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THE RELATIONSHIP BETWEEN THE MODELS OF SPORT COMMITMENT AND SELF-DETERMINATION AMONG ADOLESCENT ATHLETES

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Summary. This study examined the relationship between the Sport Commitment Model and the Self-Determination Theory. The participants were 214 adolescent athletes who completed the Hungarian version of the Sport Commitment Questionnaire-2 and the Hungarian version of the Sport Motivation Scale. Several commitment sources predicted SMS scores as well. Amotivation was predicted by the obligatory reason for commitment such as Personal Investment-Loss and Other Priorities. External Regulation was predicted by Social factors of commitment. Introjected Regulation was determined by Desire to Excel-Mastery and Personal Investment-Loss. Identified Regulation was explained by Desire to Excel-Mastery, Valuable Opportunities, and Personal Investment-Loss. Integrated Regulation was explained with Valuable Opportunities, Desire to Excel-Mastery, Personal Investment-Loss and Social Support-Informal. The Intrinsic Motivation subscale was significantly predicted by Desire to Excel-Mastery, Personal Investment-Loss, Sport Enjoyment and Social Support-Informal. As we see the types of commitment showed a clear association with SMS, however the commitment sources showed a complex relationship with self-determination, thus it is hard to separate them on the Self-determination continuum.

***Key words**:* enthusiastic commitment, constraints commitment, regression, athletes, motivation

Introduction

Researchers across the globe have identified many important positive effects of regular physical activity (e.g., prevent cardiovascular disease; Warburton & Bredin 2017). Understanding the motivations behind sport activities is fundamental in helping individuals to realize these benefits that can be accrued through physical activity participation. Different concepts of sport motivation from varied perspectives have been examined in studies (Clancy, Herring, MacIntyre & Campbell 2016). For example, motivation has been investigated in terms of internal and external motives (Mallett & Hanrahan 2004), influences of coaches (Gillet, Vallerand, Amoura & Baldes 2010), the role of perfectionism and burnout (Appleton & Hill 2012) and associations with eating behavior (Homan, Crowley & Sim 2019). Investigations have been based on various motivational theories such as Achievement Goal Theory (Nicholls 1989) and Self-Determination Theory (Deci & Ryan 1985). Self-Determination Theory (SDT) is one of the most commonly used motivation theory in the sport domain. The theory is based on three basic psychological needs (competence, relatedness, autonomy) that are assumed to drive motivated behaviour (Deci & Ryan 1985), altogether there are six types of regulations: nonregulation, external regulation, introjected regulation, identified regulation, integrated regulation (these are also called extrinsic motivations), and intrinsic regulation. These types are represented on a continuum where at one end of the spectrum there are the least motivated (least self-determined) individuals and the most motivated at the other end (self-determined). Describing the continuum, the least self-determined types of motivation is called amotivation. Deci & Ryan (2000) define it as the lack of either intrinsic or extrinsic motivation. The Self-Determination Theory refers to different types of intrinsic and extrinsic motivations as well. The first type of extrinsic motivation on the continuum is *external regulation* or motivation, which is controlled by rewards or punishments. The next step on the continuum is *introjection* where individuals affect their ego stimulation via praise or avoidance of shame (Mariager-Anderson, Cort & Thomsen 2016). Further along the continuum is found *identified regulation,* which refers to persons who participate in an activity because it becomes important for them. The final type of extrinsic motivation is *integrated regulation*, which is the most autonomous form of extrinsic motivation. It describes the individuals' complex goals. Besides extrinsic motivations, internal forms of motivation can be recognized as well (Mariager-Anderson et al. 2016). Namely, intrinsic motivation is the last type of regulation. It represents the individual's full and free engagement and those who are the most self-determined without reward or constraints (Deci & Ryan 2000). Self-Determination Theory often serves as a theoretical basis

for studies investigating motivation. For example, Ntoumanis (2001) investigated the relations between self-determination and achievement goals. The study found that task orientation predict a high level of self-determination and ego orientation predict a low level of the self-determined motivational variables. Other researchers have found that autonomy is more important than controlling support for intrinsic motivation, regardless of goal involvement (Spray, John Wang, Biddle & Chatzisarantis 2006). Besides the joint project of the theories of Self-Determination and Achievement Goal other associations were established on different aspects of Self-Determination (i.e. Vansteenkiste, Lens, Witte & Feather 2005).

These studies encourage us to further analyzation of the role of Self-Determination Theory in relation to sport motivation using a different approach. Therefore, we investigated self-determination from a commitment perspective. Sport commitment has been defined as a "psychological construct representing the desire and resolve to continue sport participation" (Scanlan, Chow, Sousa, Scanlan & Knifsend 2016, p. 235). The origin of the Sport Commitment Model was introduced in 1993 and consisted of five determinants of commitment; namely, enjoyment, investments, opportunities, alternatives, and social constraint (Scanlan, Carpenter, Simons, Schmidt & Keeler, 1993). However, over the years researchers identified additional possible sources of sport commitment and explored a more complex model (Scanlan, Russell, Magyar, & Scanlan 2009; Lu et al. 2012; Weiss & Weiss 2003). Scanlan and her colleagues (2016) expanded the model and determined two possible types of commitments; enthusiastic and constraints types of commitments. They also determined ten possible sources that could predict sport commitment, namely: Sport Enjoyment, Social Constraints, Valuable Opportunities, Other Priorities; and two types of Personal Investments, Social Support and Desire to Excel. Previous studies have found that Sport Enjoyment, Opportunities Social Support and Desire to Excel to be the strongest positive sources of Enthusiastic Commitment (Carpenter, Scanlan, Simons & Lobel 1993; Scanlan et al. 1993, 2003, 2016). The strongest predictors of constrained types of commitment were Personal Investments, Social Constraints and Other priorities (Scanlan et al. 2016). Sport Enjoyment, Valuable Opportunities and Other Priorities were sources associated with both types of commitment (Scanlan et al. 2016). Pedro and his colleagues (2019) carried out the Spanish adaptation, and they concluded that the model (two types and 10 sources of commitment) is appropriate for cross-cultural studies as well.

The relationship between Self-Determination and Sport Commitment is not well established. However, Zahariadis, Tsorbatzoudis & Alexadnris (2006) examined the association between the two constructs. Their results showed amotivation had a small negative relationship with commitment and a strong positive association with intrinsic motivation.

However, they did not find any significant correlation with extrinsic motivation and sport commitment. Davidson and Beck (2018) in a recent study investigated relationship of commitment and motivation among college students. They found that the satisfied basic needs go together with high level of commitment. To the best of our knowledge, no other studies have previously examined the relationship between Self-Determination Theory and the Sport Commitment Model; and the updated version of the model (Scanlan et al. 2016) has not previously been examined from the Self-Determination perspective. Therefore, the main objective of our study was to examine relationships between sport motivation and the types of sport commitment and their determinants.

There were two main goals of this study: To this end, we investigated: 1) how the types of commitment were associated with the types of motivation (e.g., constrained commitment with external regulation); 2) how the types of motivation were associated with Sport Commitment sources (e.g., amotivation with other priorities). In accordance with the literature, it was hypothesized that Enthusiastic Commitment would be associated with intrinsic types of motivation (high self-determination). In contrast, Constrained Commitment would be associated with extrinsic motivation and amotivation (low self-determination). Furthermore, it was hypothesized that amotivation and extrinsic types of motivations were positively associated with Other Priorities, Social Constrained, while Intrinsic types of motivation would be positively associated with Sport Enjoyment, Valuable Opportunities, and Desire to Excel. The mixed findings of other researchers (see e.g., Scanlan et. al. 2003, 2009, 2016) suggest that the complex function of Social Support and Personal Investment might be associated with both intrinsic and extrinsic motivation.

Methods

Two-hundred fourteen Hungarian adolescent athletes (66 males and 148 females) were involved in this study (mean age = 16.84 years; SD = 1.38). They participated in their sport for an average of 7.78 years (SD = 3.91) and they spent an average of 7.55 hours (SD = 4.66) in training weekly. The athletes were representatives of 25 different sports (individual sports = 59.8 %; team sports = 39.7 %). In terms of competition, 77.7 % of our sample consisted of athletes who were competing at international, national or local level. Only 22.3 % of our sample reported that they are not competing at any level.

Social-demographic data were collected on the athletes' age, gender, educational background, family status and characteristics of their sport activity (i.e., "How many hours do you spend in training in a week?").

Sport Commitment was measured by the Hungarian version of the Sport Commitment Questionnaire-2 (Scanlan et al. 2016). The scale was translated and adapted in a previous study (Berki & Pikó 2018). It contains 52 items which could be answered by a five-point Likert-type scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). The Questionnaire consists of the two types of commitment and the ten possible sources of sport commitment. Enthusiastic Commitment (EC) represents the desire to continue sport participation. Constrained Commitment (CC) represents the obligation to continue sport participation. The ten possible sources of commitment are the following: Sport Enjoyment (SE) representing the joy and happiness in sport activity; Other Priorities (OP) – alternatives of sport activity; Valuable Opportunities (VO) – opportunities that may stem only from sports; Social Constraints (SC) are the social expectation and norms; Personal Investment-Quantity (PI-Q) means the amount of resources that an athlete puts into sport; Personal Investment-Loss (PI-L) represents the loss of investments that cannot be recovered when the participation is discontinued; Social Support-Emotional (SS-E) represents encouragement from others; Social Support-Informal (SS-I) provides useful information from others; Desire to Excel-Mastery (DE-M) means striving to improve and achieve; Desire to Excel-Social (DE-S) means winning and establishing superiority over the others. The adapted version of the scale showed suitable internal consist reliability. The Cronbach's alpha values varied from .66 to .91 on the subscales of commitment; however the whole scale showed a value of .94.

Sport motivation was measured with the revised Sport Motivation Scale (SMS-II; Pelletier, Rocchi, Vallerand, Deci & Ryan 2013). The scale was translated and adapted in a Hungarian sample by Paic and his colleagues (2017). The questionnaire contains 19 items and 6 subscales. The response options varied from 1 (Strongly disagree) to 7 (Strongly agree) on a seven-point Likert-type scale. The items measure the different types of motivations from the Self-Determination Theory (Deci & Ryan 2000). The subscales contained the following motivations: Amotivation, External Regulation, Introjected Regulation, Identified Regulation, Integrated Regulation; Intrinsic Motivation. The Cronbach's alpha value on the whole scale was .88 and the subscales varied between .50 to .89.

After receiving ethical approval from the university (Institutional Review Board), the questionnaires were sent out to 6 different sports schools in Hungary. Four of these schools agreed to participate in our research, which was authorized by the school principals. Through

the mail from school teachers, parents and students were informed about the goals of our research and asked for their consent. Questionnaires were self-administered, anonymous and voluntary, and no personal data (e.g., names) were collected from the participants. The questionnaires were guided by Physical Educators in PE classes and it took student respondents approximately 15-20 minutes to fill out the form. The students were assured that there were no right or wrong answers on the questionnaire they were asked to complete.

After data collection, SPSS for Windows software was used for data analysis. We used parametric tests to analyse our results. In addition to descriptive statistics (i.e., means, standard deviations) and bivariate correlations (r), linear regression (r^2) with stepwise method was used to identify the main predictors of the Sport Commitment Questionnaire and the Sport Motivational Scale. First, we analysed Enthusiastic and Constrained Commitment as dependent variables and elements of Self-Determination theory as the independent variables. In the second part of our analysis, variables of Self-Determination theory were the dependent ones and sources of commitment were the independent variables. The significant level of acceptance was 0.05.

Results

Descriptive statistics and bivariate relationships

Table 1 shows means, standard deviations, ranges, skewness, kurtosis, bivariate correlations and alpha reliabilities (along with the diagonal) for the Sport Commitment Questionnaire-2 and the Sport Motivation Scale. The participants of this study had moderate level ($M < 3.2$) of Constrained Commitment, Personal Investment-Loss, Other Priorities, Social Constrain, Social Support-Informal, Amotivation, External Regulation; and high level of Enthusiastic Commitment, Sport Enjoyment, Valuable Opportunities, Personal Investment-Quantity, Desire to Excel-Master, Desire to Excel-Social, Social Support-Emotional, Introjected Regulation, Identified Regulation, Integrated Regulation, Intrinsic Motivation. Consistent with other studies, Cronbach alpha values varied between .64 and .91 for the Sport Commitment Questionnaire-2 (Sánchez-Miguel 2019) and .50 to .83 for the Sport Motivation Scale (Sukys, Tilindienė, Cesnaitiene & Kreivyte 2019). Introjected Regulation had poor Cronbach alpha value. Cronbach alpha is sensitive to the number of items in a scale (Pallant 2010), but the inter-item correlations of the two items subscale had .33 mean, which is in the optimal range (Briggs & Cheek 1986). Thus, Introjected Regulation subscale remained in the

study. Skewness and kurtosis between -2 and 2 were considered as normally distributed due to George and Mallery (2010) suggestions.

The pattern of the bivariate correlations showed a previously established relationship between commitment types and sources (Scanlan et al. 2016). As we expected, Enthusiastic Commitment had a significant inverse relationship with Constrained Commitment and Other Priorities; and Constrained Commitment had a significant and positive relationship with Personal Investment-Loss, Other Priorities and Social Constrained. The correlation table displays the relationships between the two scales. Among the items, Amotivation, Constrained Commitment and Other Priorities indicated mostly inverse relations, but the rest of our items showed a positive pattern. A series of linear stepwise regression analyses with stepwise method were performed to determine how Sport Motivation Scale could predict Constrained and Enthusiastic types of commitment. Enthusiastic Commitment was explained with the 62 % of the variance and it was significantly predicted initially by Intrinsic Motivation (β = .22), which was followed by Integrated Regulation (β = .21), Amotivation (β = -.12), Introjected Regulation (β = .12). Constrained Commitment was explained with 28 % of the variance in the most predictive model and was determined by Amotivation (β = .15), External Regulation (β = .19) and Intrinsic Motivation (β = -.10).

In the next step, a series of linear stepwise regression analyses were conducted to verify how sources of commitment predict the Sport Motivation. Amotivation (R^2 = .35) was predicted by Sport Enjoyment (β = -.52), Personal Investment-Loss (β = .38), and Other Priorities (β = .39). External Regulation (R^2 = .27) was predicted by Social Constrained (β = .41), Sport Enjoyment (β = -.23), and Social Support-Informal (β = .29). Introjected Regulation (R^2 = .32) was determined by Desire to Excel-Mastery (β = .27) and Personal Investment-Loss (β = .19). Identified Regulation (R^2 = .47) was explained by Desire to Excel-Mastery (β = .39), Valuable Opportunities (β = .22), and Personal Investment-Loss (β = .24). Integrated Regulation (R^2 = .58) was explained in the first step with Valuable Opportunities (β = .24) than Desire to Excel-Mastery (β = .24), Personal Investment-Loss (β = .14) and Social Support – Informal (β = .13). The Intrinsic Motivation subscale explained 57 % of the variance on the best model and it was significantly predicted by Desire to Excel-Mastery (β = .77), Personal Investment-Loss (β = .42), Sport Enjoyment (β = .37) and Social Support-Informal (β = .42).

To summarize our findings, a model was built from the results of the stepwise regression (Figure 1). The model shows the positive and negative associations with the

standardized regression weights between the types and sources of commitment on the Self-Determination continuum.

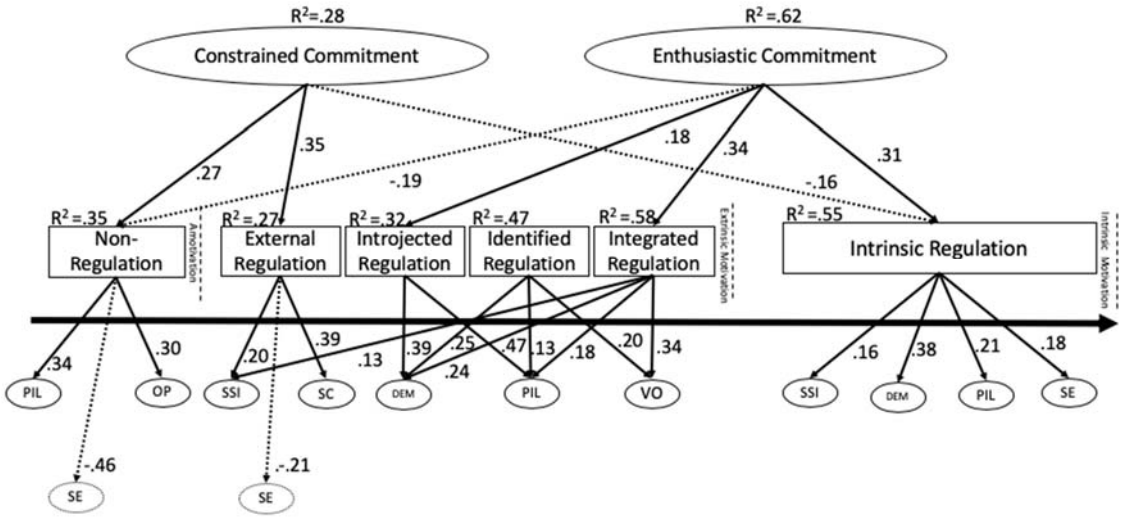

Figure 1

Sport Commitment Model on the Self-Determination Continuum with standardized regression weights. Note. SE= Sport Enjoyment; VO=Valuable Opportunities; PIL=Personal Investment-Loss; OP=Other Priorities; DEM=Desire to Excel-Mastery; SC=Social Constraints; SSI=Social Support-Informal

Discussion

This study aimed to examine the relationship between the Sport Commitment Model and the Self-Determination Theory among adolescent athletes from various sports. Stepwise regression was used to examine data and assess our results. To the best of our knowledge, there have been no other investigations examining Self-Determination Theory and the updated Sport Commitment Model.

In our first step, we investigated associations between types of commitment (enthusiastic, constrained) and the forms of sport motivation. As hypothesized, Intrinsic Motivation was positive predictors of Enthusiastic Commitment. Besides the intrinsic association, Enthusiastic Commitment was positively predicted by Integrated and Introjected Regulations as well. This finding represents that enthusiastically committed athletes primarily engage in sport for "want to" reasons (e.g., satisfaction; Wilson et al. 2004). Yet, it appears also that internal feelings and importance for physical activity are important predictors of Enthusiastic Commitment (Scanlan et al. 2016) which includes as well Integrated and Introjected regulations (Pelletier et al. 2013). Introjected Regulation, built on shame and guilt, appears to have a clear connection with Constrained Commitment because of obligatory influence (Lazarus 2000). Previous studies found that introjection was associated with high

levels of physical activity without showing negative effects (Gillison, Osborn, Standage & Skevington 2009). Other studies suggest that guilt-based introjection might decrease the individual's well-being, eating regulation and exercise (Verstuyf, Patrik, Vansteenkiste, & Teixeire, 2012). We believe that our findings support the concept that a high level of motivation requires both intrinsic and extrinsic motivations (Cameron, Pierce, Banko & Gear 2005). Integrated Regulation is the most autonomous form of extrinsic motivation incorporating the individual's life goals, objectives, and needs; and Integrated Regulation is highly related to Enthusiastic Commitment. Previous studies of commitment showed that Desire to Excel-mastery was one of the most important predictors of Enthusiastic Commitment (Scanlan et al. 2016). Enthusiastic Commitment was negatively predicted by Amotivation as well, which consisted of non-regulation and lack of intention to participate (Deci & Ryan 2002). These findings affirm that Enthusiastic Commitment has an inverse relationship with obligatory reasons for sport participation (e.g., Social Constraints; Scanlan et al. 2003, 2009, 2016).

In the process of investigating predictors of Constrained Commitment, we found that External Regulation and Amotivation were positive and Intrinsic Motivation was a negative predictor of Constrained Commitment. The construct represents perceptions of obligation to persist in a sport (Scanlan et al. 2016). These obligations come from social constraints, investment, alternatives, and the lack of enjoyment (e.g., Scanlan et al. 2016). Previous findings align with our result (e.g., Weiss & Weiss 2003). We believe that an individual's increased level of Constrained Commitment may be associated with the lack of intention to participate; therefore, heightening risk of dropout in sports participation. External rewards or punishments are important to evaluate in studies of motivation (e.g., Cameron, Banko, & Pierce 2001). Burton (1989) suggested that we should avoid extrinsic reward as a motivator of sport participation. However, more recently, studies suggest that external reward may increase Intrinsic Motivation for physical activity (Cameron, et al. 2005). We contend that external reward may increase commitment. Further, interrelationships among the types of sport commitment and motivations may change over time according to Weiss & Weiss (2006).

In the second aspect of our study we investigated relationships among the sources of Self-Determination and Sport Commitment. Amotivation was positively predicted by Personal Investment-Loss and Other Priorities; and negatively by Sport Enjoyment. This finding is consistent with previous sport commitment findings, since alternatives have negative and enjoyment has positive effects on sport commitment (Scanlan et al. 1993, 2009, 2016). Personal Investment may have an obligatory effect on sport participation, because the individual's investments can be lost if sport participation is discontinued (Scanlan et al. 1993, 2009, 2016).

Therefore, this association with Amotivation appears to be logical. Our results also suggest that Personal Investment-loss is a more complex construct since we found positive connections with extrinsic and intrinsic motivation as well.

Extrinsic motivation was associated with six predictors. Sport Enjoyment was a negative predictor of Amotivation and External Regulation. As expected, this factor shows the individual's positive feelings towards sport participation. The negative effect of Sport Enjoyment has been found in previous sport commitment studies as well (e.g., Wilson et al. 2004). External Regulation was predicted by Social Support-Informal and Social Constrained. These predictions were expected on the basis that these factors represent support from coaches or peers as well as social expectations (Scanlan et. al. 2016). Our findings support the hypothesis that expectations and support put pressure on the athletes to continue their sport participation and indicate a higher level of external regulation. It is important to note that Social Support-Informal is a predictor of Integrated Regulation as well. It might indicate that Support from coaches and peers can effect the athletes' internal feelings, which help them with commitment to their sports.

We found that Introjected and Integrated regulations were predicted by Personal Investment-Loss, Valuable Opportunities and Desire to Excel-Mastery sources. Thus, it appears that Desire to Excel-Mastery is an important predictor of the 3 types of extrinsic motivation. This factor represents the individual's desire to improve and achieve in sport (Scanlan et al. 2016) and supports that not only intrinsic but also extrinsic factors can contribute to the achievement of the athlete's goals. For example, athletes seeking for better performance are likely to determine that they must devote time to training in and not skip training sessions. There are different reasons for this, including conscience (introjection), the importance of the training (identification), thoughts related to more goals and objectives which are necessary to improve their performance (integration).

Personal Investment-loss positively predicted Introjected Regulation and Identified Regulation. We believe that there are two main reasons for these associations. First, Personal Investment represents the amount of energy, money, and time what an athlete invests in sport (Scanlan et al. 2006). Second is the loss of the investment might associate with the feelings such as guilt or shame. Valuable Opportunities as a variable was hypothesized to be an intrinsic predictor because previous studies have shown a strong association with Enthusiastic Commitment (Scanlan et al. 2016). However, we found positive relationships with Identified and Integrated Regulations. Qualitative studies demonstrated the diversity of Valuable Opportunities in sport representing many aspects of sport experience, such as travels,

performance, friendship and even job opportunities (Scanlan et al. 2003, 2009). We conclude that the athlete's opportunities and important motives may come from different attributes (e.g., trainings, travels, motor skills)

In the last part of our study we investigated the relationships between Intrinsic Motivation and the sources of sport commitment. As hypothesized, Sport Enjoyment was a strong predictor of intrinsic regulations. However, it was unexpected that Valuable Opportunities was not a significant predictor of Intrinsic Motivation. We believe that the Valuable Opportunities variable has a complex role, since it contains both external (e.g., experience of competition) and internal (e.g. learning skills) feelings. The three predictors of Intrinsic Motivations (Desire to Excel-mastery, Personal Investment-loss, Social Support-informal) were predictors of extrinsic motivation as well. It appears that these three factors can be viewed across a continuum and that these constructs represent wide aspects of sport participation. For example, Desire to Excel-mastery may reflect either the inside urge to perform or the personal importance with other life goals as well.

Conclusion

The association between the Sport Commitment and Self-Determination theories is complex and the sources of commitment cannot be individually separated from the Self-Determination continuum. Whereas the Sport Commitment is a complex construct, we postulate that aspects of Sport Commitment and Self-Determination influence each other in a bi-direction manner. For example, athletes with a high level of Social Support and External Regulation might feel the pressure to continue their sport participation, but in the long term it might influence their goals, lead to the increased satisfaction and help them engage in their sport activities.

We acknowledge that 3 out of the 10 commitment sources were not involved as predictors of sport motivation (Desire to excel-Social, Social Support-Emotional, Personal Investment-Quantity). Further investigations are necessary to explain this phenomenon. Our conclusions include the following points: 1) Constrained Commitment (associated with low self-determination) is at one end of the continuum and Enthusiastic Commitment is at the opposite end of the continuum (associating with high self-determination). However, because of its complexity external elements are associated with it as well; 2) Obligatory factors are predicted by Amotivation and external regulation (e.g., other priorities); 3) Enjoyment is an

important predictors of Intrinsic motivation; and 4) Several commitment sources varied across the continuum (e.g., Personal Investment-loss, Social Support-informal).

The current study has limitations that need to be mentioned. First, the gender distribution of research subjects was not equal (more females by 34 %). Second, some of the examined subscales showed low internal consistency reliability. However, we believe this problem can be solved by increasing our sample size. Therefore, the future direction is to increase the sample size and equal gender differences. Besides these, there are several other directions for further elaboration of our study. For example, it would be productive for future research to investigate sport commitment from different motivation perspectives (e.g., Achievement goal theory). In this study, only adolescent athletes were examined but investigating other age groups can help understand the link between the types of commitment and psychological behaviour.

In summary, a strength of the current study is that provides a cross-cultural application of the Sport Commitment Model and adds to the literature greater understanding of the model's association with Self-Determination. This study provides a representation of how the Sport Commitment Model incorporates with Self-Determination theory and provides direction for further research in this area of motivation research. These findings are useful in providing guidance to professionals who are striving to help young athletes maintain their sports activity and prevent dropout from sport.

References

1. APPLETON, P. R. & A. P. HILL, 2012. Perfectionism and athlete burnout in junior elite athletes: The mediating role of motivation regulations. *Journal of Clinical Sport Psychology.* ***6***(2), 129-145. doi:10.1123/jcsp.6.2.129.
2. BERKI, T. & B. PIKÓ, 2018. Comparison of sport commitment among adolescent athletes in light of some characteristics of sporting. *Hungarian Review of Sport Science.* **76**(4), 3-11.
3. BRIGGS, S. R. & J. M. CHEEK, 1986. The role of factor analysis in the development and evaluation of personality scales. *Journal of Personality.* ***54***(1), 106-148. doi:10.1111/j.1467-6494.1986.tb00391.x
4. BURTON, D, 1989. Winning isn't everything: Examining the impact of performance goals on collegiate swimmers' cognitions and performance. *The Sport Psychologist.* ***3***(2), 105-132. doi:10.1123/tsp.3.2.105.

5. CAMERON, J., K. M. BANKO & W. D. PIERCE, 2001 Pervasive negative effects of rewards on intrinsic motivation: The myth continues *The Behavior Analyst.* **24**(1), 1-44. doi:10.1007/bf03392017.
6. CAMERON, J., W. D. PIERCE, K. M. BANKO & A. GEAR, 2005. Achievement-based rewards and intrinsic motivation: A test of cognitive mediators. *Journal of Educational Psychology*. ***97***(4), 641-655. doi:10.1037/0022-0663.97.4.641.
7. CARPENTER, P. J., T. K. SCANLAN, J. P. SIMONS & M. LOBEL, 1993. A test of the sport commitment model using structural equation modeling. *Journal of Sport and Exercise Psychology. **15***, 119-133.
8. CLANCY, R. B., M. P. HERRING, T. E. MACINTYRE & M. J. CAMPBELL, 2016. A review of competitive sport motivation research. *Psychology of Sport and Exercise. **27***, 232-242.
9. DAVIDSON, W. & H. P. BECK, 2018. Analyzing the Commitment of College Students Using a Brief, Contextualized Measure of Need Satisfaction from the Perspective of Self-Determination Theory. *Psychological Reports. **122***(3), 1145-1166. doi: 10.1177/0033294118769452.
10. DECI, E. L. & R. M. RYAN, 1985. *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Plenum Press.
11. DECI, E. L. & R. M. RYAN, 2000. The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry. **11***(4), 227-268. doi:10.1207/s15327965pli1104_01.
12. DECI, E. L. & R. M. RYAN, 2002. *Handbook of self-determination*. Rochester, NY: University of Rochester Press.
13. GEORGE, D. & M. MALLERY, 2010. SPSS for Windows Step by Step: A Simple Guide and Reference, 17.0 update (10a ed.) Boston: Pearson.
14. GILLET, N., R. J. VALLERAND, S. AMOURA & B. BALDES, 2010. Influence of coaches' autonomy support on athletes' motivation and sport performance: A test of the hierarchical model of intrinsic and extrinsic motivation. *Psychology of Sport and Exercise. **11***(2), 155-161. doi:10.1016/j.psychsport.2009.10.004.
15. GILLISON, F., M. OSBORN, M. STANDAGE & S. SKEVINGTON, 2009. Exploring the experience of introjected regulation for exercise across gender in adolescence. *Psychology of Sport and Exercise. **10***(3), 309-319. doi:10.1016/j.psychsport.2008.10.004.

16. HOMAN, K. J., S. L. CROWLEY & L. A. SIM, 2019. Motivation for sport participation and eating disorder risk among female collegiate athletes. *Eating Disorders.* ***27***(4), 369-383. Retrieved from DOI: 10.1080/10640266.2018.1517527.
17. LAZARUS, R. S., 2000. How emotions influence performance in competitive sports. *The Sport Psychologist.* ***14***(3), 229-252. doi:10.1123/tsp.14.3.229.
18. LU, F. J., Y. EVA, J. WANG, J. CHANG, M. HUANG & C. WANG, 2012. Exerciser identities and exercise dependence: The mediating effect of exercise commitment. *Perceptual and Motor Skills*. ***115***(2), 618-631. doi:10.2466/06.13.21.pms.115.5.618-631.
19. MALLETT, C. J. & S. J. HANRAHAN, 2004. Elite athletes: Why does the 'fire' burn so brightly? *Psychology of Sport and Exercise.* **5**(2), 183-200. doi:10.1016/s1469-0292(02)00043-2.
20. MARIAGER-ANDERSON, K., P. CORT & R. THOMSEN, 2016. 'In reality, I motivate myself!'. 'Low-skilled' workers' motivation: between individual and societal narratives. *British Journal of Guidance & Counselling.* ***44***(2), 171-184. doi: 10.1080/03069885.2016.1145191.
21. NICHOLLS, J. G., 1989. *The competitive ethos and democratic education*. Cambridge, MA: Harvard University Press.
22. NTOUMANIS, N., 2001. Empirical links between achievement goal theory and self-determination theory in sport. *Journal of Sports Sciences.* ***19***(6), 397-409. doi: 10.1080/026404101300149357.
23. PAIC, R., A. KAJOS, B. MESZLER & G. PRISZTÓKA, 2017. Validation of the Hungarian Sport Motivation Scale (H-SMS). *Cognition, Brain, Behavior. An Interdisciplinary Journal.* ***21***(4), 275-291. doi:10.24193/cbb.2017.21.17.
24. PALLANT, J., 2010. *Spss Survival Manual: A step by step guide to data analysis using SPSS*.
25. McGRAW-HILL INTERNATIONAL. PELLETIER, L. G., M. A. ROCCHI, R. J. VALLERAND, E. L. DECI & R. M. Ryan, 2013. Validation of the revised sport motivation scale (SMS-II). *Psychology of Sport and Exercise.* ***14***(3), 329-341. doi: 10.1016/j.psychsport.2012.12.002.
26. PELLETIER, L. G., K. M. TUSON, M. S. FORTIER, R. J. VALLERAND, N. M. BRIÉRE & M. R. BLAIS, 1995. Toward a new measure of intrinsic motivation, extrinsic motivation, and amotivation in sports: The Sport Motivation Scale (SMS). *Journal of Sport and Exercise Psychology.* ***17***(1), 35-53. doi:10.1123/jsep.17.1.35.

27. RYAN, R. M. & E. L. DECI, 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist.* ***55***(1), 68-78. doi:10.1037//0003-066x.55.1.68.
28. SÁNCHEZ-MIGUEL, P. A., G. M. CHOW, C. SOUSA, T. K. SCANLAN, F. J. PONSETI, L. SCANLAN & A. GARCÍA-MAS, 2019. Adapting the Sport Commitment Questionnaire-2 for Spanish usage. *Perceptual and Motor Skills.* ***126***(2), 267-285. doi:10.1177/0031512518821822.
29. SCANLAN, T. K., P. J. CARPENTER, J. P. SIMONS, G. W. SCHMIDT & B. KEELER, 1993. An introduction to the Sport Commitment Model. *Journal of Sport and Exercise Psychology.* ***15***(1), 1-15. doi:10.1123/jsep.15.1.1.
30. SCANLAN, T. K., G. M. CHOW, C. SOUSA, L. A. SCANLAN & C. A. KNIFSEND, 2016. The development of the Sport Commitment Questionnaire-2 (English version). *Psychology of Sport and Exercise.* ***22***, 233-246. doi:10.1016/j.psychsport.2015.08.002.
31. SCANLAN, T. K., D. G. RUSSELL, K. P. BEALS & L. A. SCANLAN, 2003. Project on Elite Athlete Commitment (PEAK): II. A direct test and expansion of the Sport Commitment Model with elite amateur sportsmen. *Journal of Sport and Exercise Psychology.* ***25***(3), 377-401. doi:10.1123/jsep.25.3.377.
32. SCANLAN, T. K., D. G. RUSSELL, T. M. MAGYAR & L. A. SCANLAN, 2009. Project on Elite Athlete Commitment (PEAK): III. An examination of the external validity across gender, and the expansion and clarification of the Sport Commitment Model. *Journal of Sport and Exercise Psychology.* ***31***(6), 685-705. doi:10.1123/jsep.31.6.685.
33. SPRAY, C. M., C. K. JOHN WANG, S. J. BIDDLE & N. L. CHATZISARANTIS, 2006. Understanding motivation in sport: An experimental test of achievement goal and self determination theories. *European Journal of Sport Science.* ***6***(1), 43-51. doi:10.1080/17461390500422879.
34. SUKYS, S., I. TILINDIENĖ, V. J. CESNAITIENE & R. KREIVYTE, 2019. Does emotional intelligence predict athletes' motivation to participate in sports? *Perceptual and Motor Skills.* ***126***(2), 305-322. doi:10.1177/0031512518825201.
35. VALLERAND, R. J., L. G. PELLETIER, M. R. BLAIS, N. M. BRIERE, C. SENECAL & E. F. VALLIERES, 1992. The Academic Motivation Scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement.* ***52***(4), 1003-1017. doi:10.1177/0013164492052004025.
36. VANSTEENKISTE, V., W. LENS, H. WITTE & N. T. FEATHER, 2005. Understanding unemployed people's job search behaviour, unemployment experience and well-being: A

comparison of expectancy-value theory and self-determination theory. *British Journal of Social Psychology.* ***44***(2), 269-287. doi:10.1348/014466604x17641.

37. VERSTUYF, J., H. PATRICK, M. VANSTEENKISTE & P. J. TEIXEIRA, 2012. Motivational dynamics of eating regulation: a self-determination theory perspective. *International Journal of Behavioral Nutrition and Physical Activity.* ***9***(1), 21. doi:10.1186/1479-5868-9-21.
38. WARBURTON, D. E. & S. S. BREDIN, 2017. Health benefits of physical activity. *Current Opinion in Cardiology.* ***32***(5), 541-556. doi:10.1097/hco.0000000000000437.
39. WEISS, W. M. & M. R. WEISS, 2003. Attraction- and entrapment-based commitment among competitive female gymnasts. *Journal of Sport and Exercise Psychology.* ***25***(2), 229-247. doi:10.1123/jsep.25.2.22.
40. WEISS, W. M. & M. R. WEISS, 2006. A longitudinal analysis of commitment among competitive female gymnasts. *Psychology of Sport and Exercise.* *7*(3), 309-323. doi:10.1016/j.psychsport.2005.08.010.
41. WILSON, P. M., W. M. RODGERS, P. J. CARPENTER, C. HALL, J. HARDY & S. N. FRASER, 2004. The relationship between commitment and exercise behavior. *Psychology of Sport and Exercise.* ***5***(4), 405-421. doi:10.1016/s1469-0292(03)00035-9.
42. ZAHARIADIS, P., H. TSORBATZOUDIS & K. ALEXANDRIS, 2006. Self-determination in sport commitment. *Perceptual and Motor Skills.* ***102***(2), 405–420. https://doi.org/10.2466/pms.102.2.405-420.

Table 1

Correlations. alpha coefficients and descriptive statistics for the study variables

	EC	CC	SE	VO	PIQ	PIL	OP	SC	DEM	DES	SSE	SSI	Amot.	Ext. Reg.	Intro. Reg.	Iden. Reg.	Integ. Reg.	Intrin. Mot.
EC	(.91)																	
CC	-.15*	(.65)																
SE	.67**	-.42**	(.89)															
VO	.76**	.03	.51**	(.77)														
PIQ	.72**	-.00	.50**	.72**	(.87)													
PIL	.47**	.23**	.25**	.60**	.59**	(.77)												
OP	-.35**	.21**	-.19**	-.14*	-.25**	-.09	(.73)											
SC	.50**	.28**	.17**	.56**	.60**	.56**	-.16*	(.81)										
DEM	.76**	-.21**	.66**	.63**	.74**	.44**	-.28**	.39**	(.85)									
DES	.64**	0.01	.48**	.69**	.70**	.49**	-.22**	.56**	.69**	(.76)								
SSE	.53**	-.02	.33**	-0.04	.60**	.36**	-.30**	.53**	.57**	.54**	(.75)							
SSI	.53**	.07	.33**	.27**	.52**	.38**	-.12	.52**	.48**	.46**	.57**	(.72)						
Amot.	-.27**	.43**	-.41**	.44**	-0.1	.16*	.33**	.12	-.27**	-.09	-.08	-.01	(.76)					
Ext. Reg.	.19**	.42**	-.08	.55**	.24**	.27**	.03	.50**	.10	.29**	.24**	.35**	.39**	(.83)				
Intr. Reg.	.57**	.00	.36**	.61**	.49**	.43**	-.16*	.36**	.51**	.38**	.29**	.28**	-.03	.25**	(.50)			
Iden.Reg.	.64**	-.10	.46**	.60**	.50**	.45**	-.20**	.37**	.61**	.50**	.39**	.39**	-.17*	.16*	.59**	(.83)		
Integ.Reg.	.69**	-.11	.46**	.72**	.60**	.47**	-.22**	.41**	.63**	.58**	.45**	.44**	-.11	.23**	.53**	.79**	(.82)	
Intr. mot.	.70**	-.12	.53**	.60**	.58**	.48**	-.25**	.37**	.68**	.55**	.47**	.45**	-.13	.22**	.60**	.77**	.73**	(.89)
Range	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-7	1-7	1-7	1-7	1-7	1-7
Skewness	-.68	.32	-1.29	-.44	-.88	-.29	.39	-.03	-1.08	-.80	-.65	-.16	.47	.53	-.35	-.49	-.47	-.77
Kurtosis	-.22	-.67	1.30	-.76	.24	-.71	-.32	-1.05	1.03	-.06	-.57	-.89	-.67	.16	-.45	-.38	-.45	.25
M	3.72	2.42	4.26	3.38	3.94	3.16	2.54	3.01	4.07	3.77	3.66	3.08	3.05	2.87	4.58	4.79	4.57	4.86
SD	1.05	.92	.83	1.15	.95	1.10	.97	1.16	.85	1.00	1.14	1.17	1.66	1.69	1.54	1.26	1.66	1.46

Note. EC= Enthusiastic Commitment; CC=Constrained Commitment; SE= Sport Enjoyment; VO=Valuable Opportunities; PI-Q=Personal Investment-Quantity; PI-L=Personal Investment-Loss; OP=Other Priorities; DE-M=Desire to Excel-Mastery; DE-S=Desire to Excel-Social; SC=Social Constraints; SS-E=Social Support-Emotional; SS-I=Social Support-Informal; mot.=Amotivation; Ext. Reg.=External Regulation; Intro. Reg.=Introjected Regulation; Iden. Reg.=Identified Regulation; Integ. Reg.= Integrated Regulation; Intrin. Mot. = Intrinsic Motivation*p<0.05 **p<0.01

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GENDER DIFFERENCES IN QUALITY OF LIFE AND PHYSICAL ACTIVITY OF HIGH SCHOOL STUDENTS

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Summary: This article demonstrates the gender differences between the physical activity (PA), the joy of physical activity (PACES) and quality of life areas of boys and girls from high schools with different sports level and in the different ages. In this survey participated 630 boys and 672 girls from high schools in the age from 16 to 19 years. The quality of life is measured by the SQUALA survey, joy of the movement by the PACES survey, and the level of physical activity per week in hours by PAQ survey. The level of sports performance is defined by levels (occasional, active and registered sportsman). The data are presented by descriptive characteristics (n, M, SD) and the significance of differences and the relations are measure by non-parametric methods (W, rs). Differences in the PA, PACES, SQUALA levels at the group of boys and girls in the different age and sports level are rare. Different load of physical activity relates to sport level. It was not proven that with the increasing sports level, the joy of the physical activity also rises. The interactions between indicators of PA, PACES, and SQUALA in boys and girls in the different age and sports level were proven sporadically with a predominance of negative correlations. In most cases, the positive interactions of PA with PACES and areas of physical well-being was not proven. The higher appearance of positive correlations of PA with areas of SQUALA prevails in 18-years old girls. Boys show the higher number of interactions of PACES with areas of SQUALA. The joy of the movement positively correlates with spiritual well-being in groups of 18-19 years old boys, which perform physical activities in all sports levels. The gender differences between monitored indicators show that the gender factor is very important in this study. The age and sport level factor contributed significantly in the differentiated results of high school boys and girls.

Key words: quality of life, joy of the movement, physical activity, age, gender, sports level

Introduction

Physical activity is an essential part of everyday life. It can be influenced by many factors. Today's so-called "modern age" have on physical activity mainly negative impact (Vaskan et al. 2018). It is important to create conditions for the various physical activities in the preschool age and continuously raise their level by all age categories till adulthood. Quality and level of physical activities cannot be lowered also in Physical Education lessons in high schools (Medeiros et al. 2018. According to Campo-Ternera et al. (2017), physical activity (PA) plays an important role in promoting health well-being in adolescence period of life. According to studies of Palomino-Devia et al. (2018), the relation between the general and mental health and physical function and vitality in adolescents was detected. Higher physical activity raises the quality of life connected with health, PA, and joy of the movement itself (Broďáni 2012, 2015; Zurita-Ortega et al. 2018).

Except for the PA performed in the Physical Education lessons, most adolescents practice the PA outside of the school institutions as occasional, active or top (registered) sportsmen. These types of physical activities allow them to have more fun and support the social relations between them (Gonzáles et al. 2016). Some of the authors coincide in their studies of PA that the PA plays one of the most important role in the prevention of public health (Garcia et al. 1998; Anderson et al. 2005; Norris et al. 1992). Regular PA around 3-5 times a week can be beneficial for physical fitness improvement and it can increase the general quality of life (Broďáni 2016). Nevertheless, according to these authors, adolescence age is a very risky because the biggest decline of overall PA was registered right in this period of life.

Another important factor which differentiates PA is gender. From the viewpoint of gender differences, the authors as Chahín et al. (2011), Hernando et al. (2013), Hutchens et al. (2016), Medina et al. (2018) proven higher sports level in boys than in girls. The reason of this fact can be the high care for body appearance and slightly narcissistic expression to look always good which support self-confidence and this may reduce girls' interest in PA (Norris 1992).

Interactions between these factors have a broader background. The phenomenon of subjective evaluation of the joy of the movement comes to the fore "PACES“ which shows a high frequency of interactions between the quality of life areas "SQUALA" more than between the overall volume of "PA". Despite of enough PA per week and high level of PACES, the expected interactions of SQUALA areas in high school students have not been proven. Low

rates of positive interactions indicate the necessity of monitoring this construct also in connection to the gender, different sports level and age.

Based on the above facts, in our paper we focus on gender differences between physical activity (PA), joy of physical activity (PACES) and the areas of quality of life (SQUALA) in boys and girls from high schools at different ages and sports level.

Aim

Aim of this work is to reveal the gender differences in the interactions between the physical activity, joy of the movement and subjective evaluation of the quality of life of boys and girls from high school with different age and sports levels.

Material and Methods

The questionnaire survey was focused on finding of the frequency of physical activity in a week, level of sport performance, joy from the physical activity and the quality of life. The survey was attended by 630 boys and 672 girls (16 – 19 years old) from Slovak high schools. Physical activity in the week (PAQ) was determined by the overall hours of physical activity without physical education. Groups with different sports level were defined as follow:

Occasional athletes (A): do not seek physical activity, attend mandatory sports activities at school or at work or seek physical activity, not regular in a week, physical activity is not organized,

Active athletes (B): regular activity in a week, no membership in sport organization,

Registered athletes (C): they are members of sport organizations, national level, international level, top sport level.

For the evaluation of the joy of the movement we used questionnaire PACES – Physical Activity Enjoyment Scale which consist of 16 statements. Respondents express themselves by the 5 points, Likert scale. Total score is obtained by the counting of individual answers. High values represent the joy of the movement and the low value from summary score represents less joy from the physical activity (Heesch et al. 2006).

The questionnaire of quality of life contained several parts from the SQUALA questionnaire (Dragomirecká et al. 2006; Zannotti & Pringuey, 1992; Ocetková 2007; Sýkorová 2008). The questionnaire defines the areas from the subjective point of the view “How are you

satisfied with…". The areas in questionnaire were assessed by respondents on a 5-point scale. The questionnaire items were evaluated in terms of these spheres:

1. sphere of physical well-being (health, sleep, solution of everyday activities, do not have health problems),
2. sphere of psychosocial well-being (family, personal relationships, intimate relationships, hobbies, safety),
3. sphere of spiritual well-being (justice, freedom, beauty and art, the truth),
4. sphere of material well-being (money, good food),
5. education (to be educated),
6. leisure time (possibility to spend your free time, have enough things for play and fun),
7. appearance and ownership of the things (to look good, to dress nicely, to own nice things).

For the data presentation we used basic descriptive statistics (frequency n, arithmetical mean M, standard deviation SD). Differences between independent groups were assessed by Kruskal Wallis χ^2 test for multiple choices. For finding the interaction between criteria "frequency of the physical activity in a week, joy of the physical activity" and "areas of quality of life" we used the Spearman´s correlation coefficient (r_s). For the assessment of the statistical significance of differences and relations we used the level of significance $p < .20$; $p < .10$; $p < .05$ and $p < .01$.

Results

Aim of the work was to reveal the gender and age differences in levels and interactions between physical activity, the joy of physical activity an in the subjective evaluation of individual areas of quality of life between 16 to 19 years old boys and girls from high schools. In every age groups, students were divided into other groups according to their sports level as occasional, active or registered sportsmen (tab. 1 – 4).

Table 1

Level of physical activity, joy of the movement and quality of life areas of 16 years old boys and girls with different sports level

Indicators	Sports performance 16 years boys						Sports performance 16 years girls					
	A Occasional [n=49]		B Active [n=51]		C Registered [n=73]		A Occasional [n=99]		B Active [n=74]		C Registered [n=39]	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Physical activities per week witout physical education [h]	2,65	1,71	5,10	2,82	8,86	3,56	2,28	1,74	5,96	2,87	8,64	4,39
Total physical activities per week [h]	4,63	1,78	7,33	2,89	10,95	3,54	4,51	1,90	7,93	2,89	10,95	4,29
Joy of movement	49,78	7,33	49,43	5,80	53,16	6,99	49,93	6,00	53,46	7,05	50,44	4,45
Physical well-being	3,80	,55	3,56	,75	3,74	,50	3,64	,62	3,76	,56	3,85	,57
Psychosocial well-being	3,62	,57	3,71	,54	3,69	,55	3,63	,52	3,67	,55	3,91	,49
Spiritual well-being	2,93	,78	2,95	,74	3,06	,80	2,90	,72	3,16	,68	3,23	,69
Material well-being	3,59	,73	3,61	,80	3,71	,75	3,57	,80	3,60	,86	3,76	,82
Education	4,03	,77	3,67	,75	3,76	,74	3,77	,73	3,84	,74	3,81	,68
Leisure time	3,72	,78	3,84	,77	3,89	,78	3,64	,80	3,81	,80	3,99	,67
Appearance and Property affairs	3,81	,69	3,95	,73	3,80	,80	3,74	,71	3,82	,76	3,99	,63

Table 2

Level of physical activity, joy of the movement and quality of life areas of 17 years old boys and girls with different sports level

Indicators	Sports performance 17 years boys						Sports performance 17 years girls					
	A Occasional [n=77]		B Active [n=42]		C Registered [n=64]		A Occasional [n=86]		B Active [n=64]		C Registered [n=45]	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Physical activities per week witout physical education [h]	3,10	2,09	6,60	2,82	8,67	3,79	2,55	2,02	6,39	3,67	10,13	3,73
Total physical activities per week [h]	5,06	2,16	8,86	2,68	10,85	3,93	4,55	1,98	8,59	3,61	12,13	3,53
Joy of movement	49,26	6,41	50,86	6,30	52,44	6,19	49,55	4,95	49,52	4,27	48,98	5,48
Physical well-being	3,66	,62	3,76	,52	3,81	,60	3,77	,69	3,81	,51	3,92	,57
Psychosocial well-being	3,64	,54	3,77	,57	3,80	,53	3,75	,55	3,70	,53	3,84	,44
Spiritual well-being	3,12	,83	3,20	,70	3,29	,70	2,97	,72	2,94	,80	3,14	,76
Material well-being	3,50	,79	3,55	,91	3,70	,79	3,60	,80	3,62	,84	3,52	1,02
Education	3,69	,93	3,75	,81	3,83	,62	3,76	,77	3,68	,77	3,42	,81
Leisure time	3,70	,86	3,82	,77	3,67	,87	3,59	,97	3,80	,90	4,09	,83
Appearance and Property affairs	3,86	,65	3,79	,54	3,89	,71	3,89	,61	4,11	,58	4,07	,63

Table 3

Level of physical activity, joy of the movement and quality of life areas of 18 years old boys and girls with different sports level

Indicators	Sports performance 18 years boys						Sports performance 18 years girls					
	A Occasional [n=68]		B Active [n=65]		C Registered [n=58]		A Occasional [n=94]		B Active [n=62]		C Registered [n=29]	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Physical activities per week witout physical education [h]	2,84	1,96	5,88	3,51	8,59	3,84	2,63	2,11	5,77	3,46	10,17	3,96
Total physical activities per week [h]	4,63	1,99	7,96	3,42	10,55	3,84	4,68	2,26	7,98	3,50	12,21	4,20
Joy of movement	49,22	6,07	54,08	7,33	52,53	6,91	51,71	7,08	49,18	5,27	51,31	4,83
Physical well-being	3,63	,55	3,73	,60	3,77	,59	3,59	,68	3,75	,62	3,80	,74
Psychosocial well-being	3,66	,46	3,62	,56	3,73	,47	3,62	,60	3,55	,47	3,67	,66
Spiritual well-being	3,03	,73	3,44	,81	3,11	,83	3,08	,71	2,95	,66	3,12	,80
Material well-being	3,63	,80	3,50	,94	3,71	,79	3,52	,90	3,61	,68	3,57	,91
Education	3,76	,87	3,65	,90	3,50	,89	3,53	,84	3,70	,75	3,79	,90
Leisure time	3,78	,85	3,72	,91	3,72	,97	3,66	,97	3,81	,85	3,72	,93
Appearance and Property affairs	3,83	,58	3,87	,72	3,83	,77	3,74	,81	3,84	,69	3,89	,75

Table 4

Level of physical activity, joy of the movement and quality of life areas of 19 years old boys and girls with different sports level

Indicators	Sports performance 19 years boys						Sports performance 19 years girls					
	A Occasional [n=28]		B Active [n=34]		C Registered [n=21]		A Occasional [n=59]		B Active [n=19]		C Registered [n=2]	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Physical activities per week witout physical education [h]	2,36	2,06	5,56	3,52	9,62	3,89	3,10	1,74	5,00	2,60	11,00	1,41
Total physical activities per week [h]	4,18	2,11	7,24	3,59	11,90	3,86	4,75	2,03	6,89	2,96	14,00	,00
Joy of movement	50,50	8,60	52,18	6,10	54,10	5,51	51,86	7,63	53,47	7,61	59,00	9,90
Physical well-being	3,69	,45	3,76	,76	3,54	,64	3,83	,63	3,85	,79	4,40	,85
Psychosocial well-being	3,71	,44	3,69	,59	3,74	,56	3,82	,47	3,87	,56	3,70	,42
Spiritual well-being	3,13	,76	3,16	,76	3,32	,91	3,33	,77	3,61	,74	4,13	,18
Material well-being	3,63	,85	3,72	,87	3,71	,77	3,56	,72	3,63	,91	4,50	,71
Education	3,98	,63	3,84	,76	3,71	,99	3,98	,80	4,11	,70	2,75	1,77
Leisure time	3,75	,78	3,68	,82	3,83	,84	3,86	,75	4,08	,73	5,00	,00
Appearance and Property affairs	3,75	,59	4,19	,51	4,02	,70	3,88	,62	3,98	,79	4,33	,94

Comparing boys and girls in the individual age groups with different sports level (tab. 1 – 5) it can be stated that statistically significant differences in the monitored indicators are rare. Differences in physical activity ($\chi^2 = 3.72$; $p < .05$) were monitored only between the groups of registered 17 years old boys (M = 10,85, SD = 3,93) and 17 years old girls (M = 12.13, SD = 3.53) while in the girls group was monitored lowered level of joy of physical activities ($\chi 2 = 7.1$; $p < .01$). The lower level of joy of the physical activity ($\chi^2 = 14.03$; $p < .01$) we monitored also in the group of 18 years old girls but at the same level of physical activity as 18-year-old boys. The exact opposite was manifested between the groups of 16 years old active sportsman with the same level of PA, where girls (M = 53.46; SD = 7.05) performed physical activities with the higher joy as boys (M = 49.43; SD = 5.80). Statistically significant differences between the genders in the subjective evaluation of the quality of life are also very rare (tab. 5). There are no logical connections and common signs concerning gender, age, and sports level. For this reason, we do not evaluate them further.

Table 5

Comparison of the level of PA, joy of PA and quality of life between boys and girls with different sports level

Indicators	Sports performance											
	16 years			17 years			18 years			19 years		
	Occasional	Active	Registered	Occasional	Active	Registered	Occasional	Active	Registered	Occasional	Active	Registered
Physical activities per week witout physical education [h]	2,42	3,24	,17	3,29	,99	**4,08***	3,29	,01	3,20	3,06	,04	,30
Total physical activities per week [h]	,30	1,63	,01	3,05	1,21	**3,72***	3,05	,00	3,15	1,43	,05	,98
Joy of movement	,30	**7,23****	2,88	,00	,21	**7,1****	,00	**14,03****	,00	,52	,15	,97
Physical well-being	1,82	1,19	1,35	1,53	,43	,80	1,53	,20	,13	1,19	,32	1,89
Psychosocial well-being	,02	1,62	3,31	2,42	,88	,21	2,42	,05	,08	,92	,42	,05
Spiritual well-being	,19	2,37	1,06	,95	3,45	1,29	,95	**12,81****	,05	1,36	3,67	2,03
Material well-being	,00	,00	,49	,90	,28	,84	,90	,04	,27	,40	,24	1,84
Education	**5,91***	2,22	,01	,12	,42	**7,65****	,12	,09	2,25	,19	1,65	1,01
Leisure time	,45	,00	,32	,48	,01	**7,5****	,48	,42	,00	,67	2,39	**4,01***
Appearance and Property affairs	,25	,74	,94	,06	**10,38****	1,49	,06	,06	,31	,53	,74	,31

*Notes: Kruskal Wallis Test $p < 0.01$**; $p < 0.05$*; without* statistically insignificant difference*

Table 6

Comparison of PA, joy of PA and quality of life of boys and girls with different sports level (Occasional vs. Active vs. Registered)

Indicators	Sports performance boys				Sports performance girls			
	16 years	17 years	18 years	19 years	16 years	17 years	18 years	19 years
	χ2	χ2	χ2	χ2	χ2	χ2	χ2	χ2
Physical activities per week witout physical education [h]	**85,68****	**84,41****	**75,09****	**37,03****	**107,56****	**100,14****	**80,91****	**13,06****
Total physical activities per week [h]	**86,92****	**89,39****	**80,73****	**38,45****	**100,51****	**104,20****	**80,46****	**12,59****
Joy of movement	**10,57****	**8,29***	**17,77****	4,13	**12,91****	,59	4,60	2,20
Physical well-being	2,57	2,35	2,32	2,51	3,15	1,40	3,69	1,40
Psychosocial well-being	1,21	4,93	2,62	,15	**7,74***	2,55	1,67	,15
Spiritual well-being	1,56	2,14	**9,51****	1,13	**7,24***	2,04	1,66	4,37
Material well-being	,53	3,23	1,11	,29	2,19	,17	,24	2,84
Education	**9,18****	,28	3,17	,56	,76	**6,99***	3,62	2,31
Leisure time	1,02	,50	,09	,52	5,72	**10,39****	,84	5,14
Appearance and Property affairs	1,13	1,67	,47	**8,23***	3,53	**6,72***	1,27	1,04

*Notes: Kruskal Wallis Test p < 0.01**; p < 0.05*; without* statistically insignificant difference*

Different amount of physical activity without the PE lessons and the whole amount of physical activities per week ($p < .01$) of boys and girls divided to groups according to the sports level closely relates to increasing sports level (tab. 6).

We found differences in the joy of PA between groups of 16 – 18 years old boys with different sports level and in 16 years old girls. The same level of joy of PA was monitored between the groups of 17 – 19 years old girls with different sports level and in 19 years old boys. It was not been confirmed that with the increasing sports level of 16 to 19 years old girls and boys, the joy of PA grows too (tab. 1 – 4).

Higher frequency of significant differences in the subjective evaluation of quality of life areas between the groups with different sports level was monitored in 16 years old girls in the psychosocial well-being ($\chi2 = 7.74$; $p < .05$) and spiritual well being ($\chi2 = 7.24$; $p < .05$) and in 17 years old girls in the evaluated areas of education ($\chi2 = 6.99$; $p < .05$), leisure time ($\chi2 = 10,39$; $p < .01$) and in the evaluated areas of appearance and property affairs ($\chi2 = 6.72$; $p < .05$). Other differences in the subjective evaluation of the quality of life areas are also very rare.

Results of correlation analysis show in 16, 17, 18 and 19 years old boys and girls with different sports level (tab. 7 and 8) differentiated interactions between the overall physical activity, joy of movement and areas of quality of life.

Table 7

Correlation of joy of movement to the areas of quality of life of 16 – 17 years old boys and girls with different sports level

			Joy of movement	Physical well-being	Psychosocial well-being	Spiritual well-being	Material well-being	Education	Leisure time	Appearance and Property affairs
			r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s
Boys	16 years	Occasional	-,079	,012	,001	**-0,222***	**0,301*****	**0,201***	-,026	-,109
		Active	,132	,078	**0,183***	,180	,066	**-0,189***	,025	-,062
		Registered	-,002	-,029	-,029	**-0,292*****	,067	**-0,209****	,072	,065
	17 years	Occasional	-,104	**0,206****	,133	,058	,001	,120	-,022	,031
		Active	-,050	**0,207***	,013	,000	,070	,000	**-0,280****	-,034
		Registered	,130	-,068	-,010	,086	**-0,184***	-,119	**-0,219****	,034
	18 years	Occasional	-,041	-,016	,105	-,030	,108	-,023	-,027	,003
		Active	,057	-,124	,025	,085	,157	-,078	**0,237****	,026
		Registered	,169	-,064	-,041	,030	-,017	-,127	,144	,101
	19 years	Occasional	-,118	,247	,080	-,023	,233	**-0,339****	,003	**0,351****
		Active	-,217	,001	-,090	-,188	-,006	-,008	-,070	,045
		Registered	**-0,314***	,098	,282	-,099	,016	,269	-,109	,015
Girls	16 years	Occasional	**0,200*****	-,058	,057	,038	-,128	-,066	-,065	,037
		Active	,092	-,025	**-0,176***	,006	-,021	-,127	-,046	-,015
		Registered	,112	-,017	-,039	**0,317*****	-,012	-,050	**-0,424******	-,149
	17 years	Occasional	-,009	,045	**-0,162***	-,047	-,105	,009	-,075	-,134
		Active	,029	-,109	-,003	-,006	,034	-,093	,039	,131
		Registered	-,163	,070	,177	-,181	-,078	-,175	-,092	,050
	18 years	Occasional	,060	,040	,079	,074	**0,165***	**0,133***	**0,143***	**0,202****
		Active	-,039	,090	,014	-,021	**0,276*****	,158	**0,183***	-,027
		Registered	-,045	,193	-,124	-,052	,079	,119	,173	,078
	19 years	Occasional	**0,322*****	,099	,080	,106	**0,200***	-,013	,016	,040
		Active	-,129	,215	,154	-,090	,074	,072	-,043	,251

Notes: r_s – Spearman correlation coefficient p < 0.20, p < 0.10**, p < 0.05***, p < 0.01******

Higher positive or negative interactions are found in the correlation between the joy of movement with areas of quality of life (tab. 7). 16 - 17 years old boys in the groups with different sports level showed higher interactions of the joy of movement with areas of quality of life than girls (CH16-19 = 28 < > D16-19 = 18). The joy of the physical activity or joy of the movement positively relates to the spiritual well-being of 18 and 19 years old boys and girls in every sports level. In younger boys in the age of 16 and 17, we monitored positive correlations only in groups of active sportsmen (CH16 r_s = .215, p < .20), and registered sportsmen (CH16 r_s = .261, p < .05; CH17 r_s = .211, p < .10). Positive interactions of the joy of movement were found among 18 and 19 years old boys with the area of education. In the other significant interactions prevailed mainly the negative ones.

By the analysis of the interaction between the overall physical activity per week with the indicators of the joy of movement and the quality of life areas of boys and girls with different age and sports level, we did not find as many correlations as with the joy of the movement (tab. 8).

Table 8

Correlation of physical activity to the joy of movement and areas of quality of life of 16 – 19 years old boys and girls with different sports level

			Physical well-being	Psychosocial well-being	Spiritual well-being	Material well-being	Education	Leisure time	Appearance and Property affairs
			r_s	r_s	r_s	r_s	r_s	r_s	r_s
Boys	16 years	Occasional	-,148	-,095	,079	,018	-,123	-,083	,104
		Active	,011	,117	**0,215***	,088	-,074	-,043	-,018
		Registered	**-0,217****	**-0,331******	**0,261*****	**-0,295*****	,062	**-0,250*****	**-0,517******
	17 years	Occasional	,023	,008	,112	-,095	,135	-,065	-,026
		Active	**-0,334*****	**-0,264****	-,169	,022	-,088	**-0,203***	-,195
		Registered	**-0,236****	-,114	**0,211****	-,079	,009	**-0,237****	-,108
	18 years	Occasional	,054	-,055	**0,218****	,149	**0,266*****	**-0,158***	-,075
		Active	-,112	-,049	**0,402******	,120	-,009	**0,264*****	,023
		Registered	-,007	-,145	**0,420******	-,098	**0,343******	,099	-,049
	19 years	Occasional	-,018	-,041	**0,454*****	**-0,322****	**0,253***	-,210	-,148
		Active	,023	-,075	**0,256***	**0,228***	-,197	-,186	**-0,278***
		Registrovaní	-,032	,104	**0,425****	-,211	-,074	-,209	**-0,401****
Girls	16 years	Occasional	-,032	-,010	,111	,110	-,090	,069	**0,150***
		Active	-,023	**-0,198****	,143	,124	**-0,301******	**-0,249*****	**-0,259****
		Registered	,155	,098	,157	,026	,061	-,045	-,116
	17 years	Occasional	,053	,113	,123	,145	**0,180****	-,018	-,028
		Active	-,082	-,043	,093	,051	-,073	-,059	-,075
		Registered	-,057	-,183	,176	,083	,111	,190	-,118
	18 years	Occasional	,036	-,011	**0,519******	**0,142***	,063	,098	-,005
		Active	**-0,283*****	-,120	**-0,340******	**-0,247****	-,090	**-0,221****	**-0,196***
		Registered	-,242	-,185	-,188	,039	-,044	**-0,25***	**-0,397*****
	19 years	Occasional	-,092	**-0,28*****	**0,198***	,027	-,087	-,132	,015
		Active	-,214	-,264	**0,371***	-,275	,096	,184	,075

Notes: r_s – Spearman correlation coefficient p < 0.20, p < 0.10**, p < 0.05***, p < 0.01*****

In most cases, the positive interaction between the overall physical activity per week with the joy of movement and areas of the physical well-being of high school students has not been proven. Higher frequency of interactions with areas of quality of life was monitored only in 16- and 17-years old boys, where the negative correlations prevailed. Physical activity positively correlated with the physical well-being only in 17 years old boys from a group of occasional sportsmen (r_s = .206, p < .10) and active sportsmen (r_s = .207, p < .20).

Higher frequency of the interaction of physical activity with the indicators of the joy of movement and quality of life was demonstrated in 16- and 18-years old girls. In the group of 18 years old occasional sports girls, the physical activity showed positive correlations with the material well-being (r_s = .165, p < .20), leisure time (r_s = .143, p < .20), education (r_s = .165, p < .20), appearance and property (r_s = .202, p < .10) and in the 18 years old active sports girls with the material well-being (r_s = .276, p < .05) and with the leisure time (r_s = .183, p < .20). The positive correlation of physical activity with the joy of movement was measured in occasional sports girls in the age of 16 (r_s = .200, p < .05) and 19 years (r_s = .322, p < .05).

Discussion

Aim of this work was to demonstrate the gender and age differences on the level of interaction between the physical activity, joy of movement and in the subjective evaluation of areas of quality of life of 16 to 19 years old boys and girls from high schools. The regular physical activity during the adolescence period is very important (Verhulst 1989). One of the main features of leisure time activity is the joy of the movement. This attribute contributes to the long-termed persistence of person in physical activity (Šutka 2013; Broďáni 2014, 2015, 2016, 2018). In our monitoring, based on the comparison of the nationwide researches, was proven that in addition to the factor of sport level, gender, type of high school or region, the age also affects the monitored parameters (Broďáni 2012). Effect of the age factor and its influence to the quality of life and physical activity was demonstrated in the whole period of adolescents (Gill 1994; Yarmak et al. 2017). The positive effect of physical activity on disease prevention and life satisfaction also confirm Maciel (2014) and Massida (2015).

According to the age, the high school students with the different sports level have reached rare statistically significant differences. Important differences were monitored in the groups of registered 17 years old boys and girls. Here and in the group of active 18 years old sportsmen, girls showed lower level of joy of PA. The exact opposite occurred in the group of 16 years old active sportsmen, where at the same physical activity girls showed more joy of PA as boys.

Between the groups of high school students with different sports level we found differences in the joy from physical activity in 16 – 18 years old boys and 16 years old girls. In 17 – 19 years old girls and 19 years old boys was the joy of the PA at the same level. The increasing joy from the PA by the increasing sports level has not been confirmed. Between these groups we monitored in the 16 years old girls the significant differences in the psychosocial and spiritual well-being and among the 17 years old girls in the areas of leisure time, appearance and property affairs.

By correlation of joy of PA and areas of quality of life, the higher number of interactions prevailed between the 16 – 19 years old boys with different sports level. In the 18 – 19 years old boys and girls in each sports level, the relation between the spiritual area with the joy of movement was monitored. Positive correlations were found in the group of 16 – 17 years old active and registered boys. In the group of 18 – 19 years old boys, there were interactions of the joy of PA and the areas of education. In the most cases of interactions between the overall

PA per week, the joy of PA and areas of quality of life of high school students divided to the groups according to the gender, age, and sports level, the positive interactions were not proved or proved in minimum.

These rare interactions are the evidence of the previous researches, that the influence of the physical activities realized regularly, organized, with joy, happiness and fun had a positive impact to the quality of life of high school students (Martins et al. 2015). Another examples of the positive impact of PA on joy and quality of life comparing the external and internal activities are found in Moghaddaszadeh (2016) and Thompson-coon (2011).

Conclusion

Differences in the level of physical activity per week, joy of movement, subjective evaluation of the quality of life areas of boys and girls in different age and sports level are rare. The different volume of physical activity is related to the increasing sports level. It has not been confirmed that as sport levels increase, the joy of physical activity also increases. The interactions between the indicators of physical activity per week, the joy of movement, subjective evaluation of the quality of life areas of boys and girls with different age and sports level was proven very sporadically with mainly negative correlations. In most cases, the positive interaction of PA with PACES and areas of physical well-being has not been confirmed. Higher occurrence of positive correlation of physical activity with the areas of quality of life prevailed among 18 years old girls. Boys showed a higher number of interactions of the joy of movement with the areas of quality of life. The joy of the movement positively correlated with spiritual well-being in groups of 18 – 19 years old boys who perform physical activities at all sports level. Gender differences between monitored indicators demonstrate that the gender factor is very important in the case of this study. The factor of age and sports level had an important impact on the differentiated result of high school students. Low frequency and importance of the interactions of physical activities with the areas of quality of life point to the need for the future monitoring of this element in the life of high school students. The questions is, which other factors can determine these relations. One of them can be a deeper selection of the files based on the level of joy of the movement.

References

1. ANDERSON, CH. B., T. BARANOWSKI & K. B. WATSON, 2005. Adolescent Patterns of Physical Activity Differences by Gender, Day, and Time of Day. *American Journal of Preventive Medicine*. **28**(5), 447-52.
2. BROĎÁNI, J., 2012. The Relationship of Physical Activity and Subjective Well-Being f Students on Constantine the Philosopher University in Nitra. In: *DOULÍK P (eds.), Current Trends in Educational Science and Practice II.* Ústí nad Labem: UJEP. 19-28.
3. BROĎÁNI, J., M. SPIŠIAK & Ľ. PAŠKA, 2015. The interaction of physical activity and quality of life of adolescents. *Journal of Physical Education and Sport*. **15**(3), 518-524.
4. BROĎÁNI, J., S. LIPÁROVÁ & M. KRÁĽ, 2016. The interaction of physical activity and the life quality of students in mid and late adolescence. In: *Physical Activity Review*. **4**(1), 124-131. eISSN 2300-5076. DOI: http://dx.doi.org/10.16926/par.2016.04.15
5. BROĎÁNI, J., Ľ. ŠIŠKA & N. KOVÁČOVÁ, 2018. Differences in physical activity, joy of movement and quality of life of boys and girls from secondary schools. In: *HUBINAK A. editor. Current problems of physical education and sports VII.* Ružomberok: Verbum; 2018: 25-35.
6. CAMPO-TERNERA, L., Y. HERAZO-BELTRÁN, F. GARCÍA-PUELLO, M. SUAREZ-VILLA, O. ORLANDO MÉNDEZ & F. VÁSQUEZ-DE LA HOZ, 2017. *Estilos de vida saludables de niños, niñas y adolescentes* [Healthy lifestyles of children and adolescents]. Salud Uniorte. Barranquilla **33**, 419–428. doi:10.14482/sun.33.3.10931.
7. CHAHÍN-PINZÓN, N. & B. LIBIA, 2011. Actividad física en adolescentes y su relación con agresividad, impulsividad, internet y videojuegos. *Psychologia Avances De La Disciplina*.**5**, 9–23.
8. DRAGOMIRECKÁ, E., 2006. *SQUALA Subjectivequality of lifeanalysis: příručka pro uživatele české verze dotazníku subjektivní kvality života SQUALA*. Praha: Psychiatrické Centrum.
9. GARCIA, A., N. J. PENDER, C.L. ANTONAKOS & D.L. RONIS, 1998. Changes in Physical Activity Beliefs and Behaviors of Boys and Girls Across the Transition to Junior High School. *Journal of Adolescent Health.* **22**(5), 394-402.
10. GILL, T.M. & A.R. FEINSTEIN, 1994. *A critical appraisal of the quality of quality-of-life measurements*. JAMA. **272**, 619-26.
11. GONZÁLEZ, A. J. I., F. ZURITA-ORTEGA, V. V. GARÓFANO, MARTÍNEZ-MARTÍNEZ, A. GARCÍA, S. SÁNCHEZ & M. ESTÉVEZ DÍAZ, 2016. Actividad física

de adolescentes: implicación de sustancias nocivas, modalidad practicada y familia. *Psicología Escolar e Educacional.* **20**, 13–22. doi: 10.1590/2175-3539/2015/0201908.

12. HEESCH, K. C., L. C. MASSE & A. L. DUNN, 2006. Using Rasch modeling to re-evaluate three scales related to physical activity: enjoyment, perceived benefits and perceived barriers. *Health Education Research*. **21**(1), 58-72.
13. HERNANDO, A., A. OLIVA, & M. A. PERTEGAL, 2013. Diferencias de género en los estilos de vida de los adolescentes [Gender differences in adolescents' lifestyles]. *Psychosoc. Inter*. **22**, 15–23. doi: 10.5093/in2013a3.
14. HUTCHENS, A., E. G. SOLTERO, S. BARQUERA, L. LÉVESQUE, E. JAUREGUI, J. LOPEZ TAYLOR et al., 2016. *Influencia de la percepción de los padres sobre seguridad escolar y del género en la actividad física de niños en México: un estudio transversal Salud Publica Méx*. **58**, 7–15. doi: 10.21149/spm.v58i1.7662.
15. MACIEL, E.D.S., VILARTA, R., MODENEZE, D.M., SONATI,J.G., VILELA, G.B. & M. OETTERER, 2014. Quality of Life at Levels of Physical Activity of Volunteers from the University Community. *American Journal of Health Research.* **2**(5), 275-283.
16. MADEIROS, E. R., D. G. C. REBOUÇAS´, A. C. S PAIVA, C. P. A. NASCIMENTO, S. I. B. SILVA & E. S. G. PINTO, 2018. Studies evaluating of health interventions at school : an intergrative literature review. *Rev. Lat. Am. Enfermagem***. 26**, e3008. doi: 10.1590/1518-8345.2463.3008.
17. MARTINS, J., B. TORRES, J. CARDOSO, A. M. COSTA & S. HONÓRIO, 2015. Influence of sociological aspects on the level of physical activity in physical education students. *Journal of Human Sport and Exercise*. **10**(3), 815-826. https://doi.org/10.14198/jhse.2015.103.07.
18. MASSIDDA, M., CUGUSI, L., MATHIEU, A. 2015. Physical activity levels and health-related quality of life in young Italian population. *J Sports Med Phys Fitness.* **55**(5), 506-12.
19. MEDINA, C., A. JÁUREGUI, I. CAMPOS-NONATO, & S. BARQUERA, 2018. Prevalencia y tendencias de actividad física en niños y adolescentes: resultados de la Ensanut 2012 y Ensanut MC 2016. *Salud Pública Méx*. **60**, 263–271. doi: 10.21149/8819.
20. MOGHADDASZADEH, A., Y. AHMADI & A. BELCASTRO, 2016. Children and adolescent physical activity participation and enjoyment during active play . *The Journal of sports medicine and physical fitness.* **57**(10).

21. NORRIS, R., D. CARROLL & R. COCHRANE, 1992. The effects of physical activity and exercise training on psychological stress and well-being in an adolescent population. *J Psychosom Res.* **36**(1), 55-65.
22. OCETKOVÁ, I., 2007. *Úloha spirituality v životní pohodě a kvalite života mladých lidí.* (Dizertačná práca). Brno : Masarykova univerzita, Česká republika). Získáno z: https://is.muni.cz/th/kjjxm/.
23. PALOMINO-DEVIA, C., F.A. REYES-OYOLA, & A. SÁNCHEZ-OLIVER, 2018. Niveles de actividad física, calidad de vida relacionada con la salud, autoconcepto físico e índice de masa corporal: un estudio en escolares colombianos. *Biomédica.* **38**, 224–231. doi: 10.7705/biomedica.v38i0.3964.
24. SÝKOROVÁ, Z. & M. BLATNÝ, 2008. *Kvalita života u adolescentov*. Brno: Masarykova univerzita.
25. SUTKA, V. et al., 2013. *Improving the quality and health of adolescents by means of physical activity at elementary and high schools*. Final report of the KEGA 014UKF-4/2013 grant. Nitra: CPU.
26. THOMPSON-COON, J., K. BODDY, K. STEIN & M.H. DEPLEDGE, 2011. Does Participating in Physical Activity in Outdoor Natural Environments Have a Greater Effect on Physical and Mental Wellbeing than Physical Activity Indoors? *A Systematic Review. Environmental Science & Technology*. **45**(5), 1761-72.
27. VASKAN, I., Y. MOSEYCHUK, A. KOSHURA, M. KOZHOKAR, O. TSYBANYUK, O. YARMAK & Y. GALAN, 2018. Comparative analysis of indicators of the morpho-functional condition of the young men aged 15-16 years during the process of physical education. *Journal of Physical Education and Sport*. **18**(4), 2504-2508.
28. VERHULST, F.C., J. PRINCE, C. VERVUURT-POORT & J. DE JONG, 1989. Mental hearth in Dutch adolescents: selfreported competencies and problems for ages 11-18. *Acta Psychiatr Scand.* **80**(356), 1-18.
29. YARMAK, O., Y. GALAN, I. NAKONECHNYI, A. HAKMAN, Y. FILAK & O. BLAHII, 2017. Screening system of the physical condition of boys aged 15-17 years in the process of physical education. *Journal of Physical Education and Sport*. **17**(3), 1017-1023.
30. ZANNOTTI, M. & D. PRINGUEY, 1992. A method for quality of life assessment in psychiatry: the S-QUA-L-A (SubjectiveQuality of lifeAnalysis). *Quality of life News Letter*. **4**(6).
31. ZURITA-ORTEGA, F., F. SALVADOR-PÉREZ, E. KNOX, V. M. GÁMIZ-SÁNCHEZ, R. CHACÓN-CUBEROS, S. RODRÍGUEZ-FERNÁNDEZ, et al., 2018. Physical activity

and health-related quality of life in schoolchildren: structural equations analysis. *Anales de Psicología*. **34**, 385–390. doi: 10.6018/analesps.34.2.299781.

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THE RELATIONSHIP BETWEEN SWIMMING PERFORMANCE AND TIME PARAMETERS OF THE START AND TURN

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Summary. The start and the turn are factors that influence performance in different swimming disciplines. The aim of this study was to find out the relationship of selected time parameters of the start and the turn with sport performance of 100 m and 1 500 m freestyle finalists in the Olympic Games 2016. Monitored parameters of the start were the start reaction, time under water after the start, and time at a distance of 15 m after the start. The monitored parameters of the turn were the time of 5 m before the turn, the duration of the turn, the time under water after the turn, and time reached at a distance of 15 m after the turn. There was any significant correlation of the resulting time to 1 500 m and the observed start indicators. The significant correlation of the resulting time to 1 500 m and the observed turn indicators was time 5 m before the turn $r = 0.952$ ($p = 0.000$); the duration of the turn $r = 0.830$ ($p = 0.011$); time at a distance of 15 m after the turn $r = 0.886$ ($p = 0.003$). The significant correlation of the resulting time to 100 m and the observed start indicators was time under water after the start $r = -0.714$ ($p = 0.047$). The significant correlation of the resulting time to 100 m and the observed turn indicators was the duration of the turn was $r = 0.905$ ($p = 0.002$). The results point out the existing relations between 100 m freestyle and time under water after start and duration of the turn. And for 1 500 m existing relations with time 5 m before the turn, the duration of the turn and time at a distance of 15 m after the turn. Therefore, our recommendations for sports practice include development of speed, power and coordination skills with technical execution of the start and the turn into regular swimming training.

Key words: aquatic sport, freestyle, Olympic games, finalists

Introduction

The start and the turn are factors that significantly affect performance especially in shorter swimming disciplines. Coaches should pay attention to these factors, because final ranking of

swimmers at the end of the race can be very close and could depend on these details. For example, the results of the top events in the sprint disciplines at 50 m confirms this significance. Improving the start can improve the resulting time of a given discipline by up to 0.1 s (Maglischo 2015). The start may contribute to short sprint disciplines up to 30 % (Lyttle and Benjamvatra 2006). Cossor and Mason (2001) reported that time from sound signal until the head of the competitor reaches 15m can contribute to final sport performance in 50 m disciplines at level of 26,1 % while in the1 500 m it is only 0,08 %. At the Rio Olympics in 2016, in the 50 m freestyle discipline, the difference between the first American Ervin and the second Frenchman Manaudu was only 0.01 s, and between winner and third American Adrian was 0.09 s. Although the French had a faster reaction than the Americans he finished second (0.69 s to 0.63 s), (Olympic 2016). The elite swimmers' start usually lasts from 5,5 to 8 s and average percentage contribution for each start phase is 11 % (0.74 s) spent at the start block stage, 5 % (0.30 s) in the flight phase, 56 % (3.69 s) in the underwater phase and 28 % (1.81 s) free swimming (Elaine Tor 2014).

According to Maglischo (2015) the turn also affects sports performance. During the 100 m freestyle in long course, the turn can be realized with an underwater phase within 15 m distance, which is 15 % of the whole performance. In the same discipline, but in short course, the athlete must make three turns, which is 45 m in total - in other words 45 % of the total length of the discipline. Maglischo (2015) further states that improving the turn technique can reduce the duration of the discipline by as much as 0.20 s at each turn, which again confirms the significance of this factor. Hay (1984) reports that the turn is a 33 % share of sports performance in short course.

The aim of this study was to find out the relationship of selected time parameters of the start and the turn with sport performance of 100 m and 1 500 m freestyle finalists in the Olympic Games 2016.

Methods

The research group consisted of elite swimmers, participants of the finals of the Rio 2016 Olympic Games in the selected disciplines of freestyle (100 m FSD; 1 500 m FLD). The basic biometric indicators were age, body height, body weight, and point performance. Individual indicators were observed at the time of the Olympic Games. Basic Biometric Indicators were age, body height, body weight, and best point performance (Table 1 and Table 2).

Table 1
Basic biometric indicators for 1500m Freestyle

	Age [y]	High [cm]	Weight [kg]	Points
Average	22.25	187.25	75	947.37
Max	27	192	88	987
Min	19	178	66	898
Var	8	14	22	89

Table 2
Basic biometric indicators for 100m Freestyle

	Age [y]	High [cm]	Weight [kg]	Points
Average	22.37	191.75	85.62	935.5
Max	28	200	100	958
Min	17	185	70	909
Var	11	15	30	49

We collected the data from available databases on the Internet. The basic biometric characteristics of the monitored group were obtained from the website https://swimswam.com/bio/. The characteristics we used to clarify the relationship to sports performance were obtained from the website*:* https://results.tritonwear.com *and* http://www.fina.org/competition-detailed-results.

To clarify the relationship of selected time parameters of the start and the turn with sport performance in 100 m and 1 500 m freestyle disciplines, we used Spearman correlation coefficient, determination coefficient, and T test in linear regression model. Cohen's methodology was used to interpret relationships.

Results and discussion

When analysing the relationship between the achieved time to the 1500m freestyle and the selected time indicators of the start, we did not find any statistically significant relationship even in one of the monitored parameters (Table 3).

Table 3
Statistical Characteristics of Start Indicators in the 1500m and 100m Freestyle

	1 500 m Freestyle	**100 m Freestyle**
Start reaction	r = 0.084	r = 0.405
Time under water after the start	r = 0.095	r = - 0.714* (*p = 0.047)*
Time at a distance of 15 m after the start	r = 0.595	r = 0.190

* - statistically significant results

Given the total length of the performance in the 1500m freestyle, the results are not surprising. However, when comparing the average times measured for the endpoints, the results indicate differences between the groups. The FSD set reached an average start response of 0.685 s, which is on average 0.06 s better than the FLD file. We therefore assume that the group of 100 m specialists is better trained in speed-power and reaction capabilities.

In a closer look at the relationship between the achieved time in the 100 m freestyle and the selected time parameters of the start, we achieved relatively surprising results. A statistically significant correlation was recorded only in the case of time spent under the water after the start (Table 3). The correlation was not statistically significant in the case of the start and the time reached for the first 15 m. The best start reaction was recorded by Marcelo Ch. 0.62 s, who finished 8th in the final. On the other hand, Olympic winner Kyle Ch. recorded a start response of 0.71 s, which was even worse than the average (0.685 s) of the final.

The results of our research could be caused by the use of different methodology. For example Mason and Cossor (2000) found a high correlation between the start and the overall performance of the swimmer in almost all swimming disciplines. On the other hand Matúš (2012) found that the start reaction does not have a statistically significant effect on the time reached at a distance of 7.5 or 10 m. Therefore, based on the results, we assume that no start reaction, but the technical handling of the start with subsequent underwater work is ultimately more decisive for the performance.

When analysing the relationships between the achieved times of the 1 500 m freestyle and selected time indicators of turn, we found a statistically significant correlation between the 5 m distance before the turn, the turn, the time at the distance of 15 m after the turn, and time under water after the turn (Table 4).

Table 4
Statistical Characteristics of Turn Indicators in Disciplines 1500 m and 100 m of Freestyle

	1 500 m Freestyle	**100 m Freestyle**
Time at 5 m before turn	r = 0.952 * *(p = 0.000)*	r = 0.651
Duration of turn	r = 0.830 * *(p = 0.011)*	r = 0.905 * *(p = 0.002)*
Time under water after the turn	r = - 0.071	r = 0.690
Time at the distance of 15 m after the turn	r = 0.886 * *(p = 0.003)*	r = - 0.095

* - statistically significant results

A statistically significant relationship was shown not only for an indicator of time spent underwater after the turn. In this case, we assume that during the endurance disciplines the respiratory system demands are higher than in the case of shorter disciplines, so it is more difficult for swimmers to withstand a longer distance under water. As a result, the time spent under water is therefore shorter, as is confirmed by our results, when the average underwater time for a 100 m group was 2.32 s. In the case of the average time in the 1 500 m group it was 1.83 s. However, as in the case of the start, further research is needed to reveal closer relationships.

A statistically significant relationship between the achieved time per 100 m freestyle and the selected time indicators of turn was confirmed in our research only for the indicator of duration of turn (Table 4). In this case, we assume that due to the equilibrium performance of our group (the difference between the first and the eighth place was 0.83 s), the observed group was too small to show a statistically significant result.

However, as Mason and Cossor (2000) write:

"*in generalizing the conclusions of our research, we must be aware that strong correlation between race performances and turn time does not imply that the turning ability of a swimmer was the predominant contributing factor in determining the race result. If there is a strong correlation between two variables, this does not imply a cause and effect relationship*".

Conclusion

The results point out the existing relations between 100 m freestyle and time under water after start and duration of the turn. And for 1 500 m existing relations with time 5 m before the turn, the duration of the turn and time at a distance of 15 m after the turn. Therefore, we recommend

to sports practice to include development of speed, power and coordination skills with technical execution of the start and the turn into a regular swimming training.

There is a presumption that, with a higher number of subjects in the investigated group we could reveal a close relationship between the monitored variables and maximum performance at 100 m freestyle. Further research verification is needed to confirm these conclusions.

Based on our results, and in line with the authors' views on the importance of observation of sports performance (Masaryková 2005) we can formulate practical recommendations for swimming coaches and 100 m freestyle swimmers:

- develop reaction skills,
- develop the explosive power of the lower limbs and abdominal and back muscles which determine the fast start, the technique of swimming under water and the turn,
- regularly improve the start technique,
- focus on underwater work after the start and turn.

Practical recommendations for swimming coaches and 1 500 m freestyle swimmers:

- regularly improve the turn technique,
- develop the explosive power of the lower limbs and abdominal muscles which determine the fast turn.

References

1. COHEN, J. 1988. *Statistical Power Analysis for the Behavioral Sciences*, 2 vyd.. Hillsdale, NJ: Erlbaum.
2. COSSOR, J. & B. MASON, 2001. *Swim start performances at the Sedney 2000 Olympic Games.* XIX International Symposium on Biomechanics in Sports.
3. ELAINE, T. et al., 2015. Comparing three underwater trajectories of the swimming start. In: *Journal of Science and Medicine in Sport*. Vol. 18, s. 725-729.
4. HAY, J. G. 1984. Turning technique of elite swimmers. In: *Journal of Sports Sciences*. Vol. 2, s. 241-255.
5. LYTTLE, A. & N. BENJANUVATRA, 2006. *Start right?: A biomechanical review of dive start perfomance*. Scotland: CoachesInfo.
6. MAGLISCHO, E. W., 2015. *A Primer for Swimming Coaches.* Nova Science Publishers, Incorporated.

7. MASON, B., & J. COSSOR, 2000. What can we learn from competition analysis at the 1999 Pan Pacific Swimming Championships?. In *ISBS-Conference Proceedings Archive* (Vol. 1, No. 1).
8. MATÚŠ, I., 2012. *Prejav rýchlostno-silových parametrov v jednotlivých typoch štartových skokov v plávaní*. Dizertačná práca. Bratislava: Univerzita Komenského, 2012.
9. MASARYKOVÁ, D., 2005. Diagnostics of training state by using standard swimming tests, blood tests and sporttesters. In: *Scientific fundaments of human movement and sport practice.* Bologna : Centro Universitario Sportivo Bolognese, s. 420–422.

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THE EFFECT OF BIOLOGICAL AGE IN THE EVALUATION OF PHYSICAL INDICATORS AND THE CHANGES IN SELECTED MOTORIC TESTS OF YOUNG FEMALE BASKETBALL PLAYERS

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Summary. Basketball is a complex team sport, which combines cyclic and acyclic motion structures consisting mainly of fast and dynamic moves with or without a ball. The puberty is characterized by considerable variability that may occur earlier (developmental acceleration, early maturing) or later (developmental retardation, late maturing): an example can be a 12-year-old girl whom biological age could range from 9.5 to 14.5 years. For this study we selected 6 girls-players from the whole team. Two players were according to the norms from the zone of developmental retardation (BioRet), two players whose decimal and biological age i.e. bone age was identical (DC = BV), and the other two were in the biological acceleration zone (BioAkc.). All players were 13-years old and competed in the U14 category. We have confirmed that there are great differences in biological age in a group of 13-years old girls – in our research it has shown almost four years difference. We did not confirm the author's conclusions that biologically accelerated individuals achieved better results than the retarded ones in the speed and strength tests.

Key words: biological age, decimal age, young athlete, somatic and speed abilities, strength

Introduction

Basketball is a complex team sport, which combines cyclic and acyclic motion structures consisting mainly of fast and dynamic moves with or without a ball (Erčulj 1998). The most common moves are short sprints, rapid stops and changes of motion, acceleration, various jumps with and without a ball, shooting and passes. Successful and effective implementations of these moves in game like situations determine the performance. The quality

of performance is also affected by the age of the athletes specifically by their psychomotor and functional abilities. In Gamble's (2008) opinion „the basic movement supports the specific movement". That means that the basic abilities of an athlete will determine her ability to perform specific movement. The higher level of these abilities, faster and more efficient player can handle even the most difficult activities with and without the ball and can adjust to the fast changing conditions in game. In our case it means to learn the proper technique of running, jumping and throwing/passing. We are observing an enormous deficit in this area among young population and athletes. It is very important to train these relatively simple movements throughout the whole youth period because as it was already mentioned, „the basic movement supports the specific movement".

In ontogenesis, motoric development is functionally and morphologically connected with the development of motoric abilities. Chiviacowsky et al. (2008) explain the changes in motoric development dividing it into two components – to the "hardware" change (i.e. structural change) which includes growth/physical changes and increases in body height (BH) and body weight (BW) as well as changes in the CNS; and "software" changes when the capacity and utilization of this structure increases: meaning the cognitive changes which are result of the development of information processing capacity of the brain.

The age from 12 to 18 is the transition period between childhood and adulthood. The high rate in biological-psycho-social changes is triggered by the activity of endocrine glands and the differences in their hormone production (Perič et al. 2012). Šelingerová & Šelinger (2016) stated that growth and biological adolescence are interrelated processes that affect the level of physical fitness. The puberty is characterized by considerable variability that may occur earlier (developmental acceleration, early maturing) or later (developmental retardation, late maturing): an example can be a 12-year-old girl whom biological age could range from 9.5 to 14.5 years.

As many authors mentioned, e.g. Volkov & Filin (1983), Ortega et al. (2008) Šelingerová & Šelinger (2009/a), biological age is very important for the evaluation of the results achieved in motoric tests, because the acceleration or retardation of pubertal somatic development can significantly affect (positively or negatively) the level and development of the motor and sports performance of young athletes. Biologically accelerated or retarded individuals differ in their BH, BW, and body proportionalities, which affects their results in motoric tests. According to Šelingerová & Šelinger (2009/b) biologically accelerated young athletes achieve better results in strength and speed tests.

The aim of this thesis was to evaluate the level of physical indicators and changes in selected motor abilities of young basketball players in the annual macrocycle with regards to their biological age.

Methodology

For this study we selected 6 players from the whole team. The selection was made on the recommendations: two players were according to the norms from the zone of developmental retardation (BioRet), two players whose decimal and biological age i.e. bone age was identical (DC = BV), and the other two were in the biological acceleration zone (BioAkc.). All players were 13-years old and competed in the U14 category.

The entire tracked period was a 1-year macrocycle. We investigated the decimal (calendar, chronologic) and biological (bone) age, level of the physical development, body height prediction, length of the sports specialization (Table 1) and the level of selected general and specific motor abilities and skills (Table 2). In the tests we evaluated the standing long jump (SLJ), throw with 2 kg med ball (TMB), 20 m acceleration run (20 m) and 20 m acceleration run with dribble (20 m dribble). Dribbling was only by the dominant arm. Both runs were measured with photocells with an accuracy of one hundredths of a second. The training process focused on the development of general motoric abilities and specific basketball skills. The first testing was conducted in August, at the beginning of the general basketball preparation phase. Output tests were made shortly before the end of the main competition period, more precisely before the final preparation for the Slovakian Championship (MSR) in April. The same conditions for warm-up and the same number of training and evaluated attempts have been administrated.

Biological maturation (assessed by bone age) and body height prediction by Tanner et al. (2001) evaluated an expert at FTVS UK. When processing and evaluating research data, we used logic methods to compare, deduct, and generalize.

Results and discussion

Decimal age, which is the age in years and months, is commonly used when assessing the performance (in tests) of children and adolescents. However, many studies have demonstrated how the performance level is different in relation to biological age, i.e. sexual maturity, especially in adolescents (Kohoutek 1995; Šelingerová & Šelinger 2016; Ortega et al.

2008). In this life period the peers undergo the most significant biological changes; nevertheless the talent and selection procedures for sports classes, sports schools, and first picks for U14, U16 national basketball teams are made as well (Lithuania, Srbi, Letter, Šelingerová & Šelinger 2016). As can be seen in Table 1, a homogeneous group of players with the same decimal year was selected in our group; the age was ranging from 13.3 to 13.9-years. However, if we look at their biological age, we see very large individual differences. The biggest variances were in the developmentally accelerated i.e. early maturing (2.2 and 1.9 years) and developmentally retarded i.e. late maturing players (1 and 1.7 years respectively). This large variation in the biological age, in our case almost 4 years, has confirmed research by authors who spoke about the problematic puberty period in terms of great developmental variability. Body height is one of the basic prerequisites for success in basketball. Therefore, the basketball clubs should focus to choose girls who are tall, or have a predisposition for an above average body height (compare to the population). In the first testing we found a more favorable, i.e. higher body height (BH) values for girls who were late maturing but also early maturing. Their height varied from 176 to 178 cm; and they were classified according to the norms above the average height of the 13-year-old population (Sedláček & Cihová 2009). On the other hand, large individual body weight (BW) values ranging from 49.5 to 76.3 kg were recorded with the players. Authors Sedláček & Cihová (2009) refer to BMI standards for a 13-year-old population as follows: average 17.0 – 20.5, above average 20.5 – 22.7 and above 22.7 significantly above average. In the comparison of these values, it can be seen that both late maturing players and one of the early maturing one have average BMI. The others are classified significantly above average. However, for a more accurate assessment of players it would be better to measure their body fat percentage than a BMI conversion that is used for the population.

Besides the biological age, it is also important to know the sport age of the players, which can also significantly affect the results in motoric tests. Trninić, Papić et al. (2008) stated that players with longer sports training/preparation more supposedly achieve better results in motoric tests. According to the authors, players who mature faster (accelerants) and who have a longer training experience are more effective in the game (even in game statistics) than those who are slower in maturing (retardants). Therefore, it is important to know that maturing retardants may have considerably greater potential in the long term than accelerants. In our case, the sport specialization age was 6 years, except for 2 players.

In Table 1 we also predict players BH in adulthood. Higher values are calculated for players biologically retarded, i.e. late maturing. Still, it is necessary to stress out that the

predicted BH in the pubertal period is influenced by many factors, and it can differ greatly in adulthood.

Table 1

The characteristics of decimal and biological age, body height, body weight, BMI, height prediction in adulthood, and age of specialization

Player		DA (age)	BA (l)	BH [cm]	BW [kg]	BMI (l)	Prediction of BH [cm]	Specialization training age
BioRet	J.I.	13,3	12,3	177	58	18,58	184 - 186	6
BioRet	K.J.	13,9	12,2	176	49,5	16,35	182 - 185	6
DC=BV	Z.M.	13,5	13,6	166	65,9	23,91	173	3
DC=BV	K.H.	13,3	13,4	166	64,8	23,73	173 - 174	4
BioAcc.	P.V.	13,8	16,0	178	76,3	24,08	181 - 182	6
BioAcc.	V.M.	14,1	16,0	178	64	20,2	182	6

Note: DA - decimal age, BA - biological age, BH – body height, BW – body weight, Specialization training age – years of specific basketball preparation, BioRet - biological retardation, BioAcc. - biological acceleration

When comparing the input values of players in motoric tests (Table 2) we cannot say that the early maturing players were getting better results in all strength and speed-specific tests compare to the late maturing players or those with a same decimal and biological age.

Table 2

Input values of motoric performance in general and specific tests

Player		SLJ [cm]	TMB [cm]	20 m [s]	20 m dribble [s]
BioRet	J.I.	185	600	3,82	4,09
	K.J.	162	560	3,92	4,39
DC=BV	Z.M.	153	550	4,13	4,45
	K.H.	182	640	3,51	4,07
BioAcc.	P.V.	153	680	3,77	4,01
	V.M.	160	630	3,54	3,83

Note: SLJ - standing long jump, TMB - 2 kg medicine ball throw from standing position, 20 m – 20 m acceleration run, 20 m dribble -20 m acceleration run with dribble

The first test was to assess the explosive strength of the lower extremities, which is one of the key factors influencing the sport performance in basketball. Explosive strength is used in many individual player's actions (rebounding, shooting), as well as when starting, accelerating and changing the direction of movement (Šimonek 2004; Šimonek, Doležajová & Lednický 2007). Parisi (2008/a) considers it to be one of the components of so-called "GameSpeed". We measured a very low level of explosiveness in test results of the early maturing players (153

and 160 cm). Player P.V. attained the lowest performance, in our opinion mostly due to her high BW and BMI that were documented at the input measurement. Biologically accelerated players were by the norms for 13-years old population in SLJ (Sedláček & Cihová 2009) under average; while biologically retarded player K.J. was above average (185 cm).

However, the early maturing players used their height and weight as advantage in the TMB test. The performance of late maturing players in the TMB test was according to the standards for the population (Sedláček & Cihová 2009) average to above average, while the early maturing players were classified as above average or significantly above average.

Specific basketball tests 20 m acceleration run and 20 m acceleration run with dribbling are used for the evaluation of basketball players performance in our country (Bulík & Doležajová 2006; Tománek & Moravec 2005), but also in other countries (Paulauskas 2003; Erčulj 2005; Simovic & Mijanovic 2007; Erčulj & Bračič 2008). Nonetheless, there are not yet made the performance standards of these tests for the population, or for specific sports. The quality of running speed is an elementary basis and a necessary prerequisite for achieving a high sport performance. Running speed and its maximum level is the potential of an athlete; without it an athlete cannot successfully compete in sports where the speed abilities are limiting factors of the sport performance. In certain sports in which the running speed is mediated through others, more complex factors it can be partially compensated, but it is always problematic to a limited extent (Sedláček 1992).

In the test 20 m acceleration run, the best performance 3.51 s was achieved by K.H., a player in the DV = BV group. Little bit lower values were recorded by the early maturing players: 3.54 s and 3.77 s, while players biologically retarded obtained the worst results in this test. In the specific basketball test 20 m acceleration run with dribble is the speed of the run combined with the specific dribbling skill. This means that this is not a "pure" conditional test. The best performances 3.83 s and 4.01 s achieved the biologically accelerated players.

Player V.M. achieved a good result (3.54 s) in acceleration speed test, but showed a relatively low, under average explosive strength of the lower extremities evaluated by the SLJ test (only 160 cm). Lower performance was recorded also by the biologically retarded player K.J. (4.39 s), with similar result in the test 20 m run. The worst result was achieved by player Z. M. from the group DV=BV (4.45 s). This result could have been affected by her age of sport specialization because this player had the lowest (3 years) specialization age of all participants observed.

Table 3

Characteristics of the output somatic indicators after 8 months

Player		**BH [cm]**		**BW [kg]**		**BMI (I)**	
		output	change	output	change	output	change
BioRet	J.I.	185	+8	64,6	+6,4	18,88	+0,30
	K.J.	181	+5	57,1	+7,6	17,43	+1,08
DC=BV	Z.M.	170	+4	66,7	+0,8	23,08	+0,83
	K.H.	170	+4	64,8	0,0	22,42	-1,31
BioAcc.	P.V.	179	+1	78,2	+1,9	24,41	+0,33
	V.M.	181	+3	67,4	+3,2	20,57	+0,37

As we mentioned in the introduction, the puberty period is one of the most dynamic periods in terms of physical growth. This fact was proved in our group of girls. At the end of the 8-months period we evaluated the body indicators (Table 3). We recorded significant individual increases in all monitored indicators. We monitored that the biggest changes of individual BH occurred with the late maturing players (values increased by 8- and 5 cm). Their BH was getting closer to their predicted maximum values (185 and 186 cm respectively). We monitored the lowest growths (1 and 3 cm) with the early maturing players.

Major changes in BW occurred in a group of late maturing players (6.4 and 7.6 kg). None or very low increases (0 - 3.2 kg) were recorded in the other two groups. Anyhow, these changes in the BH and BW indicators were proportional and did not really show on BMI.

Table 4

Output level and changes in the general and specific motoric tests during macrocycle

Player		**SLJ [cm]**		**TMB [cm]**		**20 m akc. [s]**		**20 m dribble [s]**	
		output	change	output	change	output	change	output	change
BioRet	J.I.	185	0	630	+30	3,64	-0,18	3,94	-0,15
	K.J.	190	+28	630	+70	3,86	-0,06	3,98	-0,46
DC=BV	Z.M.	167	+14	550	0	3,89	-0,24	3,98	-0,47
	K.H.	200	+18	740	+100	3,32	-0,19	3,61	-0,46
BioAcc.	P.V.	170	+17	660	-20	3,73	-0,03	3,98	-0,03
	V.M.	189	+29	580	-50	3,31	-0,23	3,51	-0,32

In the final testing of general and specific motoric abilities, we found great differences in all three groups of players (Table 4). In the speed-strength test SLJ, we have seen varying levels of players performance - from stagnation to improvement by 29 cm. Among the more significant improvement are those which were the lowest in the initial test (28 and 29 cm). We assume that these results were affected not only by biological development but also by the

general training effects. In the TMB test, the range of changes was even more obvious (from decrease of 50 cm to 100 cm improvement). Surprisingly, we measured lowering of the achieved result by biologically accelerated players and improvements of both late maturing players. The most significant improvement was recorded by the DV = BV player. In the 20 m acceleration run test the peak performances was achieved by players with DV = BV (improvement -0.24 s) and by one of the biologically accelerated player (-0.23 s). Interestingly, the smallest improvement (only -0.06 s) we recorded by the biologically retarded player although she had almost the highest increase in the test 20 m run with dribble (-0.46 s). This fact confirmed conclusion made by Hirtz et al. (1985) that those significant changes in body height might negatively affect the level of coordination capabilities, especially frequency of movement. The improvement in the 20 m test with dribble indicates the positive impact of the training process. This player had almost the worst performance at the first testing (4.39 s). The same applies to a DV=BV player who achieved an improvement -0.47 s in the test 20 m with dribble from the entry level of 4.45 s. Improvement occurred despite the fact that this player was the youngest according to the sport age from the whole group.

We are aware of the complexity and the timeliness of this subject, because in this age the development of the motor abilities and learning the skills is influenced by many factors, which might not be noticed by a coach. Besides the visible factors resulting in changes in the physical indicators, there are many other hidden factors the coach might not be aware of (family problems, poor school results, social environment, etc.). Changes in the physical indicators can positively affect the performance in speed- strength tests and also mediate and improve the individual sport specific skills.

On the other hand, the higher somatic gains negatively affect the running speed, especially the frequency of a movement (Hirtz et al. 1985). Another factor is the process of motoric learning of new motoric skills (e.g. dribbling) and their transition into e.g. acceleration run with a dribble. The length of sports specialization also has an impact on the changes in performance.

Conclusions

1. We have confirmed that there are great differences in biological age in a group of 13-years old girls – in our research it has shown almost four years difference.

2. We found out that differentiated gains occurred in physical indicators and in motor performance in groups with the same decimal and biological age; and in groups of biologically retarded (late maturing) or accelerated girls (early maturing).
3. We did not confirm the author's conclusions that biologically accelerated individuals achieved better results than the retarded ones in the speed and strength tests.
4. It is necessary to monitor body weight gains and levels of motor abilities (as well as other factors) that interrelate to increasing the performance in the pubertal period.
5. We found out those biologically retarded individuals i.e. late maturing players achieve greater improvements in the test results and they were gradually catching up on the biologically accelerated ones. On this basis we recommend to pay attention in the training process to the players who appear as non-perspective due to their current biological development.
6. We are aware of the fact that the above test results are indicative, given the number of players, and their validity should be proved on a larger number of players.

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References

1. BULÍK, M. & L. DOLEŽAJOVÁ, 2006. Efektivita rozvoja rýchlostných schopností mladých basketbalistov špecifickými prostriedkami. In MAČURA, P. *Zborník vedeckých prác Katedry FTVŠ UK č. 5.* Bratislava: Občianske združenie Športové hry a FTVŠ UK: pp. 13-18. ISBN 80-89197-51-5.
2. ERČULJ, F., 2005. Impact of Speed of Alternating Leg Movements and Take-off Power on Acceleration Speed in Young Basketball Players. In DIKIĆ, N., ZIVANOVIĆ, S., et al. (ed). *10th Annual Congress of the European College of Sport Science*, Beograd : Sport Medicine Association of Serbia: pp. 262-263. [elektronická pošta]. Správa pre: Tatiana GALLOVÁ. 2010-8-4 (citované 8.4.2010). Osobná komunikácia.
3. ERČULJ, F. & M. BRAČIČ, 2008. Raven razvitosti nekaterih motoričnih sposobnosti mladih košarkaric iz devetnajstih evropskih držav in Slovenije. In *Trener košarke.* dec. 2008, letn. 7, št. 1: pp. 78-84, ilustr., graf. prikazi. [elektronická pošta]. Správa pre: Tatiana GALLOVÁ. 2010-8-4 (citované 8.4.2010). Osobná komunikácia. Dostupné z: <http://orbis.kzs-zveza.si/slozkts/ftp/trener_kosarke_1_2008.pdf>.

4. GAMBLE, P., 2008. Approaching Physical Preparation for Youth Team-Sports Players. In *Strength and Conditioning Journal.* **1**, vol. 30, February 2008: p. 29-42. ISSN 1524-1602
5. HIRTZ, P. et al., 1985. *Koordinative Fähgkeiten im Schulsport*. Berlin : Volk und Wissen volkseigner Verlag.
6. CHIVIACOWSKY, S. et al., 2008. Learning Benefits of Self-Controlled Knowledge of Results in 10-Year-Old Children. In *Research Quarterly for Exercise and Sport*, Vol. 79, No. 3, September 2008, Reston, VA : American Alliance for Health, Physical Education, Recreation and Dance: pp. 312-318. ISSN 0270-1367.
7. ORTEGA, F.B. et al., 2008. Health-related physical fitness according to chronological and biological age in adolescents. The AVENA study. In *The Journal of Sports Medicine and Physical Fitness.* **48(**3). Torino: Edizioni Minerva Medica: pp. 371-379. pISSN 0022-4707, eISSN 1827-1928.
8. PAULAUSKAS, R., 2003. Altitude training for basketball. In *FIBA ASSIST MAGAZINE 2.* May/June: pp. 59-60.
9. PERIČ T., A. LEVITOVÁ & M. PETR, 2012. *Sportovní příprava dětí*. Praha: Grada. ISBN 978-80-247-7142-7
10. SEDLÁČEK, J., 1992. Efektivita výberu talentovanej mládeže v behoch na krátke vzdialenosti so zameraním na motorické faktory. Dizertačná práca. FTVŠ UK.
11. SEDLÁČEK, J. & I. CIHOVÁ, 2009. *Športová metrológia.* Bratislava: ICM Agency. ISBN 978-80-89257-15-7
12. SIMOVIĆ, S. & M. MIJANOVIĆ, 2007. Diskriminativna analiza parametra izabranih i odbačenih kadetkinja za sudjelovanje u ljetnjoj školi sporta „Trebinje 2007“. In BILIĆ, Ž. *Acta Kinesiologica. International Scientific Journal on Kinesiology.* **1**(2): pp. 23-28. ISSN 1840-2976.
13. ŠELINGEROVÁ, M. & P. ŠELINGER, 2009/a. Biologické aspekty športovej prípravy mládeže. In *Výsledky somatických a antropomotorických výskumných meraní v oblasti mládežníckeho športu*. Bratislava: FTVŠ UK: pp. 76-88. ISBN 978-80-89257-17-1.
14. ŠELINGEROVÁ, M. & P. ŠELINGER, 2009/b. Vzťah medzi biologickým vekom a motorickou výkonnosťou u mládeže v puberte. In *Výsledky somatických a antropomotorických výskumných meraní v oblasti mládežníckeho športu*. Bratislava: FTVŠ UK: pp. 97-104. ISBN 978-80-89257-17-1.
15. ŠELINGEROVÁ M. & P. ŠELINGER, 2016. *Športová antropológia.* Bratislava. ICM Agency.

16. ŠIMONEK, J., L. DOLEŽAJOVÁ & A. LEDNICKÝ, 2007. *Rozvoj výbušnej sily dolných končatín v športe*. Bratislava: SVSTVŠ. ISBN 978-80-89075-32-4.
17. VOLKOV, V. & V. M. FILIN, 1983. Sportivnyj otbor. Moskva: FiS.
18. TOMÁNEK, Ľ. a R. MORAVEC, 2005. Úroveň rýchlostných schopností vo vzťahu k hernej výkonnosti u 14 – 15 ročných basketbalistov. In MAČURA, P., TÓTH, I. *Zborník vedeckých prác Katedry hier FTVŠ UK č. 3.* Bratislava : Občianske združenie Športové hry a FTVŠ UK: pp. 157-161. ISBN 80-89197-30-2.
19. TRNINIĆ, S., V. PAPIĆ, V. et.al., 2008. Players selection procedures in team sports games. In BILIĆ, Ž. *Acta Kinesiologica. International Scientific Journal on Kinesiology.* **2(**1): pp. 24-28. ISSN 1840-2976.

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MOTIVATION AND PHYSICAL EDUCATION LEARNING ACHIEVEMENT AMONG STUDENTS WITH HEARING IMPAIRMENT

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Summary: Playing is a pleasure for every child with no exception to the children who have physical disorder and their capability of motion is limited. Children with hearing impairment need appropriate motivation for learning and performing physical activities. This motivation affects also their Physical Education. For students with the hearing impairment, the materials that are supposed to be taught during the physical education lessons are divided according to the level of disability. Under these circumstances, the research is conducted to determine the relationship between the motivation to learn during the Physical Education lessons and the academic achievement among students with hearing impairment. Researchers used traditional Quantitative methods of research with 40 Junior High School students with hearing impairment from Indonesia, *Sekolah Menengah Pertama Luar Biasa* (SMPLB), category B. We used the questionnaire dealing with learning motivation of children to collect the data. The data were processed using the SPSS and analyzed by descriptive quantitative operations. Results of the study showed, that there is a relationship between learning motivation of Physical Education and learning outcomes of Physical Education among students of Category B SMPLB, where the value of 0,000 is less than 0.05.

Key words: learning motivation, Physical Education, academic achievement, deaf students.

Introduction

Sports and Health Physical Education is an integral part of overall education, aims to develop the aspects of physical fitness, movement skills, critical thinking skills, social skills, reasoning, emotional stability, moral actions, aspects of healthy lifestyle, and to introduce the importance of the clean environment through the physical activities. Sports and Health Physical Education is systematically planned in order to achieve national education goals (Sukarso 2007). The results in some cases are correlation of transforming physical education into academic or quasi-academic subjects, a collection of discursive knowledge and complete understanding of class lessons and written assignments. Students achieve the qualifications and certificates that testify their understanding of the theoretical principles involved in sports, games, and so on (Reid 2013).

Physically, playing provides opportunities for children to develop their motor skills. Games, that are irreplaceable part of sports develop flexibility, strength and muscular endurance among children. Physical development has a very big influence on the child's ability to do something if the child's physical development is not good, it will be difficult for the him to do various things and he can be limited in some actions.

Some types of physical abilities lead to real development of the strength, balance, and coordination. Children's lives are very active, more active than at any other point in the life cycle. In addition to developing motorically and physically, children also always experience cognitive development. Normal physical development allows children to adjust to the situation and their movements are not limited because they have a healthy and strong physical body, except for children with disabilities.

Deaf children are children who experience hearing loss partly or in overall. Deaf children have a unique perspective (Braun et al. 2018) in learning. Therefore, deaf children must be equipped with real and concrete experiences (Cheng et al. 2016). In following physical education children who are disabled can not do the same sport as normal children and they are limited in some sports. But they also want to do sports as well as the normal children do so it is necessary to modify the game and adapt it to the level of disability and physical condition. This is also explained in the national sports system law number 3 of 2005 which states that "Sports with disabilities are sports specifically carried out by the condition of a person's physical and/or mental disabilities".

Deaf can be interpreted as a state of hearing loss that results in a person unable to capture various stimuli, especially through the sense of hearing (Dwidjosumarto 1990). However, children with hearing impairment have visual or visual sensory powers. Children with hearing impairment can communicate with the senses of the eye, both by gesture and lip language (oral). Communication skills of deaf children are accompanied by emotional conditions of children. Children who have difficulty to communicate with others show a different expression than children who master in communication with others. The second group of children exnjoy the interaction (Netten et. al. 2015). Therefore the communication with deaf children must be adjusted to the characteristics of the child, when children are comfortable in communicating then the child will be excited in the interaction.

The patients with hearing impairment need the motivation to improve her interest in physical activity. Motivation is the force that motivates someone to do something to achieve goals. These forces are stimulated by the existence of various needs, such as (1) desires to be fulfilled, (2) behavior, (3) goals, (4) feedback (Uno 2013). It is very important to use a normal approach for the deaf students and also to felt supported by the presence of peers who strengthen their confidence during the learning process. Deaf children are different from deaf adolescents according to the level of confidence Deaf children have a lot of experience and socialization in learning, while young deaf children have a limited environment (Martin, et. al. 2011). Therefore it can be interpreted that teaching deaf children needs to include active, creative, critical learning supported by their peers in strengthening confidence.

However, this cannot be easily done. This is because the approach used could be seen as an insult. (Marschark 2001). The motivation that is owned by students in each learning activity is very instrumental to improve student's achievement in certain subjects (Nashar 2004). According to Winkel in Hidayat and Hartati (2015: 154-159) suggests that learning achievement is evidence of success in learning new things that someone has achieved. Then learning achievement is the maximum result of what has been achieved by someone after carrying out learning efforts. In the world of sports, motivation is also important, especially for athletes. Athletes who practice diligently and regularly have the goal and desire to become champions or winners in the branch they are part of. To achieve these goals, it does not include only the good technique, physical fitness and tactics, but an athlete must have the motivation that can make him enthusiastic in achieving these goals.

Children who have physical limitations or disabilities also want to enjoy the feeling of getting useful knowledge, playing with friends in school like normal children. Children with disabilities also need proper education for a better future. The percentage of students with

hearing impairment among black Americans who graduated from high school and who were prepared to continue to university, was very low in comparison to white students (Williamson 2007: 7).

The physical education learning process at school conducted by the teacher at schools is the same in general, but what is different is the learning method, which means the strategy of the way the teacher delivers the material to be taught to students by the level of disability. All instructions are given using deaf sign language.

Sports and Health Physical Education is a medium to encourage the growth of physical and psychological development, motor skills, knowledge, reasoning, appreciation of the values (attitude, mental, emotional, sportsmanship, spiritual, social), as well as habituation patterns of living healthy, which are geared to stimulate the growth and development of the quality of the physical and psychic balance (Sukarso 2007).

In the process of learning physical education in this school the teacher also provides a learning model with modifications in the form of a game so that students do not experience boredom in attending physical learning at school. Subjects taught include big ball games such as volleyball, basketball, soccer and small ball games such as table tennis and badminton and also the athletics (running, long jumping, high jumping, throwing discs, and dropping bullets). There are obstacles that are often encountered in the physical education learning process between the teacher and students. Sometimes students do not understand what movements are actually displayed and performed by the teacher and vice versa sometimes the teacher is also less able to understand what the students want. The purpose of this study was to determine the relationship between the learning motivation during the lessons of Physical Education and academic achievement among deaf students.

Research methods

A. Types of research

This research used a quantitative descriptive methodology which is defined as a form of research based on data from empirical facts systematically obtained that can be measured by numbers which are then described in the form of narration (Sugiyono 2015: 75). The purpose of this study was to test the relationship between motivation and learning during the lessons of physical education and academic achievement among students with hearing impairment.

B. Time and Place of Research

This research was conducted at the Telanai Pura SMPLB, Jambi City. This research was conducted for 1 month and a half starting from 11 July to 26 August 2018.

C. Research Samples

The sample in this study involved 40 SMPLB students category B in age 12 – 15 years, 13 males and 27 females with degree of hearing impairment in a level from low to medium category. The sampling technique used in this study was to use a total sampling technique that involved a total number of students who were deaf in SMPLB.

D. Data collection technique

The data collection technique was carried out using questionnaire dealing with learning motivation and academic achievement, containing 15 items. It was distributed to 40 deaf students. Students were accompanied by Physical Education teachers. The results of data collection from a questionnaire were tabulated and then analyzed using quantitative descriptive

E. Measuring instrument

As the research tool for measurement was used questionnaire based on five indicators including physiological needs, sense of security needs, will needs, actualization of self and social and supplies needs.

Results

After the methodology and data collection techniques were carried out on deaf students, we found out their motivation to learn during the Physical Education lessons. Various theoretical findings were found related to learning motivation and academic achievement of deaf students at Telanai Pura SMPLB, Jambi City.

The data for the descriptive calculation were obtained from the questionnaire that was filled in by students of SMPLB category B (Deaf). The results of categorizing data concerning the motivation of students in participating in Physical Education can be seen in the following table 1.

Table 1

Categories of student motivation data

Value Interval	Frequency	Percentage (%)	Creteria
1-20	0	0	Low
21-40	11	27.5	Middle
41-60	29	72.5	High

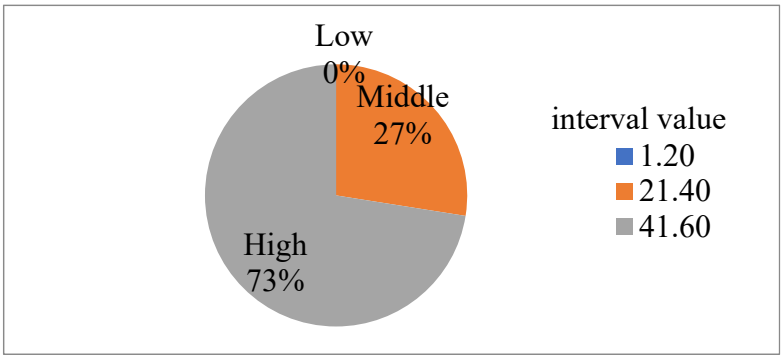

Figure 1
Circle diagram of categories of student motivation data

For interval values 1 – 20, there are 0 students with a percentage of 0 % categorized as low motivation. 21 – 40 value intervals mounting to 11 students with a percentage of 27.5 % categorized as moderate motivation and interval values 41 – 60 mounting 29 students with a percentage of 73.5 % categorized as high motivation.

Table 2
Correlation test

Information		**X**	**Y**
X	Pearson Correlation	1	.886 **
	Sig. (2-tailed)		.000
	N	40	40
Y	Pearson Correlation	.886 **	1
	Sig. (2-tailed)	.000	
	N	40	40
**. Correlation is significant at the 0.01 level (2-tailed).			

The hypothesis is accepted where the value of 0,000 is smaller than 0.05, so it means that the hypothesis that there is a relationship between the motivation to learn during the lessons of Physical Education and the learning outcomes of Physical Education is accepted.

Discussion

Based on the analysis of the data and the results of the questionnaires obtained in this study, it is expected to produce a conclusion that is by the data obtained. Thus the conclusions drawn are a description of the data expected during the study. The discussion in this study examines the relationship or correlation between x and y variables using SPSS 19.0, this test is conducted to answer the problem formulation in this study, if there is a relationship between the motivation to learn while you are taking part in Physical Education and the learning

outcomes of Physical Education students in SMPLB category B (deaf child) Telanaipura District, Jambi city.

The data were obtained to see the relationship between student motivation and Physical Education learning outcomes in Category B SMPLB (children with disabilities) carried out by distributing questionnaires to 40 students. The data collection technique used in this study is a quantitative descriptive analysis technique as outlined in the form of a percentage. Based on the results of data analysis we saw the level of motivation of SMPLB category B students (children with disabilities). 11 students had a motivation that is in the medium category with a percentage of 27.5 %, 29 other students had a motivation that is in the high category with a percentage of 72.5 %.

To see the relationship between motivation of students and learning outcomes we used the results of the questionnaire that were related to student's report cards using SPSS 19.0, which showed that the hypothesis has been accepted with a value of 0,000 < 0.05 which indicated that there was a close relationship between the motivation for learning while taking part in the Physical Education lessons and the learning outcomes of Physical Education among the students from SMPLB category B (children with hearing impairment) Telanai Pura District, Jambi city.

Conclusion

Based on the data analysis conducted, it can be concluded that there is a relationship between learning motivation during the Physical Education lessons and the learning outcomes of Physical Education among students of Category B SMPLB (Tunarunggu children). When the value of 0,000 is less than 0.05, then the hypothesis is accepted. 11 students had motivation in the medium category with a percentage of 27.5 %, while 29 students had a motivation that was in the high category with a percentage of 72.5 %.

Based on the conclusions, researchers provide recommendations for teachers to be able to improve the method of providing material by sharing various forms of learning models, so that it can bring more joy and sincerity to students and also arouse the confidence among student . It is also expected that schools will always provide full support to physical education learning activities by taking into account various factors that exist for the development and achievement of the objectives of physical education learning activities.

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Reference

1. BRAUN, D. C., M. D. CLARK, A. E. MARCHUT, C. M. SOLOMON, M. MAJOCHA, Z. DAVENPORT & C. GORMALLY, 2018. Welcoming Deaf Students into STEM: Recommendations for University Science Education. *CBE—Life Sciences Education.* ***17***(3), es10.
2. CHENG, S., X. HU & K. F. SIN, 2016. Thinking styles of university deaf or hard of hearing students and hearing students. *Research in developmental disabilities*, *55(1)*, 377-387.
3. DWIDJOSUMARTO, A., 1990. *Ortopaedagogik Anak Tunarungu*. Bandung: Depdikbud.
4. HIDAYAT & HARTATI, 2015. The relationship of physical fitness levels to academic achievement of nurse 2 class XI students of SMK 10 November Sidoarjo. *Journal Sports and Health Education* **03**(01), 154-159.
5. MARSCHARK, M., 2001. *Educating Deaf Students*. New York: Oxford University Press.
6. MARTIN, D., Y. BAT-CHAVA, A. LALWANI & S. B. WALTZMAN, 2010. Peer relationships of deaf children with cochlear implants: Predictors of peer entry and peer interaction success. *Journal of Deaf Studies and Deaf Education.* **16**(1), 108-120.
7. NASHAR, 2004. *The Role of Motivation and Early Skills in Learning Activities*. Jakarta: Delia Press.
8. NETTEN, A. P., C. RIEFFE, S. C. THEUNISSEN, W. SOEDE, E. DIRKS, A. M. KORVER & DECIBEL Collaborative study group, 2015. Early identification: Language skills and social functioning in deaf and hard of hearing preschool children. *International journal of pediatric otorhinolaryngology.* **79**(12), 2221-2226.
9. REID, A., 2013. Physical education, cognition and agency. *Educational Philosophy and Theory.* **45**(9), 921-933.
10. SUGIYONO, 2015. *Quantitative qualitative research methods and R&D*. Bandung: Alfabeta.

11. SUKARSO, E., 2007. *Model Pembelajaran Pendidikan Khusus*. Jakarta: Direktorat Jendral Pendidikan Dasar dan Menengah, Direktorat Pembinaan Sekolah Luar Biasa, Departemen Pendidikan Nasional.
12. Uno,B. H., 2013 . *Learning Motivation Theory and Measurement*. Jakarta : Earth Literac y.
13. WILLIAMSON, 2007. *Black A Model for Deaf Educational Students success*. Washington: Gallauder University Press.

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SPINAL MOBILITY IN WOMEN WITH SEDENTARY JOB

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Summary: The aim of the paper is to provide insight into the spine mobility of a selected group of women. The task was to diagnose and evaluate spinal mobility in women aged 25 to 30 , who are dominated by a sedentary way in workplace but also outside the work environment. Spinalmouse® technology was used for diagnostic purposes, which records the shape and mobility of the spine in the sagittal and frontal plane. Tests were performed in the sagittal and frontal plane of the baseline. The sm® software evaluated the measured data immediately. Based on the results of the measurements, we found different curves in specific spine sectors outside the standards. Changes in spine movement range were also noted. The research continues**.**

Key words: intervention. Mobility. Movement. Spinal mouse. Scoliosis. Curvature.

Introduction

On the basis of scientific and technological progress, the type and the number of jobs that force the employees to be seated for several hours a day are constantly increasing without any compensatory movement. The problem of modern society is the fact that at the time of personal leisure, most of the people do not engage themselves in any physical activity. Due to the constant static overload of the spine and the absence of movement, primary muscular imbalances arise which subsequently grow into structural changes with the result of degenerative diseases. Limited mobility of the entire spine or individual segments is characterized by accompanied pain, discomfort and reduced quality of life (American Heart Association 2015). In general, the sooner a positive change in the locomotor system action occurs, the more likely it's to alleviate the difficulties caused by static spine overload and lack of adequate locomotor regime (Devra, Gohdes, Jensen & Jewell 1987).

Upper body muscle strenght is 48 % lower on average level in adult women compared to the men according to Miller, MacDougall, Tarnopolsky and Sale (1993). We know that intersex differences in muscle and skeleton are conditioned by sex steroid hormones since puberty. Changes in the energy requirements of the body during pregnancy are noticeable, often with changes in the curvature of the spine due to the weight of the fetus, typical is low back pain (Wang et al. 2004). In terms of physiological changes and differences with the combination of these issues, women of productive age can be considered more vulnerable and as a group at higher risk of developing vertebrogenic disorders. The topic of the problem of women's spine mobility is discussed in studies by Okanishi, Kito, Akiyama & Yamamoto (2012) or Oleksik, Lips, Dawson, Minshall, Shen, Cooper & Kanis (2000).

The issue is also summarized within Sports for all. In practice, a situation occurs where such a woman decides to train with a coach to support and strengthen her health but this does not for various reasons, set the training process according to the client's health status. Thus, adequate exercise with a client with vertebrogenic difficulties isn't realized and as a result a woman's health condition can worsen. Lenková (2013) presents health as one of the main attributes of a fitness centre visit by women. For these reasons, more attention needs to be paid to the healthy functioning of women's spine.

The aim of the work was to diagnose the curvature and mobility of the spine of the women using the SpinalMouse® technology.

Methods

Subjects

The research group consisted of 14 women at the age of 25 – 30, in whom sedentary lifestyle is dominated. None of the diagnosed women were pregnant at the time or already had children.

Study design

The research organization took place in the afternoon on April 04, 2019 with the assistance of Wioletta Mikuľáková at the Department of Physiotherapy, Faculty of Health Sciences, Prešov University in Prešov. The diagnosis was made using SpinalMouse® diagnostic technology that records spine movements in sagittal and frontal plane tests. Spine mobility test were performed from the baseline and the extent of movement in flexion and

extension of the trunk was measured within the sagittal plane, lateroflexia within frontal plane and also from the basic position (Kociová & Mikuľáková 2011).

Statistical analysis

The data collected during the diagnosis was recorded by SM® software, which graphically presented the spinal curvature in each section. The data collection stage was followed by an evaluation stage, in which we recorded the data obtained with the percentage changes in shape and extent of spine movements using tables.

Results

Following Figure 1 we can see graphical design of spine being diagnosed by SpinalMouse® technology, the middle line represents the spine in a basic position, standing straight. The left line represents the spine in a flexion, the right one represents an extension of the spine, all that in a sagittal plane.

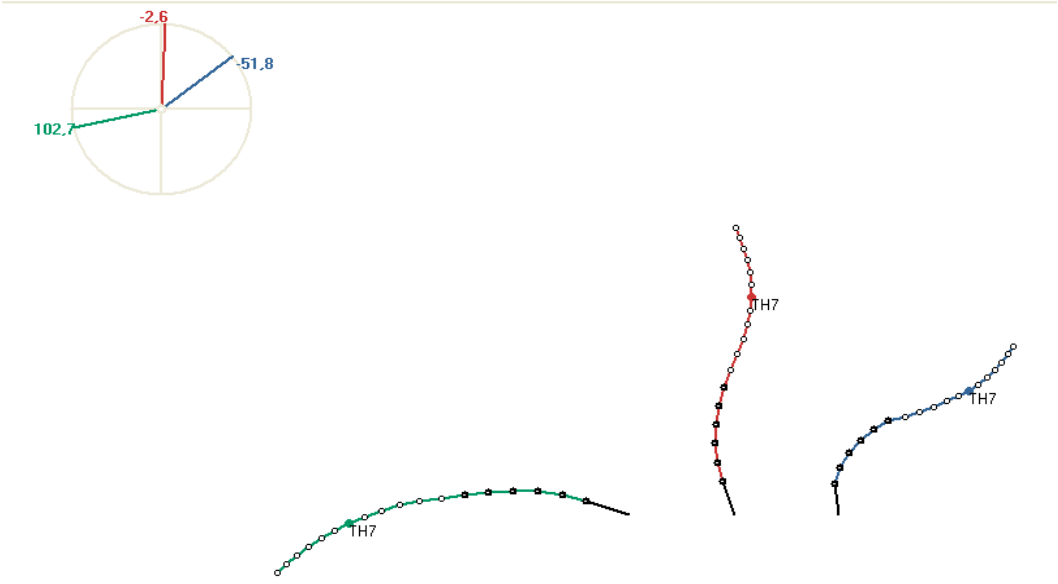

Figure 1
Graphical design of the diagnosis of the spine in sagittal plane

Following tables represents an entering data of diagnosis of all tested women in sagittal plane.

Table 1

The curvature of the spine in standing straight position in sagittal plane

Sectors of the spine	Decreased curvature (%)	Correct curvature (%)	Increased curvature (%)
Thoracic	7,1	42,8	50
Lumbar	35,7	64,2	0
Cross	50	50	0

Table 1 shows the results of curvature of the spine in sagittal plane at basic position in percent. The biggest problem in tested women was in the thoracic sector. Up to half of the women had hyperkyphotic curvature of the thoracic spine. In the lumbar sector 35,7 % of women had a reduced curvature but 21,4 % had an increased spinal curvature in this area. In cross sector most of the women, 71,4 % had the right curvature.

Table 1

The curvature of the spine in flexion in sagittal plane

Sectors of the spine	Decreased curvature (%)	Correct curvature (%)	Increased curvature (%)
Thoracic	7,1	42,8	50
Lumbar	35,7	64,2	0
Cross	50	50	0

Table 2 describes the results of the women measurements in flexion in the sagittal plane. As in the previous measurements, hyperkyphotic curvature of the spine in the thoracic sector was again detected in 50 % of women. In the lumbar sector, 35,7 % of women had a reduced curvature.

Table 2

The curvature of the spine in extension in sagittal plane

Sectors of the spine	Decreased curvature (%)	Correct curvature (%)	Increased curvature (%)
Thoracic	7,1	50	42,8
Lumbar	28,5	71,4	0
Cross	92,8	7,1	0

Table 3 contains sagittal baseline measurements and 42,8 % of tested women showed hyperkyphotic curvature in the thoracic sector of the spine. Decreased curvature in the lumbar sector was measured in 35,7 % of tested women. In the sagittal plane, the bend measurements in our subjects have basically confirmed the results of standing measurements within the sagittal plane. These tests were followed by measurements of the sagittal spine motion of the spine, the results are shown in the following tables.

Table 3

The range of the spine in motion into the flexion in sagittal plane

Sectors of the spine	Decreased mobility (%)	Correct mobility (%)	Increased mobility (%)
Thoracic	14,2	64,2	21,4
Lumbar	28,5	71,4	0
Cross	35,7	57,1	7,1

When measuring the range of spine movement from standing to forward bend in the sagittal plane, it was found that in the thoracic sector hypermobility is in 21,4% of tested women and 14,2% is diagnosed with hypomobile spine in this area. Correct mobility of the lumbar sector was measured in 71,4% of women and 28,5% of them were hypomobile in this area. Also, the cross sector of the spine was hypomobile in 35,7% of women as seen in Table 4.

Table 4

The range of the spine in motion into the extension in sagittal plane

Sectors of the spine	Decreased mobility (%)	Correct mobility (%)	Increased mobility (%)
Thoracic	21,4	71,4	7,1
Lumbar	14,2	50	35,7
Cross	78,5	7,1	14,2

Table 5 describes the observed values of spinal mobility measurements from standing to backward bend in the sagittal plane. Hypomobility of the spine was measured in 21,4% of women in the thoracic sector and 71,4% of women had correct spine mobility in this region. In the lumbar sector, hypermobility was found in 35,7% of tested women, 50% of them had the right mobility in this section. Up to 78,5% of women were measured with hypomobility in the cross sector of the spine.

Table 5

The range of the spine motion from backward to forward bend in sagittal plane

Sectors of the spine	Decreased mobility (%)	Correct mobility (%)	Increased mobility (%)
Thoracic	14,2	78,4	7,1
Lumbar	92,8	7,1	0
Cross	14,2	42,8	42,8

As the last measurement in the sagittal plane was the range of spine movement from the backward bend to the forward bend. Decreased mobility in the thoracic sector was found in 14,2% of women but 92,8% of women had decreased mobility in the lumbar sector. In the cross sector 42,8% of women had increased mobility and the same percentage of women was found

in this spinal section for correct mobility.

The following tables contain results from measurements within the frontal plane.

Table 6

The curvature of the spine in standing position in frontal plane

Sectors of the spine	**Standard (%)**	**Scoliotic curvature (%)**
Thoracic	100	0
Lumbar	92,8	7,2
Cross	100	0

In the basic position, meaning standing on the frontal plane, we found in our subjects that in the thoracic and cross section of the spine all diagnosed women have the correct spinal curvature. Scoliotic curvature in the lumbar spine was found in 7,1% of women. Further, lateroflexia tests followed.

Table 7

The curvature of the spine in left lateroflexia in frontal plane

Sectors of the spine	**Standard (%)**	**Scoliotic curvature (%)**
Thoracic	85,7	14,2
Lumbar	71,4	28,5
Cross	50	50

Table 8 contains the measurement results of the curvature of the spine on the left in the frontal plane. In the thoracic sector the scoliotic curvature was found in 14,2 % and in the lumbar sector in 28,5 % of women and in the cross sector it was the half of the women.

Table 8

The curvature of the spine in right lateroflexia in frontal plane

Sectors of the spine	**Standard (%)**	**Scoliotic curvature (%)**
Thoracic	85	14,2
Lumbar	78,5	21,4
Cross	50	50

Table 9 shows the results of the spine curvature measurements for the right lateroflexia in frontal plane. We found that scoliotic curvature had up to 50% women in the cross sector. This test also showed us that in 21,4% of the diagnosed women had scoliotic curves measured in the lumbar sector and in the thoracic sector it was in 14,2% women.

Discussion

Based on the diagnosis we can conclude that we have found negative changes in the shape of the spine and mobility in both sagittal and frontal planes. The results aren't alarming due to the fact that it is a relatively young age group so the imbalances have not deepened, it is likely that they will be positively influenced.

SAGITTAL PLANE: It's evident from the results of the spine curvature in the basic position that in the thoracic sector half of the women, exactly 7 of them, had increased curvature of the spine, round back showing, indicating muscle imbalance in the form of upper cross syndrome. The other half of the women had normal, that is the correct curvature of the spine shape in the thoracic sector. In the lumbar sector 5 women had reduced spinal curvature, 6 had normal curvature and 3 women had increased curvature of the spine. There was no increased curvature of the spine in the cross sector. In the number of 10 women, normal curvature was found and only 4 had a reduced curvature.

From the results within the forward bend of the spine it's clear that in the thoracic sector 7 women had an increased curvature and 6 women has a normal, correct curvature. Only one of the women was diagnosed with reduced curvature of the spine. In the lumbar sector there was no increased curvature in forward bend in any of the women, 9 had correct curvature and 5 had decreased curvature in this test. Within the cross sector it was found that exactly half of them had correct curvature and the other half had reduced curvature, so no increased curvature was found in any of the diagnosed women in this case.

From the results in backward bend in sagittal plane, increased curvature was found in 6 women, 7 women had normal curvature and 1 reduced curvature of the spine. There was no increased curvature in the lumbar sector. In the number of 10 women, the correct curvature of the spine was found and the remaining 4 women were diagnosed with reduced spinal curvature in this test of backward bend. The increased curvature of the spine in the cross sector was not found in any of the women. One of the diagnosed women had correct curvature and other 13 women had reduced spinal curvature on this sector.

According to the results from testing the range of spinal motion from standing to forward bend we found that in the thoracic sector of the spine 3 of the women had an increased curvature, 9 of them had a correct curvature and in 2 women we measured a reduced spinal curvature. In the lumbar sector none of the tested women had an increased curvature, 10 women had a normal curvature and the remaining 4 had a reduced curvature in the test. In the spinal cord sector only

one woman had an increased curvature, 8 normal curvature and 5 showed a reduced curvature.

From the range of motion of the spine from standing position to the backward bend it's clear that one of our women had increased curvature in the thoracic sector of the spine, 10 had normal and 3 had reduced curvature. In the lumbar sector, 5 women had increased curvature, 7 of them normal curvature and 2 showed reduced curvature. In the cross sector of the spine we diagnosed 2 women with increased curvature, one had correct curvature and the other 11 women showed reduced curvature during this test.

Based on the measurements of the range of the spine from backward bend into the forward bend in sagittal plane it is clear that in the thoracic sector of the spine only one woman had increased curvature, 11 had correct and 2 had reduced curvature. A normal curvature was found in one woman within the lumbar sector of the spine, remaining 13 had decreased curvature and increased curvature was not measured at all. In the cross sector, 6 women had increased curvature, in the same number we measured correct curvature and 2 women had reduced spinal curvature in the area.

FRONTAL PLANE: We did not find scoliotic curvature in the thoracic area of the frontal plane, the curvature was normal in all women. In one woman we found a scoliotic curvature in the lumbar sector of the spine and we didn't find a scoliotic curvature in the cross sector as well.

From the results of the spinal shape on the left lateroflexia in the thoracic sector we found scoliotic curvature of the spine in 2 women, in 12 women the curvature was correct. In the lumbar sector, scoliotic curvature was diagnosed in 4 women and 10 of them had curvature in the norm. In the cross sector of the spine a scoliotic curvature was found in a half of the tested women during this test.

On the basis of the data found in the right lateroflexia of the thoracic sector we found scoliotic curvature in 2 women and other 12 had a spinal curvature in a correct form. In the lumbar spine sector, scoliotic curvature was found in 3 women, 11 were normal. In the cross sector we again found scoliotic curvature in a half the tested women.

Conclusion

According to analysis of the mobility of the spine on the basis of diagnostics we were able to evaluate the functional state of the spine in women of productive age with sedentary job. The aim of the paper was to introduce the findings of tested women who form the age group of

25 – 30 years and predominate in the sedentary way of life, as well as to highlight the issue of healthy spine in a selected population group.

We can find negative effects of sedentary regime and absence of movement on adequate function of spine movement in this group of women. It's beginning to appear so-called round back as part of body posture and early signs of scoliosis appear. Because they are women of relatively young age, a significant positive change in the area of spine mobility with the relief of painful or restrictive conditions is expected, also thanks to the active intervention of women in the intervention. It is clear from the results of the diagnosis that the onset of more restrictive vertebrogenic problems is up to date, so it's necessary to apply compensatory in meaning to avoid or eliminate the symptoms of vertebrogenic changes. Otherwise, without compensation in the case of sedentary regime, the risk of spine functional disorders increases with the consequent outcome of various types of musculoskeletal disorders. As we know that with increasing age, changes in the function and structure of the spine are very difficult, it is more than appropriate to promote good movement and active attitude in this group of women.

References

1. AMERICAN HEART ASSOCIATION. Recommendations for exercise for physically active adults. https://www.heart.org/HEARTORG/GettingHealthy/PhysicalActivity/FitnessBasics/American-Heart-Association-Recommendations-for-Physical-Activity-in-Adults_UCM_307976_Article.jsp accessed April 25th 2015.
2. DEVRA K. EINKAUF, MARY L. GOHDES, GAIL M. JENSEN & MARTHA J. JEWELL, 1987. Changes in Spinal Mobility with Increasing Age in Women. In *Physical Therapy.* Volume 67, Issue 3, 370-375.
3. KOCIOVÁ, K. & W. MIKUĽÁKOVÁ, 2011. Kineziologická analýza axiálneho systému človeka pomocou zariadenia Spinal Mouse. In *Molisa 8*. Prešov, Grafotlač, s.r.o, Prešov. 2011. s. 59-66.
4. LENKOVÁ, R., 2013. Štruktúra voľného času a faktory návštevnosti fitnescentier ženami. Nitra: *Šport a rekreácia* : zborník vedeckých prác. ISBN 978-80-558-0385-2.
5. MILLER, A. E. J., J. D. MACDOUGALL, M. A TARAOPOLSKY & D. G. SALE, 1993. Gender differences in strenght and muscle fiber characteristics. *Eur J Applied Physiology.* **66**: 254-262.

6. OKANISHI, N., N. KITO, M. AKIYAMA & M. YAMAMOTO, 2012. Spinal curvature and characteristics of postural change in pregnant women. In *Acta obstetricia et gynecologica Scandinavica.* **91**(7), 856-861.
7. OLEKSIK, A. , P. LIPS, A. DAWSON, M. E. MINSHALL, W. SHEN, C. COOPER & J. KANIS, 2000. Health-Related Quality of Life in Postmenopausal Women With Low BMD With or Without Prevalent Vertebral Fractures. *J Bone Miner Res.* **15**: 1384-1392.

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THE EFFECT OF HIGH-INTENSITY EXERCISE ON CHANGES OF BLOOD CONCENTRATION COMPONENTS IN ALGERIAN NATIONAL JUDO ATHLETES

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Summary: The aim of the present study to verify the impact of judo competition on changes in the blood count of judo athletes during an official competition. Also to compare these results with the different weight category. Methods: fifteen youth trained athletes were included in the study were divided into three groups according to weight category (light, medial, and heavy) weight. All subjects performed a 5x4mn round of competition with 15mn of rest between rounds and Complete Blood Count (CBC) were collected before, immediately after the competition, Data are reported as mean and standard deviation. The Shapiro-Wilk test was performed to verify the normality of the data, and the significance level was set at $P < 0.05$. Blood sample count was tested by a paired Student's t-test to compare the pre-test and post-test for the three groups. The results showed that blood cell count was significantly decreased immediately after judo competition ($p < 0.05$). However, red blood cell, White blood cell Blood platelets, Mean Cell Volume were significantly increased after the performance ($p < 0.05$). The current study showed that the judo competition (*Rondori*) effectively enhance some blood cell count; these changes are transient and probably due to the adaptation to efforts related to judo competition in highly-trained athletes.

Key words: Randori, blood count, judo Athletes.

Introduction

Judo is characterized by high-intensity intermittent efforts, resulting in high physiological demand (Franchini, Vecchio, Matsushigue & Artioli 2011), and also is a

grappling combat sport characterized by throwing and groundwork techniques and high physiological demands. Especially during the stand combat phase, judokas need to produce high levels of power to be successful in their throwing actions and score(Franchini, Sterkowicz, Szmatlan-Gabrys, Gabrys & Garnys 2011; Loturco et al. 2017), judo competition rules changed 5 times, with the last change implemented on 10 April 2017 Adaptation of the Judo refereeing rules for the next 2017 – 2020 Olympic Cycle. The International Judo Federation (IJF) introduced the modifications online ('International Judo Federation 2018. New IJF Judo Refereeing Rules). Judo competition is characterized structurally by weight category, which raises the importance of physiological control training in judo (Torres-Luque, Hernández-García, Escobar-Molina, Garatachea & Nikolaidis 2016), Competitive judo demands high-intensity intermittent actions, in which optimal physical attributes are necessary in order to achieve technical-tactical development and success in combat. judo combats rely on all three metabolisms, with the anaerobic alactic-system being responsible by the short duration powerful actions during the technique applications (Franchini, Artioli & Brito 2013), As the competitions are distributed throughout the year, the athletes need to intersperse high-intensity recovery(Belkadi 2018), and tapering training periods to achieve their best performance in the competitions (Franchini et al. 2016). The period of intensified training has as the main goal improving physical conditioning by focusing on aspects relevant to competitive success (Franchini & Takito 2014a), (Degoutte, Jouanel & Filaire 2003) Analysed that a judo match led to a rise in levels of plasma free fatty acids.

To achieve success in competition, judo athletes engage in training programs involving combat simulation (randori), technical preparation (uchi-komi and nage-komi), and strength and conditioning sessions (Franchini & Takito 2014), The requirement for anaerobic metabolism during matches can be demonstrated by the higher lactate concentrations observed after the match (Lech, Tyka, Pałka & Krawczyk 2010). In these events, the prolonged maintenance of the rate of energy release is determined in large part by the use of anaerobic sources.

High blood lactate concentrations after a maximal effort may indicate a high rate of anaerobic glycolysis, which is associated with the anaerobic capacity of the individual, since more energy is released for muscle contraction (Gastin 2001). Although the participation of the anaerobic system same us judo competition is determinant in high-intensity exercise, as in the actions performed during judo matches, it has been shown that the aerobic system responds rapidly to the energetic demand in these situations, especially when they occur

intermittently(Gaitanos, Williams, Boobis, & Brooks 1993; Gastin 2001), as is the case of judo matches(Gao, Han & Cao 2006; Almansba, Sterkowicz, Sterkowicz-Przybycien & Belkacem 2010). Besides, the aerobic component is important in cases where the match continues for 5 minutes or more (golden score) and there are sequences of matches on a single day of competition (Franchini, Nunes, Moraes & Del Vecchio 2007).

In normal men muscular work of varying duration and intensity produces a leucocytosis (Anderson 1955; Ahlborg 1967), the total white blood cell count (WBC) being higher than 10 000 mm -3 (Gimenez, Mohan-Kumar, Humbert, De Talance & Buisine 1986). Lymphocyte MDA levels and H_2O_2 production were significantly increased in the group which performed the most intense exercise(Bassini-Cameron et al. 2007; Sureda et al. 2009).

The platelet count may increase significantly following strenuous activity (Drygas 1988). Repeated bouts of maximum exercise leading to considerable acidosis (pH = 7.22; BE = -13.3) caused a significant increase in blood platelet count(Chaar et al. 2011). Information about the response of white blood cell (WBC), lymphocyte (L) and platelet (P) counts to submaximal and maximal exercise in the same subject are scarce (Hilberg, Menzel, Gläser, Zimmermann & Gabriel 2008), and it is not clear how such responses are related to the type, duration and/or intensity of exercise(Hamer, Taylor & Steptoe 2006; Chaar et al. 2011).
In addition, the performance in actions of judo during the match can be attributed to neuromuscular factors such as muscle power, which according to Franchini and Del Vecchio (Franchini, Yuri Takito, Yuzo Nakamura, Ayumi Matsushigue & Peduti Dal Molin Kiss 2003) is related to a higher number of attacks and higher efficiency in the throws.

Considering the complexity of analyzing performance during a judo match (randori) and in the search for an indicator that best describes this the present investigation used the number of throws executed in a specific judo test (Special Judo Fitness Test [SJFT]) as the main variable in performance. The result of this test has been demonstrated as able to accurately discriminate athletes of different competitive levels (Franchini, Takito, Kiss & Strerkowicz 2005; Franchini et al. 2007). The purpose of this research was to verify the impact of judo competition (*randori*) on changes in the blood count of used in response to a judo high performance fighting (*randori*) and during recovery. The aim of this work was to study the blood count responses to submaximal and maximal exercise and work duration in highly trained athletes, using biological variables that reflect the White blood cell (WBC), lymphocytes, monocytes, Granulocytes, Red Blood Cells (R.B.C), Hemoglobin, Hematocrit and Blood platelets. We therefore used CBC measurement, and Sedimentation Rate.

Methods

Participants

Fifteen youth trained athletes were included in the study, Athletes were allocated to three weight classes Lightweight (age = 18.80 ± 0.83 years, weight: 65.40 ± 2.30 kg, high: 167.3 ± 3.03 cm Ex: 7.80 ± 1.30 years) middleweight (age = 19.20 ± 1.09 years, weight: 76,80 ± 4.02 kg, high: 177.1 ± 2.60 cm Ex: 6.60 ± 0.89 years) and heavyweight (age = 20.20 ± 0.83 years, weight: 93.80 ± 4.91 kg, high: 180.6 ± 4.58 cm Ex: 6.80 ± 2.04 years) as shown in Table 1. After an explanation of all procedures, risks, and benefits, each athlete gave his informed written consent to participate in this study. None of them was taking medications or supplements. We asked athletes to maintain their normal diet during the study period. Subjects were informed of the experimental risks and signed an informed consent form before the start of this investigation. The investigation was planned according to the Helsinki Declaration (World Medical Association 2013) and was approved by the Scientific Institute of Sports Ethics Committee (N°00328/2017).

Table 1

Physical characteristics of the national judo youth elite Athletes

Weight Category		Minimum	Maximum	Mean	SD
Lightweight ***N=05***	Age(years)	18	20	18.80	.837
	Weight(kg)	62	68	65.40	2.302
	High (cm)	165	169	167.3	3.03
	Experience(years)	6	9	7.80	1.304
Middleweight ***N=05***	Age(years)	18	20	19.20	1.095
	Weight(kg)	72	81	76.80	4.025
	High (cm)	176	179	177.1	2.6
	Experience(years)	6	8	6.60	.894
Heavyweight ***N=05***	Age(years)	18	20	20.20	.837
	Weight(kg)	90	102	93.80	4.919
	High (cm)	177	183	180.6	4.58
	Experience(years)	5	9	6.80	2.049

Blood collection and analyses

Blood samplings were obtained from the antecubital vein 1 h before and 24 h after an official match (8 am) vein in a sitting position by medical staff agent and registered nurse during the day of completion and after 24 h. Samples collected using EDTA as an anti-coagulant were determined by using an automatic haematology analyser immediately after collection. It was used for the determination of total specific differential leucocyte concentration (neutrophils, eosinophils, basophils, lymphocytes and monocytes), erythrocyte concentration, haemoglobin, haematocrit, mean corpuscular volume (MCV) mean corpuscular haemoglobin (MCH), mean

corpuscular haemoglobin concentration (MCHC) and red cell distribution width (RDW)(Sawka, Convertino, Eichner, Schnieder & Young 2000; Mairbäurl 2013).

HIT protocol (rondorie)

The athletes performed four Randorie of 5 minutes duration (official time according to the International Judo Federation('International Judo Federation. (2018).New IJF Judo Refereeing Rules' 2018)) even if there was an ippon (the highest score in the competition and which determines the end of the match).The athletes executed the randori attacking and defending only in the tachi-waza (vertical posture). The randori were organized so that the opponents' body weights differed by less than 15%. After the randori 25 mL of blood were taken from the ear lobe with a heparinized capillary tube to determine the which was calibrated as recommended by the manufacturer.

Statistical analysis

Data are reported as mean and standard deviation. The Shapiro-Wilk test was performed to verify the normality of the data; and the significance level was set at $P < 0.05$. Blood sample count was tested by a paired Student's *t*-test to compare the pre-test and post-test for the three groups to find out the significant difference in selected biochemical parameters among the selected weight categories; Level of significance was accepted at $P < 0.05$.

Results

The present study performed during the game showed reaction time and blood count changes. Data obtained clearly showed that reaction time shortened during the game.

Table 2

Presents the differences between some blood count before and after a 5 round of Randori with high intensity (category = heavyweight)

Blood count	Matched differences					
	Means	SD	Means standard error	t	ddl	Sig. (bilatéral)
White blood cell (WBC)	-1.06	1.01	.454	-2.332	4	.080
Granulocytes	-1.18	.52	.235	-5.013	4	.007
Mean Corpuscular Lymphocytosis concentration MCLC	4.60	1.09	.490	9.370	4	.231
Red Blood Cells (R.B.C	-.050	.071	.031	-1.566	4	.193
Haemoglobin	.50	.937	.419	-1.197	4	.297
Blood platelets	-50.80	11.62	5.20	-9.769	4	.001
Mean Cell Volume	.320	.083	.037	8.552	4	.001
Erythrocyte Sedimentation Rate	-21.00	9.51	4.254	-4.936	4	.008

Table 3

Presents the differences between some blood count before and after a 5 round of Randori with high intensity (category = middleweight)

Blood count	Matched differences					
	Means	SD	Means standard error	t	ddl	Sig. (bilatéral)
White blood cell (WBC)	-2.00	1.22	.545	-3.664	4	.022
Granulocytes	-1.66	1.27	.571	-2.905	4	.044
Mean Corpuscular Lymphocytosis concentration MCLC	5.08	6.94	3.107	1.635	4	.177
Red Blood Cells (R.B.C)	.21	.132	.059	3.648	4	.022
Haemoglobin	.74	.397	.177	4.163	4	.014
Blood platelets	-20.80	15.44	6.90	-3.010	4	.040
Mean Cell Volume	.34	.134	.060	5.667	4	.005
Erythrocyte Sedimentation	-12.80	4.147	1.85	-6.901	4	.002

Table 4

Presents the differences between some blood count before and after a 5 round of Randori with high intensity (category = lightweight).

Blood count	Matched differences					
	Means	SD	Means standard error	t	ddl	Sig. (bilatéral)
White blood cell (WBC)	-1.32	.97	.435	-3.033	4	.039
Granulocytes	-1.40	.82	.367	-3.810	4	.019
Mean Corpuscular Lymphocytosis concentration MCLC	6.92	2.54	1.138	6.080	4	.264
Red Blood Cells (R.B.C)	.10	.20	.090	1.131	4	.321
Hemoglobin	.40	.70	.313	1.278	4	.270
Blood platelets	-17.20	19.25	8.616	-1.996	4	.117
Mean Cell Volume	.500	.45	.202	2.469	4	.069
Erythrocyte Sedimentation Rate	-19.40	3.91	1.749	-11.09	4	.000

The new finding indicate changes on some blood components Table.2 for heavyweight judo athletes (MCLC, Blood platelets, Erythrocyte Sedimentation Rate and Mean Cell Volume) comparing to the other two weight (Middle and light) another differences was identify among Mean Corpuscular Lymphocytosis, for the lightweight the difference was significant at $p < 0.05$. T-test suggested a significant effect of type of sport practised on the blood count for three groups ($p < 0.005$) (tables 2, 3 and 4).

Athletes of all groups, red blood cell count was higher than in the post-test. For all groups except lightweight the difference was significant at $p < 0.005$. The difference was significant at $p < 0.05$ for the White blood cell, Granulocytes, Lymphocytosis concentration MCLC, Haemoglobin, Blood platelets and Erythrocyte Sedimentation Rate, except for red blood cell, Haemoglobin, Blood platelets and for light and heavyweight (table 2and 4). The light and middleweight had the higher red blood cell counts, lower on average by 10.35 % than

those of the heavy group.

The lowest blood platelets were found among lightweight athletes: on average, lower by 10.10 % ($p < 0.005$) than that of the middle and heavy group of athletes. Blood platelets were higher in the athlete's heavyweight; it was lower by 9.82 % ($p < 0.005$) than that in the lightweight (table 4), followed by the middleweight (lower by 7.32 % ($p < 0.005$)). Although it was lower by 2.41% on average, the Blood platelets of middleweight were not significantly different from that of the heavyweight (table 2and 3).

No differences were found for the middleweight with respect to mean corpuscular volume (table 2, 3 and 4). Haemoglobin concentration was lowest in the lightweight (table 4) (8.04 %, 6.72 % and 6.64 %) respectively lower than that of the heavy and middleweight). The haemoglobin concentration in all the groups was below the lower reference limit for the general athlete's population of the same weight.

Discussions

The results of the present study support the findings reported by a number of authors(Spitler, Alexander, Hoffler, Doerr & Buchanan 1984; Gimenez et al. 1986; Gaitanos et al. 1993; Gastin 2001; Franchini et al. 2003; GAO et al. 2006; Chamera et al. 2015; Agostinho et al. 2017; Berria, Bachir, Eddine & Adel 2018) that the major blood count variables undergo a change in athletes (table 2, 3 and 4). T-test analysis indicates that these changes, in three groups, are dependent on the factor "sport performance intensity". We have also found, in contrast with the findings of (Boyadjiev & Taralov 2000) in pubescent untrained subjects, that there are weight dependent differences in red blood cell count, packed cell volume, and haemoglobin concentration ($p < 0.001$) in both highly trained athletes lightweight and heavyweight: the mean values in lightweight were higher than in heavyweight (table 2).

All early and late changes in the haematological variables after acute or chronic intensive physical exercise regardless of its characteristics (aerobic, anaerobic or mixed) are caused by factors associated mainly with the process of haemoconcentration and haemodilution (Vázquez et al. 2010). It also includes changes in plasma catecholamine concentration and the consequences of these mechanisms (David Bruce Dill & Costill 1974; D B Dill & Costill 1974). In prolonged chronic exercises, the changes in red blood cell variables are associated with training protocol (Charrin et al. 2018) and the involved mechanisms are chronic intravascular haemolysis associated with strength sports (Szyguła, Spodaryk, Dabrowski & Miszta 1986;

Montero & Lundby 2018) and changes in plasma erythropoietin level (Schmidt & Prommer 2008).

Nevertheless, from the present study it is not feasible to explain the exact mechanism(s) involved among the different weight category in highly trained judo athletes for the changes in their red blood count, but some speculations may be postulated. The blood volume increases with intense endurance training or prolonged exercise similar to judo competition. This is primarily resulted from an increase in blood count that occurs due to high exercise induced increased secretion after judo Randori.

However, increase in RBC volume also contributes towards increase in some blood count but the increase in the number of RBC is neither consistent nor proportional with the increase in some blood count (Varamenti, Nikolovski, Elgingo, Jamurtas & Cardinale 2018). This finding indicated that sports specific trend in the reduction of haematological parameters is irrespective of sport and weight category (Varamenti et al. 2018) as it was also found in the present study. However, the protocol of our study did not allow us to advance enough arguments for any specific mechanism by which we could explain our findings.

Conclusion

The present findings indicated that judo competition (Randori) has effects on some blood count variables. The values of RBC count, haemoglobin concentration and packed cell volume were significantly lower among judo athletes of both (middleweight and heavyweight) in comparison to their lightweight counterparts. Such reductions of some blood count variables among highly judo trained athletes of all weights category are significantly correlated with duration of the competition and period. Lightweight exhibited significantly higher values of all this variables than their (middleweight and heavyweight) counterparts. However, mean corpuscular volume and mean corpuscular haemoglobin concentration did not show any significant variation.

References

1. AGOSTINHO M. F., A. MOREIRA, F. JULIO U, G. S. MARCOLINO, B. M. M. ANTUNES, F. S. LIRA & E. FRANCHINI, 2017. Monitoring internal training load and salivary immune-endocrine responses during an annual judo training periodization. *Journal of Exercise Rehabilitation.* **13**(1), 68. https://doi.org/10.12965/jer.1732850.425

2. ALMANSBA R., S. STERKOWICZ, K. STERKOWICZ-PRZYBYCIEN & R. BELKACEM, 2010. Maximal oxygen uptake changes during judoist's periodization training. *Arch Budo.* **6**(2), 117-122.
3. BASSINI-CAMERON A., E. SWEET, A. BOTTINO, C. BITTAR, C. VEIGA CAMERON L.-C. 2007. Effect of caffeine supplementation on haematological and biochemical variables in elite soccer players under physical stress conditions. *British Journal of Sports Medicine*, **41**(8), 523–530. https://doi.org/10.1136/bjsm.2007.035147
4. BELKADI A., 2018. Etude comparative de deux protocoles de récupération en immersion en eau froide (continu et fractionné) après un entraînement intense (cas du hand-ball).
5. BERRIA M., K. BACHIR, S. N. EDDINE & B. ADEL, 2018. Study of LDH adaptations associated with the development of Speed endurance in basketball players U19. *International Journal of Applied Exercise Physiology.* **7**(3), 35–43.
6. BOYADJIEV N. & Z. TARALOV, 2000. Red blood cell variables in highly trained pubescent athletes: a comparative analysis. *British Journal of Sports Medicine.* **34**(3), 200–204.
7. CHAAR V., M. ROMANA, J. TRIPETTE, C. BROQUERE, M. G. HUISSE, O. HUE, M. D. HARDY-DESSOURCES & P. CONNES, 2011. Effect of strenuous physical exercise on circulating cell-derived microparticles. *Clinical Hemorheology and Microcirculation.* **47**(1), 15–25. https://doi.org/10.3233/CH-2010-1361
8. CHAMERA T., M. SPIESZNY, T. KLOCEK, D. KOSTRZEWA-NOWAK, R. NOWAK, M. LACHOWICZ, R. BURYTA, K. FICEK, J. EIDER, W. MOSKA & P. CIĘSZCZYK, 2015. Post-Effort Changes in Activity of Traditional Diagnostic Enzymatic Markers in Football Players' Blood. *Journal of Medical Biochemistry.* **34**(2), 179–190. https://doi.org/10.2478/jomb-2014-0035
9. CHARRIN E., J. J. DUBÉ, P. CONNES, V. PIALOUX, S. GHOSH, C. FAES, S. F. OFORI-ACQUAH & C. MARTIN, 2018 Moderate exercise training decreases inflammation in transgenic sickle cell mice. *Blood Cells, Molecules, and Diseases.* **69**, 45-52.
10. DEGOUTTE F., P. JOUANEL & E. FILAIRE, 2003. Energy demands during a judo match and recovery. *British Journal of Sports Medicine.* **37**(3), 245-249. https://doi.org/10.1136/bjsm.37.3.245

11. DILL D. B. & D. L. COSTILL, 1974. Calculation of percentage changes in volumes of blood, plasma, and red cells in dehydration. *Journal of Applied Physiology.* **37**(2), 247–248. https://doi.org/10.1152/jappl.1974.37.2.247
12. DILL DAVID BRUCE & D. L. COSTILL, 1974. Calculation of percentage changes in volumes of blood, plasma, and red cells in dehydration. *Journal of Applied Physiology.* **37**(2), 247-248.
13. DRYGAS W. K., 1988 Changes in Blood Platelet Function, Coagulation, and Fibrinolytic Activity in Response to Moderate, Exhaustive, and Prolonged Exercise*. *International Journal of Sports Medicine.* **09**(1), 67–72. https://doi.org/10.1055/s-2007-1024981
14. FRANCHINI E., G. ARTIOLI & C. BRITO, 2013 Judo combat: Time-motion analysis and physiology. *International Journal of Performance Analysis in Sport.* **13**.
15. FRANCHINI E., U. F. JULIO V. L. G. PANISSA, F. S. LIRA, J. GEROSA-NETO & B. H. M. BRANCO, 2016. High-Intensity Intermittent Training Positively Affects Aerobic and Anaerobic Performance in Judo Athletes Independently of Exercise Mode. *Frontiers in Physiology.* **7**. https://doi.org/10.3389/fphys.2016.00268
16. FRANCHINI E., A. V. NUNES, J. M. MORAES & F. B. DEL VECCHIO, 2007. Physical fitness and anthropometrical profile of the Brazilian male judo team. *Journal of Physiological Anthropology.* **26**(2), 59-67.
17. FRANCHINI E., S. STERKOWICZ, U. SZMATLAN-GABRYS, T. GABRYS & M. GARNYS, 2011. Energy system contributions to the special judo fitness test. *International Journal of Sports Physiology and Performance.* **6**(3), 334–343.
18. FRANCHINI E. & M. Y. TAKITO, 2014a. Olympic preparation in Brazilian judo athletes: description and perceived relevance of training practices. *Journal of Strength and Conditioning Research*. **28**(6), 1606-1612. https://doi.org/10.1519/JSC.0000000000000300
19. F RANCHINI E. & M. Y. TAKITO, 2014b. Olympic preparation in Brazilian judo athletes: description and perceived relevance of training practices. *Journal of Strength and Conditioning Research.* **28**(6), 1606–1612. https://doi.org/10.1519/JSC.0000000000000300
20. RANCHINI E. & M. Y. TAKITO, M. KISS & S. STRERKOWICZ, 2005 Physical fitness and anthropometrical differences between elite and non-elite judo players. *Biology of Sport.* **22**(4), 315.

21. FRANCHINI E., F. B. D. VECCHIO, K. A. MATSUSHIGUE & G. G. ARTIOLI, 2011. Physiological Profiles of Elite Judo Athletes. *Sports Medicine.* **41**(2), 147-166. https://doi.org/10.2165/11538580-000000000-00000.
22. FRANCHINI E., M. YURI TAKITO, F. YUZO NAKAMURA, K. AYUMI MATSUSHIGUE & M. A. PEDUTI DAL MOLIN KISS, 2003. Effects of recovery type after a judo combat on blood lactate removal and on performance in an intermittent anaerobic task. *Journal of Sports Medicine and Physical Fitness.* **43**(4), 424-431.
23. GAITANOS G. C., C. WILLIAMS, L. H. BOOBIS & S. BROOKS, 1993. Human muscle metabolism during intermittent maximal exercise. *Journal of Applied Physiology.* **75**(2), 712-719.
24. GAO B., E. HAN & P. CAO, 2006. The Research on the relationships between Characteristics of Body Composition and Anaerobic Metabolism Capacity of Chinese Elite Male Judo Athletes [J]. *Journal of Tianjin University of Sport.* **3**.
25. GASTIN P. B., 2001. Energy system interaction and relative contribution during maximal exercise. *Sports Medicine.* **31**(10), 725-741.
26. GIMENEZ M., T. MOHAN-KUMAR, J. C. HUMBERT, N. DE TALANCE & J. BUISINE, 1986. Leukocyte, lymphocyte and platelet response to dynamic exercise. *European Journal of Applied Physiology and Occupational Physiology.* **55**(5), 465–470. https://doi.org/10.1007/BF00421638.
27. HAMER M., A. TAYLOR & A. STEPTOE, 2006. The effect of acute aerobic exercise on stress related blood pressure responses: A systematic review and meta-analysis. *Biological Psychology.* **71**(2), 183–190. https://doi.org/10.1016/j.biopsycho.2005.04.004.
28. HILBERG T., K. MENZEL, D. GLÄSER, S. ZIMMERMANN & H. H. W. GABRIEL, 2008. Exercise intensity: Platelet function and platelet–leukocyte conjugate formation in untrained subjects. *Thrombosis Research.* **122**(1), 77–84. https://doi.org/10.1016/j.thromres.2007.08.018.
29. International Judo Federation, 2018. New IJF Judo Refereeing Rules. 2018, January 28. https://www.ijf.org/ijf/documents/6 (accessed 28 January 2018).
30. International Judo Federation, 2018.New IJF Judo Refereeing Rules. (n.d.). https://www.ijf.org/ijf/documents/6 (accessed 28 January 2018).
31. LECH G., A. TYKA, T. PAŁKA & R. KRAWCZYK, 2010. Effect of physical endurance on fighting and the level of sports performance in junior judokas. *Archives of Budo.* **6**(1). Retrieved from http://archbudo.com/view/abstracts/issue_id/10653.

32. LOTURCO I., L. A. PEREIRA, C. WINCKLER, J. R. BRAGANÇA, R. DA FONSECA, R. KOBAL, C. C. CAL ABAD, K. KITAMURA, F. Y. NAKAMURA & E. FRANCHINI, 2017. Performance Changes of Elite Paralympic Judo Athletes During a Paralympic Games Cycle: A Case Study with the Brazilian National Team. *Journal of Human Kinetics.* **60**, 217-224. https://doi.org/10.1515/hukin-2017-0111.
33. MAIRBÄURL H., 2013. Red blood cells in sports: effects of exercise and training on oxygen supply by red blood cells. *Frontiers in Physiology.* **4**. https://doi.org/10.3389/fphys.2013.00332
34. MONTERO D. & C. LUNDBY, 2018. Regulation of Red Blood Cell Volume with Exercise Training. In: Comprehensive Physiology. American Cancer Society. https://doi.org/10.1002/cphy.c180004
35. SAWKA M. N., V. A. CONVERTINO, E. R. EICHNER, S. M. SCHNIEDER & A. J. YOUNG, 2000. *Blood Volume: Importance and Adaptations to Exercise Training, Environmental Stresses and Trauma Sickness*. ARMY INST OF SURGICAL RESEARCH FORT SAM HOUSTON TX, ARMY INST OF SURGICAL RESEARCH FORT SAM HOUSTON TX. Retrieved from http://www.dtic.mil/docs/citations/ADA628432
36. SCHMIDT W. & N. PROMMER, 2008. Effects of various training modalities on blood volume. *Scandinavian Journal of Medicine & Science in Sports.* **18**(s1), 57-69. https://doi.org/10.1111/j.1600-0838.2008.00833.x
37. SPITLER D. L., W. C. ALEXANDER, G. W. HOFFLER, D. F. DOERR & P. BUCHANAN, 1984. Haptoglobin and serum enzymatic response to maximal exercise in relation to physical fitness. *Medicine and Science in Sports and Exercise.* **16**(4), 366-370.
38. SUREDA A., M. D. FERRER, P. TAULER, D. ROMAGUERA, F. DROBNIC, P. PUJOL, J. A. TUR & A. PONS, 2009. Effects of exercise intensity on lymphocyte H2O2 production and antioxidant defences in soccer players. *British Journal of Sports Medicine.* **43**(3), 186-190. https://doi.org/10.1136/bjsm.2007.043943.
39. SZYGUŁA Z., K. SPODARYK, Z. DABROWSKI & H. MISZTA, 1986. Post-exercise anaemia as a result of exercise overloading of the organism. *Physiologia Bohemoslovaca*, **35**(2), 104–111.
40. TORRES-LUQUE G., R. HERNÁNDEZ-GARCÍA, R. ESCOBAR-MOLINA, N. GARATACHEA & P. T. NIKOLAIDIS, 2016. Physical and Physiological Characteristics of Judo Athletes: An Update. *Sports.* **4**(1), 20. https://doi.org/10.3390/sports4010020.

41. VARAMENTI E., Z. NIKOLOVSKI, M. I. ELGINGO, A. Z. JAMURTAS & M. CARDINALE, 2018. Training-Induced Variations in Haematological and Biochemical Variables in Adolescent Athletes of Arab Origin Throughout an Entire Athletic Season. *Journal of Human Kinetics*, **64**(1), 123–135. https://doi.org/10.1515/hukin-2017-0187
42. VÁZQUEZ B. Y. S., J. MARTINI, A. G. TSAI, P. C. JOHNSON, P. CABRALES & M. INTAGLIETTA, 2010. The variability of blood pressure due to small changes of hematocrit. *American Journal of Physiology - Heart and Circulatory Physiology.* **299**(3), H863–H867. https://doi.org/10.1152/ajpheart.00496.2010
43. World Medical Association, 2013. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA.* **310**(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053

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GENDER DIFFERENCES IN SUBJECTIVE WELL-BEING OF HEALTHY HIGH- SCHOOL STUDENTS

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Summary: The objective of this study was to analyse the level of subjective well-being (SWB) through five SWB dimensions and compare it between healthy male and healthy female high school students preferring sedentary leisure time activities. The research sample comprised of 90 male high school students (mean age 16.72 ± 1.33) and 126 female high school students (mean age 16.71 ± 1.36) who preferred sedentary types of leisure time activities with self-reported good health status. A standardized The Bern Subjective Well-Being Questionnaire for Adolescents (BFW) was used as a primary research method. We found significantly higher level of positive SWB dimension (U = 4281, p = 0.002, r = 172) and significantly lower level of negative SWB dimension (U = 2835, p = 0.000, r = 424) in the group of male high school students with self-reported good health status in comparison to female high school students. Parents should be involved in the selection of their children's leisure time activities, so it should not have only the sedentary character but also sport leisure time activities, mainly among young girls.

Keywords: positive and negative dimensions, male and female high school students, self-reported health status, sedentary types of leisure activities.

Introduction

As the name suggests, Subjective Well-being (SWB) is a subjective evaluation by an individual of her/his life in overall (Diener 2000). In a broad sense, SWB measures provide "a sense of how (people's) lives are going, through the interaction between their circumstances, activities and psychological resources" (New Economics Foundation 2018, p. 18). Following the World Health Organization's proposal in 1948 that, "Health is not merely the absence of

disease but a state of wellbeing," well-being has become an increasing focus of research, as well as conceptual debate (La Placa & Knight 2014). It is now generally agreed that well-being is multidimensional and subjectively assessed (Organization for Economic Cooperation 2013). General well-being is regularly described in terms of happiness, with happiness often loosely defined as SWB (Layard 2006). The construct of SWB was developed in response to the weak empirical links found between people's objective circumstances (e.g., material wealth) and their reported levels of happiness (Layard 2006).

The "bottom-up" theory of SWB argues that global SWB is based on a person's evaluating of well-being across key life domains (e.g., leisure, work, health) (Headey et al. 1991). Leisure can fulfil needs and desires that are thwarted in other areas of one's life, such as work, which can protect one's overall well-being (Kuykendall et al. 2018). Leisure may provide certain unique well-being benefits that cannot be obtained through other domains in life, as leisure is typically characterized by autonomy or greater freedom of choice than other life domains (Graef et al. 1983). The influence of basic psychological needs on well-being has been documented across various life domains, such as work (Van den Broeck et al. 2010), education (Mouratidis et al. 2011), sport (Stenling & Tafvelin 2014) and across diverse cultural samples (e.g., Chen et al. 2015). Although leisure can be solitary or social, social leisure activities strongly contribute to SWB (Parsons, Mackenzie & Brymer 2019). For instance, leisure with friends has been shown to increase immediate well-being, while leisure time with a partner benefits global well-being (Larson et al. 1986). Social leisure activities can build social relationships, promote positive emotions, and improve quality of life (Ryan & Deci 2000). As we mentioned above, participation in the social leisure activity like sport, increase a personal well-being by higher level of the positive aspects as well as lower level of negative aspects of the SWB (Pačesová, 2019).

There is a very close connection between sedentary leisure activities and health problems already in young age category people. It has been suggested that young people spend too much time in sedentary activities, which further increases their risk of future health problems (Van Sluijs et al., 2008). In a cross-sectional sample of American 11–15-year-olds, where sedentary behaviour was self-reported but more widely defined (including screen time and activities such as listening to the radio and talking on the phone), age was also positively associated with overall sedentary behaviour (Norman et al., 2005). Moreover, sedentary behaviour-specific psychological factors (such as self-efficacy, and perceived pros and cons), family environmental factors and hills in the neighbourhood were associated with high levels of sedentary time (> 240 min.) among girls, whereas only self-efficacy and barriers to change

were associated among boys (Van Sluijs et al. 2010). For our investigation we selected male and female high school students with self-reported sedentary leisure time activities preferences and self-reported good health status. The objective of this study was to analyse the level of subjective well-being in healthy high school students preferring sedentary leisure activities. Furthermore; this study should deepen the knowledge of the level of subjective well-being dimensions and compare it between male and female high school students.

Methods

Participants and data collection

The research sample comprised of 90 healthy male high school students (mean age 16.72 ± 1.33 years of age) and 126 healthy female high school students (mean age 16.71 ± 1.36 years of age) who preferred sedentary types of leisure time activities. The most preferred sedentary leisure activities in male high school students were TV watching and playing on the electronic devices and the most preferred sedentary leisure activities in female high school students were meeting/chatting with friends – socializing, listen the music and doing nothing. The data was collected from February to June 2019 at six different high schools and vocational schools in Slovak cities Nitra, Liptovský Hrádok, Ružomberok, Bratislava, Humenné and Spišská Nová Ves. The questionnaire was distributed in paper form and respondents were instructed on how to complete it and informed of survey questions related to health status and preferred leisure time activities. For this study, we selected only students who had prefer sedentary leisure time activities and reported good health status. The Ethics Committee of the Faculty of Physical Education and Sports, Comenius University in Bratislava (ref. no. 10/2019), had approved this research. Each participant voluntarily provided written informed consent before the participation in the research.

The Bern Subjective Well-Being Questionnaire for Adolescents (BFW)

A standardized The Bern Subjective Well-Being Questionnaire for Adolescents (BFW; Grob et al., 1991) was used as a primary research method. The BFW questionnaire consists of 28 items scale that measure both positive and negative feelings about yourself, covering five main SWB dimensions: (1) Overall life satisfaction" supported by 6 items, (2) "Current psychological problems" supported by 7 items, (3) "Current physical difficulties" supported by 8 items, (4) "Self-esteem" supported by 3 items and (5) "Depressive mood" supported by 4 items. Items of four dimensions (1, 2, 4, and 5) were answered using a 6-point Likert scale format ranging from strongly disagree (point 1) to strongly agree (point 6) and dimension 3

Current physical difficulties were answered using a 4-point Likert scale format ranging from not at all (point 1) to very often (point 4). Two SWB dimensions (1 and 4) evaluate a positive attitude of SWB and higher scores indicate higher SWB and three dimensions (2, 3 and 5) evaluate a negative attitude of SWB and higher scores indicate a lower SWB. In this study, a Slovak version of the BFW was used (Džuka 1995).

Data analysis

The program IBM SPSS Statistics version 23.0 was used for data processing. The data were described using absolute and relative frequencies, including the mean ($\overline{x}$) and standard deviation (± SD). The Kolmogorov-Smirnov test was used to evaluate data normality and non-parametric Mann Whitney *U*-test was used to assess differences between two independent groups of male and female high school students. The significance level was set at $\alpha \leq 0.05$ (*) and $\alpha \leq 0.01$ (**). The rate of dependence (effect size) between the two samples of features was conveyed by means of the coefficient *r* (r > 0.90 - very large effect size, r = 0.70 – 0.90 - large effect size, r = 0.50 – 0.70 - medium effect size, r = 0.30 – 0.50 - small effect size, r < 0.29 – very small effect size) proposed by Pett (1997).

Results

SWB dimensions analyses show significantly higher level of Overall life satisfaction in the group of healthy male high school students (4.378 ± 1.055 points of the mean score) compare the group of healthy female high school students (4.165 ± 0.942 points of the mean score) (U = 4 799, p = 0.050, r = 0.106) (Table 1). Analysing different items of the SWB dimension Overall life satisfaction we found significantly higher satisfaction with one of six items, concretely of Life plans organisation in the group of male high school students (4.133 ± 1.317 points of the mean score) comparing female high school students (3.778 ± 1.123 points of the mean score) (U = 4754, p = 0.037, r = 0.144).

Results further revealed significantly higher occurrence of Current psychological problems in the group of female students (2.416 ± 0.783 points of the mean score) compared to male students (1.965 ± 0.785 points of the mean score) (U = 3713, p = 0.000, r = 0.276) In this SWB dimension female high school students presented significantly higher level of problems with 6 of 7 items, concretely in the last few weeks they were significantly more worry with other people (U = 4651, p = 0.022, r = 0.157), relationships (U = 4520, p = 0.009, r = 0.154), study (U = 4559, p = 0.008, r = 0.140), health (U = 4389, p = 0.003, r = 0.157),

partner (U = 4561, p = 0.004, r = 0.139) and finances (U = 4148, p = 0.000, r = 0.215) than their male peers. In the SWB dimension of Current physical difficulties results further declare significantly higher occurrence of current physical difficulties again in the group of female students (2.169 ± 0.615 points of the mean score) compare male students (1.640 ± 0.450 points of the mean score) (U = 2785, p = 0.000, r = 0.441). Surprisingly healthy female high school students reported in the last few weeks significantly higher occurrence of stomach-ache (U = 4126, p = 0.000, r = 0.259), palpitation (U = 4271, p = 0.001, r = 0.248), lack of appetite (U = 4319, p = 0.001, r = 0.203), dizziness (U = 4376, p = 0.000, r = 0.285), sleep (U = 4206, p = 0.001, r = 0.224), fatigue (U = 3163, p = 0.000, r = 0.394) and headache (U = 3198, p = 0.000, r = 0.397) than healthy male high school students.

Significantly higher level of Self-esteem was presented by healthy male high school students (4.796 ± 1.227 points of the mean score) comparing their female peers (4.209 ± 1.175 points of the mean score) (U = 3852, p = 0.000, r = 0.237). The score of all three evaluated items of the SWB dimension of Self-esteem was significantly higher in the group of healthy male students in comparison female students. Concretely male students were able to do things as well as most people (U = 4601, p = 0.016, r = 0.147), they felt as valuable as the others (U = 4233, p = 0.001, r = 0.205) and they had a positive attitude towards themselves (U = 3903, p = 0.000, r = 0.245). The SWB dimension Depressive mood was significantly higher in the group of female students (2.917 ± 1.115 points of the mean score) comparing to their healthy male peers (2.325 ± 0.932 points of the mean score) (U = 3821, p = 0.000, r = 0.277) supported by three of four items. Female healthy students achieved significantly higher level of laziness (U = 3821, p = 0.000, r = 0.314), total disinterest (U = 3821, p = 0.000, r = 0.241) and life sense disinterest (U = 3821, p = 0.000, r = 0.158) comparing male high school students.

Table 1

SWB dimension comparison between healthy male and female high school students

SWB dimensions	**Male students** (n = 90)	**Female students** (n = 126)	***U***	***Z***	***p***	**abs (*r*)**
	$\bar{x}$/ ± SD (point score)					
Overall life Satisfaction	4.378 ± 1.055	4.165 ± 0.942	4799	-1.926	0.050*	0.106
Current psychological problems	1.965 ± 0.785	2.416 ± 0.783	3713	-4.329	0.000**	0.276
Current physical difficulties	1.640 ± 0.450	2.169 ± 0.615	2785	-6.386	0.000**	0.441
Self-esteem	4.796 ± 1.227	4.209 ± 1.175	3852	-4.034	0.000**	0.237
Depressive mood	2.325 ± 0.932	2.917 ± 1.115	3821	-4.095	0.000**	0.277

*Note. U and Z = Mann-Whitney U-test statistics; p = statistical significance (p-values *≤.05, **≤.01); abs(r) = absolute value of r = effect size*

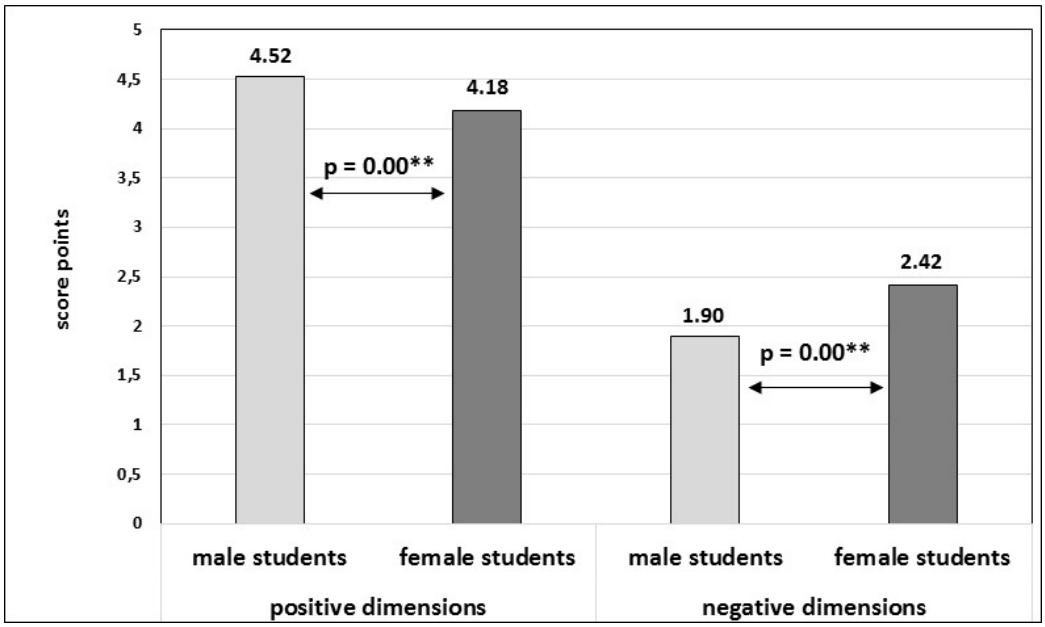

Figure 1

A comparison of positive and negative SWB dimensions between male and female high school students

Summarising the achieved results of the present study we found significant differences in all five SWB dimensions between male and female healthy high school students. Concretely male high school students presented significantly higher level in two positive SWB dimension (4.517 ± 1.017 vs 4.180 ± 0.909 points of the mean score; U = 4281, p = 0.002, r = 172) and significantly lower level in three negative SWB dimension (1.904 ± 0.511 vs 2.417 ± 0.583 points of the mean score; U = 2835, p = 0.000, r = 424) in comparison to female high school students (Figure 1). Observed data generally presented significantly higher SWB in the group of healthy male high school students comparing to female high school students.

Discussion

Sedentary behaviour (or sitting) is ubiquitous in the developed world with young people now spending the majority of their leisure time in sedentary pursuits such as screen-viewing (eg, television/DVD viewing, computer use and internet use), sedentary socialising and inactive forms of transport (Biddle, Petrolini & Pearson 2014). Sedentary behaviour comprises sitting or lying, during waking hours, with low-energy expenditure (Sedentary Behaviour Research Network 2012). There is a growing public health concern over the effects that sedentary lifestyles are having on the physical and psychological health of children and adolescents. The objective of this study was to analyse the level of subjective well-being among healthy high school students preferring sedentary leisure activities. Furthermore; this study should deepen

the knowledge of the level of subjective well-being dimensions and compare it between male and female high school students. Observed data show significantly higher level of the Overall life satisfaction as well as the Self-esteem in the group of male healthy high school students comparing to their female peer. On the other side the results further revealed significantly lower level of the Current psychological problems, the Current physical difficulties and the Depressive mood in the group of healthy male high school students comparing to their female peers. Male high school students with self-reported good health presented significantly higher level of positive SWB dimension and significantly lower level of negative SWB dimension in comparison to their female high school students.

Nemček (2017a) investigated the SWB through the level of self-esteem in the group of people who are deaf and hard of hearing preferring sedentary leisure activities (n = 90). This minority group of population achieved in the Rosenberg's Self-esteem Scale the highest score in two items. They felt, that they are a people of worth, at least on an equal level as the others as they are able to do things as well as most other people. Individuals who are deaf and hard of hearing may be disadvantaged in terms of health and participation in beneficial physical activities compared to the majority of society due to their information deficit and limited auditory perception (Kurková, 2016). Nemček (2017b) investigated SWB in the group of population with physical disabilities preferring sedentary leisure activities (n = 98). This minority group of population declared positive SWB by the highest Rosenberg's Self-esteem Scale score in different items compared to deaf and hard of hearing population. Sedentary people with physical disabilities took a positive attitude toward themselves and they felt that they have a number of good qualities. Healthy population preferring sedentary leisure activities revealed higher level of SWB declared by higher level of life satisfaction comparing sedentary population with chronic diseases (Bendíková & Nemček 2016) and sedentary population with disabilities (Nemček 2016a).

As we already mentioned, surprisingly female high school students who reported a good health status, presented significantly higher occurrence of the physical as well as psychological problems and difficulties in comparison to healthy male high school students. In the last few weeks they were significantly more worried with other people, relationships, study, health, partner and finances than male students. And also, in the last few weeks they registered significantly higher occurrence of stomach-ache, palpitation, lack of appetite, dizziness, bad sleep, fatigue, headache than their healthy male peers.

Population with physical disabilities who prefer sedentary leisure activities revealed in the study of Nemček (2016b) the positive SWB by the highest satisfaction in their life with

home environment, family relations, food, and population who are deaf and hard of hearing declared the positive SWB by the highest satisfaction with family relations, children and love. On the other hand, the negative SWB was presented by both minority groups with sedentary behaviour with dissatisfaction with political situation and justice. People with physical disabilities showed in addition the negative SWB by dissatisfaction in their life with sport participation and deaf people dissatisfaction with finances like female high school students in the present study (Nemček 2016c).

We can further discuss that in the future investigation we need to focus to analyse the level of SWB in the group of female adolescents with different health status level and compare the SWB with healthy girls.

Limits of the study

For our investigation we used only self-reported measures of preferred leisure activities and health status level which are easy to use, less invasive and less expensive. The future investigation needs an objective measure of the health status level and leisure time activities character (sedentary, active) in high school students.

Conclusion

Observed data of the present study reported significantly higher level of SWB in healthy male high school students comparing to healthy female high school students preferring sedentary types of leisure activities. Many researches indicated a very close positive connection between regular participation in sport leisure activities and SWB (Pačesová et al. 2018; Pačesová, Šmela & Antala 2019; Pačesová, Šmela & Kraček 2019). The parents are the most responsible for the leisure time spending by their children and the leisure activities choice. They should be involved in the selection of their children's leisure activities, so it should not have only sedentary character but also sport leisure activities, mainly in young girls. Parents have to control and reduce television viewing, watching videos/DVDs, computer and internet use, chatting with friends through the social nets, playing electronic devices of their children and spend with them more leisure time in the nature by playing different sport and motor (funny) games, cycling, hiking, running, etc. This should lead to increase a SWB of young people with focus on the lifelong physical activity.

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References

1. BENDÍKOVÁ, E. & D. NEMČEK, 2016. Life satisfaction of healthy people and people with non-communicable diseases: differences between active and inactive individuals. In: *Sport Scienc.* **9**(suppl. 2), pp. 19-23.
2. BIDDLE, S.J., I. PETROLINI & N. PEARSON, 2014. Interventions designed to reduce sedentary behaviours in young people: a review of reviews. In: *British Journal of Sports Medicine.* **48**(3), pp. 182-186.
3. CHEN, B., M. VANSTEENKISTE, W. BEYERS, L. BOONE, E.L. DECI, J. VAN DER KAAP-DEEDER, . . . J. VERSTUYF, 2015. Basic psychological need satisfaction, need frustration, and need strength across four cultures. In: *Motivation and Emotion*. **39**(2), pp. 216–236.
4. DIENER, E., 2000. Subjective well-being: the science of happiness and a proposal for a national index. In: *The American Psychologist.* **55**(1), pp. 34–43.
5. DŽUKA, J., 1995. Faktorová analýza modifikovanej verzie Bernského dotazníka subjektívnej pohody (BDP). In: *Československá psychologie.* **39**(6), pp. 512-522. ISSN 1804-6436.
6. GRAEF, R., M. CSIKSZENTMIHALYI & S.M. GIANINNO, 1983. Measuring intrinsic motivation in people's everyday lives. In: *Leisure Studies.* **2**(2), pp. 155–168.
7. GROB, A., R. LÜTHI, F.G. KAISER, A. FLAMMER, A. MACKINNON & A.J. WEARING, 1991. Berner Frageboden zum Wohlbefinden Jugendlicher (BFW). In: *Diagnostica.* **37**(1), pp. 66-75.
8. HEADEY, B., R. VEENHOVEN & A. WEARING, 1991. Top-down versus bottom-up theories of subjective well-being. In: *Social indicators research.* **24**(1), pp. 81–100.
9. KURKOVÁ, P. 2016. Physical activity among older people who are deaf and hard of hearing: perceived barriers and facilitators. In: *Physical Activity Review.* **4**, pp. 72-80.
10. KUYKENDALL, L., L. BOEMERMAN & Z. ZHU, 2018. The importance of leisure for subjective well-being. In: DIENER, E., S. OISHI & L. TAY (eds). *Handbook of well-being. DEF Publishers*, Salt Lake City.

11. LA PLACA, & A. KNIGHT, 2014. Well-being: its influence and local impact on public health. In: *Public Health.* **128**(1), pp. 38-42.
12. LARSON, R., R. MANNELL & J. ZUZANEK, 1986. Daily well-being of older adults with friends and family. In: *Psychology and Aging.* **1**(2), pp. 117-126.
13. LAYARD, R., 2006. Happiness: lessons from a new science. Penguin, Oxford.
14. MOURATIDIS, A., M. VANSTEENKISTE, G. SIDERIDIS & W. LENS, 2011. Vitality and interest–enjoyment as a function of class-to-class variation in need-supportive teaching and pupils' autonomous motivation. In: *Journal of Educational Psychology.* **103**(2), pp. 353-366.
15. NEMČEK, D., 2016a. Life satisfaction of people with disabilities: a comparison between active and sedentary individuals. In: *Journal of Physical Education and Sport.* **16**(2) pp. 1084-1088.
16. NEMČEK, D., 2016b. Quality of life of people with disabilities: differences in satisfaction with indicators and domains between active and inactive individuals. In: *Physical Activity Review.* **4**, pp. 62-71.
17. NEMČEK, D., 2016c. Quality of life of people with disabilities from sport participation point of view. In: *Acta Facultatis Educationis Physicae Universitatis Comenianae.* **56**(2), pp. 77-92.
18. NEMČEK, D., 2017a. Self-esteem analyses in people who are deaf or hard of hearing: a comparison between active and inactive individuals. In: *Physical Activity Review*, **5**, pp. 95-104.
19. NEMČEK, D., 2017b. Self-esteem in people with physical disabilities: Differences between active and inactive individuals. In: *Acta Facultatis Educationis Physicae Universitatis Comenianae.* **57**(1), p. 34-47.
20. NEW ECONOMICS FOUNDATION, 2018. National accounts of well-being: bringing real wealth onto the balance sheet. New Economics Foundation Publishing. [online]. Dostupné z: https://neweconomics.org/uploads/files/2027fb05fed1554aea_uim6vd4c5.pdf
21. NORMAN, G.J., B.A. SCHMID, J.F. SALLIS, K.J. CALFAS, & K. PATRICK, 2005. Psychosocial and environmental correlates of adolescent sedentary behaviors. In: *Pediatrics.* **116**(4), pp. 908-16.
22. ORGANISATION FOR ECONOMIC COOPERATION (OECD), 2013. How's life? 2013: measuring well-being. Paris: OECD Publishing, [online]. Dostupné z: https://doi.org/10.1787/9789264201392-en.

23. PAČESOVÁ, P., 2019. *Vybrané psychologické aspekty športovania adolescentov a adolescentiek*. Bratislava: Slovenská vedecká spoločnosť pre telesnú výchovu a šport. ISBN 978-80-8907-78-2.
24. PAČESOVÁ, P., P. ŠMELA, & B. ANTALA, 2019. Male's level of personal well-being and anxiety trait regarding a sport activity level. In: *Sport Mont Journal.* **17**(2), pp. 59-62.
25. PAČESOVÁ, P., P. ŠMELA, & S. KRAČEK, 2019. Personal well-being as part of the quality of life: Is there a difference in the personal well-being of women and men with higher level of anxiety trait regarding their sport activity? In: *Physical Activity Review.* **7**, pp. 201-208.
26. PAČESOVÁ, P., P. ŠMELA, S. KRAČEK & L. PLEVKOVÁ, 2018. Women's Well-Being, State and Trait Anxiety Regarding their Sport Activity. In: *Sport Mont Journal.* **16**(2), pp. 33-38.
27. PARSONS, H., S.H. MACKENZIE, S. FILEP & E. BRYMER, 2019. Subjective Well-being and Leisure. W. LEAL FILHO et al. (eds.). *Good Health and Well-Being*, Springer: Nature Switzerland AG.
28. PETT, M.A., 1997. *Nonparametric statistics for health care research: Statistics for small samples and unusual distributions*. Thousand Oaks, CA: Sage.
29. RYAN, R.M. & E.L. DECI, 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. In: *American Psychologist.* **55**(1), pp. 68-78.
30. SEDENTARY BEHAVIOUR RESEARCH NETWORK, 2012. Letter to the Editor: standardized use of the terms 'sedentary' and 'sedentary behaviours'. In: *Applied Physiology Nutrition and Metabolism.* **37**(3), pp. 540-2.
31. STENLING, A. & S. TAFVELIN, 2014. Transformational leadership and well-being in sports: the mediating role of need satisfaction. In: *Journal of Applied Sport Psychology*, **26**(2), pp. 182–196.
32. VAN DEN BROECK, A., M. VANSTEENKISTE, H. DE WITTE, B. SOENENS & W. LENS, 2010. Capturing autonomy, competence, and relatedness at work: construction and initial validation of the Work-Related Basic Need Satisfaction Scale. In: *Journal of Occupational and Organisational Psychology.* **83**, pp. 981-1002.
33. VAN SLUIJS, E.M.F., A. PAGE, Y. OMMUNDSEN & S.J. GRIFFIN, 2008. Behavioural and social correlates of sedentary time in young people. In: *British Journal of Sports Medicine.* **44**(10), pp. 747-755.

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CHANGES OF BODY POSTURE IN ELEMENTARY SCHOOL PUPILS BY APPLYING PROPRIOFOOT CONCEPT IN P.E. LESSONS

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Summary: Searching for active, effective intervention approaches, aimed to improving health protection, not only among children and youth, is an up-to-date research intention from a number of points of view. The reason is the prevalence of civilization diseases, in our case the muscular and skeletal system offers a number of issues of the prevention in relation to feet position and body posture. Based on the above, the aim of research was to identify change of body posture in elementary school pupil by applying Propriofoot Concept in physical and sport education. The monitored group (n = 1), within selected seventh year of Elementary School Radovan Kaufman in Partizánske, consisted of male pupil (n = 1) (12 years of age, 48 kg, 160 cm and 18.75 Bmi) in pubescence who underwent various data acquisition methods (plantogram and visual scale method, index method, method of evaluation body posture, evaluation of dynamic spine function), after and before applying Propriofoot Concept, within lessons of physical and sport education, as their processing and evaluation was realized with the help of clinical case reports. The analysis and synthesis, inductive and deductive approaches, comparisons and generalizations were used, as well as the primary statistics (arithmetic mean (±) and percentage frequency analysis (%). The obtained research results pointed to the positive changes in all of the above mentioned data acquisition methods, i.e. in the plantogram and visual scale method (from pes planus/ 1st pes planus to norm), index method (- 0.24), method of evaluation body posture (from bad to good posture) and dynamic spine function (tests of Schober - + 1.8, Stibor - + 3.1 and Otto - + .7, + .8). The applied six-week intervention physical program, in the form of Propriofoot Concept, and within the school lessons of physical and sport education changed the body posture in the elementary school pupil and therefore the Propriofoot Concept is considered as health tool in acting and changing the body posture through the foot proprioception. The mentioned concept is considered as diversification of school physical and sport education, in connection with the applying new variants of health tools and changing body postures of the elementary and high school pupils/ students.

Key words: Body posture, Foot, Muscular and skeletal system, Propriofoot Concept, Pupil.

Introduction

A prevalence of current level of skeletal and muscular system, primarily in school population significantly differs, as an occurrence of various functional and structural disorders in an area of a spine increases yearly, even doubles (Bendíková 2012), starting in period of:

1. Preschool (Bendíková & Stacho 2010),
2. Younger school age/ pubescence (Mitova 2015; Azabagic 2016),
3. Adolescence (Noll et al. 2016; Marko & Bendíková 2018),
4. Adulthood (Ferreira et al. 2011; Singh et al. 2014),
5. Old age (Fleming et al. 2011; Gheno et al. 2012).

However, the increased occurrence of the functional and structural disorders of the muscular and skeletal system is associated with influence and functionality of a foot, within all periods of human development:

1. Childhood (Cibulka 1999; Arya 2014),
2. Adulthood (Leveille 1998; Menz et al. 2013),
3. Old age (Houghton 2008; Malanga & Ramirez 2008; Hagedorn et al. 2013).

The school reform, which is valid since the school year 2008/2009, has changed the status of physical and sport education (PaSE), as it has specified a minimal number of PaSE lessons to two and has diverted from the well-established, performance-oriented towards health and its support. It may be increased by one lesson of PaSE, but it depends on subjective and objective factors of school director and place within the school curriculum (Antala, 2009; Bendíková, 2012). Despite of the above listed; the Slovak Republic has reached the last places within the European Union, because school institutions do not use the possibility of increasing the lesson of PaSE through the school education program (Stupák 2017).

The modernization of school PaSE in 2015 has changed the content of PaSE, but no positive changes were recorded in the increase of compulsory PaSE and its participation as elementary school pupils and high school students support it, through their passive (non)participation in PaSE from number of objective, but especially subjective reasons (Boreham & Riddoch 2001; Krčmárik 2012; Zrnzević & Arsić 2013; Balážová 2014; Harris 2015).

At present, diversification of PaSE offers improvement of the level of muscular and skeletal system, through implementation of the various intervention physical programs, in

teaching the PaSE (Bendíková 2016; Bendíková & Dobay 2017; Smoleňáková & Bendíková 2017). The prevention of the functional and structural disorders of the muscular and skeletal system in areas of spine and foot are possible via various physical programs. It is shown and realized:

1. At home (Hand 1964; Ahmad & Akthar 2014; Jorgić et al. 2015),
2. PaSE (Bendíková 2016; Bendíková, Marko & Šmída 2018; Marko & Bendíková 2018),
2. Competitive sports (Rothermel 2004; Mulligan & Cook 2013; O'McKeon 2015).

With the application of the physical programs, there are number of different views associated with the length of intervention. Within the muscular and skeletal system, the views of authors on the intervention of physical programs with positive changes differ, not to mention flat feet:

Spine	Foot
1. Rowe & Jacobs (2012) – 12 min.,	1. Riccio et al. (2009) – 3 x/week,
2. Kanasová (2013) – 4 mon./ 2 x/ 15 min,	2. Ahmad et al. (2014) – 36 weeks./ 3 x,
3. Bendíková (2015) – 6 weeks,	3. Stanisic et al. (2014) – 2 mon./ 3 x,
4. Bendíková (2018) – 3 mon./ 3 x/ 12 min.	4. Kolooli et al. (2014) – 6 weeks./ 3 x.

The muscular and skeletal system, within the area of the foot, is tight pack of form/ function, while consisting of 26 bones and 19 muscles (Dungl 1988). Incorrect physiological loading, insufficient prevention, hygiene, etc., within the lower limb can cause various problems as are transmitted to the muscular and skeletal system, mainly in areas of the spine. And therefore, sensorimotor stimulation is used in a therapy of various functional and structural disorders of muscular and skeletal system. Its main purpose is to improve balance, incorrect body posture, postural stabilization, etc. That is the reason for choosing the Propriofoot Concept, which uses the sensorimotor activation of the foot to influence muscular and skeletal system (Palaščáková, Špringrová 2017). The aim of the study was to identify the change of body posture in elementary school pupil by applying Propriofoot Concept in PaSE.

Methods

Subjects

In accordance with the aim of the study, the monitored group (n = 1), of selected Elementary School Radovan Kaufman in Partizánske, as was chosen on purpose (foot/ spine deformities), consisted of male pupil (n = 1) (12 years of age, 48 kg, 160 cm and 18.75 Bmi) in

pubescence who was without any health problems. The primary characteristics of the monitored group (n = 1) is presented in table 1.

Table 1

The primary characteristics of monitored group (n = 1)

Measured values	Monitored group
Age [years]	12
Body weight [kg]	48
Body height [m]	160
Body mass index [kg/m^2]	18.75

Study design

The research was realized within interval of 18 February 2019/29 March 2019. The physical program of Propriofoot Concept (Baicry, Paris 2017) was realized 6 weeks/ 2 x/ 12 minutes, at the end of lessons of PaSE (Tuesday and Thursday). The monitored group (n = 1) proceed according to recommendations of Propriofoot Concept (20 exercises/ from the easiest to the most difficult). The research consisted of three stages:

1. Input testing and case history - data acquisition methods (19 February 2019),
2. Realization of physical program - Propriofoot Concept (18 February 2019/ 29 March 2019),
3. Output testing - data acquisition methods (29 March 2019).

The introduction was based on the method of studying literary sources, especially of foreign literature - English. The characteristics of the monitored group (n = 1) were done by method of somatometry and observation (aspection) was used in plantogram and visual scale methods (Kapandji 1985; Dungl 1988). The last method of evaluation foot arch is the index method, which is based on evaluation of the previous plantogram by equation (if i < 1.6 - Good foot arch, i > 1.7 - Flat foot) (Srdečný 1982; Bendíková 2011):

i = Width x 10/ Length

While using the method of the evaluation body posture, we used standardized method, typical for clinical and PaSE practice - Klein and Thomas modified by Mayer, which is based on the following (Vojtaššák 2000):

The body components (I. - V.), to which are given points (1 - 4), are according to quality of body posture. The overall body posture is expressed by total points and quality levels (A - D):

I. Head and neck posture,

II. Shape of chest,

III. Shape of abdomen and pelvis inclination,

IV. Overall curvature of spine,

V. Height of shoulders and scapulae position.

Classification of postures:

A.	Correct posture	5 points,
B.	Good posture	6 – 10 points,
C.	Bad posture	11 – 15 points,
D.	Incorrect posture	16 – 20 points.

The last data acquisition method was method of evaluation dynamic spine function. It is also standardized method, typical for clinical and PaSE practice, which consists of following tests (the underlined tests were used) (Labudová & Vajcziková 2009):

1. Thomayer's test,
2. Schober's test,
3. Stibor's test,
4. Otto's test,
5. Test of lateroflexion.

Schober's test (lumbar spine)

Description: The 5th lumbar vertebra is marked up by 10 cm.

Norm: While bending forward the distance increases by 4 – 6 cm.

Decreased flexibility: If it is less than the norm.

Stibor's test (lumbar and thoracic spine)

Description: Measuring the distance from the 7th cervical vertebra to the 5th lumbar vertebra.

Norm: While bending forward the distance increases by 7.5 – 10 cm.

Decreased flexibility: If it is less than the norm.

Otto's test (thoracic spine)

Description: The 1st thoracic vertebra is marked down by 30 cm.

Norm: While bending forward the distance increases by 2 – 3 cm. While leaning backward the distance decreases by 2.5 – 3 cm, as the sum of variation should be 6 cm.

Decreased flexibility: If it is less than the norm.

Analysis and synthesis, inductive and deductive approaches, comparisons and generalizations were used, while within the primary statistics were used arithmetic mean (±) and percentage frequency analysis (%). Not to mentioned clinical case report.

Results and discussion

Based on the aim and below presented results, which are subject to accurate monitoring and processing, they cannot be generalized, but it is necessary to understand them in the overall context, in relation to health, through the prism of the muscular and skeletal system, namely in areas of spine and foot.

Clinical case report

Family case history - Parents actively played and have played sports (father/ soccer, mother/ handball). Sibling played and has played sports (brother/ soccer, sister/ handball).

Personal case history – Common childhood illnesses; without any broken bone, sprain muscle or surgeries.

Social case history – Lives in flat with parents and siblings (both of them study at universities) and has dog.

Physical case history – The seventh year of Elementary School R. Kaufman in Partizánske.

Sport case history – Playing occasional sports, more devoted to studying, dominant lower limb is right (does not smoke or drink).

Plantogram and visual scale methods

One of the easiest ways, in clinical and PaSE practice, to evaluate the foot arch is by using the method of observation (aspection). It was done by using the plantogram method, which was compared within the visual scale method, according to Srdečný (1982) and Kapandji (1985). The results of input and output testing of the obtained plantogram of the monitored group (n = 1) pointed to positive changes. Within Srdečný (1982) the male pupil moved from pes planus to norm and within Kapandji (1985) the change was recorded from the 1st pes planus to norm, as well (table 2).

Table 2

The results of plantogram and visual scale method of monitored group (n = 1)

Evaluation methods/ Measured values	Srdečný (1982)	Kapandji (1985)
Input testing	Pes planus	1st pes planus
Output testing	Norm	Norm

Index method

Even though, the plantogram method has been already used, its usage is within index method, as well. After applying the physical program of Propriofoot Concept, the values (length and width) of input and output testing changed. The six-week intervention positively changed

the foot arch, as the equation results moved from 1.82 (flat foot) to 1.58 (norm/ good foot arch). Not only the observation (aspection), but now the index method showed the positive results of applying the physical program of Propriofoot Concept in lessons of PaSE (table 3).

Table 3

The results of index method of monitored group (n = 1)

Evaluation method/ Measured values	Index method
Input testing	1.82
Output testing	1.58
Difference	0.24

Method of evaluation body posture (Klein and Thomas modified by Mayer)

After applying all of the methods of evaluation foot arch, we move from areas of lower limbs to spine. The first method of the evaluation body posture is very common within clinical and PaSE practice, mainly because of its character (observation/ aspection). The body posture is expressed by total points and quality level, in which the initial body posture was recorded as bad posture, but after applying the Propriofoot Concept, it has changed to good posture. By using the values of points, it has decreased from input testing of 12 to output testing of 10 (table 4).

In terms of the body components, the most affected were shape of abdomen and pelvis inclination and height of shoulders and scapulae position. Both of them were recorded in the input testing with mark 3, however the six-week physical program changed it in output testing to 2. By the way, the listed areas of body components are the most frequent within the children and youth (Kanásová, 2004; Bendíková, 2011, 2013). The other body components did not change, as they obtained the same mark 2 (table 4).

Table 4

The results of method of evaluation body posture of monitored group (n = 1)

Measured values/ Evaluation method	Input testing	Output testing
I.	2	2
II.	2	2
III.	3	2
IV.	2	2
V.	3	2
Total	12	10

Legend: I. Head and neck posture, II. Shape of chest, III. Shape of abdomen and pelvis inclination, IV. Overall curvature of spine, V. Height of shoulders and scapulae position.

Method of evaluation dynamic spine function

Not only the last method of evaluation the areas of spine, but the overall method of research is the method of evaluation dynamic spine function, which originally consists of five tests, but according to various studies of applying the Propriofoot Concept, the most visible changes are in Schober's test, Stibor's test, and Otto's test.

While bending forward in the Schober's test, the 5th lumbar vertebra marked up by 10 cm was changing from initial values of 12.5 cm (input testing) to 14.3 cm (output testing). Therefore, the intervention of physical program caused positive changes within the listed test. Measuring the distance from the 7th cervical vertebra to the 5th lumbar vertebra was realized in the Stibor's test, in which were recorded positive changes as well. The values of input testing increased from 25.6 cm to values of output testing of 33.2 cm. Because of its difference of the 7.6 cm, it is marked as positive change.

The last test within the method of evaluation dynamic spine function is the Otto's test, which consists of movements bending forward and leaning backward. While the 1st thoracic vertebra is marked down by 30 cm, the initial values were up by 1.4 cm and output values were up by 2.1 cm. Increasing of values was recorded in leaning backward as well. There was shift from 2.1 cm to 2.9 cm, therefore after counting it together, we may conclude that positive chance was recorded, as well as in all of the previous data acquisition methods. It was mainly done by applying the physical program of Propriofoot Concept, within the monitored group (n = 1) in the lessons of PaSE (table 5).

Table 5

The results of method of dynamic spine function of monitored group (n = 1)

Evaluation methods/Measured values	Schober's test	Stibor's test	Otto's test
Input testing	12.5	30.2	31.4/ 32.1
Output testing	14.3	33.3	32.1/ 32.9
Difference	1.8	3.1	.7/ .8

Legend: All of the values are in centimetres.

Conclusion

The aim of the study was to identify the change of body posture in elementary school pupil by applying Propriofoot Concept in PaSE. Before we answer whether the aim of the study was reached, it is needed to stress that passive non-attendance of lessons of PaSE, for the variety of objective and subjective reasons affects health of school population. The lack of physical activity is therefore transformed into the muscular and skeletal system and its formation of the

vertebrogenic disorders, which has had gradual tendency, within the listed school population (Kanásová, 2004; Marko, Bendíková, 2018).

The aim of the study was reached, as positive changes occurred, within the monitored group (n = 1), in all of the data acquisition methods. The observations methods, such as plantogram and visual scale methods, pointed it without any counting or measuring the foot arch therefore it is easily applicable in lessons of PaSE. The index method (foot arch) and methods of body posture and evaluation of dynamic spine function (spine) showed the positive changes as well, therefore the applied six-week physical program of the Propriofoot Concept changed the body posture in elementary school pupil (n = 1).

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References

1. AHMAD, I. & N. AKHAR, 2014. Comparison of Effect of Weight-Bearing and Non-Weight-Bearing Exercise on Gait parameters in Flexible Flatfoot Children. *International Journal of Orthopaedics and Physiotherapy*.
2. ANTALA, B. 2009. *Telesná a športová výchova v základných a stredných školách v SR po prvom roku transformácie vzdelávania*. [online]. 2009 [cited 14.12.2018]. Available at: < https://boo ks.google.sk/books?id=w->.
3. ARYA, R., 2014. Low Back Pain. *Journal, Indian Academy of Clinical Medicine*.
4. AZABAGIC, S. et al., 2016. Epidemiology of Musculoskeletal Disorders in Primary School Children in Bosnia and Herzegovina. *Materia Socio-Medica*.
5. BAICRY, J. & L. PARIS, 2017. Propriofoot. [online]. [cited 14.12.2018]. Available at: <http://www. propriofoot.com/proprioception-cheville/home.html>.
6. BALÁŽOVÁ, D., 2014. Športové drevá? Kotúľ trénujú žiaci aj dva mesiace. *Pravda*.
7. BENDÍKOVÁ, E. & K. STACHO, 2010. Vplyv kompenzačných cvičení na rozvoj pohyblivosti chrbtice u žiakov II. stupňa ZŠ. *Studia kinantropologica*.
8. BENDÍKOVÁ E., 2011. *Oporný, pohybový systém, jeho funkcia, diagnostika a prevencia porúch*. Banská Bystrica: Univerzita Mateja Bela v Banskej Bystrici.
9. BENDÍKOVÁ, E., 2012. *Oslabený oporný a pohybový systém žien a jeho úprava pohybovým programom*. Banská Bystrica: Fakulta humanitných vied, Univerzita Mateja Bela v Banskej Bystrici.

10. BENDÍKOVÁ, E., 2013. Držanie tela žiakov mladšieho školského veku. *Aktuálne problémy telesnej výchovy a športu II*.
11. BENDÍKOVÁ, E. et al., 2015. The Influence of Exercise Program on the Muscular System of Female Pupils in the Lessons of Physical Education and Sport. *Sport Science*.
12. BENDÍKOVÁ, E., 2016. The Changes in Posture of Students Due to Equipment-aided Exercise Programs Applied in Physical and Sport Education. *Journal of Physical Education and Sport*.
13. BENDÍKOVÁ, E. & B. DOBAY, 2017. Physical and Sport Education as Tool for Development of a Positive Attitude Toward Health and Physical Activity in Adulthood. *European Journal of Contemporary Education*.
14. BENDÍKOVÁ, E., M. MARKO & L. ŠMÍDA, 2018. Influence of Change in Content of Physical and Sport Education as Case Study on Level of Dynamic Function of Spine among Secondary School Female Students. *European Journal of Contemporary Education*.
15. BENDÍKOVÁ, E. et al., 2018. Effect of Applied Health-oriented Exercises in Physical and Sport Education on Musculoskeletal System of Female Students. *Acta Facultatis Educationis Physicae Universitatis Comenianae*.
16. BOREHAM, C. & C. RIDDOCH, 2001. The Physical Activity, Fitness and Health of Children. *Journal of Sports Sciences*.
17. CIBULKA, M., 1999. Low Back Pain and Relation to the Hip and Foot. *Journal of Orthopaedic and Sports Physical Therapy*.
18. DUNGL, P., 1988. *Ortopedie a traumatology nohy*. Praha: Avicenum.
19. FERREIRA, G. et al., 2011. Prevalence and Associated Factors of Back Pain in Adults from the Southern Brazil. *Brazilian Journal of Physical Therapy*.
20. FLEMING, J. et al., 2011. Epidemiology of Back Pain in Older Adults. *Rheumatology*.
21. GHENO, R. et al., 2012. Musculoskeletal Disorders in the Elderly. *Journal of Clinical Imaging Science*.
22. HAGEDORN, J. et al., 2013. Foot Disorders, Foot Posture and Foot Function. *Plos One*.
23. HAND, B., 1964. *The Effect of a Corrective Exercise Program on Ninth Grade Boys with Foot Deviations.* Ellensburg: Central Washington University.
24. HARRIS, S., 2015. One in Three Primary Pupils' Hate Exercise. *Daily Mail*.
25. HOUGHTON, K., 2008. Review for the Generalist. *Pediatric Rheumatology Online Journal*.
26. JORGIĆ, B. et al., 2015. Effects of Exercise Program on Pes Planus in Children under 18 Years of Age. *Acta Kinesiologica*.

27. KANÁSOVÁ, J., 2004. *Funkčné svalové poruchy u 10 - 12 ročných žiakov a ich ovplyvnenie v rámci školskej telesnej výchovy.* Bratislava : Fakulta telesnej výchovy a športu v Bratislave.
28. KAPANDJI, A., 1985. *The Psychology of Joint*. London : Churchill Livingstone.
29. KOLOOLI, M. et al., 2014. Effects of an 8-Week Corrective Exercise Program on the Navicular Height of Teens with Flat Feet. *Asian Journal of Multidisciplinary Studies*.
30. KRČMÁRIK, R., 2012. Hodina telocviku nepribudne, aj keď ho treba. *Pravda*.
31. LABUDOVÁ, J. & S. VAJCZIKOVÁ, 2009. *Športová činnosť pri poruchách orgánov opory a pohybu*. Bratislava : Slovenský zväz rekreačnej telesnej výchovy a športu.
32. LEVEILLE S., 1998. Foot Pain, Disability in Older Women. *American Journal of Epidemiology*.
33. MALANGA, G. & J. RAMIREZ, 2008. Common Injuries of Foot and Ankle in the Childhood and Adolescent Athlete. *Physical Medicine and Rehabilitation Clinics of North America*.
34. MARKO, M. & E. BENDÍKOVÁ, 2018. *Level Changes of Musculoskeletal System in High School Female Students by Physical Program within the Physical and Sport Education*. Istanbul : Marmara University.
35. MENZ, H., 2013. Foot Pain, Mobility Limitations in Older Adults. *The Journal of Gerontology*.
36. MITOVA, S., 2015. Frequency and Prevalence of Postural Disorders and Spinal Deformities in Children of Primary School Age. *Research in Kinesiology*.
37. MULLIGAN, E. & P. COOK, 2013. Effect on the Plantar Intrinsic Muscle Training on the Medial Longitudinal Arch Morphology and Dynamic Function. *Manual Therapy*.
38. NOLL, M. et al., 2016. Back Pain Prevalence and Associated Factors in Children. *Revista de Saúde Pública*.
39. O'McKEON, P., 2015. Foot Core System. *British Medical Journal*.
40. PALAŠČÁKOVÁ ŠPRINGROVÁ, I., 2017. *Studijní materiál pro kurz Propriofoot Concept*. Čelákovice: Rehaspring Centrum.
41. RICCIO, I. et al., 2009. Rehabilitative Treatment in Flexible Flatfoot. *Journal of Musculoskelet Surg*.
42. ROTHERMEL, A., 2004. Effect of Active Foot Positioning on the Outcome of Balance Training Program. *Physical Therapy in Sport*.
43. SRDEČNÝ, V., 1982. *Tělesná výchova zdravotně oslabených.* Praha : Spn.
44. SINGH, V. et al., 2014. Epidemiology of Low Back Pain. *Neuromodulation*.

45. SMOLEŇÁKOVÁ, N. & E. BENDÍKOVÁ, 2017. Effect of the Content Standard for Changing the Level of Knowledge of Secondary School Students. *Journal of Physical Education and Sport*.
46. STANISIC, R. et al., 2014. Posturalni status nogu i svoda stopala kod dece predškolskog uzrasta i efekti korektivnog vežbanja u okviru usmerenih aktivnosti. *Sinteze*.
47. VOJTAŠŠÁK, J., 2000. *Ortopédia*. Bratislava : Slovak Academic Press.
48. ZRNZEVIĆ, N. & R. ARSIĆ, 2013. The Motivation of Students for Physical Education Classes. *Activities in Physical Education and Sports*.

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THE EFFECTS OF A 6-WEEK STRENGTH AND ENDURANCE CIRCUIT TRAINING ON BODY IMAGE OF HIGH SCHOOL GIRLS

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Summary: The aim of this study was to extend the knowledge about the influence of strength and endurance circuit training intervention on body image of the female high school students. Our hypothesis was: The objectively and subjectively measured body image among the 16 – 17 years old females will be significantly improved after the participation in 6-week strength and endurance circuit training. We used experiment with 2 groups from 2nd class from the secondary school: experimental (intervention) group consists of 15 female students ($\bar{x}_{age}$ = 16.99 ± 0.29 years) and control group consists of 20 female students ($\bar{x}_{age}$ = 17.11 ± 0.36 years). The experimental factor was the strength and endurance circuit training, practicing during 6 weeks (twice a week), performed during the physical education lessons. The body image of the girl was measured using 2 methods: the objective one was the somatometry (body height, body weight and Body Mass Index), subjective measurements of the body image were the Silhouettes – Contour Drawing Rating Scale (Thomson & Gray 1995). After these 6 weeks we succeeded in every measurement of the body image – the significant effect was noticed in the experimental group in pre- and post-test on Body Mass Index (p = 0,003) and on Contour Drawing Rating Scale (p = 0,003). According to the received knowledge we suggest to integrate this movement program to the lessons of the physical and sport education for the female adolescents.

Keywords: body image, high school female students, strength and endurance, circuit training

Introduction

Body image, which has been studied for over a century, was defined as a multifactorial construct consisting of affective, cognitive, perceptual, and behavioral components (Cash and Pruzinsky 2002; Cash 2011). It reflects how individuals think, feel, see, and act toward their

bodies (Cash 2004). Tylka and Wood-Barcalow (2015) defined positive body image as the love, respect, and acceptance that people have for their bodies. Despite many components of body image, the researchers tend to investigate only its negative or pathological aspects. Statistics revealed that poor body image is associated with low self-esteem, which is believed to cause the anxiety and depression; moreover, it can play a significant role in the eating disorder etiology (Polivy and Herman 2002). Many researches revealed a positive impact of physical activity on children´s as well as adult´s, especially on female´s body image (Duncan 2009; Campbell and Hausenblas 2009). The relation between the exercise and body image is complex and as Williams and Cash (2001) noted, there is a need to do the research concerning the role of regular exercise on the body image. The aim of the study was to extend the knowledge about the influence of strength and endurance circuit training on the body image of 16-17-years-old females. Our hypothesis was: The objectively and subjectively measured body image among the 16-17-years-old females will be significantly improved after the participation in 6-week strength and endurance circuit training. And our task: To recognize and to compare pre- and post-test of objectively and subjectively measured body image of 16-17-years-old females in a given experimental and control group.

Methods

Subjects

Experimental (intervention) group: 15 female students from 2nd grade ($\bar{x}_{age}$ = 16.99 ± 0.29 years, $\bar{x}_{height}$ = 167.73 ± 6.66 cm, $\bar{x}_{weight}$ = 58.10 ± 6.78 kg) of Ladislav Novomeský secondary school in Bratislava. Before the beginning of our study, we informed every girl and their parents about the main information concerning the aim, procedure and the conditions of the realization of our study.

The participants had to follow these two instructions to stay in a given experimental group:

1. to take part in 10 from 12 physical education lessons of strength and endurance circuit training,
2. to take part in providing the pre-test and post-test information.

Control group: 20 female students from 2nd grade ($\bar{x}_{age}$ = 17.11 ± 0.36 years, $\bar{x}_{height}$ = 169.80 ± 5.01 cm, $\bar{x}_{weight}$ = 59.50 ± 6.78 kg) of Ladislav Novomeský secondary school in Bratislava, which had only standard lessons of physical education and take part in a providing the pre-test and post-test information.

Study design

Firstly, we applied the pre-test on experimental and control group, which consisted of:

1. Objective indicator of body image – using the somatometry:
   a) body height – it was measured by height measurement on the wall and on the floor. Our girls did not wear the shoes, stood with their feet together in front of the wall, they had to be with their head, back, buttock and heels right close to the wall and look straight ahead. The body height was then the distance between floor and vertex (highest point on cranium) – we measured to the nearest 0.5 cm;
   b) body weight – we measured with the digital scale on the floor. They had to stay in the centre of the digital scale and we measured to the nearest 0.5 kg;
   c) weight status – Body mass index – was determined as kg/m^2 – the body weight divided by the square of the body height.
2. Subjective indicator of body image – measured using the Silhouettes:
   a) Contour Drawing Rating Scale (CDRS) from Thomson & Gray (1995) (Figure 1) – consisted of 9 silhouettes ranging from thin to fat. Every girl chose one silhouette in two steps: first of all, she was supposed to choose the most similar silhouette to their actual figure and in the second step to choose the silhouette that she would like to look like (ideal silhouette). After the choices were made, we calculated degree of dissatisfaction with body of every single girl, which provide us the difference between actual figure and ideal figure.

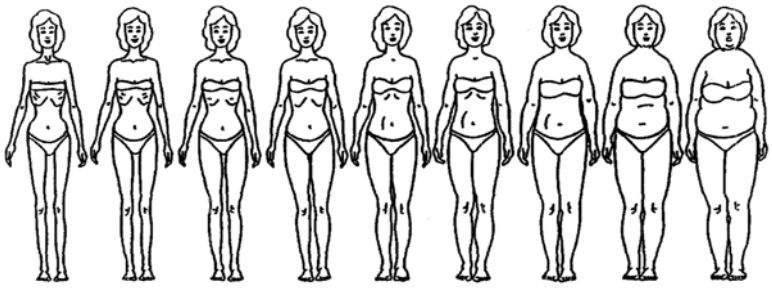

Figure 1

Countour Drawing Rating Scale (CDRS) (Thomson & Gray 1995)

Secondly, the experimental group participated in 6-week strength and endurance circuit training during the physical education lessons. Every lesson with the intervention program was performed twice a week for the next 6 weeks, lasted 45 min and consisted of the following parts:

1. warm up (5 – 12 min),

2. strength and endurance circuit training (20 – 35 min) – we used 8 – 12 numbers of exercises, 3 circles, while the duration of every exercise in the circles was 30 seconds, the recovery cycle between the two exercises was 15 seconds, the recovery cycle between the two circles was 2 min,
3. cool down (3 – 10 min).

The control group had only the regular lessons of physical education and sport. The third step was to apply the post-tests on the experimental and control group which included methods of objective and subjective body image.

Statistical analysis

In our study we used comparative analysis as an experimental method focused on the clarification of the issues related to our topic. During the procession of the results, we used the basic descriptive characteristics such as: the arithmetic mean, the extent of variation, variance and standard deviation. We used the Wilcoxon T-test to compare the pre- and post-test measurements in each group. The Mann-Whitney U test was used to reveal the statistically significant differences in changes among our experimental and control group.

Results

The integration of the strength and endurance circuit training into lessons of physical education has proved to be a good choice. The average BMI of the experimental group decreased and they were less dissatisfied with their bodies.

Objective indicator of body image – body mass index

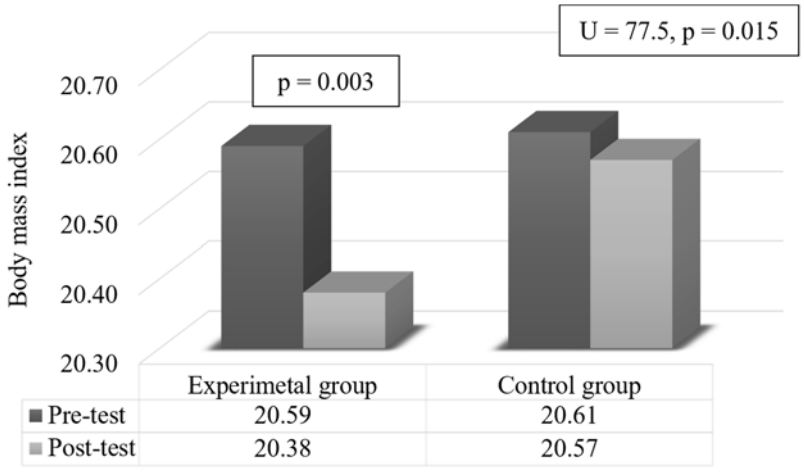

Figure 2
Pre-test and post-test of Body mass index

In the pre-test measurement of the experimental group was the average BMI 20.59 ± 1.97, in post-test measurement the average of BMI has decreased on 20.38 ± 1.91 (Figure 2), while the average body height stays the same (166.73 ± 6.67 cm), the average body weight has decreased from 58.10 ± 6.78 kg to 57.53 ± 6.76 kg. From 15 female students, 13 have decreased their BMI, no one had the same BMI and 2 increased Body mass index (the same effect was with body weight). The minimal value of BMI has decreased from 17.1 (pre-test) to 16.9 (post-test) and maximum has decreased too, from 32.1 (pre-test) to 31.8 (post-test). The results of the Wilcoxon test revealed the significant effect on BMI in pre- and post-test measurements in the experimental group (Z = -3.010, p = 0.003).

The average BMI in the control group was in the pre-test 20.61 ± 1.87 (Figure 3), while the average body height was 169.80 ± 5.01 cm and the average body weight 59.50 ± 6.78 kg. After the six weeks the average BMI has decreased to 20.57 ± 1.86, the body height was the same like in the pre-test and the average body weight has decreased to 59.38 ± 6.67 kg. From 20 female students, 9 of them have decreased their BMI (maximal decrease was 0.5), 6 girls have their BMI increased and 5 students had the same value of BMI in the pre- and post-test measurements. The minimal value of BMI has increased from the value 17.7 to 17.9; the maximal value of BMI has increased too, from 24.2 to 24.6. The results of the Wilcoxon test revealed no significant changes in the BMI in the pre- and post-test measurements in the control group (Z = -1.319, p = 0.187).

Subjective indicator of body image – countour drawing rating scale

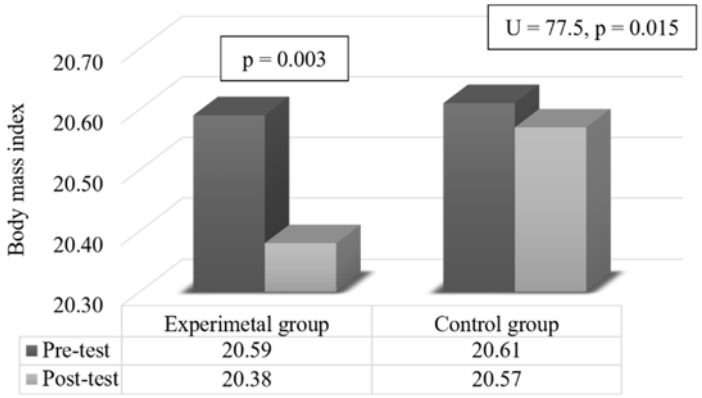

Figure 3

Pre-test and post-test of Contour Drawing Rating Scale

Before the application of our movement program, 16-17-years-old female students from the experimental group ranked their body dissatisfaction from 0 to 4 points (the highest possible 8), while the average was 1.67 ± 1.11 points. In the pre-test measurement the only one girl was

satisfied with her body, 10 girls found themselves fatter than their ideal figure and 4 girls found themselves slimmer than their ideal body. After the movement program, the body dissatisfaction was ranked from 0 to 4 points too, but we noticed the decrease of their average body dissatisfaction to 1.07 ± 1.28 points. 7 girls were satisfied with their body, 6 found themselves fatter and 2 found themselves slimmer than their ideal figure. The results of the Wilcoxon test revealed significant change in the Contour Drawing Rating Scale in pre- and post-test measurement in the experimental group ($Z = -3.000$, $p = 0.003$).

For the comparison of the changes during the 6-weeks, we used the control group that had only the regular lessons of physical education. After these 6-weeks, the control group has the same results in the pre- and post-test: the average body dissatisfaction was 1.70 ± 1.22 points. 16 girls found themselves fatter than their ideal silhouette, no one thought that she is slimmer and 4 girls were satisfied with their body. The results of the Wilcoxon test revealed no significant differences between the pre- and post-test in the control group ($Z = 0.000$, $p = 1.000$).

With these results we confirmed our hypothesis, because we found out that the statistically significant positive changes have occurred in BMI and the results of Contour Drawing Rating Scale among the experimental group.

Discussion

Accessible researches and studies have indicated contradictory outcomes. Some of them have reported a significant relationship between physical activity and body image (Burgess, Grogan & Burwitz 2006; Fountoulakis & Grogan 2014; Peráčková & Peráček 2016; Plevková, Peráčková, Pačesová, Kukurová & Mókušová 2018; Plevková 2019). Some have found no significant improvement of body image or no changes after physical activity intervention (Aşçi, Kin & Koşar 1998; Zabinski et al. 2001; Peráčková, Chovancová, Kukurová & Plevková 2018).

Especially in relation to women, more current studies report the positive impact of the physical activity on body image (Tucker & Maxwell 1992; Tucker & Mortell 1993; Williams & Cash 2001; Abbott & Barber 2011; Nayir et al. 2016; Peráčková & Peráček 2016; Plevková, Peráčková, Pačesová, Kukurová & Mókušová 2018; Plevková 2019). The study of Duncan et al. (2009) implied that, in contrast to the control group, participants in 6-week circuit training significantly improved body esteem scores in post intervention. In study of Southern (2014), circuit training participants decreased the waist circumference subcutaneous adipose tissue and that led to the better appearance.

Conclusion

Realization of the research was focused on the expansion of the knowledge about the influence of strength and endurance circuit training on the body image among the 16-17-years-old females. Time allocation of the experiment was six weeks, the frequency of the exercise was twice a week for 45 minutes within the lessons of physical and sport education. According to the results of the research and analysis we can say with regard to the hypothesis stated: We confirmed the hypothesis, which talked about the fact, that the participation in 6-week strength and endurance circuit training will significantly improve objective and subjective measurement of the body image among 16-17-years-old females. After the 6 weeks we succeeded in the objective and subjective measurements of body image – the significant change in the experimental group in pre- and post-test on BMI ($p = 0.003$) and on the Contour Drawing Rating Scale ($p = 0.003$). According to the received knowledge, we suggest to integrate this movement program to the lessons of physical and sport education for the adolescent girls.

ACKNOWLEDGEMENT

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References

1. ABBOTT, B., & B. BARBER, 2011. Differences in functional and aesthetic body image between sedentary girls and girls involved in sports and physical activity: Does sport type make a difference? In: *Psychology of Sport and Exercise.* **12**(3), pp333-342. doi: 10.1016/j.psychsport.2010.10.005.
2. AŞÇI, F. H., KIN, A., & N. S. KOŞAR, 1998. Effect of participation in an 8-week aerobic dance and step aerobics program on physical self-perception and body image satisfaction. In: *International Journal of Sport Psychology.* **29**(4), pp. 366-375.
3. BURGESS, G., S. GROGAN & L. BURWITZ, 2006. Effects of a 6-week aerobic dance intervention on body image and physical self-perceptions in adolescent girls. In: *Body Image.* **3**(1), pp. 57-66. doi: 10.1016/j.bodyim.2005.10.005.
4. CAMPBELL, A., & H. HAUSENBLAS, 2009. Effects of Exercise Interventions on Body Image. In: *Journal of Health Psychology.* **14**(6), pp. 780-793. doi: 10.1177/1359105309338977.

5. CASH, T. (2004). Body image: past, present, and future. In: *Body Image.* **1**(1), pp. 1-5. doi: 10.1016/s1740-1445(03)00011-1.
6. CASH, T. F., 2011. Cognitive-behavioral perspectives on body image. In T. F. CASH & L. SMOLAK (Eds.) *Body image: A handbook of science, practice, and prevention*. pp. 39-47. New York, NY: Guildford press.
7. CASH, T. F. & T. PRUZINSKY, (Eds.), 2002. Future challenges for body image theory, research, and clinical practice. In: T. F. CASH & L. SMOLAK (Eds.) *Body image: A handbook of theory, research, and clinical practice*. pp. 509-516. New York, NY: Guildford press.
8. DUNCAN, M., Y. AL-NAKEEB & A. NEVILL, 2009. Effects of a 6-week circuit training intervention on body-esteem and Body Mass Index in British primary school children. In: *Body Image.* **6**(3), pp. 216-220. doi: 10.1016/j.bodyim.2009.04.003.
9. FOUNTOULAKIS, C. & S. GROGAN, 2004. An investigation of the links between body image and exercise participation. In: *Sport & Exercise Psychology Review.* **10**, pp. 19-30.
10. NAYIR, T., E. USKUN, M. V. YÜREKLI, H. DEVRAN, A. ÇELIK & R. A. OKYAY, 2016. Does Body Image Affect Quality of Life?: A Population Based Study. In: *PLoS ONE.* **11**(9), pp. 1–13. doi: 10.1371/journal.pone.0163290.
11. PERÁČKOVÁ, J. & P. PERÁČEK, 2016. Body Image športujúcich a nešportujúcich adolescentov. [Body Image of adolescent athletes and nonathletes.] In: PERÁČKOVÁ A KOL. *Telesné sebaponímanie školskej športujúcej a nešportujúcej populácie. [Physical body self-perception of school athletes and nonathletes population.]* pp. 6-136. Bratislava, Slovakia: Comenius University in Bratislava. ISBN 978-80-223-4244-5.
12. PERÁČKOVÁ, J., A. CHOVANCOVÁ, K. KUKUROVÁ & L. PLEVKOVÁ, 2018. Self-evaluation of body image in sport active and sport inactive adolescent girls. In: *Acta Gymnica.* **48**(3), pp. 109-114.doi: 10.5507/ag.2018.014.
13. PLEVKOVÁ, L., 2019. *Vplyv diferencovaných pohybových programov na motorickú výkonnosť a body image mladších a starších žiačok. [The Influence of differentiated motion programs on motor performance and body image of younger and older female pupils.]* Bratislava. Comenius University in Bratislava. Dissertation. Faculty of Physical Education and Sports, Department of Sport Sciences in Educology and Humanities.
14. PLEVKOVÁ, L., J. PERÁČKOVÁ, P. PAČESOVÁ, K. KUKUROVÁ & O. MÓKUŠOVÁ, 2018. The effect of 6-week strength and endurance circuit training intervention on body image in Slovak primary school girls. In: *Journal of Physical*

education and Sport. **11** Supplement issue 1, Art 64, pp. 459-464. Doi: 10.7752/jpes.2018.s164.

15. POLIVY, J., & C. HERMAN, 2002. Causes of Eating Disorders. In: *Annual Review of Psychology*. **53**(1), pp. 187-213. doi: 10.1146/annurev.psych.53.100901.135103.
16. SOTHERN, M., 2014. *Safe and effective exercise for overweight youth*. Boca Raton: CRC Press, Tylor&Francis Group.
17. THOMPSON, M. & J. GRAY, 1995. Development and Validation of a New Body-Image Assessment Scale. In: *Journal of Personality Assessment.* **64**(2), pp. 258-269. doi: 10.1207/s15327752jpa6402_6.
18. TUCKER, L., & K. MAXWELL, 1992. Effects of Weight Training on the Emotional Well-Being and Body Image of Females: Predictors of Greatest Benefit. In: *American Journal of Health Promotion.* **6**(5), pp. 338-371. doi: 10.4278/0890-1171-6.5.338.
19. TUCKER, L. & R. MORTELL, 1993. Comparison of the Effects of Walking and Weight Training Programs on Body Image in Middle-Aged Women: An Experimental Study. In: *American Journal of Health Promotion.* **8**(1), pp. 34-42. doi: 10.4278/0890-1171-8.1.34.
20. TYLKA, T. & N. WOOD-BARCALOW, 2015. What is and what is not positive body image? Conceptual foundations and construct definition. In: *Body Image*. **14**, pp. 118-129. doi: 10.1016/j.bodyim.2015.04.001.
21. WILLIAMS, P. & T. CASH, 2001. Effects of a circuit weight training program on the body images of college students. In: *International Journal of Eating Disorders.* **30**(1), pp. 75-82. doi: 10.1002/eat.1056.
22. ZABINSKI, M., K. CALFAS, C. GEHRMAN, D. WILFLEY & J. SALLIS, 2001. Effects of a physical activity intervention on body image in university seniors: Project GRAD. In: *Annals of Behavioral Medicine.* **23**(4), pp. 247-252. doi:10.1207/s15324796abm2304_3.

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THE DEVELOPMENT OF THE PHYSIOLOGICAL ADJUSTMENT OF PHYSICAL LOADS AND ITS IMPACT ON THE CIRCULATORY SYSTEM AND THE SKILLS OF FOOTBALL PLAYERS

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Summary. This research was focused on the important question, what is the effect of the development of physiological adjustment of the physical load on the respiratory system and the performance of the skills of football players. In addition we tried to comfirm the relationship between the physical qualities and the performance of the skills. We have applied the experimental approach which best suits to this type of question. Proposing a program based on the physiological adjustment of the respiratory system, we applied the approach to a sample of twenty players (table 3), which were a deliberate sample divided into experimental and control, during the general physical preparation.The results confirmed that there are statistically significant differences between the pre-test and post-test of the experimental sample in both the respiratory system tests and the functional performance tests, in addition to statistical differences between the control and experimental groupe in the post-test.

Keywords: physiological adjustment, physical loads, respiratory system, skill performance.

Introduction

The modern requirements in the game of football have created the great need for the players to undergo high physical preparation. Especially as the changes in the achievement of the ball is linked to the recent acceleration of defence and offence with a high level of force. We see the defender is actively contributing to the attack and the striker going back to defend his team, and if the player wants to maintain this high effort and his physical fitness through the game for (80) minutes.

Here is the importance of the endurance as one of the most important factors affecting the level of performance of players during the course of the game, a player with physical endurance below the level will face the largest debt of oxygen, leading to slow the state of recovery and early fatigue and the consequent low level of skill (Joyner & Coyle 2008)

As football is classified as high-intensity as it can be observed during a competitive game of football, elite players run a distance ranging from 10-12 km in the medium intensity close to the anaerobic threshold with 80 – 90 % of the maximum frequency of the heart (Hfmax) or 70 – 80 % of the maximum consumption of oxygen (Vo2max .376). It is estimated that the aerobic metabolism provides 90% of the energy cost of the player in the football match. Therefore the modern game of the elite football players needs a high fitness endurance. (Pate & Kriska 1984) described a model of the three main factors that represent good athletes among athletes: the variance in aerobic performance, specifically Vo2max, the lactate threshold (LT) and the business economy (C), with many studies supporting this when studying features football players (MacDonald & Hawley 2012).

The purpose of performing aerobic exercise regularly is to significantly improve the ability to exercise as the development depends on the peak in the performance of the exercise, as it is clear according to the athletes endurance, including the physiological adjustments associated with these improvements in each of the exercise performance with maximum effort, Oxygen Absorption Rate ($\dot{V}O2max$), and stamina in exercise, with increases in both cardiovascular function and structural muscle oxidation capacity. Despite long periods of aerobic training, reductions in exercise performance occur at maximum and below extremes within week after the cessation of training. These loss of exercise performance coincides with a decrease in cardiovascular function and metabolic potential (Joyner & Coyle 2008). Significant reductions in $\dot{V}O2max$ were reported within two weeks to four weeks of discontinuation. This initial rapid decline in $\dot{V}O2max$ is probably associated with a similar reduction in maximal cardiac output, which appears to be caused by a decrease in movement size with little or no change in maximum heart rate (Neufer 1989). Therefore, the respiratory system is one of the most important devices that help the players to cope with this physical effort through the functional efficiency of this device, which is responsible for saturation of the body's cells in sufficient quantities of inhaled oxygen and energy production materials and then supply to the muscles after oxidation and disposal of CO2 and waste from the process of oxidation (Mazic 2015). Therefore the process of breathing and utilization of it is of paramount importance (Mazic et al. 2015). The recognition of the abilities and capabilities of skilled athletes is an important necessity in the field of sports which aims to reach the best possible

level. Through the application of scientific theories of physiology and sports training, which is based mainly on the events of the effects and positive changes in the functional organs, including the respiratory system and periodic work, the length of competition in football requires coaches and players to pay attention to durability as one of the most important elements of fitness. It plays a central role in the level of performance of players during the game. Hence the interest of trainers training at the beginning of the season is focused on the evaluation of physical tests used by instructors during the training units (Joyner & Coyle 2008). From this we want to know the effect of the development of the physiological adjustment of the training loads on the respiratory system and the performance of the skilled football players

Methodology

We used the experimental method to suit the nature of the study. **Sample of the research**: 20 players (U17 years) from a team in the second amateur national division has been divided into two groups: experimental group of 10 players and control group (10 players). **Training program**: After standardizing the characteristics of the sample and isolating the most confused variables that would affect the final results of the basic study, the training program was applied to the experimental group during the period devoted to the general physical preparation, programmed by the instructor where the focus was on the development of the functional efficiency of the respiratory system and learning skill performance. Accordingly, the training program included the following:

1 - Mesocycle general physical preparation period PPG
2 - Microcycle from the annual program followed by the trainer
3 - 36 training modules from 15/08/2017 to 15/09/2017

Since the sample was divided into experimental and control groups, the training program was applied to the experimental group while the sample was still trained according to the program led by the coach.

Search Tools: For the examination we chose from a number of tests dealing with the physical and skill aspects that can be applied to the sample members.

Physical and technical tests: Cooper Test, Harvard Stop Test, Physical Fitness Test PWC170, Test of The Accuracy of the Scrolling, Test the Power of Long Scrolling, Dribble Test l.

The training program. After consolidating the characteristics of the sample and isolating most of the confused variables that would affect the final results of the basic study, the training program was applied to the sample during the period of general physical preparation programmed by the trainer. Learned performance skill and the training program contains the following: the results since the sample is divided into two experimental and control sections, the training program was applied to the experimental sample while the sample was trained according to the program drawn by the trainer. The training modules were scheduled in time (Table 1).

Table 1

Content of weekly microcycle

Days	***SAT***	***SUN***	***MON***	***TUE***	***WED***	***THU***	***FRI***
First Training	Rest	Physical training	Physical training skills	Physical training	Physical training	Physical training skills	Friendly match
Second Training		Skills Training		Skills Training	Skills Training		

Table 2

Validity of physical and technical tests

Transactions / Tests		Validity	Reliability
Physical	Hardvard step test	0,87	0.93
	PWC170 Cycle Test	0,89	0.94
	Cooper test	0,81	0.90
Technical	Scroll accuracy	0,82	0.90
	Long scroll power	0,79	0.89
	Dribble Test	0,76	0.87

Level of significance = (0.05) - Table T = (0.60)

Table 3

Homogeneity of the study sample

Variable	**Control group**		**Experimental group**		**Test Levine forhomogeneity**		
	X'	**Y**	**X'**	**Y**	**F**	**Sig**	**Result**
Age (y)	16.60	0.51	16.70	0.48	**0.750**	0.39	homogeneous
Height (cm)	167.80	7.55	169.40	4.76	**0.587**	0.45	homogeneous
Weight (kg)	68.50	2.22	68.40	3.65	**2.362**	0.14	homogeneous
The training age (y)	6.60	0.51	6.60	0.51	**0.000**	1.00	homogeneous
box	68.46	3.80	62.05	3.24	**0.014**	0.90	homogeneous
PWC170 Cycle Test	2638.4	103.07	2528.07	416.70	**2.048**	0.16	homogeneous
Scroll accuracy	4.30	1.15	4.20	0.91	**1.204**	0.28	homogeneous
long scrolling force	6.90	0.73	7.10	0.99	**0.666**	0.42	homogeneous
Dribble Test (s)	23.80	1.13	24.80	1.75	**2.633**	0.12	homogeneous
Test cooper (12m)	2568.0	235.69	2460.0	238.51	**0.013**	0.91	homogeneous

The significance level is 0.05. N = 10

In the table showing the homogeneity of the sample, we note that the sample is homogenous, because the value of sig was greater than the value of (0.05).

Table 4 shows the results of the "T" test to indicate the differences between the mean scores of the respiratory system and the tribal and remote measurement of the two groups.

Table 4

The results of T-test for both respiratory system and performance

Test / Set		Type of test	arithmetic mean	standard deviation	degree of freedom	Value of "T"	Significance	value of Sig
Physiological tests For the	box	Before	62.05	3.24	09	4.01	Significant	0.00
		After	71.84	9.20				
	Test PWC170	Before	2528.07	416.70		7.37	Significant	0.00
		After	3386.13	207.45				
	Test Cooper	Before	2460.00	238.51		3.05	Significant	0.00
		After	2673.3	145.89				
Physiological tests Control group	box	Before	68.46	3.80	09	1.81	Note Significant	0.09
		After	70.75	3.27				
	Test PWC170	Before	2638.40	103.07		8.92	Significant	0.00
		After	3065.22	161.39				
	Test Cooper	Before	2568.00	235.69		0.42	No Significant	0.16
		After	2526.00	325.99				

Level of significance: 0.05 - n = 10 - Tabularity: 1.83

Table 5

Results of the "T" test to indicate the differences between the mean scores of the respiratory system and the skill performance of the two groups

Test / Set		Type of sample	arithmetic mean	standard deviation	degree of freedom	Value of "T"	Significance	value of Sig
Physiological tests For the pre-test	Box	Experimental	62.05	3.24	09	5.13	Significant	0.00
		Officer	68.46	3.80				
	Test PWC170	Experimental	2528.07	416.70		1.03	Not Signif	0.22
		Officer	2638.40	103.07				
	Cooper test	Experimental	2460.00	238.51		1.19	Not Signifi	0.10
		Officer	2568.00	235.69				
Technical tests For the pre-test	Scroll accuracy	Experimental	4.20	0.91	09	0.27	Not Signifi	0.14
		Officer	4.30	1.15				
	long scrolling force	Experimental	7.10	0.99		0.77	Not Signifi	0.11
		Officer	6.90	0.73				
	Dribble Test	Experimental	24.80	1.75		1.92	Significant	0.02
		Officer	23.80	1.13				

Level of significance: 0.05 - N = 10 - T tabular: 1.83

Table 6

Results of the "T" test to indicate differences between the two in the post-measurement of the control and experimental groups in the skill performance.

Test / Set		Type of sample	arithmetic mean	standard deviation	degree of freedom	Value of "T"	Significanc	value of Sig
Physiological tests For the pre-test	box	Experimental	71.84	9.20	09	0.45	Note Significant	0.66
		Officer	70.75	3.27				
	Test PWC170	Experimental	3386.13	207.45		4.88	Significant	0.00
		Officer	3065.22	161.39				
	Test Cooper	Experimental	2673.3	145.89		1.65	Note Significant	0.22
		Officer	2526.00	325.99				
Skills tests For the pre-test	Scroll accuracy	Experimental	6.70	0.67	09	3.76	Significant	0.01
		Officer	5.30	1.33				
	long scrolling force	Experimental	13.40	1.17		3.97	Significant	0.01
		Officer	11.70	1.25				
	Dribble Test	Experimental	20.70	0.67		3.51	Significant	0.01
		Officer	21.90	1.19				

The level of significance: 0.05 - n = 10 - Tabularity: 1.83

Table 7

The relationship between the performance of the skill and the circulatory system

Circulatory system / Performance skills	Scroll accuracy	Long scroll power	Football Interview
Box	0.71	0.69	0.81
Test PWC170	0.72	0.81	0.68
Cooper	0.78	0.73	0.75

T tabular = 0.60 N = 10

Discussion

The hypothesis that there are statistically significant differences in the variables of the respiratory circulatory system and the skill performance variables between the pre and post measurement of the experimental sample at the level of significance of '0.05' is achieved. These differences are in favor of the post-measurement. The results of this hypothesis can be explained that the differences recorded are 100 % of the sample of the study as indicated by the significance level in the table, because this stage is a preparatory phase, where we sre starting from the stage of zero. With the general preparation begins the development of the respiratory system and with the application of the special program for the experimental sample there were

clear differences and therefore the program has been the results of this experiment, especially in the experimental sample, where the focus was on the improving the functional efficiency of the players. As the study is concerned with improving the physiological adjustment of the circulatory system and the skill performance, it is the same. Ledebt et al. (2009) suggests that increasing of the physical intensity helps the rate of success of the correction, in addition to the high intensity training can improve the muscular system, especially if we know the role played by a muscles in performance skills (Watson, n.d. 2008).

The results of this hypothesis for the difference between the post-measurement of the experimental control groups showed that there were no statistically significant differences in the variables of the respiratory circulatory system and the skill performance between the control and experimental sample at the level of '0.05'. The researchers explained the absence of differences to the stage where the experiment is considered to be at the stage of general preparations for the football teams, where the normal prepartion for four weeks has given fruit and therefore there were no differences at the level of '0.05.' We may have mentioned earlier, perhaps due to lack of significance of differences in the test to the emphasis on the "Annabel," and "Hara" and "Buda" that the physiological adjustment is subject to the inherent factors and the quality of genes for each individual (Newton & May 2017). In terms of skill performance, the difference was statistically significant as described by the researchers in the interpretation of the first hypothesis and in the apartment of the skill performance.

It is clear from the results shown in Table 7 that there is a statistically significant correlation between the skill performance and the respiratory variables. The more the respiratory system develops, the higher the performance of the football players. When he is ready and physically prepared, he can perform the appropriate performance without any hindrance because the implementation of the technical movements remains dependent on the degree of physical readiness, which is in line with what he went for. This is confirmed by (Buchan et al. 2013; Di Paco 2014).

In addition, increasing physical fitness improves the skill performance because the skills are performed by parts of the body. These organs are subject to the state of the functional organs that control them. The improvement in the level of functional efficiency of breathing muscles reflects the improvement in the test capacity to meet the vital requirements of the body during the physical effort (Kerti, Balogh, Kelemen & Varga 2018).

Conclusions

1. The results of input and output measurements of the control group were for the benefit of telemetry in the measurements of the respiratory system and the performance of the skills.
2. There are statistically significant differences in the variables of the respiratory circulatory system between the pre and post measurement of the experimental sample at the level of significance of $p \leq 0.05$. These differences are in favor of telemetry.
3. There are statistically significant differences in the skill performance variables between the pre and post measurement of the experimental sample ($p \leq 0.05$) for the benefit of the post-measurement.
4. There are no statistically significant differences in the variables of the respiratory system in the post-measurement of the control and experimental sample ($p \leq 0.05$)
5. The circulatory system positively affects the performance of the skills, meaning that the more the evolution of the respiratory system increased, the more was the performance of the football players improved.

References

1. BARENE, S., P. KRUSTRUP, S. JACKMAN, O. L. BREKKE & A. HOLTERMANN, 2013. Do soccer and Zumba exercise improve fitness and indicators of health among female hospital employees? A 12-week RCT. *Scandinavian Journal of Medicine & Science in Sports.* ***24***. https://doi.org/10.1111/sms.12138
2. BUCHAN, D., S. OLLIS, J. YOUNG, S. M. COOPER, J. SHIELD & J. BAKER, 2013. High intensity interval running enhances measures of physical fitness but not metabolic measures of cardiovascular disease risk in healthy adolescents. *BMC Public Health.* ***13*** (498) https://doi.org/10.1186/1471-2458-13-498
3. Di PACO, A., G. A. CATAPANO, G. VAGHEGGINI, S. MAZZOLENI, M. L. MICHELI & N. AMBROSINO, 2014. Ventilatory response to exercise of elite soccer players. *Multidisciplinary Respiratory Medicine.* ***9***(1), 20. https://doi.org/10.1186/2049-6958-9-20
4. GREENWAY, F. L., 2015. Physiological adaptations to weight loss and factors favouring weight regain. *International Journal of Obesity.* ***39***(8), 1188-1196. https://doi.org/10.1038/ijo.2015.59
5. HAROLD W. KOHL, I. I. I., COOK, H. D., ENVIRONMENT, C. ON P. A. AND P. E. IN THE S., BOARD, F. AND N., & MEDICINE, I. of., 2013a. *Approaches to Physical Activity in Schools*. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK201495/

6. AROLD W. KOHL, I. I. I., COOK, H. D., ENVIRONMENT, C. ON P. A. AND P. E. IN THE S., BOARD, F. AND N., & MEDICINE, I. of., 2013b. *Physical Activity and Physical Education: Relationship to Growth, Development, and Health*. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK201497/
7. HUONKER, M., M. HALLE & J. KEUL, 1996. *Structural and Functional Adaptations of the Cardiovascular System by Training*. https://doi.org/10.1055/s-2007-972919
8. JOYNER, M. J., & E. F. COYLE, 2008. Endurance exercise performance: The physiology of champions. *The Journal of Physiology. 586*(Pt 1), 35-44. https://doi.org/10.1113/jphysiol.2007.143834
9. KERTI, M., Z. BALOGH, K. KELEMEN & J. T. VARGA, 2018. The relationship between exercise capacity and different functional markers in pulmonary rehabilitation for COPD. *International Journal of Chronic Obstructive Pulmonary Disease. **13***, 717-724. https://doi.org/10.2147/COPD.S153525
10. LEDEBT, A. (n.d.). *Developmental changes in temporal patterns during supported walking in infants*. Retrieved from https://www.academia.edu/18589806/Developmental_ changes_in_temporal_patterns_during_supported_walking_in_infants.
11. LEVINE, B. D., 2008. V̇O2,max: What do we know, and what do we still need to know? *The Journal of Physiology*, *586*(Pt 1), 25–34. https://doi.org/10.1113/jphysiol.2007.147629
12. MAZIC, S., B. LAZOVIC, M. DJELIC, J. SUZIC-LAZIC, S. DJORDJEVIC-SARANOVIC, T. DURMIC, … V. ZUGIC, 2015. Respiratory parameters in elite athletes – does sport have an influence? *Pulmonology. 21*(4), 192-197. https://doi.org/10.1016/j.rppnen.2014.12.003
13. MILOŠEVIĆ, B. M. & M. M. MILOŠEVIĆ, 2010. Physical preparation of elite athletes: *Standardization of management processes.* Belgrade, Serbia: APP.
14. MILOŠEVIĆ, M. B., V. NEMEC, P. NEMEC & M. M. MILOŠEVIĆ, 2017. Programming methodology and control of aerobic training by running. *Acta Kinesiologica. **11***(1), 53-57.
15. MILOSEVIC, M., M. MILOSEVIC, P. NEMEC, D. ZIVOTIC & R. IZET, 2014. A New Approach to Developing Human Maximal Muscular Force: A Case Study. *Journal of Exercise Physiology Online*.
16. MILOŠEVIĆ, M., M. MUDRIĆ, R. MUDRIĆ & M. MILOŠEVIĆ1, 2011. Using the mind in reprogramming the limits of muscle force in the process of creating champions. *SCIENCE & PRACTICE*, 39.

17. NEUFER, P. D., 1989. The effect of detraining and reduced training on the physiological adaptations to aerobic exercise training. *Sports Medicine (Auckland, N.Z.).* ***8***(5), 302-320. https://doi.org/10.2165/00007256-198908050-00004
18. NEWTON, E. R., & L. MAY, 2017. Adaptation of Maternal-Fetal Physiology to Exercise in Pregnancy: The Basis of Guidelines for Physical Activity in Pregnancy. *Clinical Medicine Insights. Women's Health*, *10*. https://doi.org/10.1177/1179562X17693224
19. OWEN, A. L., D. P. WONG, D. PAUL & A. DELLAL, 2014. Physical and technical comparisons between various-sided games within professional soccer. *International Journal of Sports Medicine.* ***35***(4), 286-292. https://doi.org/10.1055/s-0033-1351333.
20. PATE, R. R. & A. KRISKA, 1984. Physiological basis of the sex difference in cardiorespiratory endurance. *Sports Medicine (Auckland, N.Z.).* ***1***(2), 87-98. https://doi.org/10.2165/00007256-198401020-00001
21. TENENBAUM, G. & E. FILHO, 2018. Psychosocial Measurement Issues in Sport and Exercise Settings. *Oxford Research Encyclopedia of Psychology*. https://doi.org/10.1093/acrefore/9780190236557.013.225
22. WATSON, S. (n.d.). Balance Training: Benefits, Intensity Level, and More. Retrieved 19 September 2019, from WebMD website: https://www.webmd.com/fitness-exercise/a-z/balance-training

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SWIMMING PERFORMANCE TO 25 METERS BACKSTROKE DEPENDS ON SELECTED FACTORS OF EXPLOSIVE STRENGTH OF LOWER LIMBS

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Summary: The aim of our work was to analyze the partial shares of selected factors of explosive strength of lower limbs on the overall explanation of swimming performance to the 25 meters backstroke. 29 students of Physical Education took part in our research and completed 6 tests. These tests were realized on a dry-land and in the water and they consisted of swimming performance to 25 meters backstroke, swimming start speed to 4 meters, vertical jump with and without arm-swing, maximum and average velocity of take-off performance on dry land under the backstroke start conditions. The obtained data are described by descriptive statistics and all parameters were entered to the correlation analysis for their dependence evaluation. By the analysis, we found that all tests significantly correlated with each other ($p < 0.01$; $p < 0.05$) except for the start to 4 meters test and Tendo velocity average test. For the evaluation of factors that determine the swimming performance to 25 meters backstroke, we use the regression analysis of parameters where the regression model was reflected as statistically significant ($R^2 = 0.479$ %; SEE = 3.396 %). Partial shares of individual tests, except for tests of maximal and average velocity on a dryland, showed up as statistically significant ($p < 0.05$; $p < 0.01$), with the highest share of swimming start to 4 meters performance ($p < 0.01$; $r = 0.686$). We used the regression step analysis in which we decrease the indicators to the three main factors of the strength of lower limbs model, which influence the swimming performance to the 25 meters backstroke significantly with large effect ($R^2 = 0.4787$ %; $f^2 = 0.9183$; $F = 7.652$; $p < 0.01$). Again, the highest and statistically significant ($p < 0.01$) share on the explanation of swimming performance had the start to 4 meters with 43.33 % percentage share. Besides the swimming start, the Countermovement Jump test was statistically significant too ($p < 0.05$) and statistically insignificant was test of maximum velocity on a dry-land. By this study we can evaluate how individual factors of strength of lower limbs influence the swimming performance and for the future it is necessary to

complete them with the other factors for the better creation of the appropriate swimming training program.

Key words: swimming, backstroke, lower limbs, performance

Introduction

Swimming as a sport discipline is divided according to the distances to the short courses (50 m and 100 m), medium courses (200 m and 400 m) and long ones (800 and 1 500 m). In the case of the variety of courses, swimmers, coaches, and scientists must analyze the individual components of the swimming performance of each discipline separately to be able to influence the overall performance as much as possible. In comparison with the long courses where coaches are focused mainly on the endurance development, in sprint disciplines, they should pay more attention to strength development which can positively influence the performance of a sprint swimmer (Morouco et al. 2011; Wiazewicz 2016; Wiazewicz & Eider 2016). Maximal parameters of strength of lower limbs attending to be a good predictor of the swimming performance to the short courses (Keiner et al., 2015).

Strength is also transformed into another important factor of the performance which is swimming start and Cossor (2005) states that it can influence up to 30% of total swimming time. Explosive strength of lower limbs is the key determinant of swimming start performance on the short courses (Cronin, 2005; McBride, 2009) and it is possible to influence it by the wisely chosen strength and plyometric exercises while the most important in the starts is the dynamic strength ability, where the fast muscle effort in the initial phase must be developed (Pupišová, 2013). Even the smallest differences in the start phase can change the overall ranking in the swimming sprint disciplines (Ikuta et al. 2001). Backstroke is the only swimming technique where the start is performed in the water and it consists of five phases: hands-off, take-off, flight, entry, and glide. Coaches test the strength mainly in the dry conditions which are different from the water conditions and so the feedback and results of testing are not that relevant to the swimming performance (Cossor et al., 2011). According to Cossor (2011), the countermovement jumps, and squat jump tests are the best methods for testing the strength of lower limbs and the portable tools are available for testing even beside the swimming pool. According to Ramos-Garcia (2016), the best model for testing the backstroke start is the model of a squat jump, where the similar position of hips and bended knees is followed by maximum-effort extension of lower-limbs without

countermovement. For the best transfer of dry-land tests to swimming performance these tests are usually adapted and variously modified. If they show the relevance in relation to the swimming performance, they can become a quality tool for testing the swimmers.

Methods

The monitored group consisted of 29 students from the Faculty of Physical Education in UKF Nitra with an average age M = 20.48 years, SD = 1.64, weight M = 71.38 kg, SD = 12.54 kg and height M = 176.41 cm, SD = 11.95 cm. Tests used in these research were realized on the dryland and also in a water. Test of the maximal and average velocity of the backstroke start was realized on the dryland by our own designed diagnostic tool similar to the tool which was used in the study of Weimar et al. (2019) for measurement of the swimming push-off. This tool consisted of the cart connected through the nylon string to TENDO power analyzer which was situated in front of the cart and the overall track set for the take-off measurement was 2.5 meters long. Monitored probands realized three take-offs in a row and by this diagnostic tool we monitored the maximum and average velocity of their take-off. The vertical jump with and without arm-swing was measured by the optical system OptoJump. The best results from three attempts in both tests were evaluated. Test of swimming start to 4 meters was realized under the backstroke start for 25 meters conditions, where probands had to follow the auditory signal for start and their task was to pass 4 meters as fast as possible by their push-off. For proper time recording, we used two cameras situated on the edge of the swimming pool on a stand in the greatest zone for monitoring the object. Time of backstroke start was measured from the initial phase of push-off until the arms reached the axis determining 4 meters. Probands had to perform two backstroke starts and we evaluated the technically better one. Time to 25 meters backstroke was measured by using stopwatches.

Level of the individual tests of the strength of lower limbs (maximum velocity of swimming push-off on a dryland, average velocity of swimming push-off on dryland, vertical jump with and without arm-swing, swimming start to 4 meters in water and performance to the 25 meters backstroke was characterized by the mean (M), standard deviation (SD), minimum (Min), maximum (Max) and also by percentiles. Normality of the data distribution is evaluated by Kolmogorov Smirnov test and Shapiro-Wilk test (Table 1). In determining the factors that influence the performance to 25 meters backstroke we came

from the evaluation of the dependency between all variables. For reduction of the indicators, we used the step regression analysis. In this technique, we used the method Backward, which is characterized by gradual earmarking variables from the total set in the regression function. Backward regression also serves for the multicollinearity removal by eliminating the explanatory variables that have the greatest p-value. These variables are tested in back-coupling whether they statistically impact the quality of the regression model. Relation (r) and a ratio (βeta*r) of individual factors, has been estimated by correlation and regression analysis technique. Besides the multiple correlation coefficient (R), the determinant of multiple correlations (R^2), a standard error of the regression (SEE), coefficients of partial regression (b), factor significance (t) and significance of model (F), have been calculated. The effect size is measured by Cohen´s f^2 (Cohen 1998). Statistics significance is measured in the significance level $p<0.05$, $p<0.01$ and effect size in 0.02 = small, 0.15 = medium, 0.35 = large effect. The reliability of the measurement on our designed diagnostic tool was assessed from repeated attempts by the intraclass-correlation coefficient on the 1% level of statistical significance. Empirical data were evaluated in MS Excel and SPSS programs. The partial shares of individual values are presented by graphs.

Results

We tested 29 students from the Faculty of Physical Education in UKF Nitra in 6 tests (Table 1). The first test was the performance to the 25 meters backstroke where students reached the average time M = 23.15 seconds (s) (Min 16.12 s, Max 31.50 s). In the Countermovement Jump with arm-swing, they reached an average M = 36.33 centimeters (cm) and in the Countermovement Jump without arm-swing M = 31.53 cm. In the backstroke start, they overcome 4 meters around M = 1.41 s. In the tests of swimming take-off on the dry-land, they reached maximal velocity about M = 2.11 $m.s^{-1}$ and the average velocity was about 1.42 $m.s^{-1}$. According to the Shapiro-Wilk test, the data are normally distributed in all measured parameters except for parameters in the test of start to 4 meters. The measured results between the Kolmogorov Smirnov test and Shapiro-Wilk test corresponded except for the test of Countermovement Jump where in Shapiro-Wilk test the data were normally distributed in comparison with the Kolmogorov Smirnov test.

Table 1

Descriptive statistics of student´s testing results

						Percentiles			Kolmogorov Smirnov test		Shapiro-Wilk test	
	N	**M**	**SD**	**Min**	**Max**	**25th**	**50th**	**75th**	**Statistic**	**Sig.**	**Statistic**	**Sig.**
25 m backstroke [s]	29.00	23.15	4.27	16.12	31.50	21.02	20	25.38	0.09	0.20	0.96	0.36
Countermovement jump with arm-swing [cm]	**29.00**	**36.33**	**10.77**	**21.20**	**58.70**	**27.70**	**35**	**43.30**	**0.09**	**0.20**	**0.95**	**0.22**
Countermovement Jump [cm]	29.00	31.53	9.17	16.30	51.30	24.30	28.7	37.80	0.17	0.03	0.96	0.25
Start to 4 meters [s]	**29.00**	**1.47**	**0.40**	**1.05**	**2.80**	**1.25**	**1.39**	**1.50**	**0.25**	**0.00**	**0.80**	**0.00**
Tendo Velocity Max [$m.s^{-1}$]	29.00	2.11	0.42	1.37	2.92	1.78	2.14	2.38	0.08	0.20	0.98	0.76
Tendo velocity Average[$m.s^{-1}$]	**29.00**	**1.42**	**0.37**	**0.66**	**2.09**	**1.26**	**1.44**	**1.63**	**0.11**	**0.20**	**0.97**	**0.67**

In the correlation analysis of tested parameters (Table 2), we recorded the statistically significant relations between the 25 m backstroke and Countermovement Jump with arm-swig ($p < 0.05$) and with Countermovement Jump ($p < 0.05$). By the analysis, we found out that all tests significantly correlate between each other except between the start to 4 meters test and Tendo velocity average test. Statistically significant relations were measured between the Start to 4 meters and Countermovement Jump with arm-swing ($p < 0.01$) and Countermovement Jump ($p < 0.01$). The correlation between the start to 4 meters and measured results in the test of maximal velocity - Tendo Velocity max appeared to be significant ($p < 0.05$). Between both tests of dry-land take-off on average and maximum velocity was a correlation where $p < 0.01$ ($r = 0.943$).

Table 2

Correlation analysis of tested parameters

		Countermovement Jump with arm-swing	**Countermovement Jump**	**Start to 4 m**	**Tendo Velocity Max**	**Tendo velocity Average**
25 m backstroke	r	-0.424	-0.429	0.686	-0.306	-0.273
	p	0.022	0.020	0.000	0.107	0.151
Countermovement Jump with armswing	r	1	0.946	-0.522	0.468	0.428
	p		0.000	0.004	0.010	0.021
Countermovement Jump	r		1	-0.516	0.542	0.519
	p			0.004	0.002	0.004
Start to 4 meters	r			1	-0.377	-0.340
	p				0.044	0.071
Tendo Velocity Max	r				1	0.943
	p					0,000

All tested parameters oriented on the explosive strength of lower limbs entered the regression analysis (Table 3). Regression model was reflected as statistically significant (R^2

= 0.479 %) with standard error SEE = 3.396 %. The partial shares of individual tests, except for the tests of maximum and average velocity of dry-land take-off, were statistically significant in the model ($p < 0.05$; $p < 0.01$). Most valid share between all tests had the test in start to 4 meters with significance p = 0.00 and 43.11 % share (Figure 1). The second largest share on the explanation of swimming performance to 25 meters backstroke reached the Countermovement jump test (p = 0.02) with 6,99 % share. Countermovement Jump with arm-swing explained the performance by 2.17 % ($p < 0.05$). The smallest partial shares and percentage shares were noted in tests of maximum and average velocity in dry-land take-off test and they were not statistically significant.

Table 3

Correlation and regression analysis of selected factors that determine swimming performance to 25 meters backstroke

	βeta	**b**	**βeta*r**	**r**	**sig**	**t**	**sig**
Countermovement jump with armswing	0.051	0.020	-0.022	-0.424	0.022	0.079	0.937
Countermovement Jump	-0.163	-0.076	0.070	-0.429	0.020	-0.262	0.795
Start to 4 meters	0.628	6.758	0.431	0.686	0.000	3.523	0.002
Tendo Velocity Max	-0.057	-0.581	0.018	-0.306	0.107	-0.149	0.883
Tendo velocity Average	0.068	0.787	-0.019	-0.273	0.151	0.128	0.899
	R^2	0.479	**SEE**	3.396	**F**	4.232	
	R	0.692	**bo**	15.027	**sig**	0.007	
	f^2	0.920					

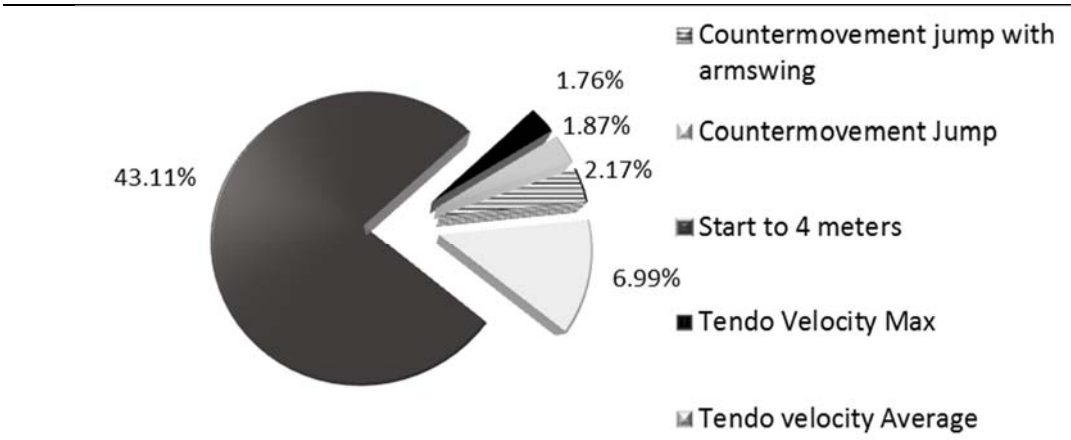

Figure 1

Partial rations of individual parameters influencing the swimming performance to 25 m backstroke

Multicorrelation and regression analysis allowed us to optimally reduce the monitored variables to the one representative model (Table 4) consisted of the three selected factors, which determine the swimming performance to 25 meters backstroke. The reduced factors significantly and with large effect explains the reliability of chosen model of

swimming performance ($R^2 = 0.4787$ %; $f^2 = 0.9183$; $F = 7.652$; $p < 0.01$) whereas the largest significant share on the overall performance explanation has the performance in swimming start to the 4 meters test which represents also the largest partial (0.040), statistically significant ($p < 0.01$) and percentual share (43.33 %) (Figure 2). As the second important factor was the Countermovement Jump ($p < 0.05$). The maximum average velocity test of take-off on dryland was also manifested in the model but without any statistical significance.

Table 4

Regression model with three variables

	βeta	**b**	**βeta*r**	**r**	**sig**	**t**	**sig**
Countermovement Jump	0.094	-0.044	0.040	-0.429	0.020	-0.501	0.620
Start to 4 meters	0.631	6.793	0.433	0.686	0.000	3.711	0.001
Tendo Velocity Max	-0.017	-0.167	0.005	-0.306	0.107	-0.095	0.925
	R^2	0.4787	**SEE**	3.25911		**F**	7.652
	R	0.6919	**bo**	14.876		**sig**	0.001
	f^2	0.9183					

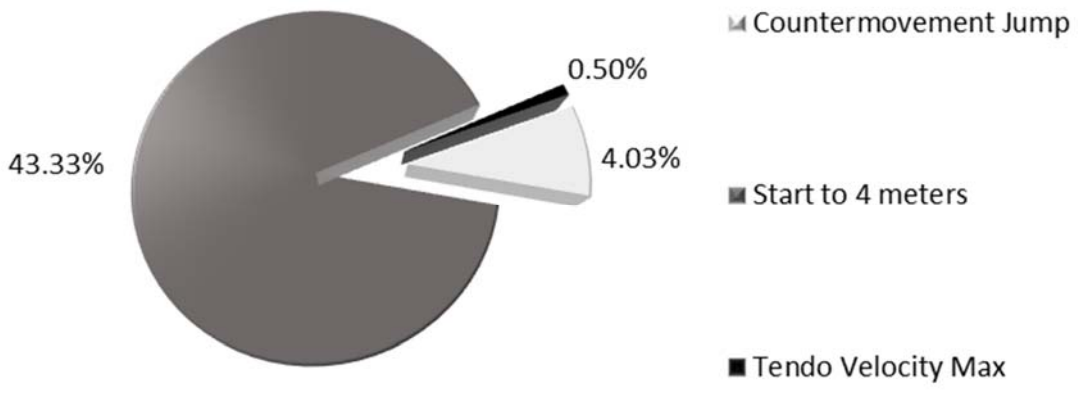

Figure 2

Partial rations of three selected variables that determine the swimming performance to 25 meters backstroke

According to the results, the diagnostic tool of backstroke take-off velocity on dry-land showed the high reliability by consecutive tests in maximum velocity (ICC = 0.899; 95 % CI: 0.797-0.951; sig = 0.000) and in average velocity (ICC = 0.924; 95 % CI: 0.845-0,964; sig = 0.000). The correlation between each measurement reached high level of tightness (ICC = 0.862; 95 %; CI: 0.775-0.932).

Discussion

The aim of our work was to point out on the hierarchy of selected factors of explosive strength of lower limbs determining the swimming performance to 25 meters backstroke and to detect their individual share on the swimming performance. As we considered, the largest impact on the overall swimming performance in backstroke sprint has the swimming start. Our findings are matching with the findings of many other authors (Thow et al. 2012; Arellano et al. 2003.; Girold et al. 2001) who states that the swimming start is the fastest part from the whole swimming performance and if it is performed fast, effectively and with correct technique, it can positively influence the medal rankings. This start is performed from the water and it is considered to be more difficult and complex movement in comparison with the other swimming stars which are performed by ventral technique (De Jesus et al. 2013) and for the future it is good to focus not only to velocity of take-off but also on the technical parameters of this start.

By analysis, we found that the strength of lower limbs can positively influence sprint abilities and the overall swimming performance to 25 meters backstroke which was confirmed also by the other authors (Coutts 2004; Hoffman 2004). Tests of explosive strength of lower limbs in vertical jumps reached in our study significant associations with the performance to 25 meters backstroke and our finding similar to study of Garrida et al. (2010), who examined mutual relations of explosive strength of lower limbs with the short swimming courses (25 m and 50 m). Tests of maximum and average velocity of swimming take-off on dryland did not appear as statistically significant and these findings correspond with findings of Weimar et al. (2019) who did a similar measurement of swimming push-offs on dryland and did not confirm the statistically significant influence of the dryland push-offs and push-offs provided in the water and also he mentioned that result of this insignificant relation can be influenced by the missing water resistance parameter.

Conclusion

This is a pilot study in which we analyzed chosen parameters that can influence the swimming performance. In our study, we focused on the chosen parameters of explosive strength of lower limbs and we would like to extend these parameters by the other factors,

for example, the strength of upper limbs and technique. It will be very interesting to analyze the changing factors influencing swimming according to the length of the swimming course.

We included the swimming start to 4 meters to the factors of explosive strength of lower limbs because the measured results significantly correlated with the other tests of explosive strength of lower limbs. In this test, we focused only at the time factor, but for the future, it will be good to focus also on the parameters of technique. By these results we can confirm that with the increasing strength the swimming performance is also improved and swimmers with similar results should focus on their swimming technique to achieve even better results. For the swimming performance diagnostics, it is important to work constantly on the better diagnostic tools and because of that, we have decided to try our own designed tool, which measures the maximum and average velocity of swimming take-off under the water condition on a dry land. Although the data measured on this device have shown little relevance it was enough to take their share on the regression model which explained the swimming performance.

References

1. ARELLANO, R., J. COSSOR, B. WILSON, J. CHATARD, S. RIEWALD & B. MANSON, 2001. Modelling competitive swimming in different strokes and distances upon regression analysis: a study of the female participants of Sydney 2000 Olympic games. *XIX International Symposium on Biomechanics in Sports*. ISSN 1999-4168. 53-56.
2. COHEN, J., 1988. Statistical power analysis for the behavioral sciences. *2nd ed. New York: Lawrence Erlbaum Associates*, 0-8058-0283-5.
3. COSSOR, J. & B. MASON, 2000. Swim start performances at the Sydney 2000 Olympic Games. *Coaches´ Infoservice – Sports Science information for coaches. University of San Francisco: Biomechanics Symposia*. 70-74.
4. COSSOR, J., S. SLAWSON, B. SHILLABEER, P. CONWAY & A. WEST, 2011. Are land tests a good predictor of swim start performance?. *Portuguese Journal of Sport Sciences.* **11**(2),183-186.
5. COUTTS, A., A. MURPHY & B. DASCOMBE, 2004. Effect of direct supervision of a strength coach on measures of muscular strength and power in young rughby league players. *J Strength Cond Res.* **18**, 316-323.

6. CRONIN, J. B. & K. T. HANSEN, 2005. Strength and power predictors of sports speed. *J Strength Cond Res.* **19**, p. 349-357.
7. DE JESUS, K., R. FERNANDES, J. P. VILAS-BOAS, R. SANDERS & K. E. De JESUS, 2014. The backstroke swimming Start: State of the Art. *Journal of Human Kinetic.* **42**, 27-40. doi:10.2478/hukin-2014-0058.
8. GARRIDO, N., D. MARINHO, T. BARBOSA, A. COSTA & A. SILVA, 2010. Relationships between dry land strength, power variables and short sprint performance in young competitive swimmers. *Journal of Human Sport and Exercise.* **5**(1), 240-249. doi:10.4100/jhse.2010.52.12.
9. GILOD, S., J. CHATARD, J. COSSOR & B. MASON, 2001. Specific strategy for the medallists versus finalists and semi-finalists in the men's 200 m backstroke at the Sydney Olympic Games. *In XIX International Symposium on Biomechanics in Sports.* ISSN 1999-4168, p.27-30.
10. HOFFMAN, J., J. COOPER, M. WEN-DELL & J. KLANG, 2004. Comparison of Olympic vs. Traditional power lifting trainig programs in football players. *J Strength Cond. Res*,18, 129-135.
11. KEINER, M., D. YAGHOBI, A. SANDER, K. WIRTH & H. HARTMANN, 2015. The influence of maximal strength performance of upper and lower extremities and trunk muscles on different sprint swim performances in adolescent swimmers. *J Sci sports*. **47**(1), 99-106. doi: 10.1515/hukin-2015-0075.
12. McBRIDE, J., D. BLOW, T, J. KIRBI, T. HAINES, A. DAYNE & T. TRIPLETT, 2009. Relationship between maximal squat strength and five ten and forty yard sprint times. *J Strength Cond Res*. **23**, 1633-1636.
13. MOROUCO, P., K. L. KESKINEN, J. P. VILAS-BOAS & R. FERNANDES, 2011. Relationship between tethered forces and the four swimming techniques performance. *Appl Biomech.* **27**(2), 161-169.
14. PUPIŠOVÁ, Z., 2013. Development of explosive power of lower legs and its effectiveness on the performance of the start jump in swimming. Krakov: Spolok Slovákov v Poľsku. [In Slovak: Rozvoj výbušnej sily dolných končatín a jej vplyv na efektívnosť štartového skoku v plávaní.]
15. THOW, J. L., R. NAEMI & R. H. SANDERS, 2012. Comparison of models of feedback on glide performance in swimming. *J Sport Sci.* **30**(1), 43-52. doi:10.1080/02640414.2011.624537.

16. WEIMAR, W., A. SUMNER, B. ROMER, J. FOX, J. REHM, B. DECOUX & J. PATEL, 2019. Kinetic Analysis of Swimming Flip-Turn Push-Off Techniques. *Sports.* **7**(2), 32. doi:10.3390/sports7020032.
17. WIAŻEWICZ, A., 2016. Shoulder joint torque analysis in young swimmers. *JKE.* **73**(26), 59-66. doi: 10.5604/17310652.1226493.
18. WIAŻEWICZ, A. J. & J. EIDER, 2016. Assessment of shoulder joint strength disproportion of masters swimmers. *Cent Eur J Sport Sci Med.* **16**(4), 85-90. doi:10.18276/cej.2016.4-09.

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DIAGNOSTICS OF DIDACTIC COMPETENCIES OF STUDENTS OF FACULTY OF PHYSICAL EDUCATION AND SPORT

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Summary. Physical education has been the subject of research for a long time. Research focuses most often on the use of time to get pupils to move actively or on their physical load during a lesson. The evaluation of the didactic interaction of the teaching student - pupil(s) is also an essential area of research. The aim of the paper is to introduce the MADI method and its subsequent use in the evaluation of didactic outputs of teaching students in subjects focused on the didactics of swimming. The method Analysis of Didactic Interaction (ADI) has been modified to assess didactic interactions between the teaching (student) - pupil(s). Modified Analysis of Didactic Interaction (MADI) was created by reducing the number of monitored categories and focusing attention on the activity of the student. The achieved results showed that the most frequent form of behaviour among the students was observation followed by instruction. This influenced both the form of their manifestations, dominated by silence, and the overall manifestation, which was neutral and mostly without material significance. In terms of activities that have been the subject of didactic interaction, students have been taught these activities. The results obtained show that the chosen method seems to be effective for evaluation of didactic output of teaching students. A deeper analysis of student didactic outcomes can contribute to influencing the quality of student didactic competencies. At the same time, it can also serve as a feedback tool on their didactic activities for their faculty teachers.

Key words: Key words: didactic interaction, communication, didactic competence, modified analysis of didactic interaction, swimming.

Introduction

In the professional education of future Physical Education teachers at Charles University FTVS, the syllabi of swimming subjects in the bachelor study program are focused on acquiring the skills of swimming locomotion, but also on the didactics of swimming methods and diagnostics of movement in water. Teaching of swimming didactics focuses on acquiring and developing student's didactic competences in the field of swimming teaching and swimming sports. Through the didactic outputs on a given topic, teaching students have the task of creating their own written lesson preparation for the teaching unit and then implementing it themselves. At the end of the lesson they are evaluated by faculty teachers. Given the time available for this evaluation, the feedback is focused more on the evaluation of didactic output as a whole. However, if we want to provide students the deeper feedback on their didactic impact, their didactic outcomes need to be analysed in more details. Particular attention should be paid to the evaluation of the teacher-pupil interaction, which will reveal the most frequently occurring characteristics in terms of the forms of teacher's behaviour, its manifestation or the type of activity that is the subject of the didactic interaction.

Didactic interaction means everything that happens between the participants of the didactic process and what is essential in terms of their interaction and the desired effect (Dobrý et al., 1996). Research on monitoring and subsequent analysis of teacher's behaviour in relation to pupils has a relatively long history. The first references are from the beginning of the last century. One of the leading authors who contributed with his ideas to the research of interaction on a global scale was N. A. Flanders. His Flander's Interaction Analysis System (FIAS) (1967a; 1967b; 1970) is one of the best-known categorical observation systems. The method was originally created for science subject research. The FIAS has undergone several transformations. One of the major changes was made by Galloway (1970), when he extended the 10 categories originally contained by FIAS to include non-verbal communication. Probably the best - known method of interaction analysis is CAFIAS - Cheffers Adaptation of the Flanders Interaction Analysis System (Cheffers 1977). Cheffers is one of the main theorists and initiators of interactive research in physical education. He considers interaction analysis to be a systematic record of the spontaneous behaviour of a teacher in their interaction with pupils, with minimal observer's error (Muzik et. al. 2013). Other figures involved in teacher's activity research who have influenced the development of didactic interaction analysis include R.F. Bales (1950), A. Bellack et al. (1966) and A. Bellack (1968).

The development of interaction research was also carried out in Czechoslovakia and later in the Czech Republic. As a result, methods of Systematic Observation of Interaction - SPIN (Svoboda & Kocourek 1987), Categorical Video Recording Assessment System - KPSV (Jansa 1987) and Analysis of Didactic Interactions - ADI (Dobrý et. al. 1996). It is a method that uses recording and computing techniques and a categorical assessment system to obtain empirical data about participants in physical education training. The original ADI was simplified by reduction of certain categories for the purposes of evaluating the pedagogical outputs of the Charles University FTVS students in the Didactics of Sporting Games subject. Only those that Süss & Marvan (2009) considered important didactic skills to acquire were retained. This modified ADI was called Modified Didactic Interaction Analysis (MADI).

The aim of the paper is to introduce the MADI method and its subsequent use in the evaluation of didactic outputs of teaching students in subjects focused on the didactics of swimming. Within the subject Theory and Basics of Swimming Didactics were realised didactic outcomes of students on the given topic. The didactic competencies of students were assessed using the MADI quantitative method.

Methods

The examined population consisted of students from the 2nd grade of the bachelor's degree program Physical Education and Sport, in the subject Theory and Basics of Didactics of Swimming at Charles University FTVS. In total 104 students participated in the research. The data was collected during the winter semester of the academic year 2015/2016. For organisational reasons, it was not possible to make audio and video footage of all the didactic outputs of the students that year. Therefore, we decided to select 30 students by simple randomisation. As a technique for this simple randomisation, we chose random numbers in published random number tables (Hendl & Remr 2017). From the recorded audio and video recordings of the selected students, their interaction profile was determined using the MADI method.

Didactic outputs of teaching students were carried out under the subject Theory and Basics of Didactics of Swimming. The length of each lesson was forty-five minutes. Thirty-five minutes was reserved for didactic outcomes of teaching students and in the remaining 10 minutes the outcomes were evaluated by their faculty teacher. The thirty-five-minute presentation was made by 3 teaching students (the 1st student led the introductory and

preparatory part, the 2nd student the main part and the 3rd student the final part of the lesson). The student who led the fixed part of the lesson was always in the role of “leading teacher”. The other two students, who were not in the position of 'lead teacher' at the time, were 'assistants'. These “assistants” were also involved in the didactic output. Their task was, for example, to correct “pupils” or to provide adequate feedback. For technical and organisational reasons, it was not possible to provide swimming lessons to real pupils of primary schools within this subject. These pupils are thus replaced by other teaching students from the group who do not have a didactic output on that day (designated “pupils”).

The study had the character of descriptive research based on the qualification of observation using a categorial system. The categorical system of Modified Analysis of Didactic Interaction (MADI) was developed based on the method of Analysis of Didactic Interaction (ADI). The MADI method (Süss & Marvanová 2009) was created for the evaluation of student’s pedagogical outcomes in the Didactics of Sporting Games subject. The main difference from the original ADI was the reduction of categories to those that are most important for teaching student’s learning didactic skills. This eliminates the complicated training required by ADI. A positive feature of the MADI method is the possibility of recording didactic outputs using video and subsequently simple coding in the computer program MS Excel.

Individual categories and subcategories of Süss & Marvan (2009):

Category 1 - forms of teacher’s behaviour: instruction, correction, feedback, observation, notification, question, reception, assessment, participation, unclear situations.

Category 4 – Forms of teacher's speech: speech, speech and locomotor manifestations, movement associated with silence, non - verbal acoustic expression, silence, others.

Category 5 - is divided into two parts:

a) Level of expression of content: Yes/No.

b) Types of attitudinal activity: integrative, dominant, neutral.

Category 6 - types of activities that are the subject of didactic interaction: teaching activities, organisational activities, other.

Categories 7, 8 & 9 - types of pupil activities, groups, classes determining the current relationship of teachers in didactic interaction: direct reception, indirect reception, performance of activities under direct control, performance of activities without direct control, answer.

Category 2 in the ADI is devoted to the activities of pupils, *Category 3* refers to the activities of a group of pupils. The modified form of ADI focuses mainly on the forms of teacher behaviour and therefore we do not include both categories.

Statistical Processing

The results of the evaluation of didactic outputs of students using MADI are given in absolute and relative frequency, which is given in percentages. For the purposes of our research, we have also used descriptive statistic averages (mean %) and standard deviation.

Results

Summary results of students in Category 1 (Table 1) showed that the most used form of behaviour was observation (45.4 %). This is mainly attributed to the organisation of swimming lessons, where "pupils" took some time to swim over the twenty-five-metre pool with exercises that the teaching student has set. Then at that moment passed to the other side of the pool and observed. We did not consider the high percentage for observation to be an entire error. There is some testimony of how much active and passive time "pupils" spent in the water. Instruction was the second most popular subcategory in our research (35.0 %). It included all the instructions that were directed towards the “pupils” by the teaching students. The relatively frequented form of student’s behaviour during didactic outputs was also unclear (9.1 %). We included, for example, situations in which the teaching students read their written preparation, communicated with their assistants or whether the didactic output was interrupted by a faculty teacher (security), etc. Surprisingly a low percentage was recorded for correction (2.1 %) and feedback (1.2 %). Although these are quite fundamental forms of teacher’s behaviour, we attributed this small percentage to the didactic outcomes of students, especially their pedagogical “inexperience” (these are their first didactic outcomes at Charles University FTVS). Another reason may be the organisation of the swimming lessons by themselves.

Table 1

Summary assessment of students in Category 1 of MADI - forms of teacher behaviour

Subcategories	Average %	Standard deviation
Instructions	35.0	8.2
Corrections	2.1	2.1
Feedback	1,2	1,8
Observation	45.4	8.3
Notifications	4.3	3.2
Questions	1.7	1.6
Reception	0.8	0.9
Assessment	0.5	0.9
Participation	0.0	0.0
Unclear situations	9.1	5.5

The results of the analysis of didactic outputs in Category 4 (Table 2) are in accordance with the forms of teacher's behaviour (Category 1). Silence (38.8 %), which was the most common form of communication that a teacher utilised, is related to observation that was most frequently used in the first category. The same connection can also be seen in speech (32.8 %) with instruction, which was also the second most popular subcategory. Higher values were also observed for physical activity associated with silence (13.8 %), which included particular situations where teaching students were moving from one side of the pool to the other and observing "pupils", and speech and physical activity (13.0 %), when the teaching students presented instruction to the pupils, these were supplemented with movement demonstrations from the edge of the pool. Other subcategories (1.4 %) and nonverbal acoustic manifestations (0.1 %) occurred minimally.

Table 2
Summary assessment of students in Category 4 of MADI - forms of teacher speech

Subcategories	Average %	Standard deviation
Speech Display	32.8	7.8
Displays of Speech and Movement	13.0	8.3
Movement Associated with Silence	13.8	9.5
Nonverbal Acoustic Displays	0.1	0.3
Silence	38.8	8.8
Other	1.4	3.7

In terms of materiality of expression of the teaching students (Table 3), the analysis showed that more than half of the teaching students' manifestations were neutral (60.4 %) and without material significance (58.6 %). Again, the link with Category 1 is reflected. In most cases, observation was neutral and without material significance. Similarly, an instruction that contains material significance was usually integrative.

Table 3
Summary evaluation of students in Category 5 of MADI

Subcategories	Average %	Standard deviation
Does speech contain material significance?		
Yes	41.3	7.4
No	58.6	7.4
Is it an integrative or dominant expression?		
Integration	23.3	6.8
Dominant	16.3	6.2
Neutral	60.4	8.2

In Category 6 (Table 4), teaching students were predominantly learning, i.e. situations where teaching students gave instructions to the pupils, announced further steps or provided correction or feedback. Organisational activities (28.8 %) included the organisation of pupils in the water, teaching students moving around the pool without observation, or giving swimming aid to “pupils”. At 11.2 % we noticed another activity where teaching students read their written preparation, communicated with their assistants at the edge of the pool, etc.

Table 4

Summary evaluation of students in Category 6 of MADI - types of activities that are the subject of didactic interaction

Subcategories	Average %	Standard deviation
Learning Activities	60.1	19.3
Organisational Activity	28.6	13.8
Other	11.2	15.2

The following categories (7, 8, 9) were related to the types of activities of the pupil, group and class (Table 5). Category 7 students did not use much, which corresponds to relatively low values: performance of activities under direct control - 1.3 %, own initiative - 0.6 % and direct reception - 0.3 %. This is mainly due to the organisation of teaching, where teaching students worked mainly with a group of "pupils" or with the whole class. In Category 8, the highest subcategory percentage was activity of the group under direct control (28.6 %). In majority of cases, this was a situation where the teaching students started the "pupils" in groups (3 – 5 "pupils") from the pool wall to perform given activities. The rest of the class was at that time undertaking activities of indirect reception or without direct control (see Category 9). The direct reception of the group, i.e. the teaching student that spoke to the whole class, devoted the content of communication to only one group (e.g. swimming the width of the pool), was recorded at 6.7 %. A smaller percentage represented the group's performance without direct control (1.6 %). In this case, the "pupils" swam alone, while the teaching students turned to the rest of the class (see Category 9, subcategory Direct Reception). In Category 9, the subcategory with the highest percentage was Direct Reception of the class (29.3 %), i.e. the scenario when the teaching students communicated with and listened to the “pupils”. A high percentage of representation also appeared in the performance of the class under direct control (27.4 %), when the entire class was under the direct control of the teaching student. During analysis, we again noticed the performance of class activity without Direct Control (22.5 %) – the attention of the teaching students was devoted to the group of "pupils" while the rest of the class continued to

carry out the activity Indirect Reception (20.7 %). The subcategory Response did not appear at all in the analysis of student didactic outputs.

Table 5
Overall evaluation of students in Category 7, 8 & 9 of MADI – other types of activities of pupils, groups and classes

	Category 7		Category 8		Category 9	
Subcategories	**Average %**	**Standard deviation**	**Average %**	**Standard deviation**	**Average %**	**Standard deviation**
Direct Reception	0.3	0.7	6.7	5.2	29.3	8.3
Indirect Reception	0.0	0.0	0.3	1.1	20.7	16.6
Performance of Activities under Direct Control	1.3	1.7	28.6	14.2	27.4	12.9
Activity without Direct Control	0.0	0.0	1.6	2.0	22.5	14.4
Answer	0.0	0.1	0.0	0.0	0.0	0.2
Own Initiative	0.6	1.0	0.2	0.3		

Conclusion

The results show that the MADI method appears to be suitable for the evaluation of didactic outputs of teaching students in swimming. However, this method is not intended for students to provide deeper feedback on their didactic outputs. At the same time, it can also be used by their faculty teachers for reflection of their didactic influence on their students. However, the results we achieved in our research are only indicative. They cannot be applied to the entire Charles University FTVS student population.

The evaluation of student didactic outcomes using the MADI method allows empirical data about events in the education and training process only to be obtained. However, this data is not enough to fully analyse the education process. It is necessary to complement them for example, on the analysis of verbal and non - verbal expression or on the assessment of direct participation in lessons (pupils) obtained through the method of questioning or interview. The combination of such data could then serve to improve the didactic competencies of future Physical Education teachers.

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References

1. BALES R. F., 1950. *Interaction Process Analysis. A method for the study of small groups* [online]. Cambridge, Mass: Addison Wesley, [cit. 2019-07-22]. Available from: https://archive.org/stream/interactionproce00bale#page/n7/mode/2up
2. BELLACK, A. A. et al., 1966. *The langure of the classroom.* New York: Teachers College Press.
3. BELLACK, A. A., 1968. *Methods for observing classroom behavior of teachers and students* [online]. New York: Columbia University, [cit. 2019-07-22]. Available from: http://files.eric.ed.gov/fulltext/ED040113.pdf
4. DOBRY, L., V. SVATOŇ, J. SAFAŘÍKOVÁ & Z. MARVANOVÁ, 1996. *Analysis of Didactic Interaction in Physical Education.* Prague: Karolinum.
5. FLANDERS, N. A., 1967a. Intent, Action and Feedback in Preparation for Teaching. *Interaction analysis, theory, research and applicatications* (pp. 294-305). Mass. Addison-Wesley.
6. FLANDERS, N. A., 1976p. Some Relationships among Teacher Influence, Pupil Attitudes and Achievement. *Interaction analysis, theory, research and application* (pp. 226-242). Mass., Addison-Wesley.
7. FLANDERS, N.A., 1970. *Analysing Teaching Behaviour.* Reading: Addison-Wesley.
8. GALLOWAY, C. M., 1970. *Nonverbal Language in the Classroom.* Bull. 29. Washington DC: Association for Student Teaching.
9. HENDL, J. & J. REMR, 2017. *Research and Evaluation Methods.* Prague: Portál.
10. CHEFFERS, J. 1977. Observing Teaching Systematically. *Quest.* **28** (1), 17-28.
11. JANSA, P., 1987. *Description and Analysis of Activities of Teachers and Pupils of Primary School in Physical Education* (pp. 175-198). Prague: Olympia.
12. MUZIK, V., J. SAFAŘÍKOVÁ, V. SÜSS & Z. MARVANOVÁ, Z., 2013. Ways to Examine Physical Education Teaching: The Importance of Didactic Interaction Analysis (ADI) and its Modification (MADI). *Pedagogical Orientation.* ***23***(2), 195-223.
13. SÜSS, V. & Z. MARVANOVA, 2009. Modified Analysis of Didactic Interaction. In: Charles University in Prague, Faculty of Physical Education and Sport, Department of Sporting Games [online]. Prague: Charles University FTVS, Department of Sporting

Games, [cit. 2019-07-18]. Available from: http://www.ftvs.cuni.cz/FTVS-748-version1-modifikovana_adi.pdf

14. SVOBODA, B. & J. KOCOUREK, 1987. Research on Personality and Teaching Activities of Physical Education Teachers. In *Physical Education* (pp. 48 – 74). Prague: Olympia.

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IMPACT OF AGE AND AGILITY PERFORMANCE LEVEL ON THE DISJUNCTIVE REACTION TIME OF SOCCER GOALKEEPERS

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Summary. The soccer goalkeeper´s reaction speed to stimulus is essential for the overall success rate of goalkeepers in soccer. Our research was aimed at finding out the impact of age and agility performance level on the length of the disjunctive reaction time of elite goalkeepers in Slovakia. The research group was comprised of 24 goalkeepers of two Slovak soccer clubs (in group A were elite players and in group B sub-elite players). To gain the research data, the disjunctive reaction time was measured using the Fitro Agility Check device. The acquired results were statistically evaluated using the Mann-Whitney U-Test and Cohen´s "d". The impact of age (n.s) and performance level (n.s) on the length of the disjunctive reaction time of goalkeepers was not statistically confirmed. However, the substantive and logical significance showed that the best goalkeepers achieved a considerably shorter time of disjunctive reaction time to the set stimulus (difference – 20 %).

Keywords:
soccer, goalkeeper, disjunctive reaction time, age, agility performance level

Introduction

Nowadays, details determines the results in soccer. In soccer is in the spotlight the individual game performance and important is the goalkeeper´s game performance. It depends greatly on his quality whether the team will be successful or not. Disjunctive reaction time is

one of the factors, which can have a significant effect on the individual game performance of soccer goalkeeper. A large number of complex and unique game situations, in which the goalkeeper often in time and space discomfort chooses the right solution of the game situation, characterizes soccer. Therefore, the requirements for the right analysis, selection and subsequent solving of the game situation are a very important part of each goalkeeper´s game performance (Babic et al. 2018; Babic et al. 2019; Obetko et al. 2019).

The term "reaction abilities" is occurring in the sports for a very long time. The approach of experts to the mentioned subject matter differs. In the past, the research was aimed more at the simple reaction time. A simple reaction to the stimulus takes about 200 milliseconds. One fifth of a second is the minimum time that the retina in the back of human eye needs to receive an information and to transform this information through synapses (gaps between neurones whose overcoming requires several milliseconds) into the primary visual cortex in the back of the brain and for the brain to send this message to the spinal cord that will set in motion the muscles. If we imagine the speed of a flying ball in soccer (more than 130 km per hour), it is just a moment. Tests of innate physical "hardware" – the qualities with which a player is born, such as simple reaction time – have helped very little and help to explain sports (game) performance. Reaction times of professional athletes (players) were still around one fifth of a second, as well as reaction times of randomly tested people. In the beginning, the coaches had an orthodox opinion that innate reflexes are of paramount importance. On the contrary, the thought that learnt perceptual skills are essential for high-quality game performance was back then unbelievable. For example, Starkes and Deakin (1984), Starkes (1987) found out those coaches of the Canadian national field hockey team relied at that time on the fact that each player sees the field in the same way. For the selection were used tests of simple reaction time and they thought that it will be a good determinant of who would be the best goalkeeper or field player. Right back then used Starkes (1987) to test this quality the signal capture tests used by air traffic controllers. She named them "occlusion" tests, test for selection of a reaction. Besides very good selection reaction, top-level players were able to reconstruct the game situation in the field. This could be applied to every sport (basketball, soccer, etc.) The question is, how important are these perception skills for professional players and whether they are the result of genetics or not. Abernethy et al. (2008) studied eye movements of elite badminton players and beginners and found out that beginners were looking at the right part of opponent´s body, but they simply did not have the database (experience) needed for extracting all the information from it. When an individual practises some game activity, whether it is bypassing an opponent, a pass or shooting, the mental processes involved in performance of that game activity are going

from the brain region in the frontal lobe, where the higher functions are going on, into more primitive regions, which control automatic processes or activities (game activities) that a player can perform "without thinking", in the subconscious. When doing sports, the automatization of brain functioning is so specific that displaying of players´ brain, who trains a particular game activity has shown that the activity in the frontal lobe weakens only when they perform this particular task (Mann et al. 2010). Although it seems that cycling does not require much conscious thinking, because when the runners were seated on a bicycle or hand bike (on which the tested person twists pedals with hands, not legs), in comparison with the situation, when they were running, the activity of their frontal lobe increased. The physical activity (game activities) which a person/player practises is specifically automated in the brain. Thinking about some activity is a feature of a beginner in sports or the key to the transformation of an elite player back into an amateur (Muller et al. 2006). Nowadays is for the numerical expression of reaction abilities used the term reaction time. One of the more recent views on this subject-matter is stated by Ehlers et al. (2018), who named the time needed for noticing the stimulus and performing the motor response as the inertia time. However, in this case, we prefer rather the term "reaction time". Reaction time is usually divided into 2 main categories:

1. Simple reaction time – simple reaction, goalkeeper reacts as quickly as he can to only one stimulus.
2. Disjunctive reaction time – selection reaction, goalkeeper reacts as quickly as he can to multiple stimuli and selects one of the solutions.

In our research we are dealing only with disjunctive reaction time, because if we proceed from the game analysis, we find out that in soccer a player has to react to a large number of stimuli in his surroundings (opponent, teammate, ball, space, time, etc.) and have to choose the right solution of a particular game situation in the shortest possible time. This is also one of the attributes of the soccer development at present – the game intensification, which means that there are increased demands on the quick reaction of players and on the selection of a right solution to a game situation.

Many factors have an impact on reaction time. Some of them can be greatly affected by the training process, while the others are genetically determined and can be changed only minimally or not at all. One of the factors significantly affecting the reaction time is age. The simple reaction time is getting shorter from childhood to the end of the 20th year of life. Later, when we are growing old, the reaction time and motor response to the stimulus begin to prolong. Until the age of 50 up to the age of 60, it is prolonging slowly and after the age of 70 it increases even faster (Jevas & Yan 2001; Luchies et al. 2002; Rose et al. 2002; Birren a Schaie 2005; Der

a Deary 2006). Chang et al. (2012) agree with this statement as well. They attribute this phenomenon to slower neurotransmission by nerve fibres. Hagovská and Nagyová (2017) complement these reflections and claim that ageing is characterised by a natural worsening of all cognitive functions, not only by increasing reaction time but also memory and concentration.

Another factor that can have a positive impact on the goalkeeper´s capability to react quickly are sports games – both the training process and matches. Sports games influence in a positive way not only the speed of reaction (disjunctive) but also the right selection of the solution of game situations. This claim was examined by Ando et al. (2001) in their work. They studied the speed of disjunctive reaction time in the central part of the visual field, but also in the temporal and nasal part. They found out that the soccer players, who were tested, had a shorter disjunctive reaction time in the central part and also in the peripheral part in comparison with the general population. Xuedong et al. (2018) found out that one of the ways how to positively influence the length of reaction time is to expand the visual field. It results in a better reaction of the player to stimuli, not only in the central part but also to stimuli, which are occurring in the peripheral part of the visual field (whether it is in the nasal or temporal part). Sports games training expand the visual field of players (Dorňák & Peráček 1979; Peráček et al. 1981).

Sports experience has also been shown in many works as a factor, which has an impact on the reaction time value. Ehlers et al. (2018) proved, that athletes with experience (higher biological age in sport) have the disjunctive reaction time shorter than beginners do. Ste-Marie et al. (2012) agree with this statement and according to them, the perception ability (to perceive the situation around you) improves based on more experience. Faster and better perception of the game situation leads to a faster reaction to a particular situation. Various stimuli, which the player notices on the periphery of the retina, ensure the proper distribution of the tonus along the skeletal muscles. Depending on the distribution of retinal cones and rods on the retina, we distinguish the central and peripheral vision. The retina periphery reacts to the colour shades worse because it contains only a few retinal cones. Peripheral vision serves for orientation in space and recognition of moving objects. Excluding central vision, orientation in space is preserved, but the ability to distinguish details of the observed object is lost (Štulrajter 1983).

Based on the ascertained knowledge, we assume two fundamental facts. The first is that goalkeepers of older age group (U19-U16) will have a significantly shorter disjunctive reaction time than the younger goalkeepers (U15-U14). The second assumption is that goalkeepers of higher agility performance level (elite players – group A) will have a disjunctive reaction time

statistically significantly shorter than goalkeepers of lower agility performance level A) will (sub-elite players – group B).

The main aim of our work is to confirm the above stated knowledge (findings) in relation to age and agility performance level-related category.

Methodology

The nature of this research fulfils the conditions of cross-sectional ex post facto research. The dependent variable was the values of disjunctive reaction time and independent variables were the age and agility performance level. The monitored group was comprised of 24 youth soccer goalkeepers of two different Slovak clubs. Monitored goalkeepers were divided according to their age into two categories:

- (U14-U15),
- (U16-U19).

Based on their agility performance level, the monitored goalkeepers were divided into 2 groups. Group A was comprised of elite players and group B consisted of sub-elite players. The calendar age of monitored goalkeepers was during the measurement 15.6 ±2.4 years. Their biological (sports) age was 7.9 ±1.56 years.

The main method for the acquisition of research data was the measurement of reaction time using the FiTRO Agility Check device. There was created a separate protocol for each measuring, in which the order of the individual stimuli was changing, in order to prevent the anticipation of goalkeepers during measurement and the consequent distortion of results.

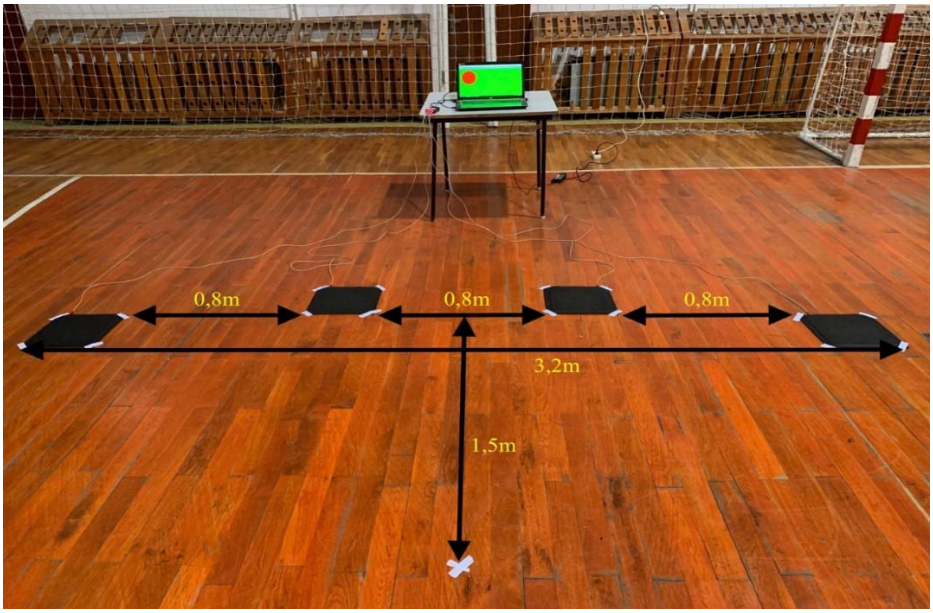

Figure 1
Modified version of the FiTRO Agility Check system

Authors of the original version of this device are Hamar and Zemková (1998). This device consists of four contact switch mattresses connected by means of a cable to the medium that communicates with the computer. Distances between the individual mattresses were adjusted to more simulate the motor structure of the goalkeeper (Fig. 1), which is typical of him when solving game situations (adequate coverage theory), so he could try the course of the measuring and know what will be expected of him. During the measuring, the goalkeepers reacted to 10 light stimuli as quickly as they could. The light stimuli were generated randomly (not only their order but also the time intervals between them). In this way were laboratory simulated various game situations in a match. The research took place under laboratory conditions in the sports hall, where we were able to ensure the stability of external influences (weather, surface) for the measurement and thus eliminated any potential unwanted deformational factors that could affect the final measurement result. The measurement was performed at the same time and day, in an identical schedule before the training unit. For processing and assessment of acquired data were used statistical methods of the Mann-Whitney´s U-Test. The level of statistical significance was in all cases selected at $p \leq 0,05$ level. Cohen´s "d" was used to find out the substantive significance.

Results

Between the reaction time of older (M = 1317.91; SD = 158.31) and younger goalkeepers – (M= 1341.09; SD= 98.71), was not found any statistical significance (Mann-Whitney U-Test), $z = -0.4977$; $p > 0.05$. The practical significance of the statistical dependence was d=0.12, which means that in our research was not shown the effect of age on performances (Fig.2).

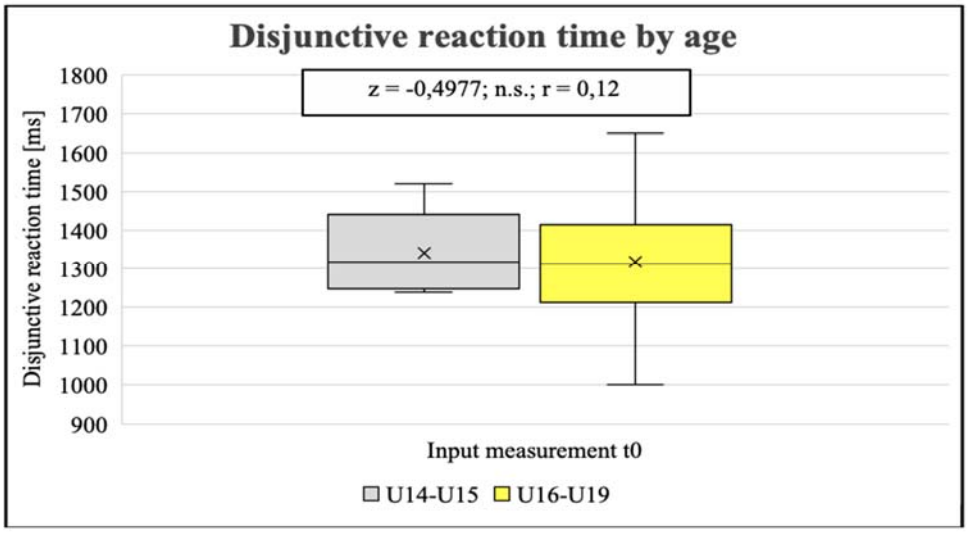

Figure 2
Comparison of disjunctive reaction time with respect to age

Table 1

Characteristics of age groups

Measuring	Numb. [n]	Mean [ms]	Min [ms]	Max [ms]	Vr [ms]	Med [ms]	SD [ms]	Cohen´s "d"	Effect
Young Juniors	10	1341.09	1237.6	1519.3	281.7	1316.45	98.71	0.12	Small
Juniors	14	1317.91	999.7	1649.6	649.9	1311.45	158.31		

Between the reaction time of elite goalkeepers (group A) (M = 1293.51; SD = 134.61) and of sub-elite goalkeepers (group B) (M = 1384.3; SD = 120.71) was not found any statistical significance (the Mann-Whitney U-Test), z = -1.7292; p > 0.05. (Fig.3). Cohen´s "d" (d = 0.35) shows that the effect of the agility performance level plays in a training practice a key role and is real.

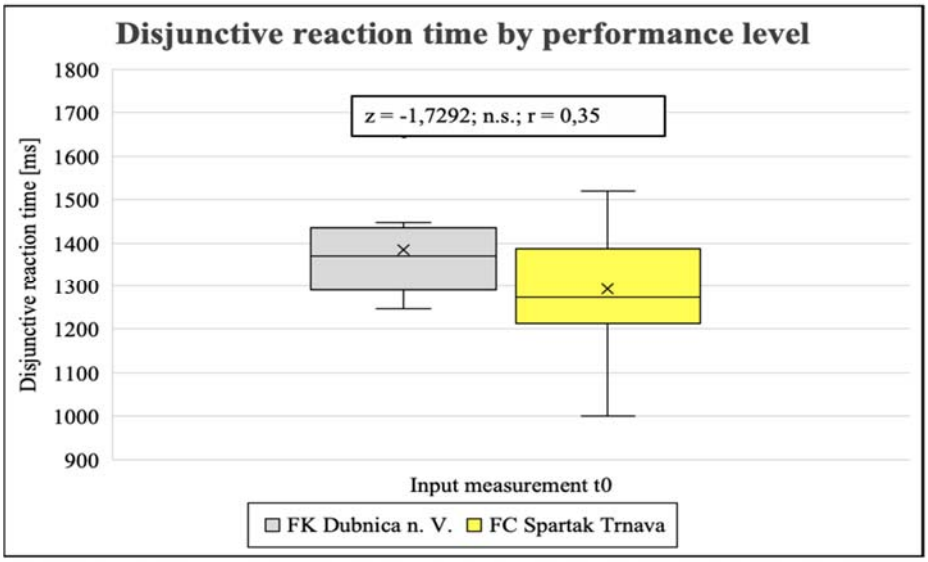

Figure 3

Comparison of disjunctive reaction time with respect to the agility performance level

Table 2

Characteristics of groups with respect to agility performance

Measuring	Numb. [n]	Mean [ms]	Min [ms]	Max [ms]	Vr [ms]	Med [ms]	SD [ms]	Cohen´s "d"	Effect
Group A	15	1293.51	999.7	1519.3	519.6	1273.5	134.61	0.35	Mean
Group B	9	1384.3	1247.3	1649.6	402.3	1369.1	120.71		

Discussion

Age aspect

Within ontogeny is the development of all functional capacities of the goalkeeper natural. This could be also applied to the disjunctive reaction time. From birth until reaching the age of majority (around the age of 20), the disjunctive reaction time is becoming shorter. Subsequently, it gradually begins to increase slower by ageing and from the age of 60 up to 70, it increases even more quickly.

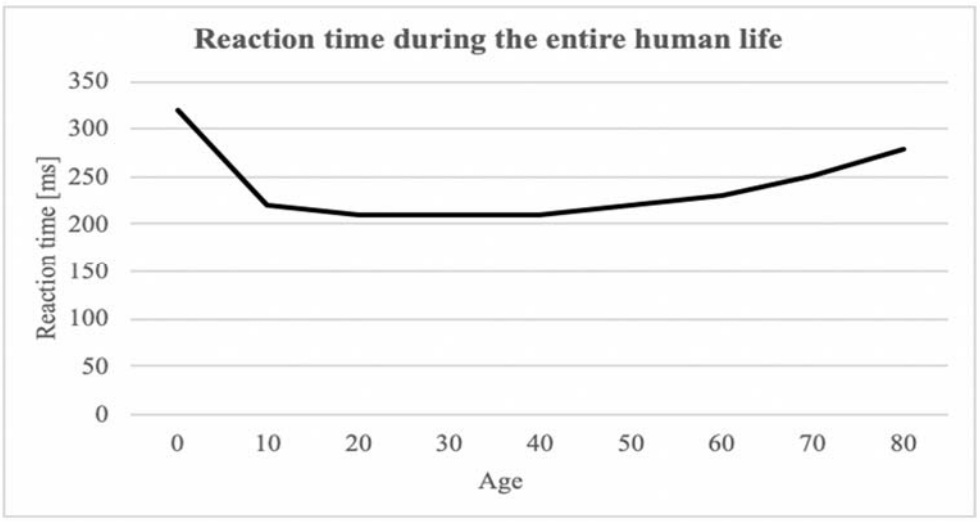

Figure 4
Reaction time during the entire human life (Peráček 1982)

Several authors (Peráček 1982; Jevas & Yan 2001; Luchies et al. 2002; Rose et al. 2002; Birren & Schaie 2005; Der & Deary 2006; Chang et al. 2012; Brychta et al. 2012; Hagovská & Nagyová 2017) support this claim. Conclusions of the above mentioned research works were confirmed in our research. The above stated authors found out that disjunctive reaction time was getting shorter with increasing age.

But in our research was this fact not statistically confirmed and the substantial significance was minimal. One of the reasons that could have an impact on this result was the effect of relative age discussed by numerous authors (Cobley et al. 2009a; Medic et al. 2009; Gómez-López et al. 2017; Sierra-Díaz et al. 2017; Brustio et al. 2018). The differences between 2 young people born in the same calendar year can be in the ontogenesis of the organism (physical, emotional, biological aspect/changes) up to 11 months (Jeronimus et al. 2015).

According to several authors (Helsen et al. 2005, Sierra-Díaz et al. 2017) athletes born in the earlier months of the same calendar year have an advantage over the athletes who are born in the last months of the calendar year. Our two age groups came right after each other

(U15 young juniors – U16 juniors). In a soccer match can be always only one goalkeeper. In the age categories, which were the subject of our research, the playing time (the number of matches) is already divided between the individual categories unequally. Coaches often prefer more mature goalkeepers, who are ahead of their peers thanks to their accelerated development (Musch and Grondin 2001). As the coaches prioritize them in matches, they achieve a larger volume of match load and thus gain more game experience. The impact of the experience was shown below, we just wanted to point out to the fact that also the age of goalkeeper affects his engagement in the matches, and therefore influence also the resulting disjunctive reaction time. In the monitored groups were not found any significant differences (working on the assumption of the effect of the relative age and small quantity of monitor groups), because in both groups there were goalkeepers, who were in goal during the matches either more often or less. However, the differences between the best goalkeepers in individual groups were evident (Fig. 2 and Table 1). The best goalkeeper of juniors achieved by 19 % (2.37 ms) better result than the young junior goalkeeper. After acquiring the basic data on disjunctive reaction time, our goal was to find out how the reaction time varies for players of different age and agility performance level (group A, group B). So we were able to prove in our work the impact of age on the soccer goalkeepers´ disjunctive reaction time, but we note that it was confirmed only for the best of them, not within the entire group.

Agility performance level aspect

It has been shown that the impact of gaining experience in sports has a positive effect on the development, not only in sports (in soccer) and game performance, but also on the personality development as a whole (Larson 2000; Fraser-Thomas et al. 2005; Holt & Neely 2011; Jannika 2016). Not only there are positive influences on the individual game performance, but also positive changes in individual factors, that affect it. It has been shown that the individual types of sports do not have an important impact on the reaction speed and perception of the situation and that sports games have a positive impact on the length of athletes´ reaction time (Ando et al. 2001). In sports games, and also in soccer, a key role within the individual game performance has players´ experience. They gain this experience in training (volume of training load), matches, and various tournaments (Kandel & Kandel 2000; Duerden & Dupont 2008). It is quite logical that not all goalkeepers have the same amount of experience. This is influenced by several factors, including the agility performance level. In general, the assumption is that the players, who are taking part in more training, matches and tournaments, will have more experience. However, it is also important at what level the particular training or

match was (Brümmer et al 2001). There is a difference between a match in the third highest competition and in the first. The goalkeeper has to solve game situations created by players with higher quality, so also the realization (intensity and also the complexity of the load) of opponent´s game activities is at higher qualitative level (Aglitoti et al. 2008). Therefore, it is not only the number of experience during the player´s career is important, but also its quality (trainings, competitions, matches). This is also confirmed in the work of Ehlers et al. (2018), in which the authors found that the disjunctive reaction time of athletes is becoming shorter with an increase of quality and quantity of gained experience. In our work was this effect not statistically confirmed, only substantially and logically. On the basis of demands on the quality of training process, material-technical provision, expertness of coaches and more demanding national and international confrontations, was confirmed that although not all goalkeepers in the research group of higher agility performance level achieved better results of disjunctive reaction time values than goalkeepers in the research group of lower agility performance group, but when comparing the best of them, we found out significant differences (Fig. 3 and Tab. 2). The difference between the best goalkeeper of the higher agility performance level and the goalkeeper of the lower agility performance level was 20 %.

It would be appropriate to extend the research and find other parameters that affect, or can have an impact on the length of soccer goalkeepers´ disjunctive reaction time, such as stimulus colour, warm-up specificity, the quantity of training units.

Conclusion

Sport positively affects the function of analysers, the transmission of impulses on neuro-muscular discs. The ability to react quickly and correctly has an impact on every action of the player in a match, therefore the disjunctive reaction time is one of the important factors affecting individual game performance in a match. Our assumption was that the disjunctive reaction time of the monitored goalkeepers would change significantly under the impact of these stimuli.

The first hypothesis, in which we assumed that older goalkeepers will have the disjunctive reaction time significantly shorter than younger goalkeepers, was not statistically confirmed and the substantive significance represented only minimal values. A key role in this played also the large range of results in the group of older goalkeepers, which was subsequently reflected in the final result. When we compared the players/goalkeepers with the best results in both groups, the differences were significant. Here we confirmed the fact that the best

goalkeepers amongst the older goalkeepers, were significantly better than the best goalkeepers amongst the younger goalkeepers, what is probably connected with the length of their biological age (sports age), but also with the quality of the training process.

In the second hypothesis, we assumed that the goalkeepers of higher agility performance level would have the disjunctive reaction time significantly shorter than the goalkeepers of lower agility performance level. This assumption was not statistically confirmed, only logically and substantially. By means of Cohen´s, "d" was found the mean effect. So we can draw a conclusion from it, that the high-quality training process, in which participate the goalkeepers of higher agility performance level, has an impact on the values of goalkeepers´ disjunctive reaction time. So, on the basis of our results, we can conclude that it is "software" and not "hardware". It means that the perceptual abilities, which separate elite players from beginners (sub-elite players) are learnt or are "downloaded" in practice (like software). It is not the basic equipment of a human machine. This fact was helpful in formulation of the most well known theory related to skills in modern sports. In it is no room for genes.

The training process, matches and experience, which the players gain, support the improvement of many functions. They have an emotional effect and as a load of various intensity significantly interfere in somatic and vegetative functions. Sports soccer training improves also the function of analysers, especially visual, motor and analyser of hearing. The adaptation of visual function manifests itself by the stabilization of the extraocular muscles balance, the improvement of sight in the dark and improvement of the visual-motor reaction.
Based on the results we recommend:

- to use disjunctive reaction time as a selection criterion for young and talented soccer players, especially goalkeepers,
- to use the diagnostic of disjunctive reaction time in the training process. It is an important functional indicator of the speed and quality of the goalkeeper´s decision-making process. It can be used with other functional and motor tests for assessment of training experience and its dynamic changes.

References

1. ABERNETHY, B. et al., 2008. Expertise and Attunement to Kinematic Constraints. *Perception*. **37**(6): 931-948.
2. AGLIOTI, S. M., et al., 2008. Action Anticipation and Motor Resonance in Elite Basketball Players. *Nature Neuroscience*. **11**(9): 1109-1116.

3. ANDO, S. et al., 2001. Central and peripheral visual reaction time of soccer players and nonathletes. In: *Perceptual and Motor Skills.* **92**(3), 786-794. ISSN 0031-5125.
4. BABIC, M., M. HOLIENKA & M. MIKULIČ, 2018. Internal load of soccer goalkeepers during the improvement of selected game activities. In: *Journal of Physical Education and Sport*. **18**(3), 1731-1737. ISSN 2247-806X.
5. BABIC, M., M. HOLIENKA & M. OBETKO, 2019. Vybrané ukazovatele herného výkonu reprezentačných brankárov Slovenska v kategórií U16. In: *Telesná výchova & šport.* **29**(3), 17-21. ISSN 1335-2245.
6. BIRREN J.E. a K. SCHAIE (Eds.), 2005. *Handbook of the psychology of aging*. 6. vyd. Burlington, MA: Elsevier Academic Press. ISBN 978-0-12-101264-9.
7. BRÜMMER, V., et al., 2001. Brain Cortical Activity Is Influenced by Exercise Mode and Intensity. *Medicine & Science in Sports & Exercise.* **43**(10),1863-1872.
8. BRUSTIO, P. R. et al., 2018. The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. In: *PLoS One*. **13**(4), e0196253. ISSN 1932-6203.
9. BRYCHTA, P. et al., 2012. Multi-choice reaction rate of the lower limbs schoolchildren is improving with age. In: Česká kinantropologie. **16**(4), 103-110. ISSN 1211-9261.
10. CHANG, Y K., et al., 2012. Effect of resistance-exercise training on cognitive function in healthy older adults: a review. In: *Journal of Aging and Physical Activity*. **20**(4), 497-517. ISSN 1543-267X.
11. COBLEY, S. et al., 2009. Annual age-grouping and athlete development: A meta-analytical review of relative age effects in sport. In: *Sports Medicine*. **39**(3), 235-256. ISSN 1179-2035.
12. DAVID, L., et al., 2010. An Event-Related Visual Occlusion Method for Examining Anticipatory Skill in Natural Interceptive Tasks. Behaviour Research Methods 42(**2**), 556-562.
13. DER, G. a I. J. DEARY, 2006. Age and sex differences in reaction time in adulthood: Results from the United Kingdom health and lifestyle survey. In: *Psychology and Aging.* **21**(1), 62-73. ISSN 1939-1498.
14. DORŇÁK, R. & P. PERÁČEK, 1979. *Význam zmien reakčného času na rôznofarebné podnety v rôznych častiach zorného poľa.* Praha, ÚV ČSTV, Sborník vědeckých prací.
15. DUERDEN, EMMA G. & D. LAVERDURE-DUPONT, 2008. Practice Makes Cortex. *The Journal of Neuroscience.* **28**(35), 8655-8657.

16. EHLERS, J. et al., 2018. A view to a click: Pupil size changes as input command in eyes-only computer interaction. In: *International Journal of Human-Computer Studies*. 119, 28-34. ISSN 1071-5819.
17. FRASER-THOMAS, J. L. J. COTÉ & J. DEAKIN, 2005. Youth sport programs: an avenue to foster positive youth development. In: *Physical Education and Sport Pedagogy*. **10**(1), 19-40. ISSN 1742-5786.
18. GOMÉZ-LOPÉZ, M. et al., 2017. Relative age effect in handball players of Spain. In: *Journal of Physical Education and Sport*. **17**(2), 705-711. ISSN 2247-806X.
19. HAGOVSKA, M. & I., NAGYOVA, 2017. The transfer of skills from cognitive and physical training to activities of daily living: a randomised controlled study. In: *European Journal of Ageing*. **14**(2), 133-142.
20. HAMAR, D. & E. ZEMKOVÁ, 1998. Test disjunktívnych reakčno-rýchlostných schopností dolných končatín. In: *Medicina Sportiva Bohemica a Slovaca*. **7**(3), 74-78. ISSN 1210-5481.
21. HELSEN, W. F., J. Van WINCKEL & A. M. WILLIAMS, 2005. The relative age effect in youth soccer across Europe. In: *Journal of Sport Sciences*. **23**(6), 629-636. ISSN 0264-0414.
22. HOLT, N. L. & K. C. NEELY, 2011. Positive youth development through sport: A review. In: *Revista de Iberoamericana de Psicología del Ejercicio y el Deporte*. **6**(2), 299-316. ISSN 1886-8576.
23. JANNIKA, J., 2016. *The influence of gender and sport type on developmental experiences and life skill development of Division 1 collegiate student-athletes. Beaumont.* Dizertačná práca. Lamar University. ISBN 978-1369051957.
24. JERONIMUS, B. F. et al., 2015. Relative age effects in dutch adolescents: concurrent and prospective analyses. In: *PLoS One*. **10**(6), 1-17. ISSN 1932-6203.
25. JEVAS, S. a J.H. YAN, 2001. The effect of aging on cognitive function: A preliminary quantitative review. In: *Research Quarterly for Exercise and Sport.* **72**(49), 38-40. ISSN 0364-9857.
26. KANDEL, L. & E. KANDEL, 2000. *Memory: From Mind to Molecules*. MacMillan, 2000, London.
27. LARSON, R. W., 2000. Toward a psychology of positive youth development. In: *American Psychologist*. **55**(1), 170-183. ISSN 1935-990X.

28. LUCHIES, C.W. et.al., 2002. Effects of age, step direction, and reaction condition on the ability to step quickly. In: Journal of Gerontology: *Medical Sciences*. **57**(4), 246-249. ISSN 1758-535X.
29. MANN, D. et al., 2010. An Event-Related Visual Occlusion Method for Examining Anticipatory Skill in Natural Interceptive Tasks. *Behavior Research Methods*. **42(**2):556-562.
30. MEDIC, N. et al., 2009. Relative Age effect in masters sports: Replication and extension. In: *Research Quarterly for Exercise and Sport*. **80**(3), 669-675. ISSN 0270-2367.
31. MULLER, S., et al., 2006. How do World- Class Cricket Batsmen Anticipate a Bowler's Intention? *Quarterly Journal of Experimental Psychology*. **59**(10), 2162-2180.
32. MUSCH, J. & S. GRONDIN, 2001. Unequal competition as an impediment to personal development: A review of the relative age effect in sport. In: *Develompental Review*. **21**(2), 147-167. ISSN 0273-2297.
33. OBETKO, M., M. BABIC & P. PERÁČEK, 2019. Changes in disjunctive reaction time of soccer goalkeepers in selected training load zones. In: *Journal of Physical Education and Sport*. **19**(suppl. 2), 420-426. ISSN 2247-806X.
34. PERÁČEK, P., 1982. *Význam reakčného času vo futbale. Bratislava*. Diplomová práca. Univerzita Komenského, Fakulta telesnej výchovy a športu, Katedra biologicko-lekárskych základov telesnej výchovy.
35. PERÁČEK, P., M. Holienka& J. Sedlárová, 1981. *Funkčné zmeny u futbalistov rôznych vekových kategórií.* Bratislava, SÚV ČSTV.
36. ROSE, S. A. et. al., 2002. A longitudinal study of visual expectation and reaction time in the first year of life. In: *Child development*. **73**(1), 47-61. ISSN 1467-8624.
37. SIERRA-DÍAZ, M. J. et al., 2017. Soccer and relative age effect: A walk among elite players and young players. In: *Sports*. **5**(1), 5-25. ISSN 2075-4663.
38. STARKES, J., L. & J., DEAKIN, 1984. Perception in Sport: A Cognitive Approach to Skilled Performance. In *W. F. Straub a J. Williams, eds. Cognitive Sports Psychology*, 115- 128, Sport Science Intl.
39. STARKES, J., L., 1987. Skill in Field Hockey: The Nature of the Cognitive Advantage. *Journal of Sport Psychology.* 9, 146-160.

40. STE-MARIE, D. M. et al., 2012. Observation interventions for motor skill learning and performance: an applied model for the use of observation. In: *International Review of Sport and Exercise Psychology*. **5**(2), 145-176. ISSN 1750-9858.
41. ŠTULRAJTER, V., 1983. Rýchlosť a kvalita reakcie a ich vzťah k hernej výkonnosti. *Tréner.* **27**(10), s. 462-465.
42. VAN RALTEN, TAMAR, R. et al., 2008. Practice Induces Function- Specific Changes in Brain Activity. *PLoS ONE.* **3**(10), e:3270.
43. XUEDONG, Y. et al., 2018. How does intersection field of view influence driving safety in an emergent situation? In: *Accident Analysis and Prevention*. 119/2018, 162-175. ISSN 0001-4575.