrović & Leburčić, 2002). In this regard, the choice of future occupation can be implicitly related to a certain lifestyle, i.e., it can be conditioned by positioned value orientations as drivers for the choice of future occupation. In this context, the personality of the future health worker is a very important link in the chain of affirmation, maintenance and improvement of public health, which, of course, emphasises the importance of a healthy lifestyle as a model of their behaviour and, in general, life habitus. Physical activity as part of healthy living habits and functioning through an active lifestyle should be the backbone of the medical and health profession (Barušić, 2018).

The results of this research draw attention to one specific construct of experiencing the quality of life among young people. Namely, they perceive the general quality of their life as quite good, without positioning their physical activities as an essential component of that quality. This can be seen from the data on self-assessment, where the vast majority of respondents believe that they live quite well ((87.9%); good - 37.6%; very good - 42.4%; much better than most - 7.9%). At the same time, their level of physical activity, based on self-assessment, shows low values in most of the sample (very weak and weak - 81.1%). Only 13.8% of the respondents in the sample have physical activity appropriate to the average student population. Such findings direct attention to the conclusion that most likely other factors, not physical exercise, sports and recreation, contribute to the feeling of quality of life among young people. This can be explained by the fact that these are people who are in the age when the health status of the majority is favourable, they do not have diseases that would significantly impair the sense of the quality of life. Also, they have positioned the focus in their life towards goals that are interesting and stimulating: studying, acquiring new knowledge, staying in a generational environment characterised by intensive social interaction. At the same time, most are not burdened with existential problems because they live with their parents, the financing of studies takes place through the state budget, with possible sources of personal income through scholarships, student loans, and the like. Also, the age of the respondents corresponds to the generation of so-called millennials, where the focus of life satisfaction is on the benefits of modern information technology. Sports and physical exercise, at least for most of this generation, obviously do not represent, at least not currently, an attractive enough environment for spending free time. Therefore, with a specific sample

of respondents, other inputs must be sought as a basis for interpreting the expressed sense of the good quality of life or practicing some other content that is relevant to today's student population. It is obvious that physical exercise is not a significant determinant of their perception of quality of life.

The results of our study can be considered consistent with similar research (Macanović et al., 2013; Nešić et al., 2015; Stojmenović & Milosavljević, 2017; Malčić & Marić-Jurišin, 2018; Nikšić, 2018; Badau et al., 2018) which emphasise the context of the pronounced tendencies of young people towards physical inactivity and the generation of a potential long-term dominant problem that may have later implications for their overall health. This is especially indicative when it comes to choosing a future profession. Future health workers should have healthy lifestyle habits, as well as nurture models of socially acceptable and health-related affirmative behaviour. Therefore, the importance of practicing regular physical activity is a desirable model of their professional orientation. However, as students of this higher education institution (and similar ones) live in an age of highly developed information technologies that inevitably lead to increasing alienation, a significant number of them are exposed to different types (and intensity) of hypokinesia. The results of the study support this despite the existing limitations (only one higher education institution, uneven distribution by gender and a limited number of respondents), and in this context once again draw attention and emphasise the need to activate all relevant scientific and social actors to raise awareness of students on the importance of preventive health actions. Such attitudes gain weight when considering the results

of recent sociological research that covered various aspects of young people's free time, which indicate that sports activities and active physical exercise are not sufficiently positioned categories in the life of the student population.

CONCLUSION

Our research, which focused on the identification of the level of physical activity among students of the College of Health Sciences in Belgrade, found that this part of the academic population is characterised by a low level of physical activity.

The data show and especially warn that the significant majority of students included in the research lead a sedentary lifestyle. The presence of very weak and weak physical activity was found in more than two-thirds of the sample. Respondents perceive the general quality of their life as quite good, without positioning physical activities adequately as an essential component of that quality, from which it can be concluded that physical exercise is not an attractive environment for them to spend free time.

Some of the possible causes of this research finding can be sought in: lack of knowledge of the student population about the values and essential determinants of kinesiology operators incorporated into various models of physical exercise, insufficient information about the importance of sports/sports recreation, but above all, the lack of a consistent system of physical education in higher education institutions.

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PROCJENA NIVOVA FIZIČKE AKTIVNOSTI I KVALITETE ŽIVOTA STUDENATA VISOKE ZDRAVSTVENE ŠKOLE U BEOGRADU

Ovo istraživanje ima za cilj da identifikuje nivo fizičke aktivnosti na osnovu samoprocjene i da utvrdi percepciju opšte kvalitete života studenata. Istraživanje je provedeno kao empirijska neeksperimentalna studija. Uzorak ispitanika je stratifikovan od studenata Visoke zdravstvene škole u Beogradu, njih ukupno 391, oba pola, prosječne starosti 20,3 godine. U uzorku ispitanika dominiraju osobe koje se uopće ne bave fizičkom aktivnošću (34,5%) ili se povremeno bave fizičkom aktivnošću (44%), dok redovni rekreativci, oni koji vježbaju svaki dan ili skoro svaki dan najmanje 60 minuta u kontinuitetu, čine 17,1% svih ispitanika. Rezultati jasno ukazuju na trend izražene fizičke neaktivnosti, odnosno dominantno prisustvo sjedilačkog načina života. U više od polovine uzorka utvrđeno je prisustvo vrlo slabe (53,4%) i slabe (27,7%) fizičke aktivnosti. Jedan od uzroka ovakvog stanja svakako se može pronaći u nedostatku znanja studentske populacije o uticaju odgovarajućih modela tjelevoježbi na zdravlje i kvalitetu života, a posebno fizičkih aktivnosti aerobne usmjerenosti. Većina studenata (87,9%) orijentisana je na visoko zadovoljstvo kvalitetom života, a što ukazuje da je praktikovanje nekih drugih sadržaja, koji su aktuelni u današnjoj studentskoj populaciji, važnija odrednica percepcije kvaliteta života od tjelevoježbe.

Ključne riječi: hipokinezija, indeks fizičke aktivnosti, kvalitet života studenata

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THE BATTLE OF THE BRANDS – MANAGEMENT OF SPORTS COMPANIES IN CONQUERING THE SPORTS MARKET

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ABSTRACT

The sports industry is developing rapidly every day, offering new products on the market and searching for new target groups. As soon as sport began to produce the mentioned success, results and services, that is, to satisfy a wide range of human needs, the need for sports management and marketing necessarily arises. Today, sport is considered a serious economic activity, with a sports market that is estimated to include about a billion people who are actively involved in sports, while it is estimated that three to four billion people regularly follow sports competitions through the mass media. Billions (of dollars/euros) are pouring into the sports industry, expanding its mission and helping its further expansion.

Keywords: sports market, sports brands, sports industry

INTRODUCTION

Sport has been developing rapidly for decades, creating an increasing number of competitions and thus developing sports companies that promote new types of sports equipment on the market every year, which has attracted media interest. From a simple amateur competition and primarily owing to the media that led to its commercialisation and professionalisation, sport managed to form its own market of supply and demand, created its own sports media, its target groups and consumers, and thus formed its own sports industry. Sports management is the main organiser within the sports industry with the role to plan future activities, organise business, manage production and service processes, as well as find the best staff who will perform the assigned obligations and control that all segments within the sports industry function. Without adequate

sports management, the sports industry itself would not be able to function. The exponents of the sports industry (athletes, coaches, managers, and the media) are able to break through all barriers. The difference between sports companies is increasingly being noticed due to the uneven investment of financial resources. Sponsors exclusively decide to sponsor sports that are attractive to the media and have a wide audience.

As can be seen in the pictures below, the sports industry consists of four basic exponents. The first are the athletes, the second are coaches, the third are sports managers, and the fourth exponents are the media. Each of these exponents has its role and is an indispensable part of the sports industry. It often happens that one person can perform or has performed several functions during his/hers career.

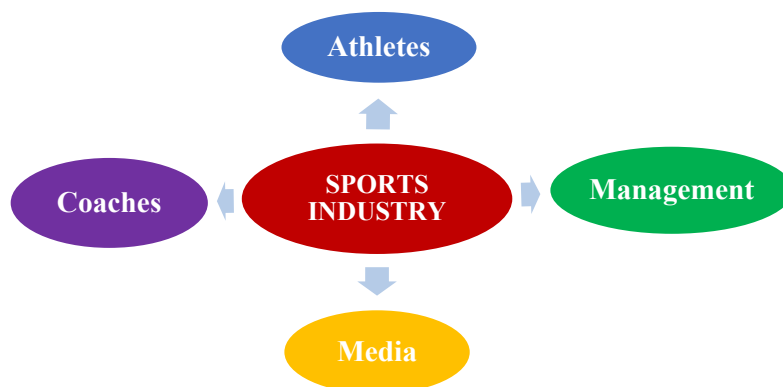


Figure 1. The main exponents in the sports industry ¹

In this paper, we will pay attention to sports management and marketing, i.e., sports companies that supply the global market with sports equipment. Sports equipment manufacturers have been competing with competitors for decades to conquer the sports market. In this battle of the brands, the management and marketing methods that companies use to attract consumers come to the fore. In the last two decades, traditional marketing advertising has become obsolete. In addition to television, sports companies continue to use the services of newspapers, magazines and billboards, but to a much lesser extent because the main type of marketing promotion has moved to the internet and social networks - digital marketing. In the search of new business methods, the sports industry has connected with other branches of industry, such as IT industry, fashion industry and environmental industry.

Comparative analysis shows us that today, compared to the past decades, sports companies have changed their business strategy and focused their attention on the neglected target groups, such as women's and children's sports, which represent a large part of the global market. In the past, sports equipment was bought exclusively for sports activities, while today, sports brands, connecting with the fashion industry, have created new styles, such as sports and casual style of dress for everyday life. Today, men wear sports sneakers with jackets, while girls wear sneakers with dresses, which was unthinkable a few years ago. Decades ago, it was unthinkable to see people in the streets walking in tracksuits, shorts and sneakers doing daily activities. At that time, the daily wardrobe consisted of shoes, pants (or skirts) and shirts and jackets, while sports equipment was used exclusively for sports activities.

Sport represents the highest degree of satisfaction of needs, desires, feelings, motives, and interests (individuals, groups), but at the same time, it is the scene of conflicts, rivalry, insults, and even small wars happening at the stadiums. On the other hand, sport is simultaneously becoming less and less a mass sport, and more and more a mass sport. Many commercial brands are trying to use the reputation of the Olympic Games for their own needs. Thanks to the fact that they are broadcast all over the world, sports have gone beyond national borders, and its financing no longer depends on the number of tickets sold, but on TV revenues and sponsors. At the level of global sponsorship, 2/3 of sponsorship is focused on sports.

Sports companies divide their business into three categories:

1. Professional sports
2. Amateur sports
3. Recreational sports

Globalisation has created a unique network of business interests and specific relationships that connect sports organisations, sports managers, sports agents, commercial partners (most often sports equipment manufacturers), and TV stations. In this way, three basic forms of modern sports merged: amateur sport (in the spirit of the Olympic Games), recreational sport (which has no competitive significance) and professional sport (which is primarily focused on commercialisation and profit). Due to the desire for a larger audience, and thus a higher income, the rules of many sports have been changed to make their transfer easier. The choice of the place and time of the competition, as well as their form, is in line with the needs of the market, and so the IOC has not managed to escape these pressures.

¹ Radošević, I., Gavrilović, A., Parčina, I., & Ahmić, D. (2020). Coaching management in the sports industry. Sport Science, International Scientific Journal of Kinesiology, University of Travnik, Faculty of Education, Vol 13, Issue 2, p. 135.

1. Professional sport means achieving sports results of an extremely high level, whether it is about athletes or sports teams. Sports companies enter into contracts for the advertising of their products with the best professional athletes and sports teams from all branches of sports because it is the best and fastest way to present their products to the target groups - consumers. The professionalisation of sports began in the period from 1970 to 1980, when the International Olympic Committee allowed professional athletes to participate in the Olympic Games. With this move, the sport grew into a professional competition on a global level, and since then, the development of the sports industry has grown unstoppably every year due to the great interest of spectators and the media, which has increased the number of sports competitions. The phenomenon of top sports today is a reflection of the global market. Now it is normal to talk, write and analyse sports competitions as a social event, market, production and consumption of goods, image, brand, profit, and entertainment. In this way, sport became not only a new perception of human possibilities, but also a social event that belongs to the visions of humanity (countries have been preparing for the organisation of large sports events for years). The development of people's needs, free time and mass media technology leads to professional and popular sports. This is reflected in sports competitions, which in certain sports and levels become sports and social events, spectacles in which athletes and clubs are marketable goods, but also idols of young people. Leaders turn into managers, athletes into gladiators who, through television, provide cheap entertainment to the public because sport is used for success at the sports market, that is, for making money.

2. Amateur sport, which is known in the world as non-professional sport, is a category of sports activities that achieve professional relationships between athletes and sports institutions. Amateur sports can be top-class, attractive (with a high degree of quality) and ordinary (with a low degree of quality) in terms of achieving a certain quality of sports results. Ordinary amateur

sport means that the athlete competes in sports disciplines only for himself, regardless of whether he achieves high sports results or his main goal is not to earn money from sports activities. Amateur sports help people to maintain fitness and health while simultaneously competing in various sports (football, basketball, tennis, golf, etc.).

Top sport is a category of sports activities in which athletes try to achieve the highest sports results with the help of their leadership, coaches and managers. Top sport exists in both amateur and professional sports. 3. Recreational sports today are the largest source of income for the sports industry due to the number of recreational athletes, which is measured in billions. From the point of view of profitability, precisely because of its mass, recreational sports bring companies the main form of income. All forms of sports are of great importance for individuals and society. The most popular recreational sports include fitness and running. Recreational sports have become synonymous with a healthy lifestyle. There are more and more people who play a sport recreationally. The main reasons for playing sports are maintaining or gaining physical fitness, maintaining or losing weight, the need for physical activity (muscle tone tightening), how to deal with everyday stress, etc.

RESEARCH

In the research on the reasons for buying sports brands on the Serbian market, which was conducted on a sample of 432 respondents aged from 18 to over 50, we came to the result that 47.9% of respondents said they regularly engage in recreational sports, that 31.3 % sometimes practise sports, that 11.3% of respondents rarely engage in sports, while 9% of the respondents do not play sports at all.

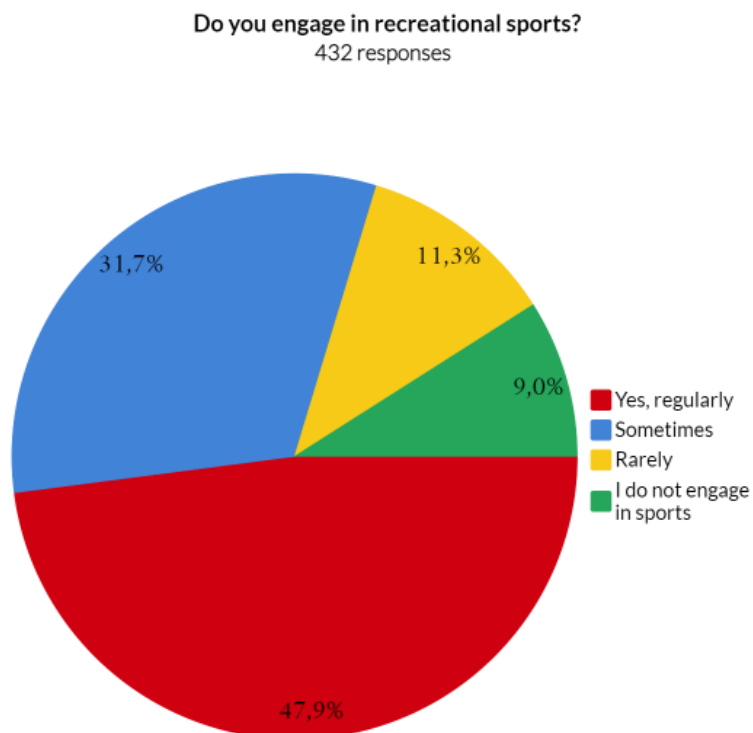


Figure 2. Percentage of respondents who practise sports

Research on the brands that respondents prefer in the purchase of sports equipment showed that the brands Nike (62.3%) and Adidas (51.4%) are most

often bought, while Under Armour (13.4%), Converse (11.8%), Asics (12%), New Balance (10.4%), Reebok and Puma (10.4%) are just behind them.

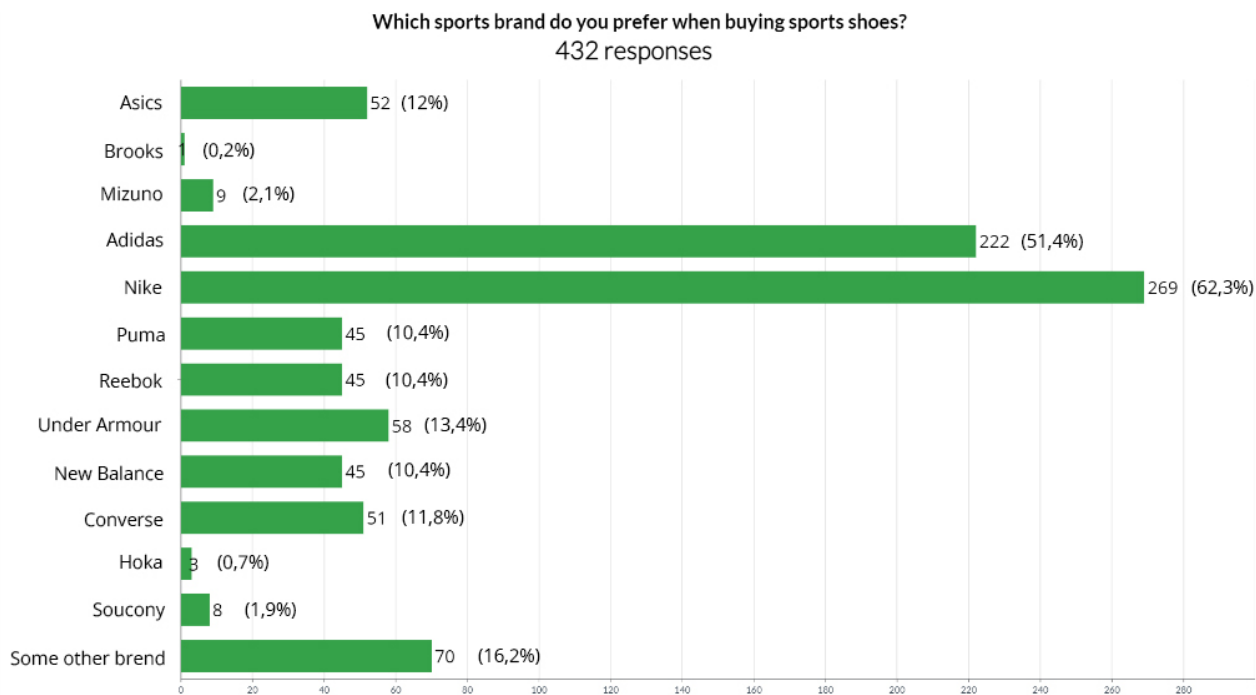


Figure 3. Brands that respondents most often buy

In excess of free time, consumer society offers sports alternatives and a form of life in which the consciousness of the masses identifies with sports aces who become deities, role models and imitators. Sport, as an activity and organisation, is also a historical product of mankind. At the end of the 20th century, sport became independent as a special social activity and production:

- from human health and psychophysical development to top level results;
- sports (physical) culture of body and mind, i.e., as sports socialisation;
- entertainment of the masses, owing to the development of mass media (TV, radio and press).

Sports segmentation

Sports companies have focused their products on the division in sports:

Team and individual sports

One of the most common divisions of sports is into team (group) and individual sports. At the global level, the most popular team sports are football, basketball, American football/rugby, volleyball, cricket, and hockey, while the most popular individual sports are tennis and athletics. The popularisation of sports is measured by the viewership, i.e., the interest of the media and thus the sponsors. Without counting tennis and athletics, individual sports are uninteresting to the audience and the media (as well as sponsors) in relation to team sports. The money earned by athletes in team sports, such as football, basketball and American football/rugby, can only be matched by tennis and golf in the category of individual sports.

Mass sports

For sports companies, mass sports represent probably the most interesting segment of the sports industry where companies see potential consumers. As the best example of sports for the masses, we can mention marathons and triathlons which have a large number of participants.

Profit and non-profit sports

Profitable sports make money for their services and products offered on the sports market. Profitable sports include football (UEFA Champions League, UEFA European Championship and FIFA World Cup), NFL (American football), NBA (Basketball League in North America), ITF (International Tennis Federation), and Formula 1. The most popular sports began to they make their own subdisciplines, some of which have already been included in the Olympic Games. Basketball made

3x3 basketball, volleyball made beach volleyball, football made futsal and beach soccer.

Many recreational sports can be classified as profitable sports. Running, fitness, cycling, skiing, and snowboarding have an increasing number of people who direct their interest, energy, time, and money towards these sports, at the same time using their products in the form of sports equipment and accompanying props. Also, there are more and more small sports clubs that use their infrastructure for commercial purposes, renting their facilities to recreational and amateur athletes in order to function and be profitable. Non-profit sports (athletics, swimming, gymnastics, martial arts, and skating) do not make a profit because they are not commercially viable. The interest of sponsors and the media in these sports is low until athletes who compete for their clubs receive money, as is the case of for-profit sports.

Extreme sports

The rapid development of the sports industry has led to the need to create new sports, new products, new markets, and new target groups. Extreme sports represent the latest sector within the sports industry, which gets more and more of its participants and followers every year owing to the media that are increasingly broadcasting sports competitions. Many companies have recognised the potential of extreme sports to create a new market for selling their products and making a profit. The best example is Red Bull, which has tied its brand to sponsoring extreme sports, such as bungee jumping, base jumping, wingsuiting, free climbing, surfing, BMX, esports, wakeboarding, ultrarunning, skateboarding, freeskiiing, air racing, skydiving, mountain biking, motorbike stunt riding, snowboarding, bouldering, motocross, cycling, rodeo, wakeskating, ski jumping, wingsuit flying, rugby, triathlon, snowmobile, rally, ironman, roller derby, sky-cross, alpine skiing, and so on, that are recognised globally. Their product (energy drink) fits perfectly with the adrenaline that is obtained from extreme sports. Participants in extreme sports are adrenaline junkies who are aware of the risk of potential injuries. The main disadvantage of many extreme sports is money because of expensive equipment for many of the extreme sports.

New sports

New sports for sports brands represent new markets, new target groups and demand for new types of sports products. As an example of a new sport, we can mention CrossFit, a new sports discipline that has become very popular in a short time, and for which more and more people who want recreational exercise prefer to go to fitness centres. As a result,

sports brands have begun to make special sports shoes for CrossFit that are different from ordinary shoes. Brands such as Reebok, Adidas, Nike, Asics, and Under Armor have been competing for decades to conquer this part of the sports market.

Sports marketing

Sports company marketing signifies marketing activities within sports companies (Adidas, Nike, Converse, Puma, Reebok, Asics, New Balance, etc.) which are used to promote sports products bearing the company logo (sneakers, wardrobe and accessories), using sponsorship agreements with athletes, sports clubs, federations, etc.

The sports marketing process begins when the manufacturing sector completes testing of its ready-to-market product. Then, using its methods, sports marketing implements a strategy of promoting a sports product in order to inform potential consumers about a new product on the sports market. The promotion of a sports product can be carried out in the following way:

- using general or classic marketing, which includes making a marketing strategy, analysing potential consumers, researching the sports market, setting product prices, and renting advertising space (television and radio commercials, newspapers and billboards);
- using digital marketing, which is the most important method in marketing promotion because its activities are aimed at advertising and promotion via the internet, thus addressing only its target groups, i.e., potential customers who use the internet;
- using social networks that have access to potential consumers (YouTube, Facebook, Instagram, TikTok, and SnapChat)

Marketing research is conducted to define the target group that sports marketing wants to address in order to promote their products and make a profit. Convincing a potential consumer, who is part of your target group, to buy your product from all the similar products on the market is a major challenge for any marketing sector in a sports organisation or company. This selected product must be distinguished from all others by the following items:

- to be part of an already built brand;
- design (the look must be attractive to potential consumers, it has to provide more of a reason for the customer to choose this product in relation to others and it must attract the attention of others who will look and comment on the purchased product);

- quality (which must be at a high level because no one wants to buy low-quality products);
- price (which must be affordable and justify the purchase)

Sports companies divide their products into spring/summer and autumn/winter collections. The spring/summer collection is made of materials where the skin can breathe (canvas sneakers, thinner materials on shorts, T-shirts and tracksuits), while the autumn/winter collection is made of firmer leather or waterproof (Gore-Tex) materials, which will prevent water, rain, snow, wind, and similar occurrences to come in contact with the skin.

Athletes' sponsorship

Why do sports brands sign sponsorship deals for the world's best athletes?

The recognisability of a brand can best be seen through a top athlete who promotes it. Nike signed a sponsorship agreement with Michael Jordan, and thus became the most recognisable sports brand in the world. Jordan even got its own sub-brand within Nike - Air Jordan, which has become a trademark of global basketball. Today, his successor is LeBron James in basketball, while Cristiano Ronaldo is a trademark for football. Ronaldo has 593 million followers on social networks, more than Real Madrid (251 MM), PSG (133 MM), Barcelona (248 MM), and Manchester United (163 MM). Nike gained incredible visibility and brand promotion through Ronaldo.

Every sports company wants to have its own sports promoters in the most profitable sports. Thanks to the results that an athlete achieves during their career, companies decide on one athlete who will promote their products throughout their career.

As part of their strategy, sports brands have begun to relate to certain sports. Adidas has become synonymous with football since its inception, while Nike has been synonymous with basketball (especially the NBA league). Asics as a brand is closely related to the marathon, and their sneakers are among the most comfortable and favourite among runners. Of course, we must mention that almost all brands have their models of sneakers and other equipment intended for most sports, trying to take over a part of the market from the competition in order to impose themselves as leaders in the sports market. That is how Nike entered the world of football, sponsoring the best football player in the world, Cristiano Ronaldo, as well as football clubs Barcelona, Liverpool, Chelsea, PSG, Atletico Madrid, Tottenham, and Inter. Adidas tried to enter the world of basketball by sponsoring the NBA League as well as several NBA basketball players, but failed to impose itself, and so they eventually withdrew while Nike remained the leading brand. Under Armor is

a relatively new brand that has emerged in the sports market, offering equipment for basketball, rugby and football.

- When choosing a club they want to sponsor, sports brands set conditions on the basis of which they decide whether to sponsor the club and how much money they will offer:
- Does the club compete in the highest rank of the competition (Champions League, Euroleague, etc.)?
- Does the club aspire to win the title/championship?
- What is the army of fans that supports the club, both in the country and abroad?
- Is the club financially stable?

CONCLUSION

The battle of brands to conquer the sports equipment market is growing every day. Strategists of leading companies are devising new methods of finding new products and new target groups of consumers in order to increase sales of their products, thus increasing their profits. Promoting brands using top athletes has proven

to be the most cost-effective method of promotion, as their followers on social networks are used, numbering in hundreds of millions. For example, if Cristiano Ronaldo (593 MM fans) posts a product on his networks, it means that almost 600 million people will see it. If they tried to address so many consumers with traditional methods, Nike would have to pay much more.

In the research, we showed how many respondents regularly play sports, how many sometimes play sports, how many rarely they play sports, and how many do not play sports. All participants are buyers of sports brands, either as participants in sports - 91% of respondents, or as those who said they do not play sports but also use sports products (sneakers, socks, tracksuits, leggings, shorts, T-shirts, etc.) for daily use - 9% of respondents. Respondents who regularly play sports buy more sports products. Research on the brands that respondents prefer in the purchase of sports equipment showed that the brands Nike (62.3%) and Adidas (51.4%) are most often bought, while Under Armor (13.4%), Converse (11.8%), Asics (12%), New Balance (10.4%), Rebook and Puma (10.4%) are just behind them.

The future of sports companies will depend on the sale of sports products. In the 21st century, owing to digital marketing and social networks, sports brands will be able to reach their target groups much faster and easier.

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BORBA BRENDOVA – MENADŽMENT SPORTSKIH KOMPANIJA U OSVAJANJU SPORTSKOG TRŽIŠTA

Sportska industrija se svakim danom ubrzano razvija nudeći nove proizvode na tržištu i tražeći nove ciljne grupe. Čim je sport počeo da proizvodi spomenute uspjehe, rezultate i usluge, odnosno da zadovoljava širok spektar ljudskih potreba, nužno se javlja potreba za sportskim menadžmentom i marketingom. Danas se sport smatra ozbiljnom ekonomskom djelatnošću sa sportskim tržištem za koje se procjenjuje da uključuje oko milijardu ljudi koji se aktivno bave sportom, dok se procjenjuje da tri do četiri milijarde ljudi redovno prati sportska takmičenja putem masovnih medija. Milijarde (dolara/eura) se slijevaju u sportsku industriju, proširuju njenu misiju i pomažu njeno dalje širenje.

Ključne riječi: sportsko tržište, sportski brendovi, sportska industrija

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