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COMPETITION EXPERIENCE, RELATIVE AGE EFFECT AND AVERAGE AGE OF THE SENIOR WORLD EVENTS' MEDAL-WINNING BASKETBALL PLAYERS

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ABSTRACT. The International Basketball Federation (FIBA) has changed its youth competition system in 2004, and due to this regulation, many players had the chance to compete every year at youth level and later, to elevate to the top. The purpose of our study was to inspect those medal-winning European basketball players who competed in the past 19 senior basketball world events. We analysed the tendencies of selection by dissecting the set-up of successful senior national teams. We investigated each one of the 281 European basketball players who won a medal during the analysed period (2000-2019). We collected data from the archive page of FIBA. Our goal was to see whether there was a relation between the youth competition experience and the minutes spent in senior world events. We used the Cramer Association Coefficient, Relative Age Effect and average age were also inspected. We found that participation in the national youth tournaments is important but not the most exclusive factor of selection. There are opportunities for success in the adult national teams for players who have covered alternative sports careers – the factor of national youth experience is not exclusive. We suppose that head coaches utilize older and more experienced players on the Olympic Games, the average ages of successful Olympic medal-winner teams are higher than other world events' medallists. Despite the fact that we were not able to find statistically proven and associative relationship between national youth recruitment eligibility and the minutes in game spent by successful adult players, further research could be gap fillers in exploring key factors in adulthood efficiency.

Keywords: *talent selection, competition experience, FIBA, basketball players, sport career.*

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Introduction

The sport sector utilizing its own economic potential has gained global proportions nowadays. Due to the media broadcasting there are more and more people start practising sports, and more and more spectacular sports appear on the horizon. Besides the micro sized and national competitions there are international championships organized, nations compete with each other for the sake of fame, and the envisioned economic benefits in a direct (in case of sport businesses) or in an indirect way (in case of national economic advantages through national teams). Professional sport has increased to such a level that demands the use of the newest techniques of selection and training methods. Therefore, there are younger and younger sportsmen appearing in the international competitions (Wiersma, 2000.).

There is great competition in the development of selection efficiency in the different sports in and out of the playing areas. The cornerstone of sport science is the exploration and understanding of factors that affect exceptional performance the most (Starkes and Ericsson, 2003; Baker and Farrow, 2015). For building and maintaining a competitive advantage it is constantly necessary to learn the latest knowledge and put it into practice. Using the toolbar of science, earlier research examined how much results and competitions define performance in the future. Can future results be predicted based on the past?

According to Baker et al (2017), the field of talent selection is based on the hypothesis that in the early period of a sportsman's development performance appears as an indicator of the sportsperson's future potential. Barreios et al. (2014) did not find any correlations between success achieved in the recruitment period and efficiency in adulthood. Inspecting rugby players, Till et al (2015) doubted the efficiency of talent selection at an early age. However, opposing their results, Harsányi (2009) doing research among athletes found that 'contest performance of athletes, who are successful at the leading edge international standards, could be a selection indicator especially if other factors confirm it (e.g. shape, psychological, social and/or training method factors)'. Schumacher et al. (2006) state that those cyclists who had taken part in the junior world championships were more successful as adults than those who had not had that opportunity. More research confirmed the point of view saying that exceptional individual performance in the recruitment can increase success in adulthood. Brouwers et al. (2012) and Pereira et al. (2014) ended up with similar result in gymnastics and tennis. Moxley and Towne (2015) found that one of the predictive systems that can be most easily localized among basketball players playing in the NBA is the players' universities; players coming from universities conferring high prestige basketball had better performance in the elite league.

This article is not intended to decide on forecasting only wishes to give a mental framework by analysing a team sport, basketball, from the viewpoint of sport competitive experience. The research aims at the analysis of the world competitions of the sport for the past twenty years with the intention of having objective and measurable data in connection with the player content of successful national teams and observing the different tendencies. We would also like to find an answer to the question: is experience in international recruitment competitions an indispensable condition for successful performance in adulthood?

Methods

Traditionally we take the medals, records, and victories as the measure of success in sport (Penney, 2000). We took the first, second and third placements as the subject of our research as a measure to analyse the relationship between adult success and participation in youth recruitment tournaments. We analysed the period starting from the Olympic Games in Sydney in 2000 to the world championship in China in 2019. In these 20 years there were 19 European championships, world championships and Olympic games organized by FIBA: 5 world cups and Olympic games respectively and 9 European continental championships. It is worth emphasizing that the subject of this research were the sportsmen of European national squad players. We analysed only those teams who achieved first, second or third placements in this period.

The most successful national basketball team with world-power is the squad of the USA, that gained 4 golden medals in the last 5 Olympic games. With its diverse and unique competition system it could become the focus of a next research, however, presently, we are taking the teams whose competition system is defined and monitored by FIBA Europe into consideration. In the 19 events the medals were distributed among 12 nations. 10 out of 12 countries were European and this concentrated distribution of medals confirmed our scope of interest. During the research we looked at team squads of 684 people altogether, based on the free to use archive pages of the webpage of FIBA on the Internet. After data organization the number of players with actual number of medals reduced to 281 people since there were more players in the national squads who performed repeatedly in the different basketball world events.

In 2004, there was a substantial alteration of the competition system of FIBA and instead of the European youth championships organized bi-annually there were series of competitions introduced with different names – called as U16, U18 and U20 European Championships – that were organized annually. Instead of the previous cadet, junior and senior age groups you could find the

above-mentioned age groups. An important stage of the alteration was the ranking the national players into Division A and B and from then on there were 16 teams competing in a group matches and then in cross matches for the more upscale places. The alteration of competition systems and the past 16 years gave us the opportunity for testing the impact mechanisms due to the transformation.

According to our hypothesis, those national squads that display strong team cohesion with their players playing together for long years tend to be more successful internationally. We suppose that teams with stronger cohesion and more homogenic squads are more successful than those which change their team members every year. The CIES in Switzerland took the 13 seasons of the TOP 5 football leagues into consideration, examining the relationship of collected points after each season and the fluctuation within the team. They found a negative correlation – the more players they had at a team the fewer points the team collected by the end of the season, and they performed better when there were fewer changes in the player personnel. We thought stability can be observed in the player squads in question as well, therefore we examined the change of percentage composition of teams that gained medals for more years.

We supposed that successful teams primarily depend upon players who were once recruited youth national players and we also presumed that the rate of recruited youth national players increased within the squad due to the transformation of the competition systems. Our hypothesis predicted a decreasing tendency in the significance of being a national player in the careers of the players in the U20 group. At this age, the best players could appear in the national players' squad already. We supposed that we would find players who never made it to the youth competition system of the FIBA but still got medals with senior national teams.

The player data saved from the archive webpage of the FIBA (archive.fiba.com) were first sorted out with the help of Microsoft Excel 2013 and summarized, then we generated two groups. The first group had the players who got medals in an adult competition in the research period and were able to play in the previous youth competition system (players born before 1984). In the second group we put those players who also got medals, but they could only participate in the youth national squads just after the transformation of the competition system in 2004 (players born in 1984 and later). 159 players represented the more experienced age group in the research period, the younger age group had 122 players with medals in the senior level. The subject of our research was aimed at the competition experience of recruited players. We used descriptive statistical methods to compare the generated groups. Besides their experience we also examined the age and date of birth when they first started playing and the changes of age average of the teams as well.

The so-called Relative Age Effect (RAE) is present in the recruitment level and so in basketball, too (Delorme et al. 2009; 2011). Integrating the data of adult players, we were curious if RAE is present in the whole sample and the two generated groups.

The most often used measures for analysing individual performance in scientific context are the game-related statistics (Sampaio et al. 2000). As it is more difficult to measure individual performance in team sports (Ericsson et al. 2003; Reilly et al. 2000), we underlined played minutes as an objective measurable unit. This is the indicator on basis of which players based on their role can be ranked.

Minutes have always been based on the decision of the head coach; the subjective, perceived usefulness of players. We generated three groups in connection with minutes: those who play many, play enough and play few minutes; the groups were defined by their minutes in their own teams. In basketball there are 12 people so selecting the team into 4-member-groups a national squad can be trisected. Our goal was to see whether there was a relationship between the youth competition experience and the minutes spent in senior world events. The Cramer Association Coefficient was used for the research the relationship between the criteria.

Results

The following figure shows the medal winning players' eligibility for national duties in recruitment:

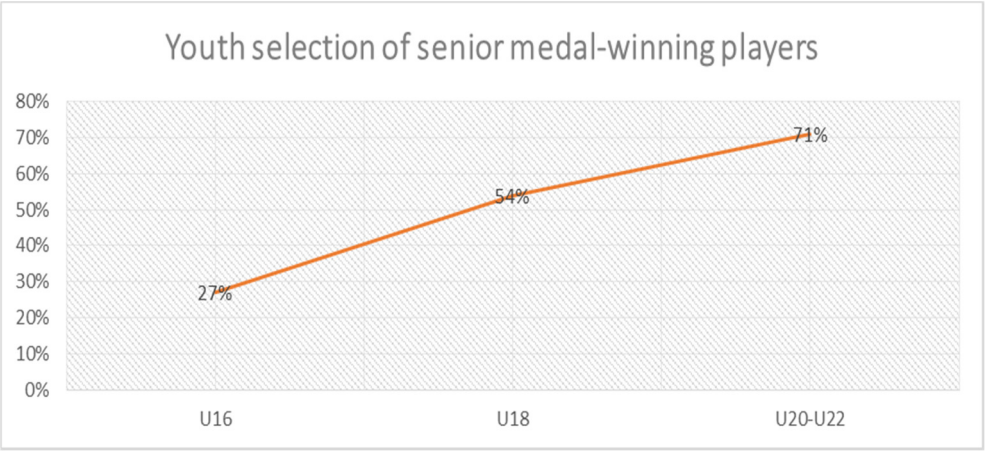

Figure 1. Players' eligibility for national duties in recruitment in the research period (2000-2019) (figure by the authors)

The least significant recruitment tournament is the cadet, or in its new name, the U16 championship where fewer than one third of the adult players took part. In the flattening of the line, we can state that there were fewer players who became U20 from U18 than U18 from U16. A probable explanation can be found in the fact that talented players got into the senior squads skipping the last step of the ladder, the U20. Regardless of all other rates in eligibility for national duties, performing in the U20 – which is the closest to the adult level – dominates with 71%. If we compare the players according to their age groups, there is a subtler picture.

In the more experienced players' age groups cadet eligibility was practically negligible from the viewpoint of getting into the senior national squads, fewer than one fifth of the players belonged to this age group. The steep line indicates that despite the rates which showed fewer recruitment players eligible for national duties who were born before 1984 in all age groups, the last step of recruitment was taken by much more players proportionally than players from the younger generations compared to those from the U18 group. This is probably due to fewer chances to play in the international field (international youth tournaments in every second year), and the hardship of getting into the senior national squad, so U20-U22 tournaments played a greater part in selection; it was a kind of breakout for the youth.

Relative Age Effect, Average Age, Changes in the Framework

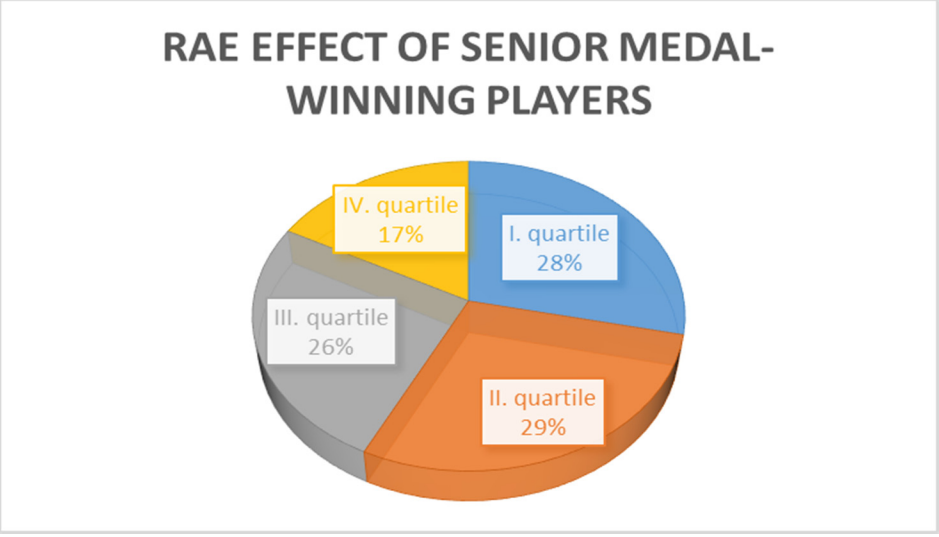

Figure 2. Medal-winning players' date of birth (figure by the authors)

The difference is less detectable between the younger players from the U18 and U20 tournaments. Prestigious international club tournaments and increased financial possibilities of the teams nowadays allow alternative individual developmental paths. The significance of the youth national team competitions shows an increasing tendency in the analysis of the framework of the adult national teams, and if we take the sample as a whole, we can see that 84% of the players participated in some recruitment national team.

Analysing dates of birth show that 57% of the players were born in the first half of the year. As early development and the inherent selection meant advantage already in the recruitment level (Gladwell, 2008), and the players born in the first or second quarter of the year were eligible in the squads sooner.

The phenomenon can be due to fewer opportunities for competition, less flexible selection methods, less cohesion and less developed scouting system, immature individual training, and the lack of knowledge in connection of developmental paths within the team sports. The so-called relative age effect can be observed primarily with the recruitment teams, later the dates of birth quartiles were equalized in the adult level and the effect is not as strong. The reason for equalization and appearance of players (who were born in the second half of the year) in the adult national squads is the so-called 'rocky road theory' (McCarthy and Collins, 2014). Young sportsmen who were able to establish a high degree of resistance and rigidity, can make profit form their perseverance and achieve eligibility to adult national squads. Development of talent is therefore not linear, many times it can be due to traumatic effects as well (Collins and MacNamara, 2012).

Sportsmen of different sports achieve the edge of their performance in various ages, moreover, we can also differentiate the career length in certain sports as well. While there is a shorter career in some individual sports the maximum performance comes at an earlier age, in team sports it is not rare for a sportsman to achieve success permanently for more years. Gymnasts reach elite performance through early specialization and deliberate practice while on the other hand marathon runners are more likely to reach their elite performance by sampling, deliberate play and by focusing later on deliberate practice (Côté, Lidor, & Hackfort, 2009). Football researchers (CIES, 2018) examined nine years of all the European leagues and found that there is a significant correlation between the average age and the UEFA ranking of the domestic leagues. The more experienced players perform in a league the higher the given league ranked in the international level. According to the research the average age of players of teams winning the football championship was 26.5.

Below, we have examined how the average age of the involved teams in the research changed every year. We found that in the European championships (average age: 26.80) and the world championship (average age: 26.93), teams with younger players could step on the podium. The squads which got medals at the Olympic Games had a team framework with a year more experience (average age: 27.67). Since the Olympic Games is considered the highest international competition of selection, we can see the coaches' rationality and caution.

Supposedly, older players must have had more trainings and participated in more sharp competition than their older fellows that can be an important factor in setting up the national squads. Head coaches tend to change the squad's composition after a four-year period and give opportunity to younger players. In the examined period there was only one occasion when the average age of the medal-winning teams increased after an Olympics. The average age of the players in our sample were 27.07 years.

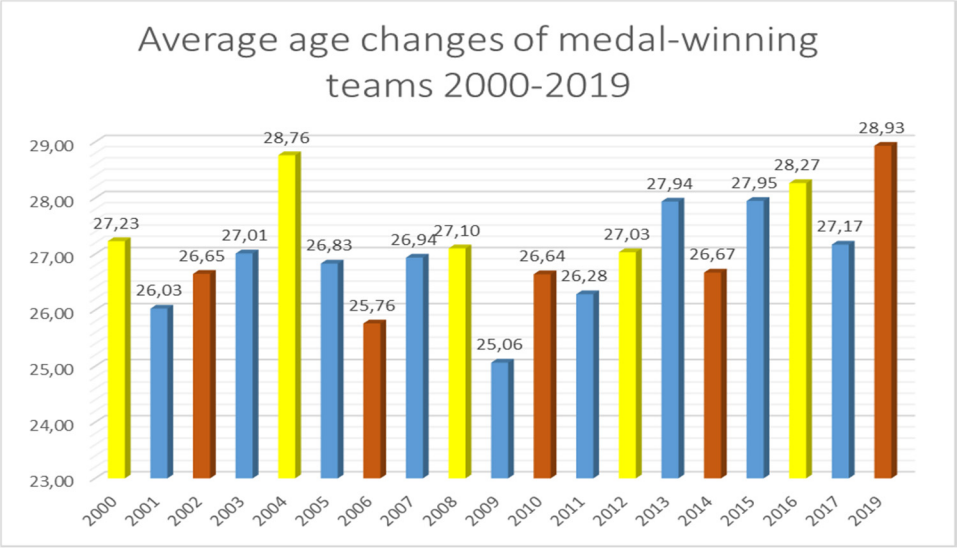

Figure 3. Changes in average age in medal-winning teams (figure by the authors)

In connection with the changes in average age and the observable cyclic nature we looked at the changes in the composition of the most successful European squads. In the research period the Spanish national team was the most successful in Europe. Their squad was based on well-defined player personnel. The determining players were present in all squads which won medals, the team gaining golden world championship medal in 2006 and the

team getting silver medal in the European championship in 2007 were based on in 100% of the same personnel. It is an informative piece of data that 5 players from the 2009 European Championship winner team were part of the winning team of the 2019 World Championship as well, and this is 41.6% of the squad. In case of the Spanish there were no squads which had not entered least 5 players from its previously medal-winning teams for the actual world competition. Among the most successful European teams we can find the French and Lithuanians as medal-winning teams. Although they did not achieve similar results as the Spanish, we can find the most determining players playing important roles for success from competition to competition.

Analysing the squads, we can state that we cannot figure out a universal recipe for success in connection of the average age and composition, however, the most successful national squads were mostly composed of an ideal mixture of experienced and young players. An exception is the European Championship in 2009, where Serbia won a silver medal with the youngest squad among all the medal-winning squads (22.93).

The Correlation between Minutes and Recruitment Eligibility

While fighting for the final victory and the glory, teams want to be the most competitive. Reaching victory requires playing of the most qualified. From these preferences comes the fact less qualified players can spend fewer minutes in game than the more qualified ones. Therefore, the minutes of players are differentiated in performance - and victory-oriented teams (Thiel and Mayer, 2009). We started out with our supposition that coaches keep their most useful players for the longest time in game for the sake of success.

Barry M. Staw and Ha Hoang (1995) researched whether there is a phenomenon present in economy that is called 'sunk costs' in basketball. They took the NBA as a base and examined all the first and second round drafted players in seven seasons. From these players, 53 never got contracts from teams and so the sample contained 246 players. The research result showed that those players who were drafted in a higher position had contracts for longer periods with higher payment than those who were among the last on the list. Previously higher ranked players could spend more minutes in game and were trusted more even if their performance were not proportional with their payment. Those who were drafted later and so were thought to have been weaker, got fewer opportunities and were changed more often.

In our own research we were curious to see whether a preliminary piece of information as experience in junior recruitment competition impacted the decision makers. Does having a recruitment eligibility have a positive effect on

the player's minutes in adult games, is there a correlation between the given minutes and the age-matched selections? We were looking for relationships among quality criteria, so we had a word association test done based on the Cramer associative coefficient during our test since we had more than two criterion versions. We tested the players who were never part of a youth national team and those who participated in every tournament (0.1), altogether (N=92). We put the players into three groups: player who played a lot, played enough and played little (1, 2, 3). We created the following conversion tables:

Basic table

	1	2	3	
0	13	17	14	44
1	18	10	20	48
	31	27	34	**92**

Chi-square table

	1	2	3	
0	0.224914	1.293515	0.314346	1.832774
1	0.206171	1.185722	0.28815	1.680043
	1.431085	4.479237	3.602496	**3.512817**

$$T = \sqrt{\frac{\chi^2}{N \cdot (n_A - 1) \cdot (n_B - 1)}}$$

Tmax = 0,8409

T =	**0,138**
C =	**0,164**

Figure 4. Basic table, Chi-square table Cuprov and Cramer associative coefficient (figure by the author)

The Cramer associative coefficient is C=0.1643, on the basis of which we can see a weak stochastic relationship between competition experience and the played minutes in game. Most (34) of the 92 players played little, however the distribution of their minutes was normal, no players of any groups were over-represented. When we grouped the players according to their participation in the old and new competition system, important differences were explored.

From the players born before 1984, there were 17 participating in all the youth championships and from them 10 players spend much time in game as a senior medal-winner (58.82%), so in the older generation who played much with a higher chance since the system rewarded all players who had got through all the steps of recruitment (e.g. Andrei Kirilenko, Sarunas Jasikevicius). There were no significant differences in connection of the minutes of adult recruitment squads. Most of them represented players who played little, 14 of the 34-member group.

In case of players born in 1984 or later and participating in all the steps of the recruitment, we explored a conflicting thing as opposed to the older ones. The greatest group was created by those who were part of the youth recruitment squad multiple times still playing little in the adult level: 17 of 31 players (54.83%). There were altogether 7 players, who were born in 1984 or later, who had not participated in any European recruitment championships. It is especially important while analysing this age group, that from those who were not recruited in their younger years, later, in the senior level they played enough or much and were determining members of their teams. For example, we can mention Luka Doncic who is said to be one of the best players in the world. A separate research examined the recruitment eligibility of the players who spent the most time in game because of the coaches' decision. In 19 world competitions there were altogether 26 players got the most opportunities from their coaches, many of them enjoying the trust of the actual head coach (e.g. Pau Gasol). 4 of them got meaningful minutes who had never participated in the youth level. This is 15.3% of the seeded players, with a rate like that of the whole sample (15.9%). The same way, seeded players were present among those who have been to all the steps of recruitment (3 players) however, the base here was from people who were eligible for national duties but did not participate in every tournament (19 players – 73.09%). In this respect the dual nature of recruitment eligibility was proven.

Conclusions

With the great competition reform of 2004, the FIBA achieved more international competition opportunities for players in the recruitment squads, players had opportunities to perform every year. Therefore, more and more players had the chance to play and develop. Our results prove that while there were players in the national squads who had not played in youth international tournaments (N=37), this number decreased spectacularly in case of younger

generations. There were altogether seven players born in 1984 or later, who got a medal in an adult competition without being a member of a youth national team.

The importance of international youth tournaments was shown since 84% of the examined players had participated in national squads sometime earlier in their lives. If we take only the senior medal winning players according to the new competition system, 94% of them had been selected to the U16, U18 and U20 events. The rate of adult sportsmen participating in youth tournaments could be supposedly higher in case of individual sports, this hypothesis can be a subject of a further research.

Talent identification programs primarily favour the early developing players (Johnston et al. 2017), however the late developers cannot be excluded since the periods of sport career and the performance ceiling can be individually different as well. Looking at the 2004 Olympic Games showed that 56% of the performing sportsmen had competed in international level first as adults (Vaeyens et al., 2009). Our results show that those who were born after 1984 and were part of the successful teams without recruitment eligibility, also played enough in their senior squads were remarkably playing much and were determining. The associative relationship between recruitment eligibility and minutes played in the adult level statistically could not be proven. The inspection of correlational relationship between the results achieved in the recruitment level and adult level can be subject to further research.

Success and performance in the recruitment age is neither sufficient nor necessary condition for the later success (Vaeyens et al., 2009). Our research shows that experience in recruitment competition (similarly to early success) is not an exclusive criteria and not sufficient preconditions for the international success later. There is a greater rate of players from youth national squads in adult level. It is assumed that these medal-winning teams have excellent supply foster systems, since it is hard to get into the adult framework from outside arrivals, however, the analysis shows that- one can get a major role with such a past and get into the senior squad.

The goal of sport associations is to ensure equal conditions for the players to achieve a long-term professional sports career; the transformations of competition system and offerings of wide range of opportunities to compete provide excellent points of reference. For the individual tailored player profiles the expanding access to developing toolbars, the sports scientific methods and statistical database can lead to further research to localize the key selection factors.

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SCHOOLING AS A POSSIBLE SUCCESS FACTOR? A NOVEL INVESTIGATION OF DETERMINING FACTORS OF SUCCESS IN FOUR SUMMER OLYMPIC GAMES

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ABSTRACT. The exploration of factors underpinning Olympic success (number of medals won) extended to the Human Development Index (HDI). Analysis of the Rio Olympic Games supported the influence of geographic and social variables. *Schooling* was one of the most important predictors and together with *population* explained 64%; when adding geographic variables (*North-West* and *temperature)* 67% of Olympic medals won were explained. This relationship was validated in the last four Olympic Games (from 2004 to 2016). This is the first study ever to demonstrate that specific social and geographical factors determine more than two thirds of the variance in Olympic success.

Keywords*: Olympic medals, HDI, schooling, population size.*

Introduction

Investigating Olympic success is an interesting and important field of research, given the importance attached to it by both a nations' citizens and governments alike. While there are some conflicting views, Olympic success is widely recognised in many countries as having positive impacts on three discrete yet often overlapping areas: image, economy, and physical activity and health.

Moosa and Smith (2004) identified that Olympic success is a source of national pride or disappointment for citizens and governments, reinforces public good and national identity, and improves a country's international image, promoting its reputation.

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Economic gains have also been attributed to Olympic success with more public spending during and after the Olympic Games (O'Brien and Onorato 2018). In economic terms, hosting an Olympic Games helps the host city to develop its infrastructure and attract tourists (Feizabadi *et al*, 2012).

Increasingly, local and national governments have linked Olympic success to the quality of people's lives with contemporary agencies focussing on physical activity and well-being. The relationship is two-fold. Olympic success boosts participation in sport, recreation and/or leisure-time physical activity. To prime these opportunities, Olympic success also encourages governments to invest more in sports and leisure facilities and the development of health-related physical activity provision.

While there have been many claims made about the benefits that may accrue from being a successful sporting nation at the Olympics, it is worth noting that there seems also to be mutual relationships between economic, political and social characteristics which can likely impact on Olympic success, either directly or indirectly (Humphreys, Maresova and Ruseski 2012). Amongst those factors, eliminating barriers such as lack of time, poor sports facilities and little financial support for sports participation seem paramount.

At the inaugural modern Olympic Games in Athens in 1896, there were only 245 participating athletes, representing 14 nations. However, over a century later there were forty times more athletes (approximately 11,250) who were representing 207 nations (International Olympic Committee [IOC] 2018). With greater participation and gender equality (BBC Sport 2018), there are more medals now for countries to win, but the numbers of countries and participants taking part have also increased thus forcing a concomitant expansion of competition for medals. However, this increase in the number of participating countries does not always lead to greater spread of medals won. Tcha and Persin (2003) noted in their work that many countries win no medals, while others with higher GDP do better across more sports.

One of the key issues thrown up by this emphasis on Olympic success and relating this success to medals won, has been considered by De Bosscher *et al* (2008). They contended that sporting success can be considered in both absolute or relative terms. In proposing analyses that veer towards relative success, they argued that absolute definition of success in which medals won created a research bias that is difficult to overthrow. For example, total medals won as a measure neglects the quality of those medals: are ten gold medals (outright winners), given the same rankings as five silver and 5 bronze medal winners? They looked at awarding points for different types of medals and found few differences in the ratings of top 10 countries in 'ranking' tables (De Bosscher *et al*, (2008). In fact, Kuper and Sterken (2001) felt that the number of participants from each country provided a better judgment of what made 'success'.

These results led De Bosscher *et al* (2008) to develop their enquiries to consider items that might be used to re-define success, from absolute to relative success. One way that they felt that success could be considered is by using two of the most obvious variables: size of population and wealth of a country. Yet, both measures show different results. For example, when looking at results from Athens in 2004, when medals or positions were divided by population, Bahamas became the most successful nation. (De Bosscher *et al* (2008). Similarly, when a country's wealth was considered the medal tally of China placed them first when GDP per head of population was involved (De Bosscher, 2008). Thus, De Bosscher *et al* (2003; 2008) work concluded that several determinants at time were needed e.g. geographical area; degree of urbanisation; religion; political system).

Until 1989, monarchies and single-party or communist systems employed different approaches to participation, training, and incentives for success on the world stage. This skewed historical data with respect to medals won due to the role of the ideological or political will of countries' leaders (Green and Oakley, 2001; Green, 2005; Tan and Green, 2008; Andreff *et al,* 2008). Political support leads to institutional support in the form of finance and rewards, which in turn leads to improved services for athletes and coaches. Very often, they also hold numerical advantages in population terms a determining characteristic that was supported by Lui and Suen (2008) and Soos *et al* (2017).

Overall, a tendency has emerged, that many wealthy nations (e.g. Germany, United Kingdom and France) as well as some other countries (e.g. United States and Russia) with large populations and strong athletic traditions, state-of-the-art training facilities, and significant sports science and coaching support have become very successful over a long period and several Olympic cycles (e.g. Andreff, 2001; Lui and Suen, 2008; Soos *et al, 2017)*.

Recently, links point to education being of importance in promoting success (Lawrence, 2017; Noland and Stahler, 2017). The latter authors stated: "Rather than per capita income, education is much more positive determinant of medal winners" (Noland and Stahler, 2017, p4).

The complexity of differentiating predictors of success can be highlighted in this area with Noland and Stahler's (2017) work identifying tight correlations between educational attainment and income measures, indicating that more affluent countries invest more heavily in education.

There have been several hypotheses that suggest what might be the most influential factors to affect Olympic medal success. These have included demographic, geographic, political, cultural, and economic hypotheses. Hong (2006) promoted the demographic hypothesis, by describing populous countries, like China or USA, that have a large talent pool based on population size. She suggested

that the size of the population provides greater opportunity to select and train more elite athletes who will be capable of winning medals at the recent Olympic Games (see also Andreff (2001))

The geographic hypothesis (Hoffmann, Ging and Ramasamy 2004) described the benefits of warm weather training conditions in some countries with optimal or more ideal climate and weather conditions being prevalent for sports. This hypothesis has been supported by Soos *et al* (2017), albeit, a more recent study by Vagenas and Palaiothodorou (2019) analysed six Olympic Games and found no climatic trends.

Some governments (like those of countries which were formerly operating with a communist structure) pay a lot of attention to success in sports for political benefits thus shaping what has been termed the political hypothesis (Johnson and Ali 2008).

The cultural hypothesis focuses on participation in mega events (e.g. sport events) that can be identified as a cultural element of a country and thus, there is a will and motivation to make success happen at many levels (Frey, Iraldo, and Mellis 2007).

Finally, focusing on economics and, in particular *GDP*, is a reasonable approach to studying this topic as it can highlight the impact of a nation's wealth on general sporting participation as well as on elite level performance (Moosa and Smith 2004).

Publication of the *HDI* (Human Development Index; United Nations Development Programme 2017) encouraged authors to consider what is now termed a social hypothesis. Halsey (2009) has already used the Gini coefficient (an index of inequality of income or wealth distribution) and the *HDI* (composite) index as independent variables in a regression analysis to investigate the influential factors of the number of medals won. The Gini coefficient did not prove to be useful predictor; the *HDI* also had a low explanation power (R^2 is about 0.13). Vagenas and Vlachokyriakou (2012) found *health expenditure* as a good explanatory variable while Jayantha and Ubayachandra (2015) identified *schooling* as a possible factor affecting Olympic performance. The authors of this current study investigated not only the *HDI* as a composite indicator, but the parts of the *HDI* as well (*Schooling* and *Life Expectancy*) to examine the social hypothesis in more details.

Existing hypotheses first try to explore the main, measured indicators of a given area. In the case of the nations' wealth, the GDP is used, albeit it is obvious that this is only a proxy (see the case of Norway and Kenya) and there are other important factors. Other variables, like unemployment, served as a refinement of the economic side. Such a refinement tool can be e.g. the distribution of wealth: the previously mentioned research of Hasley (2009) used Gini coefficient,

which can be applied for the distribution. Therefore, it might be worthwhile to use it as a weight for the GDP. There are numerous ways for the further exploration, however, findings will always be a proxy, because there are always room for further examinations. In the social-cultural field, a GDP-like main indicator is the HDI, which also did not provide the expected effect. This present study refines the social-cultural field one step further with the inclusion of the two main composites: education and healthy life.

Investigation Aims

The current study served three objectives:

First, we wanted to investigate the traditional determinants of Olympic success, in terms of *medals won* in at least two of the last four Olympic Games (more than one medal indicates that it did not "accidentally" happen and could reflect a systematic approach). Specifically, *GDP per capita* (the economic hypothesis) and the *population* (size of a nation; demographic hypothesis) as the strongest predictors were considered.

Second, the *geographic* and *temperature* data (geographic hypothesis) were included to examine further influential factors considered important in the literature.

Third, the effects of the *HDI* variables (social hypothesis) on Olympic medals were examined respecting the hypothesis that both social and economic factors influenced Olympic success to a large extent.

Methods

This investigation was carried out in three studies: Study 1, Study 2 and Study 3, each serving one of the aforementioned objectives. The reason for three studies is that existing theories required validation using the database being used by this current research (see below for greater detail of the studies).

Database

Olympic medal winning countries from the last four Olympic Games were included in the data analyses. Seventy-five countries won medals at the Athens Olympic Games 2004, eighty-six at the Beijing Olympic Games 2008, eighty-five at the London Olympic Games 2012 and eighty-seven at the Rio Olympic Games 2016. Of these countries, eighty-four were selected as a purposive

sample for analysis as they had won at least one medal in a minimum of two of those Olympic Games and were thus considered 'successful' countries in Olympic sport for this investigation. The natural logarithm of *medals won* (per capita), *population*, *GDP per capita* and *temperature* data were used throughout this investigation, because these variables in their original form are highly differentiated from a normal distribution. Analyses in this investigation will always use the logarithm version of these variables without mentioning it separately. Categorised values of *population*, *temperature* and *GDP per capita* (median based split) were also used in order to reduce the strong non-normality of the original variables. *Northern and Southern hemisphere* countries as demographic variables were also treated as a categorical variable. The following variables were employed:

- *LnPop*: Logarithm of *population* (in ten million), 2017, World Bank online sources (The World Bank 2017). *PopCat*: A categorical variable of population was also used with the median based cut value.
- *LnGDPpc*: Logarithm of *GDP per capita* in thousand dollar (current/ Olympic year), 2017, World Bank online sources (The World Bank 2017). *GDPCat*: Categorical variable of *GDP per capita* was also used with the median based cut value.
- *LnTemp*: Logarithm of *temperature*, yearly average temperature in Celsius (2017), Weatherbase database (WeatherBase n.d.). *TempCat*: Categorical variable of *temperature* was also used with the median based cut value, low: (1), high: (2).
- *NorthSouth*: *Northern and Southern hemisphere nations*, categorical variable, where the North countries are the Eurasian and the North American (as a continent) countries (1) and the South countries are the rest of the world (2).
- *Total medals won*: Gold, Silver, Bronze medals won in total; obtained from the BBC Sport website (BBC Sport 2018).
- *LnTotMedPc*: Logarithm of the *total medals won per capita*.

The Human Development Index (United Nations Development Programme 2017 and Segura and Birson, 2013, for Puerto Rico's data) is a composite index, composed of:

- *LifeExpect*: The *life expectancy* at birth (in years);
- *Schooling*: The *mean years of schooling* (in years) and
- The *gross national income per capita* (in dollars).

Total Medals per capita was used as dependent variable in all studies, either for one Games or for all Games in the case of repeated measures methods. GDP was also used as a relative measure, as a per capita GDP, therefore, this study examines the *relative* Olympic success of nations.

Study 1. First, *GDP per capita* and national *population* size were used. The hypothesis was that traditionally agreed variables have a significant effect on the dependent variable (economic and demographic hypotheses).

Study 2. Geographic variables suggested by experts (Hoffman et al. 2004) were included into the analysis. The hypothesis was that in addition to the variables examined in Study 1; these variables will also affect Olympic success (geographic hypothesis).

Study 3. Further analysis was run for the eighty-four countries. This time, the number of variables were extended to include the two additional variables (GNP excluded) reported in the *HDI* (social variables). The hypothesis was that these other social variables will affect Olympic success, however, their influence will not be as strong as the impact of those examined in Study 2.

Description of Statistical Processes and Analyses

First, multiple regression analysis was used on the Rio Games' database to examine the relationship between Olympic success and all the variables, according to each study's hypothesis, described above. The regression analysis in Study 2 and Study 3 uses the backward elimination method.

Independent samples t-tests refined and further explained the results of the regression analysis. Validity of regression analyses were also checked. Normality of dependent variables and residual variables were tested by the Shapiro-Wilk test. Multicollinearity was tested by the VIF values.

Heteroskedasticity was tested by the Breusch-Pagan test. Autocorrelation (relationship between a variable's current value and its previous values) in the specific arrangement of the sample was tested by the Durbin-Watson statistic. This approach is also appropriate for proving that there is no trend in the sample that could result in a statistically spurious correlation.

Following regression analysis, the examination was extended to all the Olympic Games to check whether the explored relationships of the regression analyses are generally valid for all Games or only specific to Rio Games. The selected, most significant variables (Results section will specify them) were tested on the four Games with help of repeated-measures analysis of covariance (ANCOVA; as a General Linear Model in SPSS). The reason for the use of ANCOVA is that the Games (participating countries) are not independent from each other (see the sphericity in the explanation below), however, traditional validation of the results with the comparison of the regression slopes will also be performed.

Statistical analyses were performed using IBM SPSS v. 25 software package, apart from the Breusch–Pagan test for testing homoskedasticity. That was conducted using statistical software R (R Development Core Team, 2008).

Results

Total medals per capita (*LnTotMedPc*) was used in all studies below as a dependent variable, therefore, the normality test of this variable is generally valid to all studies. According to the Shapiro-Wilk test, the variable has a normal distribution at 5% (Shapiro-Wilk (77) =0.969, p=0.055).

Study 1

First, the effects of the traditionally approved variables: *population* and *GDP per capita* as demographic and economic hypothesis were tested on the database, and afterwards, the difference between the four Olympic Games was analysed using repeated-measures ANCOVA.

Regression Analysis

First, regression analysis on the Rio Games' database was performed (Table 1).

Source	*B*	*SE B*	*B*	*t*	*P*	*VIF*
(Constant)	-.269	.381	.000	-.705	.483	.000
LnPop	-.594	.072	-.645	-8.219	.000	1.059
LnGDPpc	.357	.104	.270	3.437	.001	1.059

a. Dependent Variable: LnTotMedPc

Table 1. The results of Multiple Regression Analysis for the *total medal per capita* with *population* and *GDP per capita*.

Note that values in the table are in logarithm: in the case of a 1 unit increase of the *population* (*LnPop*) there is a -.594 change in total medals per capita (*LnTotMedPc*). This means – in original values – that 2.718*10 millions of an increase in population results in a 44.8% decrease (*e*(2.718) unit change in x causes *exp*(*B*)-1 percentage change in Y, based on Benoit (2011) in the *medals per capita* (which is .37 medals; the average medals per capita per nation in Rio is .827). The reason is that in smaller countries it is easier to have a higher value for one capita. In the case of *GDP per capita*: 2.718*1000-dollar *GDP per capita* increase results in .355 more medals per capita.

Population and *GDP per capita* explained a significant proportion of variance in the *total medal per capita*. Adjusted R^2 = .559, F (2, 74) = 49.074, p < .001.

Validity

There is no multicollinearity in the model (VIF values are much below 4.0; see the last column in Table 1). The Durbin-Watson statistics' value is 2.01 (D_u=1.514) which means that this concrete realisation of the sample does not have autocorrelation. The model is homoskedastic (based on the Breush-Pagan test: $\chi^2(1)=1.$, p=0.317). The residual variable is not normally distributed by the Shapiro-Wilk test (W(77)=0.955, p=0.008). These variables were then tested in the four Olympic Games with repeated-measures ANCOVA.

Repeated measures ANCOVA and the Equality of Regression Slopes

The Mauchly's test indicates that there are dependencies between the Games (W=0.682, χ^2 (5) = 22.09, p=0.001). The *LSD* test indicated that there is no one specific Games which differs from the other and the cause of the dependency: the test revealed no statistically significant differences between the individual Games.

As the Mauchly's test indicated significant differences, we therefore used the Greenhouse-Geisser test (Field 2013, p. 1605), which is a corrected form of testing within-subjects' effects (the differences), caused by the different Games.

In the regression analysis it was shown that 56% is already explained by *population* and *GDP per capita*, therefore, only the remaining differences could be explained by the Olympic Games. *Population* and *GDP per capita* are included in the analysis as between subject variables (covariates). Table 2 depicts the result of the ANCOVA.

The first row of within-subjects effects shows how the Olympic Games could explain the remaining differences after the effect of the covariates. In other words: did the *total medals per capita per nation* depend on what Olympic Games was being considered? E.G. was any difference Games location, or time specific? The significance value (0.828 > 0.05) shows that it did not matter where the Olympics took place.

#	Tests of Within-Subjects Effects					
Effect	***SS*[a]**	***df***	***MS***	***F***	***p***	**partial η^2**
TotMedPc	.157	2.494	.063	.247	.828	.004
TotMedPc * LnPop	.369	2.494	.148	.582	.597	.010
TotMedPc * LnGDPpc	.073	2.494	.029	.115	.927	.002
Error	37.405	147.159	.254			

Tests of Between-Subjects Effects						
Corrected Model	408.992[b]	11	37.181	36.831	.000	.584
Intercept	.887	1	.887	.879	.349	.003
Olympics	.513	3	.171	.169	.917	.002
LnPop	263.477	1	263.477	260.995	.000	.475
Olympics*LnPop	.392	3	.131	.129	.943	.001
LnGDPpc	57.231	1	57.231	56.692	.000	.164
Olympics*LnGDPpc	.487	3	.162	.161	.923	.002
Error	291.748	289	1.010			
Total	1060.343	301				
Corrected Total	700.740	300				

a. Calculated using SPSS default (Type III)

b. R Squared = ,584 (Adjusted R Squared = ,568)

Table 2. Tests of Within-Subjects and Between-Subject Effects of repeated-measures ANCOVA for the four Olympic Games, testing the effect of the Games. Covariates are the *population* and *GDP per capita* variables; Greenhouse-Geisser statistics are used.

The next two rows' results proved that none of the two covariates have interactions with the different Olympic Games. The effect size (partial η^2) is negligible in all cases.

Equality of Regression Slopes

The lower part of Table 2 (between-subjects effect) shows the results of the (non-repeated measures) ANCOVA. The results are the same as previously: the different Games do not make any difference (see the *p*-value of the *Olympics* row: *p*=.917). Regression slopes, considering the *population* and the *GDP* do not differ significantly, as the two *p*-values in the rows of *Olympics*LnPop* and *Olympics*LnGDPpc* (*p*=.943 and *p*= .923 respectively) indicate. The estimated Adjusted R^2 is practically the same as in the case of the Regression analysis (=.568).

The tests of the normality of the residuals in the Repeated Measures ANCOVA show non-normality in the case of the Rio Games (W(62)=.949, p=.012), but the test for the other Games are non-significant.

Thus, these results provided evidence that the traditional factors such as *population* and *GDP per capita* have significant effects on Olympic success (*won medals per capita per nation*); a finding that applies across all four Olympic

Games, as the Repeated Measures ANCOVA and the equality of the regression slopes indicate. Both the demographic and economic hypotheses were partly supported because the normality of the residual variable in the regression analysis and the Rio Games' residual variable from the repeated-measures ANCOVA were rejected.

Study 2

In the Introduction section of this paper, it was suggested that there could be support for both a *geographical location*, as well as a *temperature* effect. Therefore, the next study examined the effect of the variables, conveying those effects through backward regression analysis, looking only for variables that really have significant explanation power. Four variables were used in this study: the *population* and *GDP per capita* data (as earlier), together with the *NorthSouth* and the *temperature* variables. Additionally, three categorical variables (for the *GDP per capita,* the *temperature*, and the *population*) were also included (the *NorthSouth* geographical variable is already a categorical variable).

Regression Analysis

Table 3 displays the details of the results of the regression analysis.

Source	*B*	*SE B*	*β*	*t*	*p*	*VIF*
(Constant)	1.267	.503		2.517	.014	
LnPop	-.578	.065	-.627	-8.829	.000	1.063
TempCat	-.924	.221	-.299	-4.187	.000	1.076
LnGDPpc	.259	.097	.196	2.680	.009	1.124

a. Dependent Variable: *LnTotalMedPc*

Table 3: Results of Regression Analysis for Study 2 considering variables of *population, GDP per capita* data, together with the *North South* and *temperature* variables and three categorical variables (for the *GDP per capita*, the *temperature*, and the *population*) *
* Note that as a result of the backward method the *population* category also had a strong influence on the dependent variable, but not as strong as the continuous *population* variable, therefore this variable was manually removed from the independent variable list.

The effect of the *population* and the *GDP per capita* decreased. The *temperature* categorical variables' *B* parameter value (-.924) expresses the difference between the low and high temperature countries; the *number of medals*

per capita per nation is lower by 60% - 0.499 medals per cap (1 unit change in x causes *exp*(B)-1 percentage change in Y, based on Benoit, 2011). Independent samples t-test results also support the fact that low *temperature* countries win more medals either in total or in per capita.

Independent variables explained a significant proportion of variance in the *total medal per capita.* Adjusted R^2 = .639, F (3, 73) = 39.654, p < .001.

Validity

There is no multicollinearity in the model (VIF values are still below 4.0), despite the fact that both the *population* and the *population* category are elements of the final table. The Durbin-Watson statistics' value is 2.002 (d_u=1.577) which means that this concrete realisation of the sample does not have autocorrelation. The model is homoskedastic (based on the Breush-Pagan test: $\chi^2(1)=0.658$, p=0.417). The residual variable has a normal distribution at 5% significance level by the Shapiro-Wilk test (W(77)=0.98, p=.278). These variables are also tested in the case of the four Olympic Games with repeated-measures ANCOVA.

Repeated-measures ANCOVA and the Equality of Regression Slopes

The Mauchly's test also suggested that there are significant dependencies between the Games (W=0.683, χ^2 (5) = 21.618, p=0.001), therefore in this case, the Greenhouse-Geisser test is used as well. Table 4 displays the results of the ANCOVA model.

		Tests of Within-Subjects Effects				
Effect	***SS***[a]	***df***	***MS***	***F***	***p***	**partial η^2**
TotMedPc	.738	2.497	.296	1.166	.321	.020
TotMedPc * LnPop	.300	2.497	.120	.474	.666	.008
TotMedPc * LnGDPpc	.277	2.497	.111	.438	.690	.007
TotMedPc * TempCat	.689	2.497	.276	1.089	.349	.018
Error	36.716	144.828	.254			
		Tests of Between-Subjects Effects				
Corrected Model	469.162[b]	15	31.277	38.493	.000	.670
Intercept	27.648	1	27.648	34.026	.000	.107
Olympics	.172	3	.057	.071	.976	.001
LnPop	242.028	1	242.028	297.860	.000	.511

Olympics*LnPop	.145	3	.048	.060	.981	.001
LnGDPpc	23.043	1	23.043	28.359	.000	.091
Olympics*LnGDPpc	.425	3	.142	.174	.914	.002
TempCat	59.816	1	59.816	73.615	.000	.205
Olympics*TempCat	.191	3	.064	.078	.972	.001
Error	231.578	285	.813			
Total	1060.343	301				
Corrected Total	700.740	300				

a. Calculated using SPSS default (Type III)

b. R Squared = ,670 (Adjusted R Squared = ,652)

Table 4. Tests of Within-Subjects Effects of repeated-measures ANCOVA for the four Olympic Games, testing the effect of the Games. Covariates are the *population*, *GDP per capita* and the *temperature* category variables. Greenhouse-Geisser statistics are used.

Covariates (population, GDP, temperature) partially explained the causes of Olympic success and only the remaining part is left for the explanation by the different Games. The first row of the within-subjects' effects (*TotMedPc*) demonstrates this effect of how the Olympic Games could explain the remaining differences? The significance value (0.321 > 0.05) shows that no significant differences were observed between the Olympic Games after the influence of the covariates (see also the small effect sizes in each factor).

Equality of Regression Slopes

The lower part of Table 4 (between-subjects effect) shows the results of the ANCOVA. The results also reinforced previously demonstrated results: different Games do not make any difference (p=.976). Regression slopes, considering the population, GDP and the temperature category do not differ significantly, as the p-values in the rows of *Olimpics*LnPop* and *Olimpics*LnGDPpc* and *Olimpics*TempCat* (p=.981, p=.914 and p= .972 respectively) indicate. The estimated Adjusted R^2 is also remarkably similar to the Regression analysis (=.652).

The tests of the normality of the Repeated Measures ANCOVA model's residual variables are all non-significant, in other words, they are not significantly different from a normal distribution.

This section provided evidence that the *temperature* category (geographic hypothesis) also has significant explanatory power on the Rio Olympic successes (medals won), and - considering all the four Games - all the three involved variables (*GDP*, *population* and *temperature*) show significant effects. There is no difference between the four Games in this respect.

Study 3

Since influential factors that had previously been suggested, both in the literature and already proved by this investigation, were all such factors which can hardly be changed by a country (*population, GDP per capita*), the analyses were extended to consider social factors, including the *HDI* variables. The basic research still focussed exclusively on the Rio Olympic Games, employing also all *HDI* (Human Development Index) variables.

Regression Analysis

When the backward process stopped, there remained only those variables which had a significant relationship with the dependent variable. In this variable set, s*chooling* from the *HDI* also proved to be significant (Table 5).

Source	*B*	*SE B*	*β*	*t*	*p*	*VIF*
(Constant)	-1.983	1.146		-1.731	.088	
TemCat	-.886	.310	-.283	-2.855	.006	2.233
LnPop	-.483	.071	-.521	-6.816	.000	1.328
NorthSouth	.772	.317	.226	2.434	.017	1.950
Schooling	.242	.066	.351	3.659	.000	2.086

a. Dependent Variable: LnTotalMedPc

Table 5. The results of Multiple Regression Analysis (Backward method) for the *total medal per capita*, starting with all variables.

The effect of the *population* and the *temperature* category is similar as in Table 3. The *NorthSouth* categorical variable's *B* value is seemingly controversial, but it coincides with the result of the *population*. The *B* parameter of *schooling* (.242) means that one more year spent in education increases the *medals per capita per nation* by 27,4% that is .226 medals.

The final model did not contain the *GDP per capita* in any form, but one of the social factors, *schooling* remained in the final model. Demographic, geographic and social variables explained a high proportion (67.4%) of variance in the total medal per capita per nation. Adjusted R^2 = .674, F(4, 70) = 39.295, p = .000.

Validity

There is no multicollinearity in the model (VIF values are much below 4.0) and there is no autocorrelation: the Durbin-Watson statistics' value is 2.056 (d_u=1.768). The model is homoskedastic (based on the Breush-Pagan test ($\chi^2(1)$=0.616, p=0.432). The residual variable had a normal distribution at 5% significance level by the Shapiro-Wilk test (W(76)=0.976, p=0.175).

Variations

If the *NorthSouth* variable is removed, the adjusted R^2=.652 (F(3, 71)= 40.396, p < .001) is somewhat lower. *Population* and *schooling* together explains 64% of the variation of the *medals per capita* changes (adjusted R^2=.64 (F (2, 72)=66.77, p < .001). None of these models have multicollinearity, autocorrelation and heteroskedasticity and their residual variables are normally distributed.

The variables, the results of the backward methods (*population*, *schooling*, *temperature* category and *NorthSouth* variable) were also tested in the case of the four Olympic Games with repeated-measures ANCOVA. Results are depicted in Table 6.

Repeated-measures ANCOVA and the Equality of Regression Slopes

The Mauchly's test also proved that there are significant dependencies between the Games (W=0.691, $\chi^2(5)$=20.570, p=0.001). As a result, during the explanation of the ANCOVA model, the Greenhouse-Geisser tests were used again.

In the first row of the within-subjects effect (*TotMedPc*), the significance value (0.639 > 0.05) shows that there were no significant differences between the Olympic Games after the influence of the covariates: none of the variables (interactions of the covariates with the *total medals won per capita per nation*) have significant interaction with the Olympic Games. The table of between-subjects effects (Table 6) shows that all variables remained significant in the

case of more dependent variables (Olympic Games). Effects sizes are higher (in parallel with the *F*-statistic values). In other words, *population* and *schooling* have the highest values (.518 and .361 respectively).

	Tests of Within-Subjects Effects					
Effect	***SS*[a]**	***df***	***MS***	***F***	***p***	**partial η^2**
TotMedPc	.492	2.506	.196	.764	.494	.013
TotMedPc * TempCat	.971	2.506	.388	1.510	.220	.026
TotMedPc * LnPop	.545	2.506	.217	.847	.453	.015
TotMedPc * NorthSouth	.638	2.506	.255	.991	.388	.017
TotMedPc * Schooling	.291	2.506	.116	.453	.681	.008
Error(*TotMedPc*)	36.028	140.323	.257			
	Tests of Between-Subjects Effects					
Corrected Model	496.589[a]	19	26.136	35.314	.000	.709
Intercept	6.197	1	6.197	8.373	.004	.030
Olympics	.202	3	.067	.091	.965	.001
LnPop	134.695	1	134.695	181.992	.000	.398
Olympics*LnPop	.047	3	.016	.021	.996	.000
NorthSouth	10.566	1	10.566	14.276	.000	.049
Olympics*NorthSouth	2.134	3	.711	.961	.411	.010
TempCat	22.703	1	22.703	30.675	.000	.100
Olympics*TempCat	1.063	3	.354	.479	.697	.005
Schooling	42.050	1	42.050	56.816	.000	.171
Olympics*Schooling	.100	3	.033	.045	.987	.000
Error	203.532	275	0.74			
Total	1050.374	295				
Corrected Total	700.121	294				

a. Calculated using SPSS default (Type III)

b.R Squared = ,709 (Adjusted R Squared = ,689)

Table 6. Repeated-measures ANCOVA for the four Olympic Games, testing the within-subjects and between-subjects effect of the Games. Covariates are the *population*, *schooling* and the categorical variables of *NorthSouth* and *temperature*; Greenhouse-Geisser statistics are used.

The normality tests for the model's residual variables did not show significant alteration from normal distribution.

Equality of Regression Slopes

The lower part of Table shows the tests for the equality of regression slopes. The results also coincide with those of previously demonstrated results: different Games do not make any difference (p=.965). *Population*, *NorthSouth*, *Temperature* category and *Schooling* do not differ significantly, as the p-values in the rows of *Olympics*LnPop, Oyimpics*NorthSouth Olympics*TempCat* and *Olympics*Schooling* (p=.996, p=.411, p=.697 and p= .987 respectively) indicate. The estimated Adjusted R^2 is again similar to the Regression analysis (=.689). Further analysis of the between-subject effect in the last column shows that *population* has the highest effect (.398), followed by the *Schooling* (.171), *temperature category* (.100) and the *NorthSouth* variable (.045).

This section provided evidence that social factors are important, and *schooling* can be viewed as the second most important predictor of success, after the *size of the population*. Finally, the demographic and social hypotheses proved to be the strongest predictors. These results are valid for all the four Games examined.

Generalisation of the Schooling effect

The effect of mean years spent in school is valid in this data environment: in this study only those countries who won a minimum of two medals in the last four Olympics are present. However, this influence might be higher or lower if we consider e.g. those nations who won a minimum of one medal or three medals or more. The inclusion of those nations that did not win medals is not sound methodically as it alters the focus of the Games in which medals won is viewed as a key indicator of success: the main tables of success reflect medals won by countries. It might be assumed that nations that won medals in a minimum of two Games have a similar focus on the Olympic Games, therefore, the comparison of those countries provided acceptable results.[6] Note: it is not proved in this paper that *schooling* is the panacea for Olympic success. However, the results of the study indicate that between the successful Olympic nations

[6] The use of other statistics on this dataset is rather difficult: such as the Tobit regression as it also needs the normality of the dependent variable, which is not fulfilled with the inclusion of zero medals. Also, the Poisson regression is of no use in this study as it is created for countable dependent variable, but the dependent variable of this study is the *medal per capita*.

those are more successful, where education is more developed. The connection of *schooling* with wealth is not obvious. Statistically, the *GDP per capita* can explain the changing in *Schooling* variable by 37.6% (R^2). Furthermore, the GDP proved to be a weaker explanatory factor than *Schooling* and there are successful nations with Olympic traditions, which are not wealthy.

Discussion

According to the first aim, the Study 1 results appear to strengthen the previous as well as other reports that have claimed that the *population* size of the participating nations and *GDP per capita* are related to Olympic success (Bernard and Busse 2004; De Bosscher *et al*. 2003; Hoffmann, et al. 2004; Morton 2002). The results of Study 1 generally affirm a positive relationship between these two variables and Olympic success. However, our findings regarding the connection between *GDP per capita, population* and *total medals won* during the last four Olympic Games indicated that *population* surfaced as the more robust indicator for medals won as opposed to *GDP per capita*.

In this study, no difference was proven between the effects at any of the last four Olympic Games. Also, 56% of Olympic success is explained by the *population* size and the *GDP per capita* variables. However, the rest of the causes of success remain unknown. Nevertheless, in the past, other authors (Boudreau et al. 2014) disputed this finding, as they believed *GDP per capita* may not be a significant factor in determining success, as in places with lower standards of living (e.g. Russia or China) the decision makers may invest substantial funding for training, support and competition preparation in advance of an Olympic Games. Additionally, such countries may also commit to sending more athletes to the Olympic Games.

In this case, the more athletes that a country has competing, the greater its chance is to gain more medals (Feizabadi *et al*. 2013). Therefore, there is a significant measurable advantage to nations with larger general population sizes succeeding at the Olympic Games (Johnson and Ali 2000), if they send large(r) teams. Contrary to this finding, Johnson and Ali (2008) also stated that in many cases at mega events (e.g. at the Winter Olympic Games) small nations can outperform their larger competitors. Thus, sports specific, cultural, or environmental factors may drive success in specialist areas of sport as is found in the Winter Olympics. This conjecture needs further investigation.

Regarding the second aim, Study 2 added two variables, the geographic location (*North versus South*) and *yearly average temperature*. In this analysis four variables were included, as *temperature* of the participant countries, *population* size, *GDP per capita*, and finally a geographical location variable that was related to

whether 'winning countries' were in the *North or South*. Countries of the North and South were categorised being either part of Eurasia or North America; countries of the South were part of South America, Africa and Australia as well as the South Pacific region. This leads to the suggestion that future studies must consider the continental dimension from different perspectives such as using political, cultural and economic delineators as a differentiation tool as opposed to the equatorial or hemispheric line (Reuveny and Thompson, 2018). According to these analyses, there were no significant differences found between the *North and South* countries and the success of countries at the last four Olympic Games, however, the *temperature* category, *GDP per capita* and the *population* size had a significant effect on Olympic success and still did not differ by Olympic Games. The explanation power of this model increased though to 64%, thus strengthening the new model.

With respect to the third aim, Study 3's analysis involved social factors from *HDI* (see the details of these datasets in the *Database* section). The analysis confirmed that the most influential factors of Olympic success were *population* size and *schooling* along with *NorthSouth* and *temperature.* This is the first developed model of specific demographic, social and geographical factors, which can explain more than two thirds (67.4%) of the variance in Olympic success (medals per capita won). Unsurprisingly perhaps, a warmer climate lends itself to sporting achievements in Summer Olympic Games and this may go some way to explaining this finding. Further studies must consider the Winter Olympic Games to identify trends in that event.

Policy Implications

Given that *schooling* is more developed in the wealthy *NorthSouth*, with more people taking part in structured education, opportunities are greater to participate in structured sport (e.g. the American school and collegiate system). *Schooling,* together with *population* explain 64% (adjusted R^2=0.640) of Olympic medals won. Additionally, *schooling* is equally important in all four Olympic Games, therefore categorised as one of the most important roles in Olympic success after the *population* size. The *Schooling* variable in the HDI database measures the number of years that students attend school. *Schooling* is also only a proxy, as discussed in the Introduction, however, it clearly indicates the social-cultural features of the countries. This finding therefore opens such a wide area of research that at this point of the research it would be premature to give more accurate policy recommendations.

Future Research and Limitations

Future Research

For recommendations of future work, a study of Olympic success needs to bring in the Winter Olympics to be truly valid as smaller nations often achieve high results e.g Norway, Switzerland, Austria. Those nations seem to be wealthy, have small populations and well-established health and school systems, AND seem environmentally suited to specialist sports. These latter factors should be considered to compare and perhaps align Summer Olympic success characteristics with those of the Winter Olympics. In fact, this study could also be expanded to include environmental variables alongside those of geography, demographics, schooling and sport culture. Increased schooling implies better resourcing, focused opportunities, and better nutritional status of the population due to improved socio-economic status; the investigation of these factors should also be the topic of further research.

One final topic that could be considered is whether other 'Mega-Events', such as the FIFA World Cup, would exhibit similar findings? It may be that different sports and sporting occasions attract culturally, politically, socially, or economically different populations and therefore might have alternative factors that impact on success.

Considering the current literature, these findings are important since they show that the widely hypothesised relationship between winning Olympic medals and *GDPpc* in reality is relatively modest**.** The outcome of this current study fully matched the results of another recent analysis, which revealed that the *GDPpc* of participating countries was a weak predictor of Olympic medals won in Athens 2004, Beijing 2008 (Boudreau, Kepner and Rondone 2014). Their study identified that the physical size of participating countries and national health care expenditures were stronger indices of winning medals.

Conclusion

The findings of this study are important since they show that the widely hypothesised relationship between winning Olympic medals and *GDPpc* is relatively modest**.** The outcome of this current study fully matched the results of another analysis, which revealed that the *GDPpc* of participating countries was a weak predictor of Olympic medals won in Athens 2004 and Beijing 2008 (Boudreau, Kepner and Rondone 2014). The conclusions of this work, based on the last four Olympics and supported by previous analyses (Boudreau et al. 2014), is that the role of the *GDP per capita* to predict Olympic medals wins

appears to be inflated in literature. The size of the *population* of participating nations accounted for more than twice as much of the variance in the winning of Olympic medals than the *GDP per capita* in Study 1. This points to the fact that success at the Olympic Games is not as much dependent on a nation's share of international wealth as it was presumed earlier in previous literature.

Schooling is the other most important factor predicting Olympic success. Furthermore, it is probably the *schooling* (social factor) that is the easiest to influence by a country and offers the shortest time for returns on investment as opposed to either *population* size, or *GDP per capita*. Also, *North versus South* geographic location and *temperature* cannot be changed.

In the interim, the scholastic message of this work is that, according to this analysis of the last four Olympics, *wealth* may be a feeble factor in determining which country wins medals at the Olympic Games. These findings deserve replication with data from future Olympics (i.e. Tokyo 2021).

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THE RELATION BETWEEN THE ATTITUDE TOWARD PHYSICAL EDUCATION LESSONS AND THE ENJOYMENT IN PRACTICING PHYSICAL ACTIVITY IN STUDENTS AGED BETWEEN 18 AND 22

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ABSTRACT. Introduction: Physical activity is an important factor in the lives of young people once they complete their high school studies. Subsequent participation in adult life in physical activities will be done independently. However, we can assume that the low participation rate of Romanians in physical activities is due to a negative attitude regarding the lesson of physical education and compulsory sports throughout schooling but also to a discomfort regarding participation in physical activities. At the West University of Timisoara, the Physical Education and Sports lesson is compulsory included in the curriculum from all faculties, coming in continuation of high school. The aim of this study is to analyze how the attitude towards the PE lesson correlates with the enjoyment of students to perform physical activity. **Material and Method:** The participants in this study were 400 students (77% female and 23% male) aged 18-22 years (M = 20.1, SD = .71) from the Western University of Timisoara. To carry out this study, the questionnaire survey method was used. Two questionnaires that explored the students' attitude towards the PE lesson and the students' enjoyment in practicing physical activities were applied. The data obtained was analyzed using the SPSS Statistics program. **Results:** The score obtained ($r = .342$, $p < 0.001$) indicates a significant correlation, with a positive score between the attitude towards PE and the enjoyment of practicing physical activities in the students at the West University of Timisoara. **Conclusions:** It is found that both the attitude towards PE and enjoyment of practicing physical activities are increased.

Keywords: *attitudes, enjoyment, Physical Education, physical activity, students.*

REZUMAT. ***Relația dintre atitudinea față de lecțiile de educație fizică și plăcerea de a practica activitatea fizică pentru elevii cu vârsta cuprinsă între 18 și 22 de ani.*** **Introducere:** Activitatea fizică este un factor important în viața tinerilor chiar și după încheierea ciclului de studii liceale. Participarea

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ulterioară la activităţile fizice în viaţa de adult se va face în mod independent. Totuşi, putem presupune că rata scăzută de participare a românilor la activităţile fizice se datorează şi unei atitudini negative privind lecţia de educaţie fizică si sport obligatorie pe toata durata şcolarizării dar şi a unei neplăceri privind participarea la activităţile fizice. La Universitatea de Vest din Timişoara, disciplina Educaţie fizică şi sport este o disciplină obligatorie cuprinsă în planul de învăţământ de la toate facultăţile, venind în continuarea liceului. Scopul acestui studiu este de a analiza modul în care atitudinea faţă de lecţia de Educaţie fizică se corelează cu plăcerea studenţilor de a efectua activităţi fizice. **Material şi Metodă :** Participanţii la acest studiu au fost 400 de studenţi (77% de gen feminin şi 23% de gen masculin) cu vârsta cuprinsa intre 18-22 ani (M=20.1, SD= .71) din cadrul Universităţii de Vest din Timişoara. Pentru realizarea acestui studiu s-a folosit metoda anchetei prin chestionar. S-au aplicat două chestionare care au explorat atitudinea studenţilor faţă de lecţia de Educaţie fizică şi plăcerea studenţilor de a practica activităţile fizice. Datele obţinute au fost analizate folosind programul SPSS Statistics. **Rezultate:** Scorul obţinut ($r = .342$, $p<0.001$) indică o corelaţie semnificativă, cu scor pozitiv între atitudinea faţă de lecţia de Educaţie fizică şi plăcerea de a practica activităţile fizice la studenţii Universităţii de Vest din Timişoara. **Concluzii:** Se constată că atât atitudinea faţă de lecţia de Educaţie fizică cât şi plăcerea de a practica activităţile fizice sunt crescute.

Cuvinte-cheie: *atitudini, plăcere, Educaţie fizică, activităţi fizice, studenţi.*

Introduction

The public health problem of physical inactivity and the risk of obesity has proved resistant to all efforts by researchers to elucidate the causes and seek solutions to change its course (Blair, 2009). In most industrialized countries, the population is physically inactive or insufficiently active (Piko, 2000). In Romania, even if the proportion of adults who reported participation in physical activity increased in 2017 (13.5%) compared to 2014 (4%) it still ranks last in Europe, along with Malta, Austria and Portugal (Situation analysis, September 2020). Also, 63% of the Romanian population never participates in physical activities or a sport (New Eurobarometer on sport and physical activity, 2018).

Fishbein and Ajzen (1975) defines the attitude as "a predisposed learning to respond in a way considered favorable or unfavorable in relation to a particular topic." An attitude towards something is a behavior learned as positive or negative. An important analysis on the causes that lead to physical inactivity can be made from the perspective of the attitude towards the PE lesson. Understanding how

students form their attitudes toward physical education can help improve their later participation in physical activity in life (Subramaniam & Silverman, 2007). Numerous studies have been done on this topic (Carlson, 1995, Luke & Sincliar, 1991). Some studies have shown that an increase in student attitude for physical education may be attributed, in part, to the influence attitude may have on future participation in physical activity among youth (Subramaniam, Silverman, 2002; Prochaska et al. 2003). Also, there is evidence to suggest that students who experience unfavorable attitudes for physical education will be less involved in physical activities later in life (Carlson, 1995, Enis, 1996). A study by Mowatt, DePauw, and Hulac (1988) assessed students' attitudes toward physical activity. The aim of this study was to see the opinions of students who have already been enrolled in physical education classes in university education regarding physical activity. The results of this study showed that the students agreed that there is a scientific basis for the quality of physical education. Students expressed neutral attitudes about the value of physical education in public schools, but believed it was important to offer physical education courses. Most students indicated that it is important to be "fit" and that physical activity is important and worth the effort.

But in the same way with the attitude, the pleasure (enjoyment) has a determining role in the participation in the physical education lessons. Some studies have shown the link between self-efficacy and physical activity enjoyment with body mass index (BMI) and gender between university students (Gençay, Gençay, Aydin, Akkoyunlu & Demir, 2016) or the link between time trends in fitness and enjoyment of physical practice (Brunnquell, Spaeth, Casalegno, Gatzke, Mateski, Wiggins, Braun, 2016). However, there are very few studies that analyze the connection between the attitude towards the physical education lesson and the enjoyment of participating in physical activities. This study could create the premise of analyzing the connection between physical activities imposed by the school system and their independent practice in adulthood.

Objectives

The objective of this study is to analyze the relationship between the attitude towards the physical education lesson and the enjoyment generated by practicing physical activities in these lessons that are mandatory in the curriculum of students. It is assumed that there is a statistically significant correlation between the attitude towards the PE lesson and the pleasure of practicing physical activities in the students participating in the study.

Material and methods

Participants

This study involved a number of 400 students (77% female and 23% male) aged 18-22 years (M = 20.1, SD = .71) from the West University of Timisoara, enrolled in the 1st and 2nd year of studies, participants in the compulsory discipline of Physical Education and Sports.

Procedure

Two questionnaires were applied in this study. The first questionnaire created by Mowatt, Depauw, and Hulac (1988) contains a number of 20 items on a 5-point Likert scale. This questionnaire was translated into Romanian by a specialized translator. The 20 items are classified into 3 categories (dimensions): General Knowledge (5 questions), Physical Education Attitudes (6 questions) and Scientific Basis (9 questions). For this study, only the answers provided in the Physical Education Attitudes section were considered.

The second questionnaire used was the PACES "Physical Activity Enjoyment Scale" developed by Kendzierski and DeCarlo (1991) which contains a number of 18 items and a 7-point, bipolar Likert response scale. Eleven items are marked in reverse. Higher PACES scores reflect a higher level of pleasure. This questionnaire was also translated into Romanian by a specialist translator.

Results

a. Cronbach Alpha Fidelity Coefficient

For the PACES questionnaire (Kendzierski and DeCarlo, 1991), following its translation into Romanian, the Cronbach alpha fidelity coefficient was calculated for the complete version of 18 items. It is observed that all 18 items are focused on the same topic, looking for the same answer.

Cases	N	%	Cronbach's Alpha	Cronbarch's Alpha Standard items	No. of items
Validated	400	99.8	.921	.925	18
Excluded	0	.0			
Total	400	100.0			

Table 1. Cronbach's Alpha Index

The Cronbach Alpha coefficient of validity of the 18-item scale has a value of .921, with a strong percentage of 99.8%, which proves that the scale has a very good level of fidelity. A Cronbach's alpha coefficient greater than .800 is considered satisfactory.

b. Pearson Correlation Between the Variables Attitude and Pleasure

Out of the total respondents, 76% of the averages were registered between 3.50 - 4.00 points, 20% were between 4.00 - 5.00 points and only 4% had an average of 3.00 points. The total average in the field of attitudes towards physical activity is 3.70, a significant score that shows us that the students have a positive attitude towards physical activity.

The average obtained in the questionnaire regarding the students' attitude towards the PE lesson and the average obtained on the scale of the pleasure to participate in physical activities register a significant level of relationship.

Sets	Statistics Index	PACES Mean
Attitude Mean	Pearson Corell.	.342**
	Sig. (2-tailed)	.001
	N	400

**. The correlation is significant if p< 0.01; Sig (2).

Table 2. Pearson Correlation between Attitude and Pleasure variables

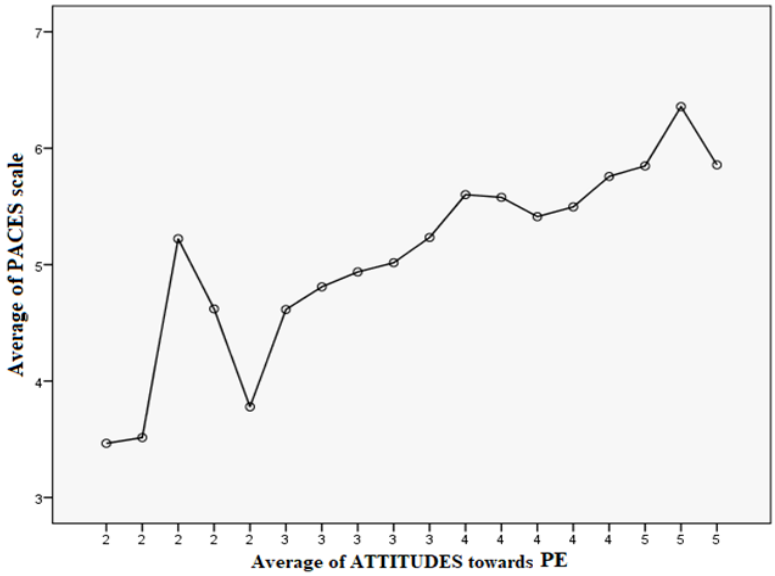
The recorded score (r = .342, p <0.001) indicates a significant correlation, with a positive score. The two questionnaires were scored with different measurement scales and the results obtained indicate that attitude and pleasure have a significant connection on the practice of physical activity in the physical education lesson.

c. Analysis of the Anova Variant of the Variables Attitude and Enjoyment

It is observed that the value of significance (p = .001, p <0.05) indicates that there is a statistically significant difference between the arithmetic averages recorded in the questionnaire on attitude towards PE and the arithmetic averages recorded in the questionnaire on students' pleasure in practicing physical activities. So that the null hypothesis is rejected. Following the graph generated after the ANOVA analysis of variance, we observe an increase in the score depending on both results, having a higher proportion of ascending lines than descending ones.

Sets	Sum of squares	SD	Mean Square	F	Sig.
Between groups	60.749	17	3.573	4.025	.001
Within groups	339.154	382	.888		
Total	399.903	399			

Table 3. ANOVA analysis between the variables Attitude and Enjoyment



Graph 1. ANOVA type analysis of the variables Attitude and Enjoyment

d. Linear Regression

The non-standardized regression coefficient between the variables Attitude and Enjoyment has the value of 0.200. This value means that for each increase by 1.00 of the horizontal axis the value on the vertical axis changes by 0.200. The 95% confidence interval for these coefficients is from .146 to .254. The 95% confidence interval shows the interval of regression slopes where the same percentage of the population will be found. The intersection point (a) is identified by the SPSS program as a constant. The intersection is presented as "Constant" and is 2,631 representing the point where the regression line intersects the vertical axis y.

The Beta column represents the Pearson correlation coefficient between the two variables with a value of .342, a significant positive correlation.

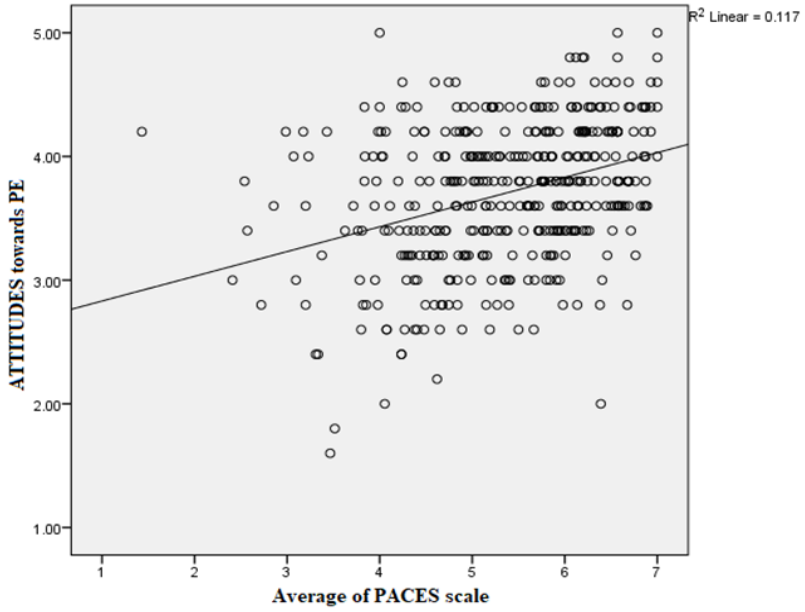
Coefficients[a]

Model		Non-standardized coefficients		Standardized coefficients	t	Sig.	95.0% Confidence interval for B	
		B	Std. Error	Beta			Inf.limit	Sup. limit
1	(Constant)	2.631	.150		17.485	.000	2.335	2.927
	PACES	.200	.028	.342	7.268	.000	.146	.254

a. Dependent variable: ATTITUDES

Table 4. Linear regression between Attitude and Pleasure variables

The regression line generated in the scatterplot diagram is oblique, from bottom right to top left, which indicates a positive relationship between the variables. The points seem relatively close to the line, which suggests with Beta (.342) it is positively significant with a relatively small confidence interval. The scatterplot diagram of the relationship between Attitude and Pleasure suggests a positive linear relationship between the two variables.



Graph 2. Linear regression

Discussions

Initially, the internal consistency index of the PACES questionnaire (Kendzierski and DeCarlo, 1991) recorded high indices (Cronbach alfa from .93 to .96). Subsequently, it was used in other foreign languages, so that many studies were done to validate it. Study by Yan, Berger, Tobar & Cardinal (2015) reported high internal consistency (Cronbach alpha = 0.93) for Chinese translation. For the French translation (Deligners & Perez, 1998) they obtained a high Cronbach's alpha index (.927), an index close to that obtained by the authors of this questionnaire. In the present study, the internal consistency index obtained (Cronbach alfa = .921) allows us to use it in Romanian.

To discuss the statistically significant link between the results of the Attitudes and Pleasure questionnaires, we will make a comparison with the study conducted by Caroll & Loumidis (2001). This study analyzes the relationship between perceived competence and enjoyment in physical education and physical activity outside school. The results indicate moderate positive and significant relationships between enjoyment in PE and perceived competence in PE ($r = .39$, $p < 0.001$). In our study, the relationship between PE attitude and the pleasure of participating in the PE lesson is also significant ($r = .342$, $p < 0.001$). Although in this study the results show that most students have positive attitudes about the PE lesson, previous studies found that students tended to become less physically active when they reach higher education (Hildebrand & Johnson, 2001).

Conclusions

Accurate and valid measurement is essential for the comparison and integrity of research. Consistent with the analyzes performed in the study, we found that the 18-element PACES used in this study was a valid model.

The results show that overall, the students participating in the study had positive attitudes regarding the participation in the physical education lesson conducted within the university program. Significant relationships were found in attitudes related to the PE lesson and the pleasure resulting from physical activity. These results may indicate that the attitude towards the PE lesson and the pleasure of participating in PE lessons are not the causes of the poor participation of adults in Romania in physical activities. Future studies will investigate using qualitative methods, the causes of the difference between a positive attitude towards the PE lesson and poor participation in physical activities.

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KINESIO TAPING USE FOR THE PREVENTION AND TREATMENT OF SPORTS INJURIES IN ATHLETES

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ABSTRACT. Kinesio taping (KT) is a simple, cost-effective, affordable and safe rehabilitation method that is currently used for enabling natural healing, as it ensures local support and stability, and corrects joint position, helping athletes to quickly recover after minor or even major injuries, and to increase their athletic performance. KT helps weakened muscles, improves local blood and lymph flow, reduces pain, removes the abnormal tension accumulated at the muscle level, alleviates muscle fatigue associated to exercising and decreases the exercise-related disruption of dynamic balance. All these effects contribute to the post-injury recovery of athletes. KT is frequently used in the acute postoperative recovery after the reconstruction of the anterior cruciate ligament, in conjunction with the rehabilitation program, as it reduces edema and pain, and increases the range and force of movement. Another frequent use of KT is in patellar tendinopathy and in reducing the risk of injury as a result of balance impairment produced by muscle fatigue. The effect of KT on the range of joint motion remains unclear, and its use is still controversial, as there are many trials that do not show any beneficial effects thereof, especially in terms of effects on muscle strength and activity, and of tendon flexibility.

Keywords*: kinesio taping, rehabilitation, athletes, recovery, sport performance.*

REZUMAT. ***Utilizarea kinesio taping în prevenirea şi tratamentul leziunilor la sportivi.*** Kinesio tapingul (KT) este o metodă de reabilitare simplă, economică, accesibilă şi sigură, folosită curent pentru facilitarea vindecării naturale, realizând sprijinul şi stabilitatea locală, precum şi corectarea poziţiei articulare, ajutând sportivii să se recupereze rapid după leziuni minore sau chiar majore şi pentru creşterea performanţei sportive. KT ajută musculatura slăbită, îmbunătăţeşte fluxul sangvin şi limfatic local, reduce durerea, îndepărtează tensiunea anormală acumulată la nivel muscular, atenuează gradul oboselii musculare asociate exerciţiilor şi reduce perturbarea echilibrului dinamic asociată acestora. Prin

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toate aceste efecte, ajută la recuperarea post-leziune a sportivilor. KT se foloseşte frecvent în recuperarea acută postoperatorie după reconstrucţia ligamentului încrucişat anterior, asociat programului de refacere, deoarece reduce edemul şi durerea şi creşte gradul şi forţa de mişcare. O altă utilizare frecventă a KT este în tendinopatia patelară şi în diminuarea riscului de leziuni cauzate de deteriorarea capacităţii de echilibru, prin oboseală musculară. Efectul KT asupra gradului de mişcare articular rămâne neclar, iar utilizarea sa la sportivi rămâne controversată, deoarece există numeroase studii care nu evidenţiază nici un efect benefic al utilizării sale, mai ales în ceea ce priveşte efectele asupra forţei şi activităţii musculare, precum şi a flexibilităţii tendoanelor.

Cuvinte-cheie: *kinesio taping, reabilitare, sportivi, recuperare, performanţă sportivă*.

Introduction

The new taping technique, created by Kenzo Kase in the 1970s, i.e. kinesio taping, is a non-invasive therapy method that can enhance endurance and performance during training sessions and matches, as well as accelerate recovery after intense exercising (Bandyopadhyay & Mahapatra, 2012; Kase, Hashimoto & Tomoki, 2003; Gligor & Gligor, 2018).

This rehabilitation method is different from traditional taping techniques (Kase, Hashimoto & Tomoki, 2003; Banerjee, Briggs & Johnson, 2016) and it is used for enabling natural healing, ensuring support and stability, without limiting the range of motion (Kase, Wallis & Kase, 2003; Trobec & Persolja, 2017; Sarkar et al., 2018). The method was first used in sports medicine, and it is currently used on a large scale in other clinical specialties as well (orthopedics, traumatology, surgery of the motor system, neurology, oncology, pediatrics). In Europe, kinesio taping was first used in 1998. After Kenzo Kase, the taping technique developed by him has several functions, i.e.: it restores muscle function by supporting weakened muscles, reduces local congestion by improving blood and lymph flow, reduces pain by stimulating the nervous system, decreases pressure on the nociceptors, and repositions subluxated joints by removing abnormal muscle tension, helping to restore the function of the fascia and muscle; it also increases proprioception by stimulating the cutaneous mechanoreceptors (Kase, Hashimoto & Tomoki, 2003; Sarkar et al., 2018; Williams, Whatman, Hume & Sheerin, 2012). This method involves the application of a very thin, special, elastic, adhesive tape directly onto the skin (Sathya, Ramakrishnan, Phadke & Jena, 2016). The tape, called kinesiology tape (K-active tape) does not contain latex or any chemical or pharmacological substances, is sensitive to heat and may be worn up to 5 days.

It has variable length and width, and it may be applied using various techniques (for removing pain, for recovery, for correcting posture and increasing sport performance) (Banerjee, Briggs & Johnson, 2016; Gligor & Gligor, 2018). Moreover, it can be stretched up to 120 – 140% of its original length. (Kase, Wallis & Kase, 2003; Hosp, Folie, Csapo, Hasler & Nachbauer, 2017) After application, it tends to return to its initial length supplying constant thrust on the skin (Hosp, Folie, Csapo, Hasler & Nachbauer, 2017). The tape may cover full parts of the body (e.g. ankle, wrist, fingers etc.) and it may prevent, especially in gymnastics, ankle injury (resulting from overuse) or wrist injury. In addition, the tape helps the patient maintain the normal biomechanics of the area (Bandyopadhyay & Mahapatra, 2012).

The purpose of this research is to review literature data on the effects of applying kinesio taping for preventing and treating sports injuries in athletes.

Methods

In order to highlight the effects of kinesio taping on sports injuries we have identified a series of specialized studies using the following online databases: PubMed, NCBI, Research Gate, Semantic Scholar, EBSCOhost, Google search. The research was limited to full-text studies in English, published between 2007 and 2018, using the following key words: kinesiotaping, kinesio tape, kinesio tape effects, kinesio tape efficacy, rehabilitation of athletes. We have included in our study scientific research that had an available abstract, original data and were discussing the use of kinesio tape for preventing and treating sports injuries, as well as review studies on the same topic.

Results and Discussions

Following the primary analysis of the scientific data obtained we selected a total number of 34 studies that were relevant for this topic. Many studies investigated the effects of kinesio taping on pain, muscle strength and flexibility, on the range of motion and proprioception in patients or healthy individuals (Aktas & Baltaci, 2011; Halseth, McChesney & DeBeliso 2004; Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016), as well as the effects on balance, posture and neuromuscular system (Bandyopadhyay & Mahapatra, 2012).

Ozmen T. et al. have recently investigated the effects of applying kinesio taping on the quadriceps femoris muscle, in terms of muscle pain and flexibility (measured as range of knee flexion), and running speed in 19 female students during their recovery after squat exercises. They found an increased muscle

pain 48 hours after squat exercises, both in the presence and in the absence of KT application on the quadriceps femoris muscle (Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016)

A temporary muscle lesion may occur after difficult exercises (e.g. with eccentric contractions), accompanied by a decrease in muscle performance, which is associated with DOMS – "Delayed Onset Muscle Soreness" (Nguyen et al., 2009; Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016). DOMS is characterized by pain, stiffness and maximum intensity, 24-48 hours after difficult exercises, especially those with eccentric contractions, which go down within 96 hours (Cheung, Hume & Maxwell, 2003; Connolly, Sayers & McHugh, 2003). If DOMS does not alleviate, it can affect the athletes' performance during successive games or training sessions, through a reduction in the knee joint range of motion, and peak torque (Cheung, Hume & Maxwell, 2003). Shoger M. et al. (Shoger, Nishi, Merrick et al., 2000; Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016) noticed that KT does not reduce the pain associated to DOMS in the flexors of the radiocarpal joint.

Merino Marban R. et al. also showed that the application of KT on the athletes' calf, after a duathlon competition, did not reduce muscle pain right away, or 10-15 minutes after the competition (Merino-Marban et al., 2011; Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016). Other researchers (Thelen, Dauber & Stoneman, 2008; Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016) noticed that pain went down immediately after the application of KT or a few days after its application. Equally, Zajt-Kwiatkowska J. et al. noticed that after the application of KT in injured individuals, pain was reduced and the edema visibly resolved (Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007). Pain relief after the application of KT was also confirmed by Herbert R. (Herbert, 2001; Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007). After knee injury. Similar results were presented by Salish G.B. et al. (Salish, Brechtter, Farwell & Powers, 2002; Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007), and Yi C. et al. showed that knee joint stability increased after the application of KT. (Yi, Brunt, Kim & Fiolkowski, 2003; Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007).

For many athletes, fast running performance is a fundamental skill; as shown by the research carried out by Ozmen T. et al. the application of KT on the quadriceps femoris muscle did not have a favorable effect on the running capacity, at 2 days of recovery after squats. Concerning the flexibility of the quadriceps femoris muscle, Ozmen T. et al. noticed that muscle flexibility maintained 2 days after recovery, this being an important condition for preventing musculoskeletal injuries in athletes (Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016; Bahr & Holme, 2003; Witvrouw, Danneels, Asselman, D'Have & Cambier, 2003). In

exchange, Merino-Marban R. et al. did not find any effect of KT application on the flexibility of tendons in healthy students. (Merino-Marban et al., 2011; Ozmen, Aydogmus, Dogan, Acar, Zoroglu & Willems, 2016).

According to Fratocchi G. and Yoshida A., the use of KT can change muscle activity and increase muscle strength (Fratocchi et al., 2013; Yoshida & Kahanov, 2007; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015). In the case of football players, in order to obtain significant muscle strength and performance improvements, they must perform endurance exercises and trainings for improving speed and movement coordination and for maintaining balance and functionality (Cunha et al., 2013; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015). In general, the studies having assessed the effects of KT on muscle strength and activity in athletes are contradictory. Thus, Slupik A. et al. found an increase in the muscle activity of the vastus medialis in healthy young people, 24 hours after the application of the kinesio tape, an increase that persisted for 24 hours (Slupik, Dwornik, Bialoszewski & Zych, 2007; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015). Similarly, Huang C.Y. et al. found an increase in the activity of the triceps surae muscle during vertical jumps, after the application of the kinesio tape in healthy athletes (Huang, Hsieh, Lu & Su, 2011; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015). In exchange, Fu T.C. et al. concluded that the application of the kinesio tape on the quadriceps muscle in healthy athletes does not change the knee extension strength, and Nunes G.S. et al. noticed that the kinesio tape does not improve jumping performance or balance (Fu et al., 2008; Nunes, de Noronha, Cunha, Ruschel & Noé, 2013; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015).

Serra M.V.G.B. et al. researched the effect of KT on knee extension strength in 34 healthy, professional football players, who performed two maximum voluntary isometric contractions of the lower limbs before and 24 hours immediately after the application of the kinesio tape, and did not find any change (Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015). They concluded that KT does not influence the strength related results obtained right away and 24 hours after the application of KT. Also, Kim H. and Lee B. did not notice any significant differences in the isokinetic muscular function of horse racing jockeys immediately after the application of KT (Kim & Lee, 2013; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015). Unlike Serra M.V.G.B. et al., other researchers found an increased eccentric knee extension strength during isokinetic exercises in non-athlete women, after the application of KT onto the skin overlying the quadriceps (Vithoulka et al., 2010; Serra, Vieira, Brunt, Goethel, Gonçalves & Quemelo, 2015).

Both for sports, and for daily life activities, it is highly important to maintain balance, which is based on the continuous feedback from the visual, vestibular, somatosensory, and proprioceptive structures (Hosp, Folie, Csapo,

Hasler & Nachbauer, 2017). In the case of physical activity involving big muscle groups (e.g. jogging, cycling, walking) muscle fatigue occurs (Simoneau, Bégin & Teasdale, 2006; Hosp, Folie, Csapo, Hasler & Nachbauer, 2017; Tajik, Shokri & Ghanbari, 2016). Many researchers showed the harmful effects of muscle fatigue on the balance capacity, which is generated by the change of proprioceptive impulses (Simoneau, Bégin & Teasdale, 2006; Hosp, Folie, Csapo, Hasler & Nachbauer, 2017). The impairment of the balance capacity caused by the fatigue induced by eccentric physical exercises is alleviated by the application of KT on the knee joint, which reduces the risk of knee injuries during sports activities, the effect being obvious especially in those with low basic balance capacity (Hosp, Folie, Csapo, Hasler & Nachbauer, 2017). According to Kase K., KT improves proprioception by the increased stimulation of the mechanoreceptors located in the skin, muscles and joint capsules (Kase, Wallis & Kase, 2003).

Hosp S. et al. investigated the effect of KT on balance capacity after eccentric physical exercises in a group of healthy young men, and they found that the application of the kinesiology tape on the knee joint has gradually alleviated the fatigue related to exercising, and low balance capacity (Hosp, Folie, Csapo, Hasler & Nachbauer, 2017).

As reported by Zech A. et al., both general and localized fatigue have effects on postural, static and dynamic control (Zech, Steib, Hentschke, Eckhardt & Pfeifer, 2012; Tajik, Shokri & Ghanbari, 2016). Fatigue may change the condition of muscular activity and slow the related influx transmission, thus weakening postural control and generating the risk of sports injuries (Munn, Sullivan & Schneiders, 2010; Tajik, Shokri & Ghanbari, 2016).

Tajik A. et al. studied the effects of applying kinesio taping to the quadriceps muscle on the dynamic postural control, after fatigue induced to the quadriceps, in healthy, amateur (non-professional) athletes. They concluded that the application of KT may reduce the harmful effect of muscle fatigue on the dynamic balance of athletes, being useful for the improvement of balance after induced fatigue (Tajik, Shokri & Ghanbari, 2016). The effect of KT on the range of motion is unclear due to the limited number of studies on the different types of joints, and divergent outcomes. The positive effects of KT found in the study conducted by Thelen M.D. et al. suggested that KT may at least have a small, brief effect on the range of motion for certain joints, as it appears from literature (Thelen, Dauber & Stoneman, 2008; Williams, Whatman, Hume & Sheerin, 2012).

Alam S. et al. investigated the immediate effect of kinesio taping on the peak torque of the external rotator muscle of the shoulder on the range of motion in healthy individuals. The results of the study showed no differences with respect to muscle strength or range of internal/external rotation motion induced by KT, when compared to the result of placebo taping or lack of taping.

In general, KT did not cause any important difference in the peak torque of the external rotation of the shoulder and in the internal and external shoulder range of motion, in healthy individuals (Alam, Malhotra, Munjal & Chachra, 2015).

The injuries of the kinetic system need recovery, and sometimes even orthopedic surgery; and the recovery process has a variable duration (of weeks or even months) (Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007).

Despite the contradictory opinions on the advantages and disadvantages of athlete taping, it is still used, with certain precautions, for the benefit of athletes, in post-injury recovery and for sport performance, as this is a simple, cost-effective, affordable and safe treatment for pain and musculoskeletal dysfunctions. During professional and recreational sports activities, both motor stress and injuries may occur, especially at the level of joints and muscles. KT enhances the therapy applied in sports medicine and allows athletes to perform physical activities when they have minor injuries or to quickly recover in case of major injuries (Bandyopadhyay & Mahapatra, 2012) .

In such situations, if there is no ligament tear and incomplete loss of joint stability, KT can be used to reduce pain and post-traumatic edema, for 1 - 2 weeks. (Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007). In female basketball players, in about 48% of cases, ankle sprain occurs to the side, and the impairment of mechanoreceptors and loss of joint position sense lead to the installation of functional ankle instability. In athletes and basketball players, ankle taping is recommended for ankle instability, as it is considered to help tissue healing and repair (Kiliç, Yildiz, Tűrker, Ömer & Şensu, 2017).

This effect is based on the functions of the kinesio tape to support the ankle, regulate muscle functions, eliminate tissue fluids and subcutaneous hemorrhage, reduce pain and correct joint position (Kiliç, Yildiz, Tűrker, Ömer & Şensu, 2017). Kiliç B.B. et al. investigated the effects of kinesio taping on the sport performance of female professional basketball players, with a clinical diagnosis of chronic ankle instability. For this purpose, they assessed the effects of KT application on the ankle in terms of endurance and muscle strength, postural stability, proprioception and value of the high jump. These researchers concluded that the short-term KT application on the ankle was not efficient for the neuromotor healing, and it only supported the ankle; therefore, it had a positive effect only on maintaining the posture, by correcting the kinematics of the standing position.

However, the authors consider that, due to its therapeutic effects, KT may be used for preventing injuries in case of chronic ankle instability (Kiliç, Yildiz, Tűrker, Ömer & Şensu, 2017). In the past years, the use of kinesio taping has become extremely popular for reducing the severity and incidence of knee

injuries. In the case of athletes, the impairment of the balance capacity due to physical fatigue represents a high risk (almost 40%) of knee injury (Changela, Selvamani & Ramaprabhu, 2012; Hosp, Folie, Csapo, Hasler & Nachbauer, 2017). KT prevents the aggravation of balance impairment induced by eccentric exercises and, in this way, it helps reducing the risk of knee injuries associated to sports activities.

As stated by Agel J. et al., the injuries of the anterior cruciate ligament account for approximately half of the knee injuries in athletes (Agel, Arendt, & Bershadsky, 2005; Balki, Göktaş & Öztemur, 2016). The complete tear of this ligament requires its reconstruction, and the recovery program after ACL (anterior cruciate ligament) reconstruction should alleviate the consequent effects such as pain, edema, motor incapacity, as well as the reduction of the range of motion, proprioception and muscle strength at the level of the lower limbs (Hohmann, Tetsworth & Bryant, 2011; van Grinsven, van Cingel, Holla & van Loon, 2010; Balki, Göktaş & Öztemur, 2016). For this purpose, both medication and other treatment methods are used, such as cryotherapy, elastic bandage, pushing exercises for the ankle, patellar mobilization, continuous passive motion therapy, KT (Boguszewski, Tomaszewska, Adamczyk & Bialoszewski, 2013; Balki, Göktaş & Öztemur, 2016).

During recovery from the ACL reconstruction surgery, it is highly important to treat postoperative edema and pain, as the edema diminishes the strength of the quadriceps, and pain reduces joint motions, (Balki, Göktaş & Öztemur, 2016); this can also be achieved by using KT (Lim & Tay, 2015; Balki, Göktaş & Öztemur, 2016). The efficiency of KT as an adjuvant to recovery after ACL reconstruction was assessed by Boguszewski D. et al., who found that the application of KT from the 28th day reduced postoperative pain and edema (Boguszewski, Tomaszewska, Adamczyk & Bialoszewski, 2013; Balki, Göktaş & Öztemur, 2016).

Balki S. et al. investigated the effects of KT application in the acute postoperative recovery phase after ACL reconstruction, with the allograft or autograft of the tendon, in a group of 30 patients; they were randomly divided into two groups: one experimental group who received a KT treatment using lymphatic and muscle correction techniques, and one control group, where false KT was applied. Both interventions were applied twice, for a period of 10 days, starting with the 4th days after surgery.

All patients followed the same recovery program for 3 months. The results of the research showed a significant decrease in pain severity, 5 days after the KT treatment, as well as a reduced edema in the operated knee. An important factor determining the functional level after ACL reconstruction is the quadriceps strength; however, the KT treatment applied in the experimental group did not result into important increases of the quadriceps strength (Bryant, Kelly & Hohmann, 2008; Balki, Göktaş & Öztemur, 2016). After having

analyzed the effects of KT in the acute postoperative recovery phase after ACL reconstruction, the authors concluded that the application of KT, in combination with the postoperative recovery program, is efficient for treating pain, edema, for increasing the range of knee flexion and strength of the hamstring muscle (Balki, Göktaş & Öztemur, 2016).

Kinesio taping is also used in professional athletes who suffer from patellar tendinopathy, a musculoskeletal injury that is also common in active persons, aged between 30 and 55 years, with an increasing prevalence. (Massei, Sanzo & Przysucha, 2017) In order to avoid the risk of tendon tear or structural injuries of the joint, the early use of therapeutic taping, with KT or leukotape (LT), is required (Massei, Sanzo & Przysucha, 2017).

Massei M. et al. carried out a pilot study for the purpose of researching the possible positive effects of therapeutic taping as to knee pain, range of motion (ROM), power, balance and strength, in individuals with an active lifestyle who suffered from patellar tendinopathy. After the application of therapeutic taping, they noticed significant effects on knee pain, range of motion and muscle strength.

The application of therapeutic taping in persons suffering from patellar tendinopathy did not significantly reduce knee pain, its effects depending on the type of technique used, on the injury and type of population. The knee range of motion, in those suffering from patellar tendinopathy, is limited by pain, and the application of KT and LT did not result into any changes in the extension or flexion of the knee (Williams, Whatman, Hume & Sheerin, 2012; Massei, Sanzo & Przysucha, 2017). Nakajima M.A. and Baldridge C. examined the efficiency of KT on muscle power, measured by assessing the height of the vertical jump, and on the dynamic postural control, measured using the SEBT test – "Star Excursion Balance Test". The obtained results showed insignificant differences between the taping conditions in terms of height of the vertical jump and dynamic postural control as per the SEBT. Maintaining the dynamic balance is essential for the sporting performance and for carrying out day-to-day occupational and functional tasks. The athletes suffering from patellar tendinopathy may have difficulties in maintaining an adequate balance, as the structure and function of the patella, and strength of the quadriceps, in general, have been compromised. The authors of the pilot study concluded that certain aspects of the motor functioning, such as strength of the knee flexor and balance, improved after the application of KT (Nakajima & Baldridge, 2013; Knežević & Mirkov, 2011).

Ostiak W. et al. assessed the efficiency of KT in treating soft-tissue injuries in adolescent football players after playing football, and found that kinesio taping is an efficient and fast method for reducing pain in the case of soft-tissue injuries, which allows football players to return to their sports activity (Ostiak, Peretiatkowicz & Krystkowiak, 2012).

The wide use of KT in the early stages, but also in the chronic stages of injuries is underlined by Zajt-Kwiatkowska J.Z. et al.; the authors found that the application of KT is a good method for supplementing the usual physiotherapy treatment, as it reduces the level of pain and increases the patient's functional capacity (Zajt-Kwiatkovska, Rajkowka-Labon, Skrobot, Bakula & Szamotulska, 2007).

Conclusions

Although kinesio taping is a rehabilitation method that is frequently used in athletes for reducing pain, increasing muscle performance (strength and flexibility), thus reducing the severity and incidence of injuries, its use remains controversial. This is due to the contradictory effects shown in many specialized studies. However, due to the limited number of specialized studies available, further, more detailed and numerous studies are necessary, in order to clarify the effect of kinesio taping on preventing and treating sports injuries in athletes. A possible use of this method in athletes is as an adjuvant to the classic rehabilitation therapy.

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PREVALENCE OF OVERWEIGHT AND OBESITY AMONG MIDDLE SCHOOL CHILDREN IN ROMANIA

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ABSTRACT. Introduction. The early ages of adolescence, between 11-14, are accompanied by a great fluctuation of the values of sudden physical growth, of temperament and of personality. Periodical monitoring of somatic indicators and determining the body mass index are methods necessary for monitoring the state of health of school children. **Goals**. The goal of this study is to assess the prevalence of overweight and obesity among children in middle school within Bihor, Cluj and Sălaj county and to compare the obtained results with the results of other studies of this nature. **Subjects and methods**. The sample group was made up of 962 middle school students. The method used was anthropometry. The body mass index was calculated in accordance with the BMI reference chart according to age and gender. The results of the measurements were statistically processed with the SPSS program. The descriptive analysis was performed and the differences between the average values were tested with the independent samples t-test. We calculated the relation between different variables using the Pearson correlation coefficient. **Results**. In this study, the prevalence of overweight and obesity were 15.1% respectively 9.8%. There was a significant positive correlation between age and BMI, $r = 0.15$, $p < 0.001$, but a negative correlation between age and physical activity, $r = -0.25$, $p < 0.001$. **Conclusions.** The prevalence of overweight and obesity was 24.9%. The prevalence of overweight and obesity is higher in boys than in girls. The prevalence of overweight is higher in urban boys than in rural boys.

Keywords*: overweight, obesity, preadolescence, height, weight.*

REZUMAT. ***Incidența supraponderalității și obezității la copiii din ciclul gimnazial din România***. **Introducere.** Parcurgerea adolescenței timpurii, cu limite între 11 și 14 ani, se produce cu o mare variabilitate a indicilor creșterii fizice bruște, a temperamentului și a personalității. Supravegherea periodică a indicatorilor somatici și determinarea valorii indicelui de masă corporală reprezintă metode necesare de monitorizare a stării de sănătate a școlarilor.

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Obiective. Obiectivul acestui studiu a fost să evaluăm incidența supraponderalității și obezității la copii gimnaziali din județele Bihor, Cluj și Sălaj și să comparăm rezultatele obținute cu cele din alte studii asemănătoare. **Subiecți și metode.** Eșantionul a fost format din 962 elevi din ciclul gimnazial. Metoda de lucru a fost antropometria**.** Indicele de masă corporală s-a calculat conform hărții de referință a IMC după vârstă și gen. Datele măsurătorilor au fost prelucrate statistic cu ajutorul programului SPSS. A fost făcută analiza descriptivă iar diferențele dintre medii au fost testate cu ajutorul testului t pentru eșantioane independente. Legătura dintre variabile a fost calculat cu ajutorul coeficientului de corelație Pearson. **Rezultate**. În studiul prezent prevalența supraponderalității a fost de 15,1% iar cea a obezității de 9,8%. A existat o corelație pozitivă semnificativă între vârstă și IMC, r = 0,15, p <0,001, dar o corelație negativă între vârstă și activitatea fizică, r = - 0,25, p < 0,001. **Concluzii.** Prevalența supraponderalității și obezității a fost de 24.9%. Excesul de greutate este mai mare la băieți decât la fete. Prevalența excesului de greutate este mai mare la băieții din mediul urban decât la băieții din mediul rural.

Cuvinte-cheie*: supraponderalitate, obezitate, preadolescență, talie, greutate.*

Introduction

According to World Health Organization (2013), obesity is recognized as a major and independent risk factor. One in three children in Europe is overweight or obese and within the last 30 years obesity rates have doubled among children. The percentage of children aged 5-19 overweight and obese increased from 4% in 1975 to 18% in 2016 (WHO, 2018).

According to the study called Health Behaviors for School-aged Children (HBSC), in Romania in the 2013-2014 school year, the percentage of overweight or obese girls of age 11 was 14%, of age 13 it was 11% and of age 15 it was 10%. In boys of age 11 this percentage was 33%, for those of age 13, it was 26% and for the 15 years old boys it was 21% (Ahluwalia et al., 2015).

The action plan of WHO (2016) for prevention and control of non-communicable diseases and adoption of a healthy lifestyle between 2016-2025, is meant to decrease with at least 25% the rates of premature mortality caused by cardiovascular diseases, cancer, diabetes or chronic diseases of the respiratory system. The body fat percentage is considered to be the most accurate way of determining adiposity (Welcome, 2017). The body mass index (BMI), which does not quantify body fat directly, has been established as a simple and effective clinical screening tool (Freedman, Horlick, Berenson, 2013 & Wohlfahrt-Veje, 2014).

Most overweight or obese children will probably be obese in their youth as well (Freedman et al., 2005), or will suffer of non-communicable diseases (Guo et al., 2000).

Obesity is associated with a significant increase in mortality, with a life expectancy decrease of 5–10 years (Berrington de Gonzalez et al., 2010; Kuk et al., 2011; Prospective Studies Collaboration et al., 2009).BMI is an instrument that represents the standard in the assessment of the risks that appear as a result of the weight excess. People whose BMI is too high or too low are predisposed to develop certain health problems. In order to determine the weight excess the current weight is referred to the ideal weight depending on height, age and gender. In this regard the Center for Disease Control and Prevention (CDC) recommends the use of growth charts.

In 2004, upon the recommendation of CDC, 15 health care organizations have revised the BMI values. Children whose BMI by age and gender was located between the 85^{th} -95^{th} percentiles, were considered as overweight and those with higher values were classified as being obese (Barlow & Committee, 2007).

Objectives

The goal of this study was to assess the prevalence of overweight and obesity among children in middle school within the Bihor, Cluj and Sălaj county and to compare the obtained results with the results of other studies of this nature.

Design, Setting, and Participants

A cross-sectional study was performed on a sample of Romanian (N=962, Boys=486, Girls=476) adolescent population. The height and the weight was measured in the second semester of the 2015-2016 school year. The sample was selected from the following counties: Bihor county (49.4%), Cluj county (38.7%) and Sălaj county (11.9%). They were pupils of 12 different schools.

In this study, the anthropometric method was used to measure the two somatic indicators: height and weight together using the cut-off points of body mass index (BMI) according to WHO standards (WHO, 2007). The Physical Activity Questionnaire for Adolescence (PAQ-A) (Kowalski, Crocker, & Faulkner, 1997) was applied to measure the physical activity level of the adolescents.

The data of the individual measurements were processed statistically on computer with the Statistical Package for Social Sciences: version 20.0 SPSS Inc. (SPSS) program. The descriptive analysis was performed and the differences between the means were tested with the independent samples t-test. We calculated the relation between different variables using the Pearson correlation coefficient.

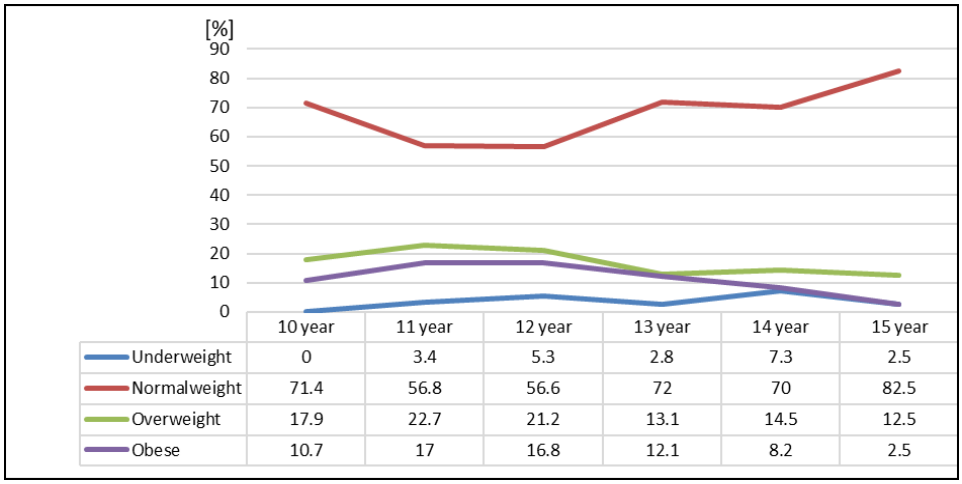
Results

A total of 962 school children were investigated, 50.5% were male (N = 486), and 49.5% were female (N = 476). The mean age was 12.74±1.39 years (12.88±1.39 of boys and 12.60±1.39 of girls. 59.9% were urban inhabitants while 40.1% were rural inhabitants. The range was from 10.0 to 15.4 years of age. In this study, the prevalence of overweight (OW) and obesity (OB) were 15.1% and respectively 9.8%. As shown in table 1, boys were more likely to be OW and OB than girls (17.3%-12.8% vs. 12.4%-7.1%, $p < 0.05$).

	Underweight (<5th) [%]	**Normal weight (5th – 85th) [%]**	**Overweight (85th-95th) [%]**	**Obese (≥ 95th) [%]**
Total sample N = 962	3.7	71.4	15.1	9.8
Girls N = 476	3.2	76.8	12.8	7.1
Urban Girls = 286	2.2	76.9	12.9	8.0
Rural Girls = 189	4.7	76.3	12.6	5.8
Boys N = 486	4.3	66.0	17.3	12.4
Urban Boys = 290	4.5	66.6	19.3	9.7
Rural Boys = 196	4.1	65.3	14.3	16.3

Table 1. BMI distribution by the gender of the subjects

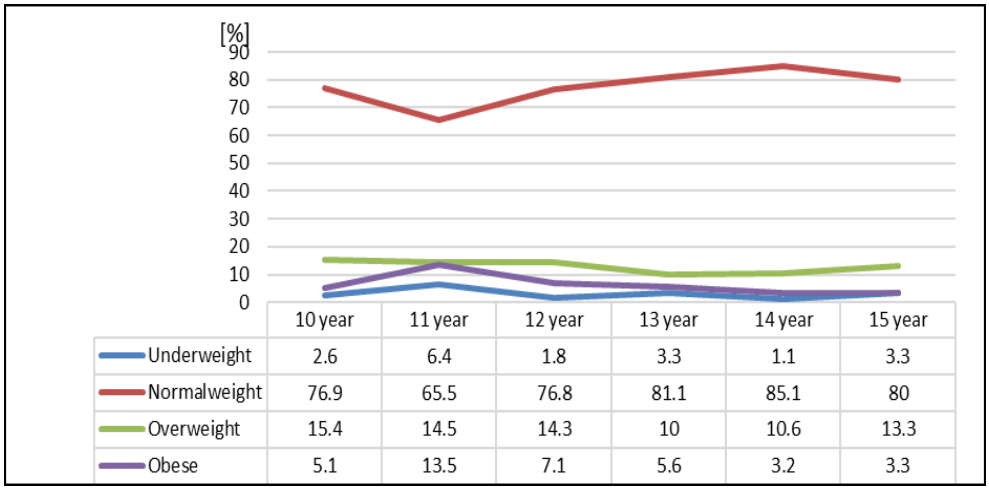
No significant differences were found between the mean BMI values of rural and urban students in either boys ($p = 0.60$) or girls ($p = 0 .730$), in contrast, there is a significant difference between the mean BMI rates of boys (20.48 ± 3.93) and girls (19.9 ± 3.74) ($p = 0.19$).



	10 year	11 year	12 year	13 year	14 year	15 year
Underweight	0	3.4	5.3	2.8	7.3	2.5
Normalweight	71.4	56.8	56.6	72	70	82.5
Overweight	17.9	22.7	21.2	13.1	14.5	12.5
Obese	10.7	17	16.8	12.1	8.2	2.5

Fig. 1. The prevalence and tendency of the overweight and obesity for boys aged 10 to 15

The first and second figure shows the categories calculated from the table broken down by age. In both cases, the same trend can be observed, with a higher proportion of children aged 10–12 years being overweight and obese, while at the same time having a lower proportion of those with a normal body weight. In both gender, there is a gradual decrease in overweight and obese people between the ages of 13 and 15.



	10 year	11 year	12 year	13 year	14 year	15 year
Underweight	2.6	6.4	1.8	3.3	1.1	3.3
Normalweight	76.9	65.5	76.8	81.1	85.1	80
Overweight	15.4	14.5	14.3	10	10.6	13.3
Obese	5.1	13.5	7.1	5.6	3.2	3.3

Fig. 2. The prevalence and tendency of the overweight and obesity for girls aged 10 to 15

We found a very weak negative correlation between BMI and Physical Activity Score for girls, $r = - 0.10$, $p = 0.04$. In overweight individuals, the correlation between the two variables is stronger, $r = - 0.18$, $p = 0.03$, whereas in obese individuals there is no correlation, $r = - 0.173$, $p = 0.12$.

There was a significant positive correlation between age and BMI, $r = 0.155$, $p < 0.001$, but a negative correlation between age and physical activity, $r = -0.25$, $p < 0.001$. The physical activity level of the boys was 2.95 ± 0.73, and of the girls was 2.74 ± 0.68, the difference between the two scores was significant ($p < 0.05$).

Discussion

During the school year 2009-2010 a sample of 3780 students aged 11 to 15, 19% boys and 9% girls, were overweight or obese (Rădulescu, Ghiorghiu, Pleşca, 2020).

In the Romanian adult population, the prevalence of overweight and obesity is extremely high compared to the world average published by WHO. According to the study of Popa et al., (2020) on 900 individuals aged 18-65, 29.56% were overweight and 21.33% were obese. In a 2016 a different study reported a higher incidence, 34.7% overweight and 31.9% obese in the Romanian population aged 20-79 (Popa et al., 2016).

According to the study of WHO, in 2016, 39% of adults aged 18 years and over were overweight and 13% were obese (WHO, 2020).

The most comprehensive study in recent years has been performed by Chirita-Emandi et al. published in 2016, of 25060 subjects age 6-19, in which the frequency of underweight was 5% (3.7% in our study), 66.6% had normal weight (71.4%), 17.5% (15.1%) overweight and 11% (9.8) were obese. Based on only the 10-15 age group, the proportion of overweight was 18.78% and that of the obese 9.46%.

In a 2013 study, Chirita-Emandi, Puiu, Gafencu, and Pienar examined subjects aged 7–18 years and found that 18.2% of the subject were overweight and 7.2% were obese (Chirita-Emandi, Puiu, Gafencu & Pienar, 2013). We believe that it is difficult to obtain representative data for Romania in terms of the incidence of obesity and overweight due to the lack of representative cross sectional studies.

The 2016 study by Chirita-Emandi et al., though it counts data from a sample of more than 25.000 subjects, measurements were made between 2006 and 2015 from 12 different research groups.

Conclusion

The prevalence of overweight and obesity in this Romanian adolescence sample was 24.9%. The prevalence of overweight and obesity was higher in boys than in girls. The prevalence of overweight is higher in urban boys than in rural boys; however, the rural boys were more likely to be obese than the urban boys. The frequency curve presented in our study was similar to curves seen in other studies in this topic. Similarly, the data we presented was almost identical to the data from other prevalence studies conducted in Romania.

Within a population of school-aged children, the chronological variability of maturation depends on the level of urbanization, environmental factors and individual factors. BMI is an indirect indicator to determine the adipose tissue. Due to the big differences between the biological age and the chronological age, the body mass index cannot be considered an instrument of diagnosis. It is rather considered a screening indicator and for additional tests we recommend using simultaneously the skinfold test or the analysis of the adipose tissue by bio-impedance.

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IMPACT OF PHYSICAL ACTIVITY ON OBESITY IN ADULTS

NUȚ RAMONA ANCUȚA[1]

ABSTRACT. The significant increase of the prevalence of overweight and obese adults raises the importance of approaching this major issue of public health. Our modern life style characterized by the intake of highly caloric food and low levels of physical activity, accompanied by long periods of sitting and a poor sleep interacts with our basic biology creating an environment where the circadian rhythms are disrupted which more often result in a higher number of metabolic disorders. The excess of body weight is associated with many negative effects upon health including but not limited to cardiovascular diseases, diabetes, some form of cancers and muscle and bone disorders. Since the physical activity is more and more performed in organized environment, the importance of physical activity in the society increased in time, not only for the individual but for the public health. Our daily life becomes less and less physically active, while organized physical training increases. The average caloric intake is increasing, which means more unconsumed energy and as a result more overweight persons with health problems. Physical training seems to be an important factor in approaching this epidemic of obesity. This paperwork aims to revise the literature to determine if the physical activity can be associated with the prevention of weight gaining in obese adults.

Keywords: *physical activity, obesity, overweight.*

REZUMAT. ***Impactul activității fizice asupra obezității la adulți.*** Creșterea semnificativă a prevalenței excesului de greutate și obezitate a crescut importanța abordării acestei probleme semnificative de sănătate publică. Stilul nostru de viață modern predominant care încorporează accesul continuu la alimente cu densitate energetică și niveluri scăzute de activitate fizică obișnuită, însoțite de perioade de ședință prelungită și calitate/cantitate inadecvată de somn interacționează cu biologia de bază pentru a crea un mediu în care ritmurile circadiene sunt perturbate, ducând adesea la o multitudine de afecțiuni metabolice. Greutatea corporală excesivă este asociată cu numeroase rezultate negative asupra sănătății care includ, dar nu se limitează la boli cardiovasculare, diabet, unele forme de cancer și afecțiuni musculo-scheletice. Deoarece activitatea fizică se desfășoară tot mai

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mult în mod organizat, rolul activităţii fizice în societate a devenit din ce în ce mai important de-a lungul anilor, nu numai pentru individ, ci și pentru sănătatea publică. Se discută că viaţa noastră de zi cu zi devine din ce în ce mai puțin activă fizic, în timp ce exerciţiile și antrenamentele organizate cresc. Aportul mediu de energie este în creștere, creând un surplus de energie și, astfel, vedem un număr din ce în ce mai mare de persoane supraponderale, ceea ce contribuie puternic la problemele de sănătate. Exercițiul fizic pare a fi un factor important pentru abordarea epidemiei de obezitate. În lucrarea de faţă se realizează o revizuire a literaturii de specialitate pentru a determina dacă activitatea fizică este asociată cu prevenirea creșterii în greutate la adulţii obezi.

Cuvinte-cheie: *activitate fizică, obezitate, supraponderalitate.*

Introduction

The significant increase of the prevalence of overweight and obese adults raises the importance of approaching this major issue of public health. Physical training seems to be an important factor in approaching this epidemic of obesity.

Physical exercise can represent a major component in weight loss and therefore, it is usually included into the weight management program. However, the effects of exercise on weight loss and change of body composition are minimal in short-term treatment programs (<6 months), compared to the effect of reduction of caloric intake.

The 2008 Report of Physical Activity Guidelines Advisory Committee (PAGAC), states that physical activity has been associated with a modest weight loss of approximately ≤3 kg, but the prevention of the weight gain as a result of reduction of overall and local adipose tissue mass prevents the risk of diseases (US Department of Health and Human Services, 2009). Moreover, the professional organizations have also identified physical activity as an important habit that contributes to the body weight regulation (Donnelly J.E., et al., 2009).

In addition, Jakicic and collaborators (Jakicic, J.M., et al., 1999) showed that participation in physical training programs is associated with long-term weight loss, and more physical exercises lead to greater weight loss. Although the physical exercises can help maintain long-term weight loss, we cannot say that physical exercises alone are enough to maintain weight loss. It has been shown that maintaining changes in both diet and reaction to physical effort is highly important for improving the long-term weight loss (Jakicic, J.M., et al., 2002).

Revision of Literature

Effects of Physical Activity on Health

The human body requires a certain amount of physical activity in order to maintain health and well-being. Nowadays people need more or less the same amount of physical activity as they did 40 000 years ago (Leonard W.R., 2010). For a regular person weighting 70 kg, this represents approximately 19 km walking each day, in addition to daily physical activity. The amount of physical activity decreases for most of the people while the planning, organized physical exercise and physical training increase.

Unfortunately, the caloric intake also increases, exceeding the daily energy consumption, which leads to calorie surplus. This is the reason for a higher number of overweight persons and one of the main causes of health issues. (Church T.S., 2011). A more sedentary life that does not reach the recommended level of physical activity, together with a high caloric intake, has effect on both physical and psychical capacity and increases the risk of diseases. Despite this, the Swedes (for instance) seem to be physically active and stressed as before, however their overall health is better in 2015, comparing with 2004. In 2012-2015 the Swedes had a better overall health and less tiredness at the same level of physical activity (~ 65% reported at least 30 minutes daily) and stress (~ 13% were stressed) than they had in 2004-2007 (SCB, 2004).

When describing the relationship between the physical activity and certain diseases, we take into consideration the relationship between the measure of effect, risk reduction as presented in studies and the duration of recommended physical activity (Borde R., et al., 2015). The individuals who change their life style from a complete sedentary life to a moderate active life reported the greatest health benefits, and the effects on health were noticed before the measurable improvements of physical performance. In the previous period, most of scientific studies collected data related only to the aerobic physical activity. However, the physical strength exercise shows promising effects on (psychical and physical) health and influence on combating diseases (Northey J.M., et al., 2018; Yamamoto S., et al., 2016).

Aerobic activity helps in weight maintaining after the initial weight loss, reduces the risk of metabolic syndrome, regulates the lipids in blood and improves the quality of life of cancer patients (Geneen L.J., et al, 2016).

It has been proved that resistance exercises as opposed to aerobic exercises, is the best measure to fight against muscular atrophy (Csapo R., et al., 2016), risk of balance loss (Tofthagen C., 2012) and osteoporosis (Cadore E.L., et al., 2014) in elderly. Strength training also prevents obesity (Garcia-Hermoso A.,

et al., 2018), and if made along with aerobic exercises improves the cognitive performance (Groot C., et al., 2016), has an important role in preventing neurodegenerative diseases (Chung C.L., et al., 2016) and improves the bone density (Ciolac E.G., et al., 2016; Castrogiovanni P., et al., 2016). The risk of accidents increases with aging due to the loss of muscle mass, of coordination and balance (Cho S.I., et. al., 2014). Physical activity counselling for muscle strengthening in addition to the aerobic activity it is highly recommended for improving the overall health.

Besides helping with the weight loss, physical exercises provide other important benefits for health. (Wei, M., et al., 1999). For instance, higher level of cardiorespiratory fitness is associated with a lower mortality due to cardiovascular diseases, while overweight adults with the highest level of fitness may have a lower risk of cardiovascular diseases than physically unfit adults of normal weight. This may be the result of exercise which decreases the risk factors for cardiovascular diseases (i.e. arterial hypertension, diabetes etc.), regardless of the changes in body weight. Therefore, even the individuals who have difficulties in losing weight can benefit from regular sessions of physical exercises if the volume and the intensity of the exercises are adequate for generating these health benefits.

Brown and collaborators (2016) mention a study regarding the relationship between physical activity and chances of maintaining a healthy body weight (which is IMC ≥18.5 up to <25 kg m − 2). Comparing with less than 0.7 MET h week − 1, the probability rate for maintaining a normal IMC was 1.18 (IC 95%, 1.00–1.40) for 0.7 to less than 8.3 MET h week − 1, 1.23 (95% CI, 1.03-1.47) for 8.3 to less than 16.7 MET h week −1 and 1.44 (IC 95%, 1.20–1.72) for 16.7 or more MET-h week-1 − 1 (Brown WJ. Et al., 2016).

Considerations Regarding the Distribution of Physical Exercises for Overweight Persons

Until recently, the public health recommendations of physical exercises and activities consisted of minimum 30 minutes of moderate intensity activity performed almost every day of the week (U.S. Department of Health and Human Services, 1996). However, more recently the Institute of Medicine suggested that 60 minutes of physical exercises may be needed for weight control, and this recommendation is almost double comparing with the previously recommended activity (Institute of Medicine of the National Academies, 2002).

In spite of limited research that evaluates the effect on weight loss of 30 de minutes of physical exercise, comparing with 60 minutes of physical exercise, the available evidence seems to support the recommendation of 60 minutes of physical exercise for long-term weight improvement (Jakicic, J.M., et al., 1999;

Klem, M.L., et al., 1997). Data of the Weight Control National Register revealed that the individuals who maintained an average weight loss of 30.0 ± 15.5 kg during approximately 5.5 years, also had a weekly average energy expenditure of 2,500 kcal with physical activities during leisure time (Klem, M.L., et al., 1997), which represents almost double of the minimum quantity recommended by public health authority (U.S. Department of Health and Human Services, 1996). According to Jakicic and collaborators' report (Jakicic, J.M., et al., 1999), the greatest weight loss was associated with a physical activity of at least 280 minutes weekly during 18 months, which is again, double than the minimum amount recommended by the public health authorities.

The studies which revealed a significant inverse correlation between physical activity and weight gain reported data for certain domains of physical activity. This included spare/leisure time, occupational activities, household activities, walking and climbing stairs, and some of the studies also reported the level of intensity of the physical activity (easy, moderate, vigorous, moderate to vigorous).

Total physical activity performed in the leisure time was constantly associated to change in body weight in all analyzed studies (De Munter JS, et al., 2015; MacInnis RJ, et al., 2014). The studies which reported moderate intensity (Drenowatz C, et al., 2016), high intensity (Williams PT., 2007) and moderate to high intensity (Gebel K, et. al., 2014) revealed consistent patterns of inverse correlations with weight gain. However, low intensity physical activity was not associated with the prevention of weight gain. (Drenowatz C, et al., 2016).

Walking has not been constantly associated with change in weight or IMC (Gradidge P., et al., 2015) or with the incidence of obesity occurrence (Rosenberg L. et al., 2013). Notwithstanding the afore said, it has been reported that walking 10,000 steps or more daily, diminished the weight gain, comparing with walking less than 10,000 steps daily. These results may suggest that in order to diminish the weight gain, a high number of (walking) steps daily is necessary.

The studies evaluated the professional and household activity, as well. Moderate to vigorous professional activity was inversely correlated with the weight gain. However, this inverse correlation was not valid for low professional activity (Adair LS., et al., 2011). In the studies regarding the household activities, no evidence was found to support that this type of physical activity reduces the weight gain. (Drenowatz C., et al., 2016).

Strategies for Choosing and Maintaining the Physical Exercises in Case of Overweight Persons

Although it is highly important to understand the level of exercise that leads to the greatest long-term weight loss, it is also important to understand the factors that do not allow choosing and maintaining certain physical exercises

for overweight adults. There are many impediments against physical exercise. The attendance to physical exercise increases as these impediments are reduced and this may lead to the reduction of body weight. Some of the most important impediments which might influence choosing and maintaining physical exercise are environmental factors that influence the convenience of exercise and factors which might influence the lack of time for performing physical exercises.

Manipulation of the environment in which a person activates (i.e. home, workplace, neighbourhood etc.) for changing the behavior related to physical training, might help to create more suitable opportunities for physical exercises that might increase the attendance to physical activity. One example of environment manipulation which is frequently used by people consists in putting fitness equipment in homes. One transversal study revealed that the volume of physical exercises and home fitness equipment was significantly associated with the levels of physical activity performed in the spare time (Jakicic, J.M., et al., 1997).

The lack of time was also identified as an impediment for overweight people to perform physical exercises and to include them in their lifestyle. For sedentary adults, one strategy to overcome this impediment would be focusing on physical activities performed during the whole day rather than physical exercises performed during one continuous session (30 to 40 minutes/session). The efficiency of encouraging the performance of physical exercises in 3-4 sessions of training of at least 10 minutes was studied in relation with the attendance to physical training and weight loss on overweight women (Jakicic, J.M., et al., 1995). The results of this study showed that this strategy can be efficient for increasing the initial rate of attendance to 6 months' plan of physical exercises in case of previous sedentary adults.

Impact of Obesity on Public Health

Weight gain leading to excess weight or obesity is associated with an increased risk of occurrence of many chronical diseases. This represents an important concern for health in many developed countries due to a high prevalence both of excess weight and obesity. Thus, although it is important to focus ourselves on treatments that works for excess weight and obesity, the implementation of efficient strategies of public health is also necessary in order to prevent approximately 0.5-1 kg of yearly weight gain and the onset of excess weight and obesity in adults. (Dutton G.R., Kim Y., Jacobs D.R. Jr, et al., 2016). The scientific evidence supports the idea that the physical activity can represent an efficient behavior included in the lifestyle, in order to prevent or minimize weight gain in adults. Therefore, the public health initiatives for preventing the weight gain, excess weight and obesity should include physical activity as a lifestyle.

Conclusions

In many countries, obesity represents a major public health issue. Physical exercises should be included as a major component of any intervention for weight loss. Although the physical exercises may have a modest impact on short-term weight loss, physical exercises can be highly efficient for long-term weight loss and for prevention of the weight gain. Moreover, the quantity of physical exercises required to facilitate the long-term weight loss can be higher than necessary in order to obtain significant health benefits, but this idea requires further investigations. When recommending physical exercises for overweight adults, it is highly important to consider the assessment strategies, the indications for training plan and interventions which might affect the attendance to and maintenance of physical exercises programs.

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HEALTH COMPONENT LEVELS OF PHYSICAL FITNESS OF STUDENTS AT PARTIUM CHRISTIAN UNIVERSITY IN ORADEA

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ABSTRACT. Introduction. In 2013, the Cooper Institute from the U.S.A., along with the Hungarian School Sport Federation, implemented the *National Student Fitness Test* battery. In order to interpret the results, NETFIT uses a criterion-referenced standard depending on age and gender called the health standard, establishing the level of the subject in relation to certain objectives. This health standard corresponds to a minimal motor performance necessary to avoid certain risks of illnesses which may occur as a result of physical inactivity. The aim of this research is to determine the levels of health components of physical fitness among students in 1st year at Partium Christian University from Oradea, depending on their residential environment and gender. **Material and methods**. The research included a sample group of 112 students, aged 18 – 19 years. The health components of physical fitness were assessed by determining the adipose tissue level, two anthropometric measurements and 5 motor tests. **Results**. The registered data regarding the BMI values show that 13% of the students were overweight and 10% fell into the obese category. The female students with a low level of adipose tissue had significantly better results from statistical point of view at the standing broad jump test (r_{xy} = - 0.42, df = 71, p < 0.001, r_s = - 0.38, df = 71, p < 0.001). According to the data obtained at the motor tests, we found that at the standing broad jump test 49%, handgrip test 62.5%, paced curl-ups test 80%, flexibility test 64% and paced push-ups test 83% of the subjects fell within the healthy fitness zone. **Conclusions.** We consider that, in order to avoid risks due to insufficient physical activity, the level of biomotor potential of students must be related to their health. Not all students dream of performance and competitions, but they all want to be healthy!

Keywords: *health component, physical fitness, adipose tissue, student.*

REZUMAT. ***Nivelul componentelor de sănătate ale fitnessului fizic al studenților Universității Creștine Partium din Oradea.*** **Introducere.** În anul 2013, Institutul Cooper din SUA, împreună cu Federația Sportului Școlar din Ungaria, a introdus

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Bateria de teste *Nemzeti Egységes Tanulói Fittségi Teszt* (NETFIT). În vederea interpretării rezultatelor, NETFIT utilizează un standard de referinţă criterial, denumit standard de sănătate, după vârstă şi gen, stabilindu-se nivelul la care se situează subiectul faţă de unele obiective. Acest standard de sănătate corespunde cu o performanţă motrică minimă necesară pentru a evita unele riscuri de îmbolnăvire apărute ca urmare a inactivităţii fizice. **Scopul cercetării.** Scopul acestui studiu constă în determinarea nivelului privind componentele de sănătate ale fitnessului fizic a studenţilor din anul I a Universităţii Creştine Partium din Oradea, în funcţie de mediul de reşedinţă şi gen. **Subiecţi şi metode.** Cercetarea a inclus un eşantion de 112 studenţi cu vârsta de 18 şi 19 ani. S-a evaluat componentele de sănătate ale fitnessul fizic prin determinarea nivelului de ţesut adipos, două măsurători antropometrice şi 5 teste motrice. Pentru determinarea relaţiei dintre nivelul ţesutului adipos şi componentele motrice am utilizat coeficientul de corelaţie Pearson şi coeficientul Spearman rho iar pentru diferenţele dintre medii în funcţie de gen şi mediul de reşedinţă au fost testate cu ajutorul testului t pentru eşantioane independente şi testul U a lui Mann-Whitney. **Rezultate.** Datele înregistrate la valorile IMC arată că 13% dintre studenţi au fost supraponderali şi 10% au intrat în categoria celor obezi. Studentele cu un nivel scăzut al ţesutului adipos au avut rezultate semnificativ statistic mai bune la testul SL (r_{xy} = - 0.42, df = 71, p < 0.001, r_s = - 0.38, df = 71, p < 0.001). Potrivit datelor obţinute la testele motrice am constatat că la testul SL 49%, la testul DM 62.5%, la testul RRT 80%, la testul de supleţe 64% iar la testul FR 83% dintre subiecţi s-au încadrat în zona de sănătate. **Concluzii**. Considerăm că, în vederea evitării unor riscuri ca urmare a activităţii fizice insuficiente, nivelul potenţialului biomotric al studenţilor trebuie raportat inclusiv stării de sănătate. Nu toţi studenţii visează la performanţe şi competiţii, însă toţi vor să fie sănătoşi!

Cuvinte-cheie: *componente de sănătate, fitnessul fizic, ţesut adipos, student*

Introduction

According to literature, the assessment of physical fitness can be performed by normative methods (normative test batteries) or criterion-referenced methods (criterion-referenced test batteries). Most test batteries use normative assessment methods, which allow the results obtained by one subject to be compared with the results of another subject from the same group.

The physical fitness level influences physical health as well as mental and cognitive health. According to studies, regular physical exercise increases physical fitness and has a beneficial effect on mental health (Sharma, Vishal, & Frederick, 2006) and cognitive development (Hogan, Mata, & Carstensen,

2013). People with an optimal physical fitness level have an increased ability to concentrate as well as an improved short-term and long-term memory (Hillman, Castelli & Buck, 2005).

In 2013, the Cooper Institute from the USA signed a partnership agreement with the Hungarian School Sport Federation regarding the implementation of a national test for the assessment of students' fitness levels. The *National Student Fitness Test (Nemzeti Egységes Tanulói Fittségi Teszt)* (NETFIT) test battery was created based on the FITNESSGRAM model and it was implemented following a previous representative study.

The NETFIT test battery consists of anthropometric measurements (height, weight), the determination of the BMI, analysis of body composition and seven motor tests: endurance shuttle run, paced curl-ups, trunk extension test, paced push-ups, handgrip test, standing broad jump and the flexibility test.

We wanted to ensure the conditions to perform exact measurements, with well-defined and unitary protocols, starting with the idea that the means of assessment and the measuring techniques of all the health components are well known. For this purpose, between September the 12th, 2014 and September the 20th, 2014, the researcher attended a professional training course called: *Physical Education in Schools within the Context of Health Development: applied methodological renewal and unitary physical fitness measuring (NETFIT) (Iskolai testnevelés az egészségfejlesztésben: módszertani megújulás és egységes fizikai fittségmérés (NETFIT) a gyakorlatban)* (N.281/8 from September the 22nd, 2014), a module consisting of 30 hours (theory and practice) which took place in Debrecen, Hungary.

Aim of the Research

1. Determining the levels of health components of physical fitness among students in 1st year at Partium Christian University from Oradea, depending on their residential environment and gender, in the 2018-2019 university year, and forwarding the results to the competent institutions.

2. Creating databases in order to compare the results with future measurements.

Subjects and Methods

The research was performed between December the 3rd-21st, 2018, on a sample group of 112, 18 and 19 year old students in the 1st year at Partium Christian University from Oradea, Faculty of Letters and Arts, Faculty of Economic and Social Sciences.

In order to interpret the results, NETFIT uses a criterion-referenced standard depending on age and gender called the health standard, establishing the level at which the subject is located in relation to certain objectives. This health standard corresponds to a minimal motor performance necessary to avoid certain risks of illnesses which may occur as a result of physical inactivity (cardiovascular diseases, type 2 diabetes, sedentariness, etc.). The values included in the health standard do not refer to the levels required in professional sports, but to those optimal to a healthy lifestyle.

In order to analyze the results regarding the body mass index values and adipose tissue percentage in relation to age and gender, we propose the subjects to be classified into three action zones, whose limits are represented by three color codes: Healthy fitness zone – green color, Needs improvement zone – yellow color and Needs continuous improvement zone – red color (high risk of developing diseases). According to their age and gender, the students that fall into the healthy fitness zone have an optimal level of physical fitness, avoiding certain risks of developing diseases which occur as a result of physical inactivity. The goal of the teacher and of the students is to maintain themselves in the healthy fitness zone or to exceed the needs improvement zone or the needs continuous improvement zone.

In case of the body mass index (BMI) and adipose tissue percentage, the healthy fitness zone was divided into two subzones. The subjects whose results were below the accepted limits, were considered to be part of the category of those that were *thin* from somatic point of view. According to Kaj, Csányi, Karsai & Marton (2014), the subjects whose BMI and adipose tissue percentage values fall within the *thin* subzone, may receive the *healthy* classification. In case of severe underweight we try to find out the causes and recommend the school doctor to be involved. The obese students fell within the needs continuous improvement zone. The BMI was also calculated based on the BMI reference chart in relation to age and gender, the percentile categories being those presented in table 1 (Barlow, 2007).

In case of motor tests regarding skeletal muscle fitness and flexibility, Kaj, Csányi, Karsai & Marton (2014) proposed two action zones: healthy fitness zone and needs improvement zone. We did not use the endurance shuttle run test and the trunk extension test.

When classifying the results into the needs improvement zone or the needs continuous improvement zone, we recommend a proper attention to be paid to the diet and the frequency with which different kind of physical activities are performed (Lukács & Hanţiu, 2017).

BMI Percentile	Nutritional Status
BMI<5 percentiles/gender/age	Underweight
BMI between 5-84 percentiles/ gender / age	Normal weight
BMI between 85-95 percentiles/ gender / age	Overweight
BMI ≥ 95 percentiles/ gender / age	Obesity

Table 1. Percentile categories regarding body mass index (Barlow, 2007)

For this study we used the anthropometric method to measure the two somatic indicators: height and weight using a Seca 213 (Marsden, UK) height measure and an Omron BF511 (Omron Corporation, Kyoto, Japan) digital scale. Adipose tissue was measured by the bioelectrical impedance (BIA) method.

The data of the individual measurements were statistically analyzed on a computer using the Statistical Package for Social Sciences software: version 20.0 SPSS Inc. (SPSS). Using the Kolmogorov-Smirnov test, we verified the normality of the distribution of the data resulted from the anthropometric and motor tests. In order to see the intensity and direction of the relation between the adipose tissue level and the motor components, we used the Pearson correlation coefficient (parametric) and the Spearman rho correlation coefficient (non-parametric). We performed the descriptive analysis (weighted mean (Xp), standard deviation (τ)), and the differences between the mean values in relation to gender and residential environment were tested using the independent sample *t-test* (parametric) and the Mann-Whitney U test (non-parametric).

Results

After processing the collected data, we found that 73 girls and 39 boys participated to the measurements. Using the Kolmogorov-Smirnov test, we verified the normality of the distribution of the data obtained from the anthropometric and motor tests of the NETFIT test battery which resulted in values below the threshold of 95% in case of the following variables: a) for girls (weight, BMI, adipose tissue, handgrip test, paced curl-ups, paced push-ups); b) for boys (standing broad jump and paced curl-ups) (table 2). For these variables, the data are not distributed normally, thus the non-parametric tests are going to be used. According to the standards of the World Health Organization (2007) regarding the growth in height of subjects in relation to their age and gender, we found that in case of 19 year old boys the mean values are close, while in case of girls this value is 2.04 cm lower (table 3).

Variable	Tests of Normality Kolmogorov-Smirnova					
	Girls			Boys		
	Statistically	df	Sig.	Statistically	df	Sig.
Height	0.064	73	0.200*	0.126	39	0.123
Weight	0.155	73	< 0.001	0.119	39	0.177
BMI	0.184	73	< 0.001	0.076	39	0.200*
Adipose tissue	0.105	73	< 0.05	0.089	39	0.200*
SBJ	0.101	73	0.062	0.143	39	0.044
HT	0.119	73	< 0.05	0.103	39	0.200*
PCU	0.270	73	< 0.001	0.226	39	< 0.001
FLT	0.088	73	0.200*	0.106	39	0.200*
PPU	0.155	73	< 0.001	0.101	39	0.200*

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 2. Testing of the normality of distribution of variables obtained at the anthropometric and motor tests (N=112)

Note: SBJ = Standing broad jump, HT = Handgrip test, PCU = Paced curl-ups, PPU = Paced push-ups, FLT = Flexibility test

Age	N	M Height (SD)	M Weight (SD)	WHO Height (SD)
Girls				
18	5	162.70±10.03	55.42±6.57	163.05±6.60
19	68	161.11±5.28	62.78±12.84	163.15±6.54
Boys				
18	3	174.16±9.11	63.86±3.52	176.14±7.47
19	36	176.79±6.40	73.69±12.10	176.54±7.29

Table 3. Mean values and standard deviations of weight and height

The registered data show that 81 out of the total of 112 subjects had a normal weight for their age. A number of 15 subjects were overweight and 11 students fell into the obese category. According to the BMI results, the number of students with weight problems was higher among girls (17 cases) than among boys (9 cases), reaching a rate of 23% of the sample group (table 4).

BMI percentile / Nutritional status	Girls		Boys		Girls + Boys	
	N	%	N	%	N	%
Underweight BMI percentile < 5	1	2	4	10	5	4
Normal weight BMI percentile 5-85	55	75	26	67	81	73
Overweight and obesity BMI >85	17	23	9	23	26	23
Obesity BMI percentile ≥ 95	8	11	3	8	11	10
Total	73	100	39	100	112	100

Table 4. BMI distribution in relation to the gender of the subjects

The BMI mean scores in case of girls (M = 23.97, SD = 4.89) are not significantly higher (t = 0.71, df = 110, bidirectional p = 0.48) than in case of boys (M = 23.30, SD = 4.31). The Mann-Whitney *U* test has concluded that the BMI mean scores of girls are not significantly higher than those in case of boys (*U* = 1413.5, N_1 = 73, N_2 = 39, bidirectional p = 0.95).

The mean scores of AT in case of girls (M = 35.54, SD = 7.89) are significantly higher (t = 10.77, df = 110, bidirectional p < 0.001) than in case of boys (M = 19.36, SD = 6.91).

Based on the Mann-Whitney *U* test it resulted that the mean scores of AT of girls are significantly higher than those in case of boys (*U* = 146.5, N_1 = 73, N_2 = 39, bidirectional p < 0.001).

The Mann-Whitney *U* test has shown that the BMI mean scores of girls from the urban area are not significantly higher than the scores of the girls from the rural area (*U* = 659, N_1 = 37, N_2 = 36, bidirectional p = 0.93). The Mann-Whitney *U* test has shown that the mean scores of AT of the girls from the urban area are not significantly higher than the scores of the girls from the rural area (*U* = 662, N_1 = 37, N_2 = 36, bidirectional p = 0.96).

The BMI mean scores in case of boys from the rural area (M = 23.32, SD = 3.63) are not significantly higher (t = - 0.01, df = 37, bidirectional p = 0.98) than in case of boys from the urban area (M = 23.29, SD = 4.76).

The mean scores of AT in case of boys from the rural area (M = 19.61, SD = 7.38) are not significantly higher (t = - 0.18, df = 37, bidirectional p = 0.86) than in case of boys from the urban area (M = 19.20, SD = 6.76).

In order to see the intensity and direction of the relation between the adipose tissue level and the motor components, we used the Pearson correlation coefficient (parametric) and the Spearman rho coefficient (non-parametric) (table 5).

Variable	Boys N = 39		Girls N = 73	
	rxy = -0.13	rs = -0.09	rxy = - 0.42	rs = - 0.38
SBJ	p = 0.41	p = 0.58	p < 0.001	p < 0.001
	n = 39	n = 39	n = 73	n = 73
	-	rs = 0.25	-	rs = 0.14
HT	-	p = 0.13	-	p = 0.21
	-	n = 39	-	n = 73
	-	rs = 0.01	-	rs = - 0.08
PCU	-	p = 0.94	-	p = 0.47
	-	n = 39	-	n = 73
	rxy = 0.06	rs = 0.05	rxy = - 0.11	rs = - 0.13
FLT	p = 0.76	p = 0.81	p = 0.45	p = 0.38
	n = 39	n = 39	n = 73	n = 73
	-	rs = - 0.08	-	rs = - 0.16
PPU	-	p = 0.62	-	p = 0.16
	-	n = 39	-	n = 73

Note: r_{xy} = Pearson correlation coefficient, r_s = Spearman rho correlation coefficient,
SBJ = Standing broad jump, HT = Handgrip test, PCU = Paced curl-ups,
FLT = Flexibility test, PPU = Paced push-ups

Table 5. The association between adipose tissue levels and motor components in case of boys and girls

In the case of girls, there is a significant negative relation between the adipose tissue level and the results obtained at the standing broad jump test (r_{xy} = - 0.42, df = 71, p < 0.001, r_s = - 0.38, df = 71, p < 0.001). Students with a low level of adipose tissue had significantly better results from statistical point of view at the jumping test. In case of boys there was no significant difference regarding the relation between the adipose tissue level and the motor component.

According to table 6, the mean scores of the results obtained by boys at the broad jump test, handgrip test, paced curl-ups and paced push-ups test are significantly higher than those obtained by girls at the same tests. According to table 7, there are no significant differences between the results of the motor tests obtained by girls from the urban area and those obtained by girls living in the rural area.

Motor component	Gender	Descriptive analysis		Independent Samples t test			Mann-Whitney U test	
		M	SD	t	df	p	U	p
SBJ	G	143.0	20.3	-12.1	110	p < 0.001	142.5	p < 0.001
	B	198.4	27.5					
HT	G	26.8	4.3	- 12.6	47.8	p < 0.001	54.0	p < 0.001
	B	45.9	8.8					
PCU	G	24.8	16.7	-	-	-	715.5	p < 0.001
	B	34.0	14.2					
FLT	G	29.2	7.9	0.3	110	0.73	-	-
	B	28.6	7.2					
PPU	G	9.1	4.2	-11.7	52.7	p < 0.001	-	-
	B	23.2	6.7					

Note: G = girls, B = boys, SBJ = Standing broad jump, HT = Handgrip test, PCU = Paced curl-ups, FLT = Flexibility test, PPU = Paced push-ups

Table 6. Presentation of differences between mean values of motor components in relation to gender

Motor component	Residential environment	Descriptive analysis		Independent Samples t test			Mann-Whitney U Test	
		M	SD	t	df	p	U	p
SBJ	Urban	140.4	24.2	-1.10	71	0.27	-	-
	Rural	145.7	15.3					
HT	Urban	27.2	4.6	-	-	-	559.0	0.24
	Rural	26.5	4.0					
PCU	Urban	22.1	11.7	-	-	-	540.0	0.16
	Rural	27.6	20.4					
FLT	Urban	29.2	9.1	-0.02	71	0.98	-	-
	Rural	29.2	6.7					
PPU	Urban	8.6	3.9	-	-	-	612.0	0.68
	Rural	9.6	4.5					

SBJ = Standing broad jump, HT = Handgrip test, PCU = Paced curl-ups, FLT = Flexibility test, PPU = Paced push-ups

Table 7. Presentation of the differences between the mean values of motor components in case of girls (urban N = 37, rural N = 36) in relation to their residential environment

Also, there are no significant differences between the results of the motor tests obtained by boys from the urban area and those obtained by boys from the rural area (table 8). Regarding the BMI values, 69% of the total of

112 students (52 girls and 26 boys) were within the healthy fitness zone, 18% (10 girls and 10 boys fell within the needs improvement zone and 13% (11 girls and 3 boys) of the subjects were in the needs continuous improvement zone (table 9).

Motor component	Residential environment	Descriptive analysis		Independent Samples t test			Mann-Whitney U Test	
		M	SD	t	df	p	U	p
SBJ	Urban	196.8	29.3	-	-	-	171.5	0.80
	Rural	201.1	25.2					
HT	Urban	46.4	10.1	0.42	37	0.67	-	-
	Rural	45.1	6.7					
PCU	Urban	30.7	10.9	-	-	-	142.0	0.26
	Rural	39.3	17.6					
FLT	Urban	28.4	7.7	- 0.18	37	0.86	-	-
	Rural	28.9	6.8					
PPU	Urban	22.9	7.7	- 0.46	37	0.65	-	-
	Rural	23.9	4.9					

SBJ = Standing broad jump, HT = Handgrip test, PCU = Paced curl-ups, FLT = Flexibility test, PPU = Paced push-ups

Table 8. Presentation of the differences between the mean values of motor components in case of boys (urban N = 24, rural N =15) in relation to their residential environment

Variable	HFZ			NIZ			NCIZ		
	Girls	Boys	Total	Girls	Boys	Total	Girls	Boys	Total
BMI	48 + 4*	22+4*	78	10	10	20	11	3	14
AT	25	24+3*	52	25	11	36	23	1	24
SBJ	35	20	55	38	19	57	-	-	-
HT	39	31	70	34	8	42	-	-	-
PCU	58	32	90	15	7	22	-	-	-
FLT	37	35	72	36	4	40	-	-	-
PPU	59	34	93	14	5	19	-	-	-
Total	305	205	510	172	64	236	34	4	38

Note: * = *thin* from somatic point of view, HFZ = healthy fitness zone, NIZ = needs improvement zone, NCIZ = needs continuous improvement zone, SBJ = standing broad jump, HT = handgrip test, PCU = paced curl-ups, PPU= paced push-ups, FLT = flexibility test

Table 9. Classification of subjects into action zones in relation to their gender

Regarding the adipose tissue percentage, 34.2% of the girls and 28.2% of the boys fell within the needs improvement zone and 31.5% respectively 2.5% into the needs continuous improvement zone. As far as the adipose tissue percentage is concerned, 65.7% of the girls and 30.7% of the boys fell within the needs improvement + needs continuous improvement zone. According to the data obtained at the motor tests, we found that at the SBJ test 49%, at the HT 62.5%, at the PCU test 80%, at the FLT 64%, and at the PPU test 83% fell within the healthy fitness zone.

Discussions

According to a study by Kalka, Pastuszak and Buśko (2019), the average height value of male students (N = 589) of the Warsaw University of Technology was 180.09 ± 7.2. As stated in a study by Podstawski, Markowski & Clark (2020) the average height value of male students (N = 2691), female students (N = 3955) of University of Warmia and Mazury in Olsztyn, Poland, between 2000-2018 was 181.12±6.08 respectively 165.06±6.47 compared to the students of the Partium Christian University with the result of 176.79 ± 6.40 for men and 161.11 ± 5.28 for women.

According to a NETFIT report drawn up for the 2018 – 2019 school year in Debrecen city regarding 18 – 19 year old subjects (N = 2298 boys, N = 2472 girls), the percentage of those who fell within the healthy fitness zone was the following: a) Girls: BMI = 81%, AT = 61%, SBJ = 76%, HT = 53%, PCU = 97%, FLT = 58%, PPU = 80%; b) Boys: BMI = 72%, AT = 69%, SBJ = 59%, HT = 68%, PCU = 95%, FLT = 77%, PPU = 71% (NETFIT Reports and Statistics, 2019)

The classification of the students of the Partium Christian University (N = 39 boys, N = 73 girls) within the healthy fitness zone, is the following: a) Girls: BMI = 71%, AT = 34%, SBJ = 48%, HT = 53%, PCU = 79%, FLT = 50%, PPU = 81%; b) Boys: BMI = 67%, AT = 69%, SBJ = 51%, HT = 79%, PCU = 82%, FLT = 89%, PPU = 87%.

Conclusions

The performed research allows us to formulate the following conclusions:

a) In Romania, the percentage of overweight and obese people has increased significantly. The number of students participating in various competitions of the Federation of School and University Sports is small.

b) We consider that, in order to avoid risks due to insufficient physical activity, the level of biomotor potential of students must be related to their health. Not all students dream of performance and competitions, but they all want to be healthy!

c) We reflect that a new vision is needed in approaching the physical education lessons in Romania and it is important that the people involved know the concept of fitness from an early age and receive feedback whenever necessary. The priority of physical education specialists should be for all students to enjoy any organized sports activity and to develop their knowledge about the advantages offered by the high level of physical fitness.

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THE SPECIFIC OF TOURIST ACTIVITIES AND PHYSICAL EFFORT ON THE SOUTHERN FACE OF DAMAVAND MOUNTAIN (IRAN, ALBORZ MOUNTAINS)

BÎCA IOAN[1]

ABSTRACT. Mount Damavand is part of the 7th Volcano Circuit and is located in the central-southern part of the Alborz Mountains in Iran, 70 km north of Tehran. Due to its altitude of 5610 m, the mountain is a challenge for climbers and imposes a series of atmospheric conditions that induce certain physical stresses during the ascent to the top. The standard route is located on the southern face of the mountain and leaves from the village of Polour to two camps, Goosfand Sara (3000 m) and Bargah Sevom (4200 m). The access to the first camp can be done by car, and from there to the second camp on foot, the luggage being transported by mules by the locals. In the second camp, Bargah Sevom, is a modern stone refuge, which belongs to the Iranian Mountaineering Federation. Sports activities take place in two major stages: acclimatization and climbing to the top, for which at least 2-3 days are allocated. The present study, carried out on the occasion of a scientific, and sports expedition, aims to analyze the organization of tourist activities, the attractive potential and the peculiarities of the effort on the southern face of the mountain, between the altitudes of 3000 m and 5610 m.

Keywords: *seven volcanoes circuit, mountaineering, mountain leisure, heart rate.*

REZUMAT. ***Specificul activităților turistice și al efortului fizic pe fața sudică a muntelui Damavand (Iran, Munții Alborz).*** Muntele Damavand face parte din Circuitul 7 Vulcani și este situat în partea central-sudică a Munților Alborz din Iran, la 70 km nord de orașul Teheran. Prin altitudinea sa de 5610 m, muntele reprezintă o provocare pentru alpiniști și impune o serie de condiții atmosferice care induc anumite solicitări fizice în timpul ascensiunii spre vârf. Traseul standard este situat pe fața sudică a muntelui, și pleacă din localitatea Polour spre două tabere, Goosfand Sara (3000 m) și Bargah Sevom (4200 m). Accesul spre prima tabără se poate face cu mașina, iar de acolo spre tabăra a doua pe jos, bagajele fiind transportate cu catârii de către localnici. În tabăra a doua, Bargah Sevom, se află un refugiu modern din piatră, care aparține Federației Iraniene de Alpinism. Activitățile sportive se desfășoară în două etape mari:

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aclimatizarea şi ascensiunea spre vârf, pentru care se alocă cel puţin 2-3 zile. Studiul de faţă, efectuat cu ocazia unei expediţii ştiinţifice şi sportive, îşi propune să analizeze organizarea activităţilor turistice, potenţialul atractiv şi particularităţile efortului pe faţa sudică a muntelui, între altitudinile de 3000 m şi 5610 m.

***Cuvinte-cheie**: circuitul şapte vulcani, muntenărie, agrement montan, frecvenţă cardiacă, debit cardiac.*

Introduction

The last decade has seen an intensification of tourism in the high mountains, as a niche in mountain tourism, due to several causes, such as:

- opening the borders for tourism;
- technical progress registered in the sports materials industry (clothing, footwear, accessories) and specific nutrition (dry food, energy bars, gels, etc.);
-increasing free time;
-circulation of specialized information on media channels;
-increasing the number of travel agencies for mountain tourism;
-the appearance of online travel agencies;
-the desire for personal development;
-the desire for new experiences in the field of mountain recreation.

The tourist market of the high mountains includes the mountainous areas with altitudes of over 4500 m, here entering some peaks of the Alps (e.g. Mont Blanc, 4810 m; Duforuspitze, 4634 m; Ostspitze 4632 m; Grenzgipfel, 4618 m, etc.), and numerous peaks. from the mountains located in North America (Cordillera Mountains), South America (Andes Mountains), Africa (Kenya, Kilimanjaro) and Asia (Ararat, Damavand, Hindukush, Karakorum, Himalaya, etc.).

In order to practice recreation in the high mountains, several requirements must be met, such as:

-good health and excellent physical condition, including good adaptation to the respective altimetric conditions (low pressure, low oxygen level);
-appropriate equipment (clothing, footwear, accessories);
-knowledge of trekking and mountaineering (rock climbing, ice climbing);
-experience in mountaineering;
-financial resources.

The teams of mountaineers vary in size, the number of members can be, in general, between 2 and 15 people, for several reasons, among which can be mentioned: better control of the technogenic risk factors, a safe ascent, the low capacity of shelters, high costs.

In making an expedition, several steps must be followed, as follows:

-establishing the route (in commercial tourism the standard route is chosen, in general);

-team forming;

-purchase of plane tickets;

-contracting services (accommodation, meals, guiding, transfer);

-flight to the location and transfer to the base camp;

-moving to the intermediate camps;

-acclimatization;

-summit day.

The sporting dimension of tourism in the high mountains is given by the following objectives to which the participants adhere:

-physical stress imposed by the route;

-adaptation of the body to specific atmospheric conditions (lower amount of oxygen-less than 70%; low pressure-less than 700 mb, low temperatures, strong winds, precipitation, fog);

- overcoming the challenges imposed by atmospheric factors, climate and relief;

-reaching the top.

In this context, it should be noted that Mount Damavand is part of the Circuit 7 Volcanoes, which brings together the highest volcanic peaks on the seven continents (Fig. 1), and this study aims to highlight the peculiarities of an ascent on this mountain.

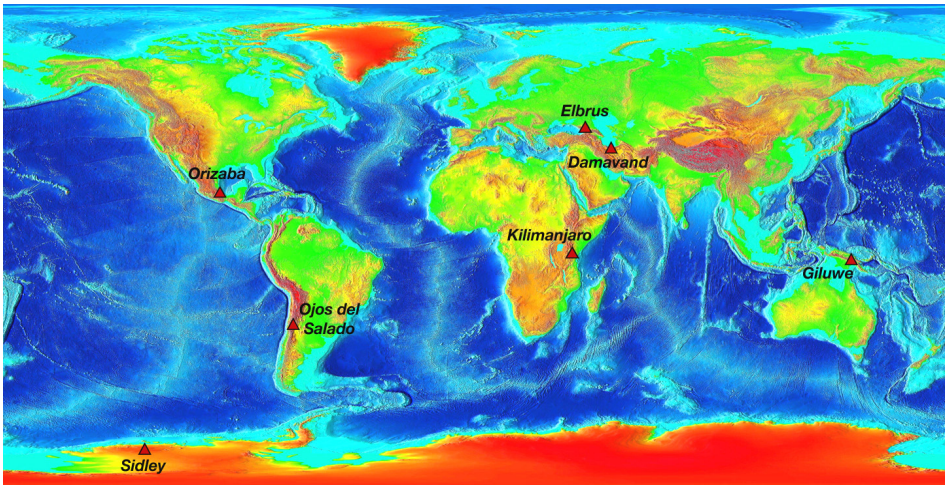

Fig. 1. The Volcanic Seven Summits
(*Source: en.wikipedia.org*)

Methodology

The theoretical preparation for the expedition to the top of Damavand was done in several stages, of which the following can be mentioned:

a) consulting the literature on the Damavand region (Amiri, et al. 2018; Berzins, et al., 2004; Davidson, et al., 2004; Ferrigno, 1991; Moghimi, et al., 2008; Nouraliee, et al., 2010; Shirazi, et al., 2014; Zareinejad, 2011);

b) consulting the tourist literature in the Damavand region (Rabieifar, et al., 2014; Yazdani, 2010) and some profile sites:

-http: //www.damawand.de/Home/About.html;
-http: //damavandmt.blogspot.com/2010/01/bargah.html;
-http: //www.damawand.de/How/Base.html;

c) study of topographic maps downloaded from certain sites:

-http: //en-gb.topographic-map.com/places/Mount-Damavand;
-http: //elevation.maplogs.com/poi/mount_damavand_iran.325.html;
-http://www.jahandar.ir/photograph/topographic-map-of-damavand/;

d) consultation of works on the influence of altitude on the human body (Lundby, Hall, 2001; Ursta, 2006; Bärtsch, Gibbs, 2007; Boos et al., 2016);

e) establishing the route and the ascent stages;

f) conducting field observations on the tourist activities within this area (organization, infrastructure, flows) and on the factors that condition the development of tourism (climate, relief, behavior of the local population, economic activities, political factors);

g) making observations on the consequences resulting from the exposure of the human body to high altitudes; the working group consisted of four climbers, aged 55, 55, 54 and 42, whose level of effort was determined during the acclimatization period at altitudes of 3000-3500 m and 4200-4800 m, and of the ascent to the top (Fig. 2).

Fig. 2. The four climbers who participate in the study

Study Area

The Damavand Massif is located in Iran, in the central group of the Alborz Mountains, 70 km NE of Tehran, in the Amol region, Mazandaran Province (Fig. 3). From a geological point of view, the massif is a stratovolcano, with a volume of 400 km^3, consisting of lava flows (trachyte, andesite, basalt) and pyroclastite (ash, gravel, blocks, slag) (Davidson et al., 2004). The volcanic structure is delimited to the south and east by the Haraz valley (tributary of the Caspian Sea), to the north by the Panjab valley (tributary of the Haraz), and to the west by the Lar valley (tributary of the Haraz valley) (Fig. 4).

The volcanic processes that built the Damavand volcano took place over several episodes in the time interval between 1.8 million years-7300 years BC. From a geomorphological perspective, the volcanic edifice consists of two compartments: the surrounding plateaus, developed between 2600-3400 m and the cone itself, with a relatively symmetrical appearance, the western flank being steeper, built from 3400 m upwards (Fig. 5).

At the top, the volcanic edifice has a collapsed crater, with a diameter of 200 m, in which rests a small glacier, evidence of the Pleistocene glaciation, which retreated since 1930 (Ferrigno, 1991). This glacier continues on the northern slope with the Sioleh and Dobi Sel glaciers. On the southern frame of the crater is the highest point of the volcano, located at 5610 m. Below the peak, on the southeast side, is a fumarole, which emits sulfur vapor, and around the cone there are several hot springs (Nouraliee et al., 2010), which confirms the dormant volcano stage of the Damavand massif.

Fig. 3. Geographical position of Mount Damavand on Elburz Mountains (*Source: www.freeworlddmaps.net*)

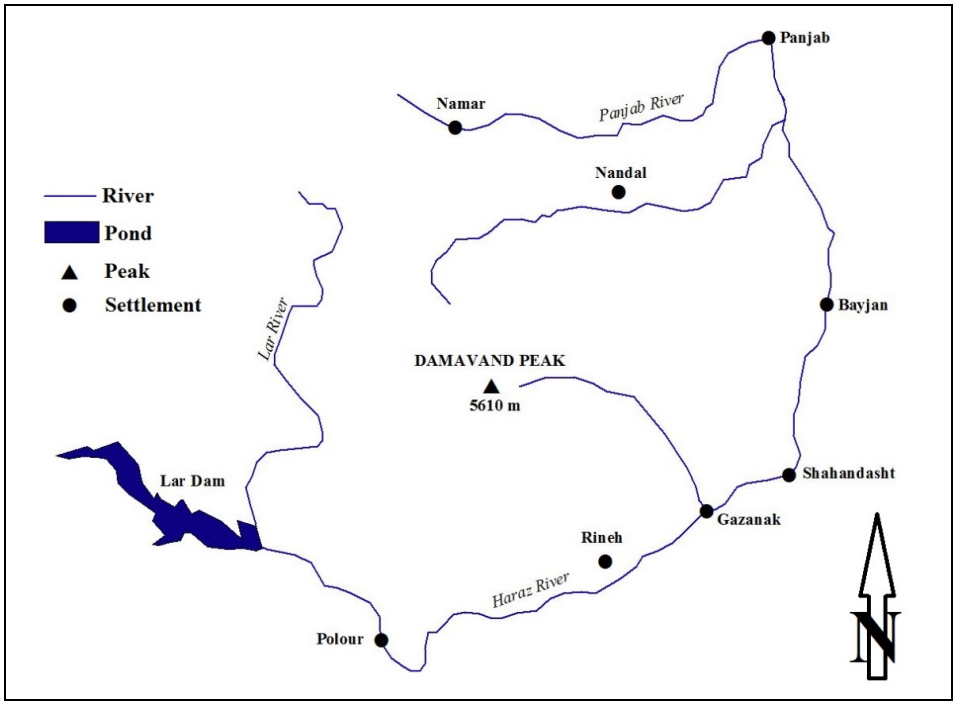

Fig. 4. The geographical limits of Mount Damavand

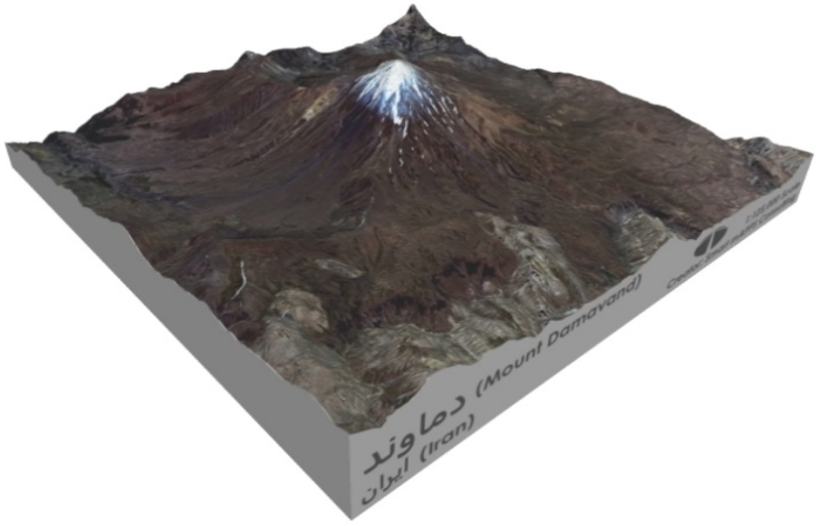

Fig. 5. The 3D perspective on Mount Damavand
(*Source: https://www.shapeways.com/mount-damavand*)

The extern modeling developed between the eruptive episodes and after the cessation of the volcanic activity dissected the volcanic cone, resulting in deep valleys, with the appearance of microcannions, flared at the top, separated by radiant-divergent rocky interfluves.

Damavand Volcano is distinguished by several elements of attractiveness, such as it is the highest peak in the Middle East, it is the 12th most prominent peak in the world (4667 m), the second most prominent peak in Asia, after Mount Everest, is the highest peak in Iran, is the highest volcano in Asia (after Kunlun in Tibet), is the fifth-highest volcano in 7 Volcanoes Circuit and the third highest volcano in the northern hemisphere, after Elbrus (5642 m) in Russia (the highest volcano on the European continent), and Pico de Orizaba (5636 m), the highest volcano on the North American continent.

At the foot of the Damavand massif lies the Lar National Park, with an area of 30,000 hectares. It was established in 1976 and was declared a protected area in 1982 by the Iranian Department of the Environment. Hunting in the park has been banned since 1991. Inside the Park is a reservoir and the Lar Dam, which is a major tourist attraction, just 70 km northeast of Tehran. The park is accessible by car on the Haraz route (Road 77).

In addition to its geological dimensions, Damavand Volcano has some cultural significance, as it is the place from which the legendary Arash launched his magic arrow to mark Iran's border with the Turan and because it is the symbol of Iranian resistance against despotism and foreign domination, it is present in Persian poetry and literature, in the texts of the prophet Zoroaster and in mythology.

Results and Discussions

a) Geographical aspects

Our research focused on the southern face of Mount Damavand, which is the most popular, due to easy access, less difficulty and the presence of the two base camps, Goosfand Sara (3000 m) and Bargah Sevom (4200 m) (Fig. 6). In this sector we have identified the following tourist elements:

a) the headquarters of the Iranian Mountaineering Federation, in Polour;

b) tourist localities: Reineh and Polour, which offer different services (accommodation, meals, information);

c) the classic ascent route, represented by a dirt road between Polour and the Goosfand Sara camp, then through a very little marked path, on soil and volcanic rock, between Goosfand Sara-Bargah Sevom-Damavand peak;

d) tourist refuges:
-Goosfand Sara-Mosque (3000 m);
-Bargah Sevom (4200 m).
The attractions in this sector are the following:
-volcanic cone, composed of trachytes, basalts and andesites;
-the crater, with glacier;
-detail relief on the edge of the crater: towers, blocks;
-fumarole below the top;
-Abshar Yakhi ice waterfall, with a height of 12 m, located at 5000 m;
-the rugged volcanic ridges that descend to the neighboring areas (planeze);
-deep valleys carved on the volcanic cone (barrancos);
-penitences on the snow patches located at 4900-5000 m;
-vulcanic landscape and viewpoints to the Haraz Valley and the Alborz Mountains;
-traditional activities: shepherding (sheep, goats, mules), luggage transport with mules, beekeeping.

Fig. 6. The South Face of Mount Damavand
(*Source: https://www.tappersia.com/wp-content/uploads/Damavand-RoadRoute-Map*)

b) Sport and medical aspects

Access to the route and to the Goosfand Sara and Bargah Sevom camps is based on the permit issued by the Iranian Mountaineering Federation in Polour. Here, the members of the Federation provide information and assistance to the mountaineers.

The sports activities during the expedition were the following:

a) acclimatization:

The body's adaptation to the new atmospheric conditions was done in several stages, as follows:

-on the first day, there was an ascent from 3000 m to 3500 m, in a light rhythm, with breaks for relaxation and breathing; we slept in the Goosfand Sara camp (3000 m);

-the next day, we left the Goosfand Sara camp to the Bargah Sevom camp (4200 m), at a light pace, with breaks for relaxation and breathing; we slept in the Bargah Sevom camp;

-on the third day, there was an ascent from the altitude of 4200 m to the altitude of 4900 m, in a light rhythm, with breaks for relaxation and breathing; we slept in the Bargah Sevom camp (4200 m);

b) summit day:

-we climbed the top at 02.30 A.M., on the route between 4200-5610 m (level difference 1410 m);

-we reached the peak at 08.30 A.M. (5 hours), the average pace of movement being 282 m / hour / 100 m level difference;

It is known that during physical exertion, to ensure muscle energy, the body increases the heart rate (HR) and increases the heart flow (HF) and the volume of blood pumped into the aorta during a ventricular systole, which increases consumption of oxygen (VO2) (Fig. 7). Since, at altitudes above 3000 m, the amount of oxygen in the air decreases, but the oxygen debt increases, the values of heart rate and heart flow increase, a situation in which it is necessary to dose the physical effort made by climbers.

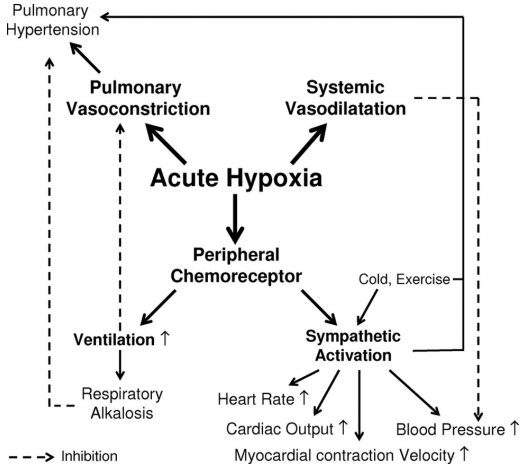

Fig.7. Effects of hypoxia on systemic and pulmonary circulation.
(*Source: https://www.ahajournals.org/doi/full/10.1161/CIRCULATIONAHA.106.650796*)

In this case, during the acclimatization days, observations were made on the heart rate, establishing the optimal heart rate for each member of the expedition, according to the formula: Optimal Heart Rate= Reserve Heart Rate x 75% + Resting Heart Rate. For this, we needed other parameters, presented in tables 1-3:

Expedition members	Age	Resting HR b/m
Member 1	55	85
Member 2	55	90
Member 3	54	82
Member 4	42	80

Table 1. Working group age and resting heart rate of members (3000 m, Goosfand Sara Refuge)

Expedition members	220-age formula	The value of maximum heart rate b/m
Member 1	220-55	165
Member 2	220-55	165
Member 3	220-54	166
Member 4	220-42	178

Table 2. The maximum heart rate of members

During the ascent from the Goosfand Sara refuge to an altitude of 3500 m, the value of the heart rate of the four climbers, determined at the level of the left radial artery, was between 100 and 120 b / m, so below the limit of maximum heart rate, which indicates an effort moderate, manifested by moving at a light pace, specific to acclimatization activities.

Expedition members	Maximum Heart rate-Resting Heart rate	The value of Reserve Heart rate b/m
Member 1	165-85	80
Member 2	165-90	75
Member 3	166-82	84
Member 4	178-80	98

Table 3. The reserve heart rate of members

In this case, the optimal heart rate during the acclimatization effort between altitudes 3000-3500 m was (table 4):

Expedition members	Reserve Heart rate x75% b/m	Resting Heart rate b/m	The value of optimal heart rate
Membru 1	80x75%=60	85	145
Membru 2	75x75%=56,25	90	146,25
Membru 3	84x75%=63	82	145
Membru 4	98x75%=73,5	80	153,5

Table 4. The optimal heart rate during the acclimatization effort between altitudes 3000-3500 m

As can be seen from table 4, the members of the expedition developed an optimal heart rate according to age, below the value of the maximum heart rate and based on a substantial reserve heart rate. In this case, the effort was moderate to intense, representing 86-88% of maximum heart rate.

For the acclimatization from the altitude of 4200 m (Bargah Sevom Refuge) the data were presented according to tables 5-7:

Expedition members	Age	Resting Heart rate b/m
Member 1	55	90
Member 2	55	95
Member 3	54	90
Member 4	42	85

Table 5. Working group age and resting heart rate of the members (4200 m, Bargah Sevom Refuge)

Expedition members	220-age formula	The value of maximum heart rate b/m
Member 1	220-55	165
Member 2	220-55	165
Member 3	220-54	166
Member 4	220-42	178

Table 6. Maximum heart rate of members

During the ascent from 4200 m to 4800 m and to the top (5610 m), the heart rate of climbers was between 120 and 150 b/m, below the maximum heart rate, which indicates an increase in exercise intensity, under the influence of low pressure and of the reduced amount of oxygen.

Expedition members	Maximum Heart Rate-Resting Heart Rate	The value of reserve heart rate b/m
Member 1	165-90	75
Member 2	165-95	70
Member 3	166-90	76
Member 4	178-85	93

Table 7. The reserve heart rate of members

In this case, the optimal heart rate during the acclimatization effort between altitudes 4200-4800 m was (table 8):

Expedition members	Reserve Heart Rate x75% b/m	Resting Heart Rate b/m	The value of Optimal Heart Rate
Member 1	75x75%=56,25	85	141,25
Member 2	70x75%=52,5	90	142,5
Member 3	76x75%=57	82	139
Member 4	93x75%=69,75	80	149,75

Table 8. The optimal heart rate during the acclimatization effort between altitudes 4200-4800 m

In this situation, too, the optimal heart rate for each member of the expedition was below the maximum heart rate, and the intensity of the effort represented 83-86% of the maximum heart rate, which indicates an efficient dosing of the pace and proper management of the amount of oxygen existing in the air at that altitude (55-60%).

From 5000 m upwards the effects of altitude were felt in intensity, the physiological effects being represented by the decrease of the amount of oxygen in the tissues, the increase of the pulmonary vasoconstriction and the increase of the sympathetic nervous flow. As such, the pace of movement decreased, with more frequent breaks for rest and muscle recovery, against the background of symptoms such as: fatigue, drowsiness and the need for hyperventilation.

Conclusions

During the expedition to reach the summit, observations were made on the organization of tourist activities on the southern face of Mount Damavand, on the volcanic landscape and on the adaptation of the organism to effort in altimetric conditions specific to high mountains, between 3000 and 5610 m. The following conclusions were drawn:

-tourist activities are organized in such a way that the climbers respond to the challenges of the mountain based on personal physical and technical training, and the locals to obtain income from luggage transfer;

-the standard route starts from Polour and reaches Camp I (Goosfand Sara) and Camp II (Bargah Sevom);

-the route between Polour and Camp I can also be travelled by off-road vehicles;

-the route between Camp I-Camp II and Damavand peak is demanding, taking place on exposed volcanic rock and on a varied terrain such as slope, microrelief (rocks, boulders, ravines) and substrate (sandy soil, rock, gravel, slag);

-in Camp I the accommodation can be made in the Mosque refuge, but there is also an area arranged for camping, with several platforms for the placement of tents;

-in Camp II there is an old refuge, a modern stone refuge and platforms for placing tents;

-drinking water is captured from streams that feed on glaciers;

-there are no route signaling elements, such as: painted markings or direction indicators;

-the surrounding volcanic landscape, although desolate and austere, induces the atmosphere specific to the high mountains, where rocks and glaciers dominate;

-the number of visitors is high, and they either carry out trekking activities between Camp I and Camp II, or climb to the top;

-the origin of the visitors is varied: Iranians, Germans, Austrians, English, Italians, Russians, Romanians;

-atmospheric conditions were characterized by atmospheric pressure between 400-600 mb and oxygen content in the air of 55-60%;

-the adaptation of the organism to these atmospheric conditions, but also to those imposed by the terrain, was done gradually, during the acclimatization days, and the climbers subjected to physiological observations made a moderate to intense physical effort, which represents 83-88% of the potential, maximum physical condition, which indicates a very good physical condition, but also effort dosing techniques in geographical conditions specific to altitudes of 3000-5000 m;

-determining factors in the process of adaptation to these altitudes were: the pace and mode of movement, the duration of exposure to high altitudes and the maximum altitude reached, respectively 5600 m.

From a practical point of view, the data obtained can be used by the organizers of mountain tourism activities in the preparation and conduct of expeditions in the high mountains.

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COMPARATIVE STUDY ON THE USE OF A PORTABLE ALTERNATIVE METHOD FOR MEASURING HIGH JUMP IN MEN'S VOLLEYBALL GAME

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ABSTRACT. Hight jump is a very important skill in the modern volleyball game. The height of the vertical detachment can be measured in a variety of ways, from the most sophisticated (jumping platform, jumping mats) to those available to all (Sargent test, and Vertec). Through this study we followed the comparative analysis of an alternative method for measuring detachment on the spot, using the G-Vert device, with a device known and currently used by several federations for measuring vertical detachment. Following the application of the Counter-movement jump Test (CMJ) or Static Vertical Test (SVT) and Approach Vertical Test (AVT), the values obtained were recorded, analyzed, and compared using the Microsoft Xcel and IBM SPSS statistical processing and analysis programs. The results of the analysis show small differences between them, which attests to the G-Vert device, as a reliable device for measuring vertical detachment. The G-Vert device, in addition to the ability to record vertical detachment, gives us information about the gravitational force that is exerted on the body during the jump, and the force with which the detachment is performed on the spot, information that can be obtained by the jumping platform.

Keywords: *G-Vert, high jump, measurements, tests.*

REZUMAT. ***Studiu comparativ privind utilizarea unei metode alternative portabile pentru măsurarea desprinderii de pe loc în jocul de volei masculin*.** Desprinderea de pe loc este o calitatea foarte importantă în jocul de volei modern. Înălțimea desprinderii pe verticală poate fi măsurată printr-o varietate de modalități, de la cele mai sofisticate (platforma de sărituri, covoarele de sărituri), la cele la îndemâna tuturor (testul Sargent,și Vertec). Prin intermediul acestui studiu am urmărit analiza comparativă a unei metode alternative pentru măsurarea desprinderii de pe loc, folosind dispozitivul G-Vert, cu un dispozitiv cunoscut și utilizat în prezent de mai mult federații pentru măsurarea desprinderii de pe loc. În urma aplicări testărilor Counter-movement jump Test, (CMJ) sau Static

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Vertical Test, (SVT) și Approach Vertical Test (AVT), valorile obținute au fost înregistrate, analizate și comparate cu ajutorul programelor de prelucrare și analiză statistică Microsoft Xcel și IBM SPSS. Rezultatele analizei celor două teste, ne indică diferențe mici între ele, fapt care atestă dispozitivul G-Vert, ca dispozitiv de încredere pentru măsurarea desprinderii de pe loc. Dispozitivul G-Vert, în plus pe lângă capacitatea de a înregistra desprinderea pe verticală, ne oferă informații legate de forța gravitațională care este exercitată asupra corpului în timpul săriturii, și forța cu care se realizează desprinderea de pe loc, informații care sunt oferite de platforma de sărituri.

Cuvinte-cheie: *G-Vert, desprindere pe verticală, săritură, măsurători, teste.*

Introduction

Vertical detachment is used to estimate sports performance in children, elderly people, performance athletes, and non-athletes.

In DEX, vertical detachment is defined, as the ability of the individual to detach from the ground in height or length easily. The measurement of height jump can be done in two ways. By methods, available to all, like the Sargent test and Vertec, the vertical jump device, that can be done in the training facilities where they are training. The other method is more demanding, time time-consuming, and requires the movement of athletes from the training facility. These measuring methods are the jumping mat and jumping platform Sattler T, Sekulic D, Hadzic V, Uljevic O, Dervisevic E. (2012).

The training process of athletes usually takes place in the same court and at the same time, in training according to planning, with the participation of several athletes. Most of the time, testing athletes using traditional testing methods require time and a dedicated team that must pay attention to the measuring process and record the data obtained.

For example, the use of motion capture methods can provide fully accurate results and be considered the gold standard when it comes to measuring vertical detachment. But this method is time-consuming, it can be done only with one athlete, it is not possible to measure several athletes at once. It requires technical expertise from the evaluators and a complex system of cameras to be able to record the actions that need to be monitored and evaluated.

Traditionally, the Sargent test is the most used method to measure vertical detachment because it is simple and does not require many materials to be implemented Luis F. A. (2000). The possibility of using portable microtechnology G-Vert, is an attractive way to monitor athletes in official competitions or training by coaches. This device is designed to support coaches and athletes in measuring vertical detachment.

It can be an important tool that helps to investigate the possibility of changing the ability to detach vertically of the athletes during attacking or blocking phases in training or official matches.

G-Vert is a small inertial measuring sensor, inserted in an elastic band. The sensor records and calculates the vertical detachment of each jump. The data obtained by the device is sent to your phone or tablet via OTA (Over the Air) wireless technology.

The ability to jump is a basic requirement of any volleyball player, to be able to perform various game-specific actions, such as passing jump, jump service, attack, and blocking Hsieh C.-Tu (2006). According to Sheppard Jeremy, Gabbett Tim, Reeberg Stanganelli Luiz, Newton Robert (2010) the performance of the attack actions are dependent on the height at which it is executed in relation to the height of the net and are determined by the player's ability to and high vertical center of gravity.

High-performance players record 250-300 actions in a 5-set match, and the vertical detachment is at the basis of all actions completed in force. Of these, attack and blockade account for 45% of all game actions Sheppard et al. (2010). In the game of volleyball, there are several specific movements associated with vertical detachment: vertical detachment at the block and vertical detachment with momentum for the attack. The vertical movements used for blocking and attacking, usually end with a maximum vertical detachment Sattler T., et al. (2011). Both are made with the help of the balance of the arms, the vertical detachment used in attacking is made after a momentum of two or three steps.

At a national level, the high jump tests used by the Romanian Volleyball Federation comprise three of the samples. Two of the jumps mentioned above by Sattler T., et al. (2011): counter-movement jump and approach counter-movement jump.

The test used by the Romanian Volleyball Federation in which they test the high jump are:

Detachment vertically, with momentum, reaching the maximum point, with one hand - attack momentum, jumping, and touching as high as possible with the arm outstretched.

Detachment vertically, from the spot, with the touch of the maximum point, with two hands, arms swing, jumping and touching with both hands as high as possible.

Methods

To carry out the study, several, volleyball players, members of the National Center of Excellence from Dej, Cluj County, participated as volunteers.

After performing a standardized warm-up protocol. All athletes participated in the presentation of the methodology for conducting the tests, providing additional explanations upon request.

The methodology for conducting the tests consists of using two types of vertical detachments measured with two different devices.

The two types of vertical detachment are recognized in the literature under several names, the biomechanics of movement being the same.

The first type of vertical detachment, from the spot, reaching the maximum point, with two hands -arms swing, jumping and touching with both hands as high as possible, is known in the international literature as Counter-movement jump Test, (CMJ), Static Vertical Test, (SVT). The second vertical detachment, test, with an approach and reaching the maximum point, with one hand - attack approach, jumping and touching as high as possible with the outstretched arm, known in the literature as the Approach Vertical Test (AVT).

Each participant had a number of three repetitions for each type of test. The G-Vert device was placed for each participant in the pelvic region using an elastic band.

The data obtained from the tests were recorded, analyzed, and compared using the statistics and analysis programs Microsoft Xcel and IMB SPSS, in order to highlight the possible differences between the two types of devices.

Results

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	87.000[a]	80	.277
Likelihood Ratio	48.547	80	.998
Linear-by-Linear Association	9.671	1	.002
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	12		

Table 1. Chi-Square Tests

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
VERTEC	25.427	11	.000	69.00000	63.0274	74.9726
GVERT	28.877	11	.000	70.41667	65.0495	75.7838

Table 2. One-Sample Test

Art. No.	Standing one hand touch	Standin Vertec the highest point reached	approach Vertec the highest point reached	CMJ Test Vertec	AVJ Test Vertec	CMJ Test G-Vert	AVJ Test G-Vert
P1	234	290	300	56	**66**	55	**68**
P2	259	305	316	46	**57**	42	**58**
P3	245	303	319	58	**74**	57	**73**
P4	259	313	324	54	**54**	54	**65**
P5	257	317	332	64	**79**	70	**80**
P6	247	305	314	48	**57**	49	**55**
P7	247	304	313	57	**66**	54	**67**
P8	233	295	308	62	**75**	57	**77**
P9	235	300	320	65	**85**	62	**84**
P10	239	303	310	64	**71**	63	**71**
P11	245	309	316	64	**71**	50	**73**
P12	237	300	310	63	**73**	65	**74**

Table 3. Result obtained after applying the tests

VERTEC	G-VERT
66	68
57	58
74	73
54	65
79	80
57	55
66	67
75	77
85	84
71	71
71	73

Table 4. Results obtained in the AVT test

VERTEC	G-VERT
56	55
46	42
58	57
54	54
64	70
48	49
57	54
62	57
65	62
64	63
64	50
63	65

Table 5. Results obtained in the CMJ test

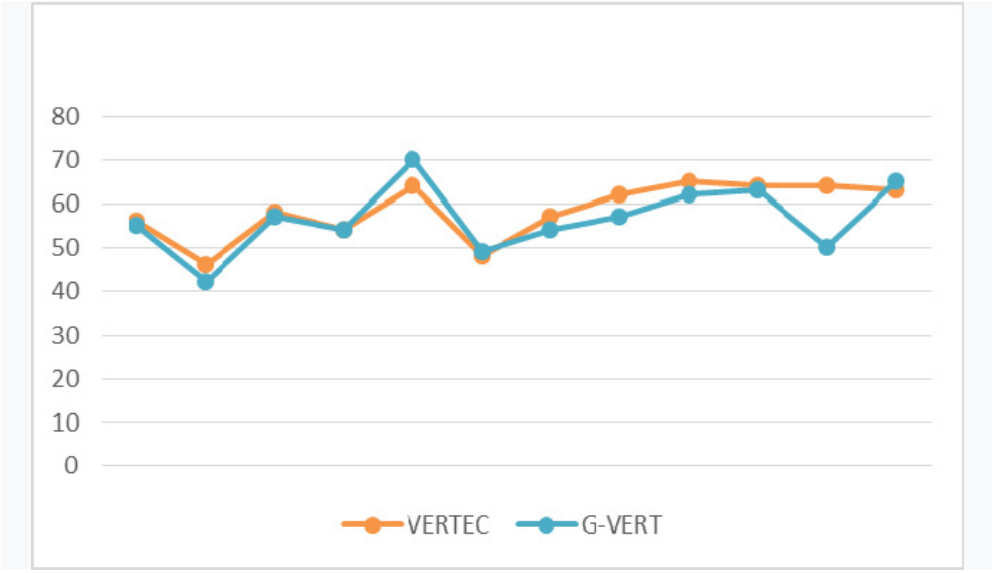

Fig. 1. Standing vertical test between VERTEC and G-VERT

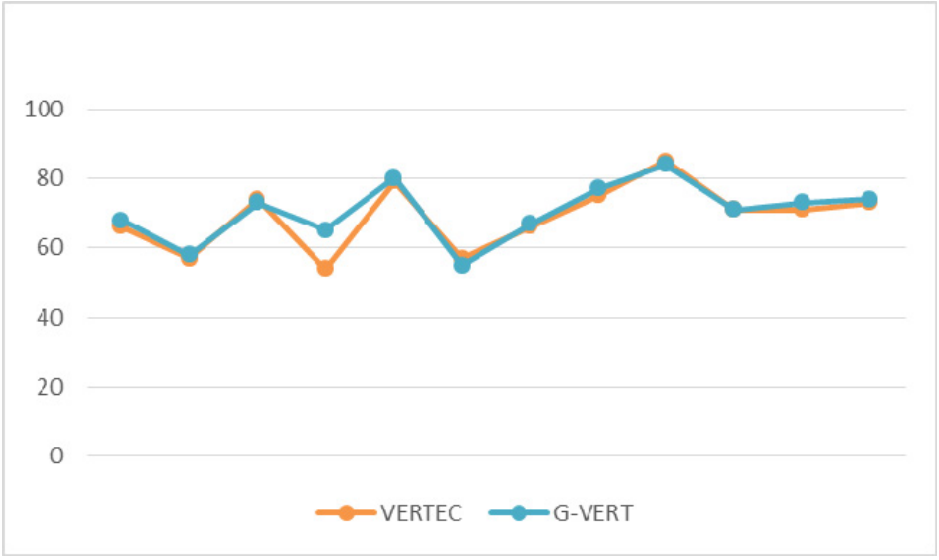

Fig. 2. Approach vertical test between VERTEC and G-VERT

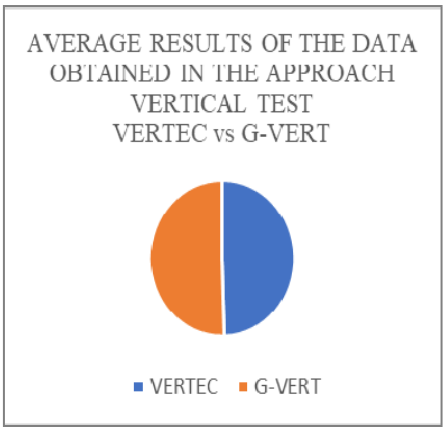

Fig. 3. Comparison of the obtained results in the approach vertical test

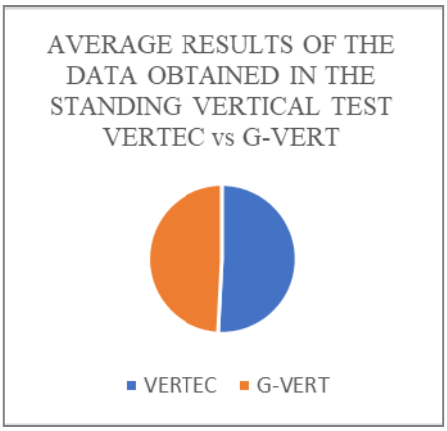

Fig. 4. Comparison of the obtained results in the standing vertical test

Conclusions

The G-Vert device proved to be a very good device for measuring vertical detachments, both on the spot and with the approach. Demonstrated acceptable validity for measuring vertical detachment in volleyball players as shown in Tables 1 and 2.

As recording possibilities compared to the Vertc device, G-Vert it has proven that it can easily and accurately record higher vertical detachment being able to offer in addition pieces of information related to the gravitational force that the body exerts during detachment, the force with which detachment is achieved and the force exerted by the body during landing.

Analyzing the results obtained in the tests taken for measuring the detachment from the vertical, CMJ, and AVJ, recorded with the Vertec and G-Vert device, we observe an average of 58.4 cm for the CMJ with the Vertec device and 56.6 cm for the G-Vert device. The difference between the two devices being only 1.9 cm higher recorded by the Vertec device When testing AVJ the average recorded between the two devices is 69 cm for the Vertec device and 70.4 cm for the G-Vert device, the difference by 1.4 cm higher recorded by the G-Vert device.

In Table no. 3 we notice that for the calculation of the vertical detachment height with the help of the Vertc device it is necessary the initial registration of the height with the outstretched arm. An additional heading, an additional measurement. The smallest differences were recorded in the AVJ test, from a

number of 12 participants to 7 participants was recorded difference between 0-1 cm, 4 participants, recorded values between 1-2 cm, and only one participant recorded values over 2 cm.

At CMJ test the values between 0-1 cm centimeters were recorded at a number of 5 participants, the value 1-2 cm at one participant, values between 3-6 cm, at 5 participants, and a single value was recorded over 6 cm. From this, we can conclude that the flexion angle of the thigh on the calf has an important role. Although the Vertec device was recorded at a certain height, due to the more pronounced flexion, the G-Vert storage was recorded a few centimeters higher.

In conclusion, using the G-Vert device we can obtain in the three tests, recorded for each test identifying the maximum and minimum value for the three jumps. The additional information provided by the G-Vert repository, information that can only be obtained by combining several devices for measuring detachment from the spot makes it a very useful tool for identifying the degree of muscle development in the lower part of the body.

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