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Effect of 6-Month Fascia-Oriented Training on the Dynamics of Changes of the Height of Vertical Jump in Well-Trained Junior Female Volleyball Players

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Abstract

Based on the research review, the fascia-oriented Fascial Fitness training (FF) may positively influence sports performance. Its component focused on the "catapult" mechanism can increase the capability of the connective tissue to store and release kinetic energy, thus enhance various movement actions, activities and skills in many sports, including the jumping skills in volleyball. The study was conducted to assess the effect of the 6-month fascia-oriented training on the height of the vertical jump in well-trained junior female volleyball players. 16 players (age 17.31 ± 0.98; height 173 ± 5.26; weight 65.25 ± 6.75), the members of the team competing in the national league, were randomly assigned for the training group (TG) and control group (CG). TG participated in the supervised 25-minute fascia-oriented training twice a week for six months. To measure the height of the jump, the force plate Bertec FP6012-15-4000 was used. Three testing measures were executed: pre-test, mid-test and post-test with three trials of the standing vertical countermovement jump with all arm movement (CMJ). Based on the FF principles, the study presupposed that due to the fascia-oriented training, the height of CMJ may rise slightly more in TG than in CG after three months. After six months, a statistically significant increase was expected in TG comparing to CG. Based on the results of the study, we conclude that the 6-month fascia-oriented training focused on the development of the height of vertical jump in well-trained junior volleyball players neither complied with the assumed dynamics in changes nor was statistically significantly beneficial. However, by observing the results we purport that the dynamics of the changes of the height of vertical jump indicates that fascia-oriented training may positively influence the stability and efficiency of the jumping performance during the in-season.

Keywords: *volleyball, fascia-oriented training, movement intervention, height of vertical jump, dynamics of changes*

INTRODUCTION

Volleyball is a popular team ball game requiring a specific level of fitness in combination with specific technical skills. Volleyball players need exceptional jumping abilities, and explosive strength is critical to the success in the game, as volleyball involves constant vertical jumping high above the net (Haník, Vlach, Lehnert, Ejem, Juda & Vorálek, 2008; Císař, 2005). In a 5-set game, an elite player is estimated to perform 250–300 attacking and blocking movements (Martinez, 2017). Ziv and Lidor (2010), who reviewed observational and experimental studies targeted on vertical jump performances in female and male volleyball players, concluded that players of more successful teams have higher vertical jumps. They also concluded that in female volleyball due to a greater disparity in jumping performance, the jumping ability seem to be more determinantal to success. Thus, our research project aimed to examine the effect of the fascia-oriented training called Fascial Fitness (FF) on jumping performance by monitoring and observing the dynamics of the changes in the height of vertical jump. If beneficial, FF may then enhance the training process as such.

In volleyball, the phases of the different types of vertical jump are similar, whether spiking, blocking and serving. Different authors define 3–8 phases, with three (takeoff, flight and landing phase) occurring in all three basic types of vertical jump. Some more phases can be involved, either the running approach and/or the counter-movement with or without the arm-swinging movement. Concerning the countermovement jumping actions, according to Turner and Jeffreys (2010), the phenomenon called the stretch-shortening cycle (SSC) is broadly agreed to occur. The SSC consists of three phases: eccentric, isometric transitional (amortization) and explosive concentric. When subjected to examination, it seems probable that the storage of the kinetic energy, nervous processes, active state, length-tension characteristics, pre-activity tension and enhanced motor coordination are the main mechanics employed in the SSC. If these components targeted in training, their improvement can bring enhancing effect in the performance of the SSC, and thus in jumping skills and activities. Turner and Jeffreys (2010) further conclude that training methods improving muscular pre-activity, such as plyometric and ballistic training, may be beneficial for the improvement of the jumping performance. They also state that the jumping capacity can be increased by SSC drills focused on the muscle-tendon cooperation, force-velocity relations, fast smooth landing, efficient storage and utilization of the kinetic energy in tendons performed with respect to an athlete's strength capacity and sport-specific variables. As the review indicates, in the SSC, the lower extremities demonstrate features similar to the ones of a spring. Regarding their findings, they closely correlates with the ideas and aims of FF.

Among the research studies aimed at the structures of the connective tissue, there are those focused on the role of fasciae and tendons in motion. They observe and examine muscle-fascia-tendon interactions and, the ability of the elastic structures of the connective tissue to store and release kinetic energy (the "catapult" mechanism) in both animals and humans. Some of the studies conclude that the observed elastic structures of the connective tissue are capable of storing and releasing kinetic energy highly effectively (Astley & Roberts, 2012; Roberts, 2006; Roberts & Konow, 2013; Kawakami, Muraoka, Ito, Kanehisa & Fukunaga, 2002; Purslow, 2002; Kram & Dawson, 1998). Humans are also capable of the mechanism (Fukunaga, Kawakami, Kubo & Kanehisa, 2002; Sawicki, Lewis & Ferris, 2009). Thus, if we try to enhance the utilization of the mechanism in sport more effectively, it may positively affect jumping performances.

The latest research findings show that the elastic structures of the connective tissue can play a very important role in movement (Schleip, Findley, Chaitow & Huijing, 2012). Schleip and Müller (2013) state that the connective tissue is trainable. It answers to strain-loading demands (EI-Labban, Hopper & Barber, 1993), which may induce changes bringing both a desired and undesired adaptation of the tissue. According to Schleip et al. (2015), and Schleip and Müller (2013), the tissue reacts to different types of training or exercise, but the specifically-targeted fascia-oriented training Fascial Fitness appears to be more effective.

FF consists of different stretching techniques and self-applied massages, whose performance should be executed in accordance with the specific principles defining the duration, intensity and frequency of the training, as well as the involvement of stretching techniques and the arrangement of exercise (Schleip & Müller, 2013). FF aims to mechanically lengthen, architecturally remodel, hydrate and release various structures of the connective tissue. It further focuses on the proprioceptive stimulation, the stimulation of fibroblasts and their bio-chemical processes, and on the effective storage and release of the kinetic energy in the structures. Last but not least it directs at their elasticity (Myers, 2009; Schleip & Müller, 2013; Schleip et al., 2015).

As for the jumping performance potential, our research review showed that no practical, longer-lasting implication of FF and its potential beneficial effect on jumping skills in sport has been examined profoundly yet. Several studies observe the impact of selected FF techniques on different motion tasks, such as hopping (Lamontagne & Kennedy, 2013), foam rolling (Barnes, 1997) and running (Holt, Roberts & Askew, 2014). Thus, we determined to examine the effect of FF on jumping performance potential in volleyball. Based on our experience in volleyball training and the experience with FF employed in the exercise methods we teach, we aimed to assess the

effect of the applied 6-month FF training on the height of the vertical jump in well-trained junior female volleyball players. Based on the knowledge of the principles of FF, we focused on the dynamics of the changes of the height of vertical jump during the course of the research experiment. If our assumption verified, besides volleyball, FF may be included in training processes in other sports where jumping skills are essential as an enhancing component.

GOALS, METHODS AND FF PROGRAMME

The goal of the research was to assess the effect of the 6-month fascia-oriented FF training on the height of the vertical jump in well-trained junior female volleyball players. The research also aimed to monitor and assess the dynamics of the changes of the height of the vertical jump in the course of the research project.

The research was conducted as a longitudinal experiment with the FF exercise programme applied to the experimental training group for the course of six month. The control group participated in the regular training programme of volleyball only without any special complementary programme, thus in the control group no interventionist, support factors are not implied.

For testing, the force plate Bertec with Simi Motion devise for 3D kinematic analysis was used to get detailed information available for future further analyses. Three testing measures were executed in the laboratory environment: pre-test, mid-test and post-test, applied before, in the middle and after the experiment respectively.

Each unit of the FF training programme lasted 25 minutes, and was applied at the end of their regular training unit twice a week to the experimental training group. The programme was designed in accordance with the principles of FF (Schleip & Müller, 2013). It included three different parts: the self-treatment massage of the feet with foot massage balls, the stretching part and the final slow self-treatment massage of the lower extremities on foam rollers, where the stretching part focused on the enhancement of the elasticity and the spring-like catapult mechanism of the connective tissue in the lower extremities primarily.

SUBJECTS

The volleyball team for research project was selected intentionally. The participants had to meet the basic predefined requirements as follows: they had to be female volleyball junior players of one team aged 15–18, training regularly for one whole season. We cooperated with the sports club KPS Brno, as we assumed their participation in the elite division would guarantee a successful completion of the whole 6-month FF training plan. The group consists of 16 subjects from one female junior team just promoted to the elite division (age 17.31 ± 0.98; height 173 ± 5.26; weight 65.25 ± 6.75). All the subjects were free of injury. All the subjects signed the informed consent about their voluntary participation in the research and agreement with the anonymous data analysis. The subjects were assigned to the experimental training (TG) and control group (CG) by their coach randomly. Both TG and CG consist of eight subjects each. One subject of TG did not participate in the mid-test due to serious family problems, but the subject participated in the whole FF training programme. For that reason, we decided not to exclude the subject from the research. Finally, 14 participants completed the experiment, seven from the TG and seven from the CG. During the experiment, two subjects had to be excluded for the health reasons.

TESTING PROTOCOL

The force plate Bertec FP6012-15-4000 operating at a sampling frequency of 360Hz was used to test the height of the vertical CMJ with all arm movement, with the synchronous 3D kinematic analysis Simi Motion version 9.0.5 recording it. The markers placed on the right and left iliac crests recorded the execution of the jump. To eliminate deviations in the differences between the right and left side, the height of the jumps was recorded as a virtual point. The centre of abscissa between markers located on the left and right iliac crests represented the virtual point. The height was calculated as the perpendicular distance of the virtual point along the plane Z towards the planes XY. To assess the effect of FF on the height of the jump, the participants performed three trials of the standing vertical countermovement jump with all arm movements. This jumping test is a variation of the Abalakov vertical jumping test, where the countermovement and the arm swing are considered as a more natural and functional approach for the increase in jumping performance (Laffayte, Wagner & Tombleson, 2014). In all the trials, the degree of knee-bend employed by the subjects was self-determined with the primary aim to jump as high as possible. The depth of the knee flexion and the amount of the arm movement were not preset. According to Laffayte et al. (2014), this functional approach is based on the assumption that skilled volleyball players choose their own course of knee-bend and arm swing to maximize the peak force and velocity, which will result in maximal jump height. When conducting the jumps, the subjects were encouraged to perform each trial with maximum effort to jump as high as possible.

STATISTICAL ANALYSES

The highest participants' trials in both the experimental training and control group were used for the statistical testing and analysis in all three testing measurements. The impact of the application of FF training on the height of the vertical jump is only expected in the experimental training group.

Due to the small number of participants, we used non-parametric methods. The results were statistically analysed by the non-parametric statistical test, Friedman's ANOVA. Friedman's ANOVA by ranks is an alternative to a one-way within-subjects analysis of variance. This test compares variables measured in dependent samples (repeated measures). The Kendall coefficient of concordance (effect size measure) essentially denotes the average rank order correlation between the cases. .

RESULTS

Figure 1 illustrates the basic values of the height of the vertical jump for both the experimental training and control group in all three measurements. Table 1 and 2 outline and introduce the basic statistical characteristics. They depict the median, lower and upper quartile of the height of the vertical jump for both groups in all three measurements. Tables 3–5 present the key results.

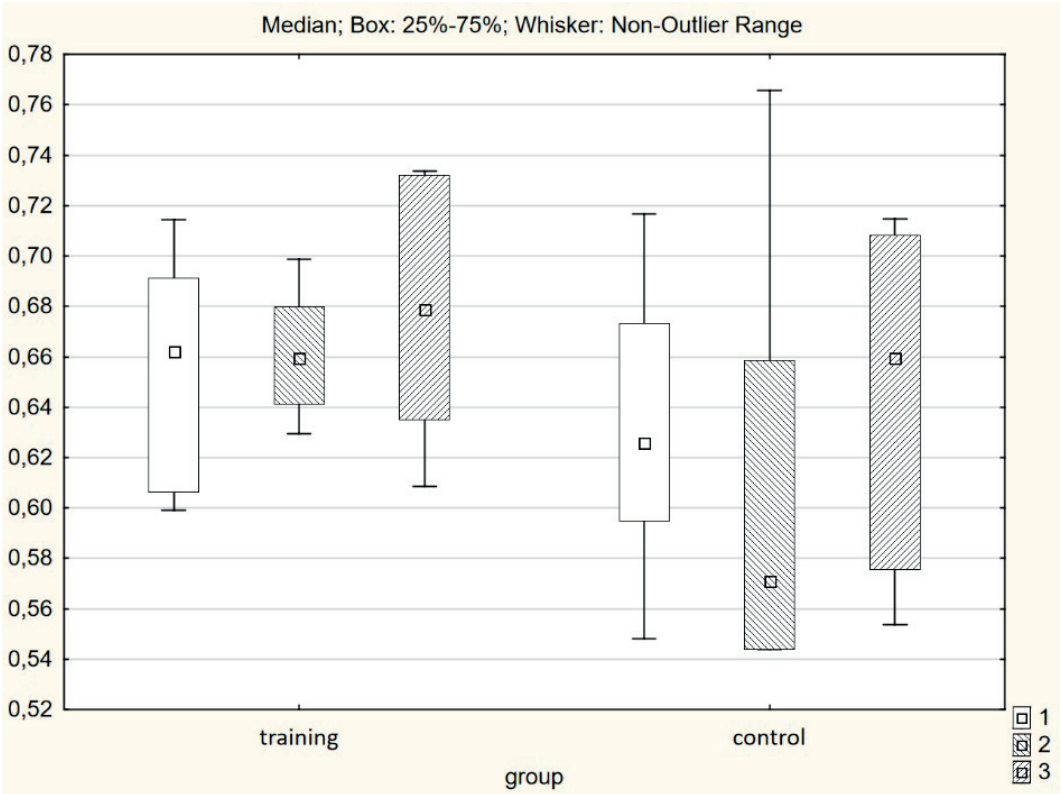

Fig. 1: Basic values of the height of the vertical jump in all three measurements – TG and CG.

Tab. 1: Basic statistical characteristics – the height of the vertical jump in TG

Measurement	Descriptive Statistics – training group					
	Valid N	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
1	7	0.662	0.599	0.714	0.606	0.691
2	6	0.660	0.630	0.699	0.641	0.680
3	7	0.679	0.609	0.734	0.635	0.732

Tab. 2: Basic statistical characteristics – the height of the vertical jump in CG

Measurement	Descriptive Statistics – control group					
	Valid N	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
1	7	0.626	0.548	0.717	0.595	0.673
2	7	0.571	0.316	0.766	0.544	0.659
3	7	0.659	0.554	0.715	0.576	0.708

Tab. 3: Result of Friedman ANOVA – the height of the vertical jump in TG

Measurement	Training group Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 6, df = 2) = 1.333 p = 0 .513 Coefficient of Concordance = 0.111 Aver. rank r = –0.067			
	Average Rank	Sum of Ranks	Mean	Std. Dev.
1	1.666	10.000	0.653	0.050
2	2.000	12.000	0.661	0.027
3	2.333	14.000	0.667	0.043

Tab. 4: Result of Friedman ANOVA – the height of the vertical jump in CG

Measurement	Control group Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 7, df = 2) = 3.429 p = 0.180 Coefficient of Concordance = 0.245 Aver. rank r = 0.119			
	Average Rank	Sum of Ranks	Mean	Std. Dev.
1	2.286	16.000	0.629	0.055
2	1.429	10.000	0.568	0.136
3	2.286	16.000	0.639	0.066

Based on the value of p in both groups, we do not reject the hypothesis of equality of the mean values of three measurements. The differences are not large enough to be statistically significant. The coefficient of concordance indicates a small size effect in the experimental group (Kendall = 0.111). The coefficient of concordance shows a middle size effect in the control group (Kendal = 0.245) given by a drop in performance in the second measurement.

Tab. 5: Differences of the height of the vertical jump in all three measurements – TG and CG

Training group			Control group	
Measurement	cm		Measurement	cm
1–2.	–0.2		1–2.	–5.5
2–3.	1.9		2–3.	8.8
1–3.	1.7		1–3.	3.3

Table 5 shows that the dynamics of the changes of the height of the vertical jump demonstrates a slight worsening (–0.2 cm) between the first and second measurements, and the increase of the height of the vertical jump between the first and third measurements (1.7 cm) in the experimental training group. Given the higher measured input parameters of the experimental training group comparing to the control group, it can be stated that after the application of the 6-month FF training, the improvement was made, although it is not statistically significant. However, there was no improvement after the first three months.

The dynamics of the changes of the height of the vertical jump in the control group differs. After the first measurement, there was a relatively large worsening (–5.5 cm), but after the following three months the height of the vertical jump improved. Comparing the input and output results, there is an improvement of 3.3 cm.

Concerning the absolute results, there is still a difference between the experimental training and control group in favour of the training one as shown in Figure 1.

DISCUSSION

Schleip and Müller (2013) state that the changes and improvements in the structure and functioning of the connective tissue that FF aims at are expected to appear within the course of 6–24 months, if trained regularly. Latest references (Meinl, 2016) suggest that the desired changes may already occur after three months of regular FF training. Based on this knowledge, we expected that the fascia-oriented training applied systematically during the course of six months would induce a statistically more significant increase of the height of the vertical jump in the experimental training group comparing to the control group finally. We further expected a moderate improvement after the first three months, and a more significant change of the height of the vertical jump was assumed in the training group compared to the control one.

As the results of our study show, both groups worsened after the first three months. Although, the worsening of the experimental training group was not so significant comparing to the control group. After six months, both groups improved. Even though the improvement of the control group was slightly higher compared to the experimental training group, neither was statistically significant and the absolute results showed a difference in favour of the experimental training group. Based on the results of the experiment, our research study concludes that the 3-month FF training did not bring the expected improvement regarding the changes of heights of the vertical jump in the experimental training group. Furthermore, despite the fact that the 6-month application of FF shows the improvement of the height of the jump in the experimental training group, the improvement is not statistically significant.

When observing the dynamics of the changes of the height of the vertical jump, based on the results of the mid-test in both groups we can propose that the application of FF for the first three months did not confirm our assumptions. However, it seems to stabilize the efficiency of the jumping performance in the experimental training group during the in-season, which should not be overlooked. In elite players whose sports performances and efficiency can be demanding to improve, this impact may bring an appreciable effect and become a stabilizing factor.

Concerning the non-confirmed dynamics of the expected changes of the height of the vertical jump and the lack of significant impact, there may be different possible reasons and explanations. As for the duration of the experiment, as written above, the most frequent recommendation of the minimum-maximum length is 6–24 months and some references even suggest three months as a sufficient period. Based on the results of our study, we propose that the duration of FF training application longer than six months may be more beneficial, and might bring the desired and statistically more significant changes, as the connective tissue reacts slowly (Schleip & Müller, 2013; Myers, 2009).

Moreover, regarding the contents of the FF training programme, there are many elaborated principles explained clearly about FF (Schleip & Müller, 2013; Schleip et al., 2015). However, there are no programmes designed in detail. When setting up the FF training programme, we proceeded from our training experience. We focused on the specific needs in jumping skills in volleyball, and on the principles of FF. We propose that in the future, more studies with elaborated designs applied in different sports could bring more profound and expert perspectives about the involvement of FF in sport.

Concerning the other extrinsic factors, the size of the group was small, which might also limit the results of the study. Additionally, the players' training history could also have an impact, as their training records showed that individual players started playing at different age.

Regarding the intrinsic factors, motivation is an extremely important factor in sport, as well as genetic predispositions. As for motivation, the cooperation with sociologists may enhance further research in the field of FF. As for genetic factors, only little research has been done in connection with FF and its impact on sports performance and efficiency. Our research did not include these aspects, but we think that further research focused on these factors could extend the current knowledge about FF in sport and support the idea of the importance of the involvement of FF in the field of sport.

CONCLUSIONS

In conclusion, the results of the current study showed that the 6-month FF training did not produced statistically significant changes in the height of the vertical jump, and the dynamics of the changes of the height of the vertical jump did not confirm our assumption. However, it seems to stabilize the efficiency of the jumping performance during the in-season. Thus, the results of the study cannot support the presupposition suggesting that the fascia-oriented training FF may be a beneficial and significantly effective complement to volleyball training to enhance jumping skills unambiguously. As the results indicate some possible beneficial impact, we further conclude that more profound applied research seems to be desirable to conduct to observe and examine potential importance and applicability of FF in sport.

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Assessment of COP characteristics and force-time changes during walking in the third trimester of pregnancy

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Abstract

Purpose: *The primary aim of this study was to analyse the COP characteristics and force-time changes during walking between weeks 27 and 36 of pregnancy. The secondary objective was to verify the influence of the specific orthopaedic shoes that were given to the experimental group. The experimental group wore patented J Hanák R biomechanical footwear and insoles, which are designed to help with redistribution of forces acting on foot, to support both longitudinal and transverse arches of the foot and to strengthen the foot muscles during movement.*

Methods: *Seventy-three pregnant women participated in this study. This group was random divided into the experimental group (35 pregnant women) wearing specific orthopaedic shoes and the control group (38 pregnant women). The motor task consisted of five gait trials where two foot prints for each leg were always recorded. The participants started barefoot walking 3 m ahead of the pressure platform and finished the trial 1 m after the end of the platform in order to preserve acceleration and deceleration in gait. Participants walked at their own preferred velocity. All pedobarometric parameters were registered by Emed walkway – trademark of Novel GmbH in Munich, Germany. Data processing was divided to two scrips. The first script processed data to these variables (COP characteristics): Centre of pressure index (COPI), centre of pressure excursion index (COPEI), distance (D) of COP, maximum velocity (MaV) and mean velocity (MeV) of COP. The second script processed data for ten pre-defined areas of the foot: hindfoot, midfoot, MH1-5 – metatarsal heads, big toe, second toe, toes 3, 4 and 5 with these applied variables (force-time characteristics): Force-time integral (FTI) and contact time (CT).*

Results: *For the experimental group, in comparison between 27th week and the 36th week of gestation, we can find lower COPI for both feet, significantly only for the left foot ($p = 0.04$). Also, significant difference in COPEI ($p = 0.03$, $p = 0.03$) for both feet was found. In comparison pre and post measurement we found higher values of parameters COPI and COPEI and that indicates more lateral weight shifting during the last trimester. We can distinctly register extension of D, especially for the left foot ($p = 0.04$). Changes in velocity of COP indicate that MaV was increased for both feet ($p = 0.00$, $p = 0.00$) and MeV was significantly increased only for the right foot ($p = 0.00$) in the 36 week of pregnancy. For the control group, we found no significant changes in COPI, COPEI or COP. MaV and MeV of COP were significantly increased for both feet in the 36 week of pregnancy ($p = 0.02$, $p = 0.00$, $p = 0.01$, $p = 0.00$). Higher values of MaV and MeV indicate that pregnant women accelerated their walking in the 36 week of pregnancy. Further, force-time characteristics in most cases did not reveal statistically significant changes in the last trimester.*

Conclusion: *Over the last three months of pregnancy, significant observable changes can be found, especially through COP parameters of the experimental and the control group. We found out that the specific orthopaedic shoes given to the experimental group influenced the trajectory of COP, which could have positive health aspects. Further, certain conflicting results of our study in comparison with other similar studies only confirm that individual biomechanic and physiological developments in pregnancy affect the kinematic and kinetic aspects of walking differently.*

Key Words: *Center of pressure, pregnancy, gait, feet*

INTRODUCTION

Pregnancy is a phase in women's lives when physical and hormonal changes occur, including weight gain, increased ligament laxity, changes in the size of the contact areas of the foot, changes in the velocity of gait, disturbed neuromuscular control and increased muscle weakness (Titianova, Mateev & Tarkka 2004). These changes may lead to an increase in postural or dynamic instability (Bertuit, Leyh, Rooze & Feipel 2017). Changes in gait and postural control during pregnancy can lead to a higher risk of falls during walking relative to non-pregnant women (Krkeljas, 2018). The risk of falling can reach up to 27% (Dunning et al., 2003). Moreover, the risk of falling is significantly higher in the third trimester of pregnancy (Inanir, Cakmak, Hisim & Demirturk, 2014). Therefore, it is important to observe and analyse kinetics and kinematics aspects in the gait of pregnant women.

Kinematic gait profile has unique development during a pregnancy and based on a several authors, the results of spatial and temporal gait parameters during pregnancy may be different. According Galleher (2001), the gait remains unchanged with similar speed, frequency, stride length and stable kinematic parameters.

On the other side, gait goes through significant changes: gait speed and step length are reduced, there is an increase of stance phase and double-support phase (Błaszczyk, Opala-Berdzik & Plewa, 2016), a decrease of swing phase (Bertuit, Feipel & Rooze, 2015; Forczek & Staszkiewicz, 2012) and a lower frequency of steps (Forczek & Staszkiewicz, 2012). Also, we can register an increase of step width (up to 50 %) in late pregnancy (Osman & Ghazali, 2002; Lymbery & Gilleard, 2005). So, as we can see, there exists a large variability in gait strategies and individual musculoskeletal adaptations in a pregnancy (Forczek & Staszkiewicz, 2012; Galleher, 2001). The center of pressure (COP) characteristics seem to be appropriate for assessing gait (Santos et al., 2008; Oliveira et al., 2009). The center of pressure is influenced by gait velocity, frequency, cycle length, the distribution of the mass of the subject and weight (Titianova, Mateev & Tarkka, 2004).

The COP velocity is lower in late pregnancy (pregnant women: 0.28 ± 0.03 m/s, control group: 0.33 ± 0.04 m/s) (Bertuit, Leyh, Rooze, & Feipel, 2017). Overall, the typical walking profile tends to increase single stance duration and double stance duration in the third trimester compared to the earlier trimesters (Ramachandra, Maiya, Kumar & Kamath, 2018; Błaszczyk, Opala-Berdzik & Plewa, 2016) and this adjustment is for gait stability improvement (Błaszczyk, Opala-Berdzik & Plewa, 2016).

One of the most significant changes is body mass gain (Opala-Berdzik, Bacik & Kurkowska, 2009; Ogamba et al., 2016) The normal body mass gain during pregnancy ranges from 11.3 kg – 15.9 kg (Vanstone et al., 2016) and abdominal mass increases by at least 31 % (6.8 kg) (Whitcome, Shapiro & Lieberman, 2007).

The primary aim of this study was to analyse the COP characteristics and force-time changes during walking between weeks 27 and 36 of pregnancy. The secondary objective was to verify the influence of the specific orthopaedic shoes that were given to the experimental group.

MATERIALS AND METHODS

Participants

73 of 100 pregnant women participated in this study. The rest of the pregnant women (27) did not finish all measurements due premature childbirth or health problems. All pregnant women were addressed based on advertising leaflets in the gynecological departments in Brno. The age (years), height (cm) and body mass (kg) of group are shown in Tables 1. This group was random divided into the experimental group (35 pregnant women) wearing specific orthopaedic shoes developed in cooperation between Masaryk University and J Hanák R and the control group (38 pregnant women). The inclusion criterion was a low-risk pregnancy and the period before the third trimester, whereas the exclusion criteria included any orthopaedic or neurological disorders that could influence the gait. The measurements were conducted at the beginning of the 27th week of gestation (pre-measurement) and at the 36th week of gestation (post-measurement). The experimental group wore special biomechanical shoes during this period. Prior to the study, participants were informed about the measurement procedure and they signed an informed consent. The protocol was approved by the Research Ethics Committee of the Masaryk University, Brno, Czech Republic.

Tab. 1: Participants' characteristics

	Age	Height	Weight 27 week	Weight 32 week	Weight 38 week
Experimental group	30.6 ± 4.2	167.2 ± 7.7	73.5 ± 10.5	76.2 ± 9.4	78.9 ± 10.1
Control group	30.7 ± 3.2	168.8 ± 6.7	73.4 ± 9.1	75.7 ± 10.0	78.4 ±1 0.3

Materials

All pedobarometric parameters were registered by Emed walkway – trademark of Novel GmbH in Munich, Germany. The platform provide accurate, reliable information for the analysis of foot function and diagnosis of foot pathologies. Specifications: (Emed-xl, platform size: 1,529 x 504 mm^2, sensor area: 1,440 x 440mm^2, number of sensors: 25,344, sensor resolution: 4 sensors/cm^2, recording frequency: 100 Hz, measuring range: 10 – 1,270 kPa, pressure threshold: 10 kPa). Data were collected at the laboratory of kinanthropological research on the campus of Masaryk University of Brno, Czech Republic.

Methods

The motor task consisted of 5 gait trials where two footprints for each leg were always recorded. The participants started barefoot walking 3 m ahead of the pressure platform and finished the trial 1 m after the end of the platform in order to preserve acceleration and deceleration in gait. Participants walked at their own preferred velocity. Data was collected from all 5 valid gait trials. This cycle of 5 gait trials always consisted of 10 steps (five steps with the right/left foot). The experimental group was wearing specific orthopaedic shoes 1–2 weeks after first measurements. Based on random selection, chosen women have got 2 pairs of experimental shoes, 1 pair for

home movement, 1 pair for movement in outside. The condition was that they had to wear shoes every day.

Patented J Hanák R biomechanical footwear and insoles are designed to help with redistribution of forces acting on foot, to support both longitudinal and transverse arches of the foot and to strengthen the foot muscles during movement (Gimunová et al., 2017; Hanák & Zvonař, 2013). Experimentally these shoes are given to pregnant women to detection changes of plantar pressure characteristics and foot characteristics during the last trimester. All measurements were done in the same conditions (laboratory, instruments).

Data processing

All parameters were sampled using Novel database pro m (version 25.3.24), which is directly connected with the Emed-xl platform. Data is displayed at the moment of first contact of the foot with the platform to the end of the walk. After collecting all data from pre/post measurements of the experimental and control groups, based on set default scripts, the data was statistically analysed. The first script processed data to these variables (COP characteristics): Centre of pressure index (COPI), a centre of pressure excursion index (COPEI), distance (D) of COP, maximum velocity (MaV) and mean velocity (MeV) of COP. The second script processed data for 10 pre-defined areas of the foot: hindfoot, midfoot, MH1-5 – metatarsal heads, big toe, second toe, toes 3, 4 and 5 (fig. 1) – with these variables: force-time integral (FTI) and contact time (CT). For statistical processing paired t-tests were used (level of statistical significance $p<0.05$). All statistical calculations are mediated by licenced software Novel pro m (version 25.3.24). This software compared each of the variables for both feet of the experimental and the control group within two measurements (the 27th week and the 36th week of pregnancy).

Description of variables:

Center of pressure index (COPI) assesses the ratio between the medial and lateral areas of the foot as determined by the center of pressure. Values of the COPI (> 1) indicate more lateral weight shifting during walking, COPI (< 1) indicates more medial weight shifting during walking (Oeffinger, Pectol & Tylkowski, 2000; Park et al., 2006; Wallace et al., 2018). Center of pressure excursion index (COPEI) assesses the concavity of the center of pressure curve from heel strike to toe-off, and can be a useful parameter in clinical evaluation. Smaller values are associated with more medially directed ground reaction forces which suggest overpronation, while larger values are associated with more laterally directed ground reaction forces, which suggest oversupination (Diaz et al., 2018). Distance (D) evaluates distance the COP traveled during the roll over process (Wallace et al., 2018). Maximum velocity (MaV) is the highest velocity achieved by the COP (Wallace et al., 2018). Mean velocity (MeV) is the mean velocity achieved by the COP (Wallace et al., 2018). Force-time integral (FTI) is a measure of force impulse or the load applied to the plantar region during a certain time (Yihong et al., 2018). Contact time (CT) is an amount of time contact in of the ten pre-defined areas (Wallace et al., 2018).

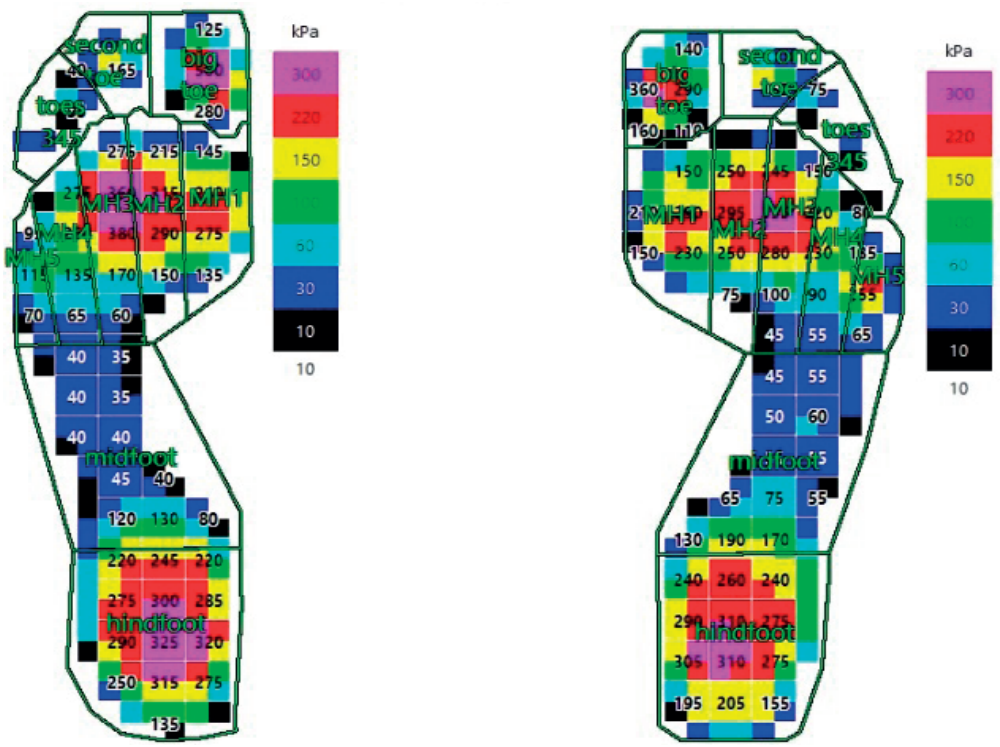

Fig. 1: Ten pre-defined areas of the foot by Novel database pro m (version 25.3.24)

RESULTS

Of 100 participants, 73 pregnant women participated in this study, contributing 365 feet with complete valid Pedobarometry screening on Emed-xl platform.

COP characteristics

The results of COP parameters for the third trimester of pregnancy of both groups are shown in Table 2 and Table 3. For the experimental group, in comparison between 27th week and the 36th week of gestation, we can find lower COPI for both feet, significantly only for the left foot ($p = 0.04$). Also, a significant difference in COPEI ($p = 0.03$, $p = 0.03$) for both feet was found. We can distinctly register extension of D, especially for the left foot ($p = 0.04$). Changes in velocity of COP indicate that MaV was increased for both feet ($p = 0.00$, $p = 0.00$) and MeV was significantly increased only for the right foot ($p = 0.00$) in the 36 week of pregnancy. For the control group, we found no significant changes in COPI, COPEI or COP. MaV and MeV of COP were significantly increased for both feet in the 36 week of pregnancy ($p = 0.02$, $p = 0.00$, $p = 0.01$, $p = 0.00$).

Tab. 2: Comparison of mean COP parameters during the third trimester of the experimental group (n = 35)

Parameters	27 week (L)	27 week (R)	36 week (L)	36 week (R)	*P* (L)	*P* (R)
COPI	1.20 ± 0.15	1.21 ± 0.14	1.17 ± 0.15	1.18 ± 0.13	0.04*	0.06
COPEI (%)	12.74 ± 8.43	14.26 ± 8.33	14.67 ± 8.69	16.05 ± 7.75	0.03*	0.03*
Distance (cm)	22.60 ± 1.35	22.77 ± 1.79	22.91 ± 1.54	23.12 ± 1.51	0.04*	0.06
MaV (m/s)	0.81 ± 0.27	0.79 ± 0.44	0.95 ± 0.38	0.93 ± 0.41	0.00*	0.00*
MeV (m/s)	0.29 ± 0.03	0.28 ± 0.03	0.30 ± 0.03	0.30 ± 0.03	0.06	0.00*

* statistical significance ($p < 0.05$)
* (L) – left foot
* (R) – right foot

Tab. 3: Comparison of mean COP parameters during the third trimester of the control group (n = 38)

Parameters	27 week (L)	27 week (R)	36 week (L)	36 week (R)	*P* (L)	*P* (R)
COPI	1.18 ± 0.13	1.17 ± 0.14	1.17 ± 0.12	1.15 ± 0.13	0.32	0.14
COPEI (%)	13.34 ± 8.47	14.17 ± 8.323	14.91 ± 8.33	15.52 ± 7.25	0.07	0.09
Distance (cm)	23.12 ± 0.98	23.19 ± 0.79	22.68 ± 0.56	23.15 ± 0.39	0.38	0.91
MaV (m/s)	0.80 ± 0.49	0.70 ± 0.18	0.93 ± 0.64	0.83 ± 0.30	0.02*	0.00*
MeV (m/s)	0.29 ± 0.03	0.28 ± 0.03	0.30 ± 0.04	0.30 ± 0.03	0.01*	0.00*

* statistical significance ($p < 0.05$)
* (L) – left foot
* (R) – right foot

FORCE-TIME CHARACTERISTICS

In most cases, analysis of the force-time parameters did not reveal significant changes in the comparison of pre/post measurements of the experimental and control group. In comparing the pre/post measurements of the experimental group (Table 4), there is only one significant increase of impulse of force (FTI) in area MH1 of the right foot ($p = 0.00$). Contact time is significantly lower in areas of MH3 ($p = 0.03$) and total object ($p = 0.00$) for the right foot. In comparing the pre/post measurements of the control group (Table 5), we can find an important increase of FTI in the hindfoot ($p = 0.03$), but paradoxically lower in toes 3, 4 and 5 ($p = 0.02$) of the right foot. For the left foot, there is a significantly higher impulse of force in areas of MH3 ($p = 0.00$), MH4 ($p = 0.01$) and total object ($p = 0.00$). Significantly shortened contact time is possible to see in toes 3, 4 and 5 ($p = 0.02$) and total object – whole foot ($p = 0.01$).

Tab. 4: Comparison of mean force-time parameters for 10 pre-defined areas of the foot during the third trimester of the experimental group (n = 35)

Parameters	27 week (L)	27 week (R)	36 week (L)	36 week (R)	*P* (L)	*P* (R)
Force-time integral (N · s)						
Hindfoot	134.20 ± 38.47	125.70 ± 42.53	138.86 ± 40.98	126.16 ± 37.03	0.27	0.91
Midfoot	36.09 ± 26.04	36.20 ± 24.17	39.34 ± 26.98	36.49 ± 24.44	0.25	0.91
MH1	48.75 ± 24.75	50.64 ± 21.11	50.34 ± 21.48	56.78 ± 22.58	0.52	0.00*
MH2	64.98 ± 21.47	67.01 ± 22.62	68.95 ± 19.74	68.34 ± 19.65	0.07	0.55
MH3	70.10 ± 21.34	71.07 ± 20.42	73.78 ± 20.19	73.03 ± 20.03	0.09	0.36
MH4	45.56 ± 17.75	46.32 ± 17.40	48.98 ± 17.55	46.66 ± 16.16	0.07	0.84
MH5	19.17 ± 11.36	19.41 ± 11.42	19.24 ± 10.55	17.77 ± 8.93	0.95	0.13
Big toe	37.48 ± 17.89	41.97 ± 22.23	36.44 ± 18.93	45.09 ± 24.17	0.59	0.20
Second toe	6.25 ± 3.28	7.53 ± 3.66	5.94 ± 3.36	7.30 ± 3.63	0.38	0.55
Toes 345	5.95 ± 4.34	8.20 ± 6.63	5.33 ± 4.11	7.16 ± 5.98	0.17	0.12
Total object	468.65 ± 96.20	474.17 ± 91.92	487.32 ± 90.26	484.87 ± 86.78	0.06	0.26
Contact time (ms)						
Hindfoot	499.48 ± 88.55	484.34 ± 108.31	496.51 ± 81.55	467.71 ± 90.86	0.74	0.12
Midfoot	497.42 ± 96.98	493.12 ± 108.81	512.80 ± 84.24	481.88 ± 105.16	0.11	0.31
MH1	610.80 ± 79.51	626.74 ± 105.31	621.42 ± 81.21	618.34 ± 79.33	0.21	0.39
MH2	641.08 ± 83.11	656.51 ± 102.48	647.37 ± 76.20	639.14 ± 76.39	0.46	0.07
MH3	660.17 ± 85.71	671.88 ± 98.01	659.88 ± 73.82	652.51 ± 73.45	0.97	0.03*
MH4	654.17 ± 83.97	660.74 ± 105.67	655.60 ± 70.79	642.97 ± 74.41	0.86	0.06
MH5	607.02 ± 87.45	609.60 ± 109.75	609.31 ± 72.96	591.82 ± 79.14	0.79	0.08
Big toe	569.48 ± 108.38	586.51 ± 125.34	574.00 ± 100.99	578.74 ± 103.90	0.68	0.52
Second toe	481.37 ± 114.40	506.68 ± 125.42	470.00 ± 110.69	490.28 ± 106.80	0.34	0.18
Toes 345	471.60 ± 142.92	501.88 ± 170.99	453.54 ± 176.41	472.22 ± 148.65	0.29	0.08
Total object	816.28 ± 91.66	835.02 ± 117.62	801.82 ± 80.83	800.45 ± 79.76	0.11	0.00*

* statistical significance ($p<0.05$)
* (L) – left foot
* (R) – right foot

Tab. 5: Comparison of mean force-time parameters for ten pre-defined areas of the foot during the third trimester of the control group (n=38)

Parameters	27 week (L)	27 week (R)	36 week (L)	36 week (R)	*P* (L)	*P* (R)
Force-time integral (N · s)						
Hindfoot	139.06 ± 33.19	131.38 ± 30.67	145.22 ± 38.44	138.51 ± 35.21	0.09	0.03*
Midfoot	37.95 ± 30.30	35.46 ± 25.63	41.69 ± 30.16	36.06 ± 24.42	0.22	0.81
MH1	43.61 ± 20.20	50.47 ± 23.16	46.18 ± 20.66	53.47 ± 22.02	0.21	0.19
MH2	65.81 ± 17.15	66.06 ± 18.26	69.32 ± 18.41	68.20 ± 17.07	0.06	0.23
MH3	70.81 ± 17.80	68.89 ± 17.24	76.06 ± 18.92	71.77 ± 18.12	0.00*	0.11
MH4	45.49 ± 15.23	43.82 ± 15.18	49.17 ± 15.11	44.97 ± 13.62	0.01*	0.43
MH5	20.14 ± 10.50	19.03 ± 10.14	20.59 ± 9.33	17.97 ± 8.18	0.65	0.26
Big toe	38.99 ± 18.84	46.63 ± 21.35	39.54 ± 23.01	47.21 ± 23.19	0.79	0.80
Second toe	8.04 ± 4.28	8.43 ± 3.47	7.93 ± 5.33	7.94 ± 3.56	0.82	0.17
Toes 345	9.27 ± 7.07	10.30 ± 7.85	8.74 ± 7.91	8.58 ± 7.34	0.49	0.02*
Total object	479.31 ± 75.62	480.66 ± 76.16	504.56 ± 81.63	494.81 ± 77.23	0.00*	0.07
Contact time (ms)						
Hindfoot	516.21 ± 79.72	505.52 ± 72.24	524.31 ± 87.65	495.94 ± 84.71	0.34	0.23
Midfoot	511.78 ± 94.11	501.00 ± 93.44	528.26 ± 81.62	497.47 ± 80.39	0.06	0.69
MH1	615.57 ± 78.03	628.73 ± 80.92	625.68 ± 85.00	624.47 ± 75.04	0.22	0.59
MH2	656.63 ± 74.89	663.00 ± 77.67	660.10 ± 85.08	651.78 ± 72.98	0.67	0.14
MH3	672.94 ± 76.84	676.36 ± 76.24	676.68 ± 81.86	666.10 ± 69.34	0.64	0.17
MH4	669.15 ± 75.20	664.73 ± 74.75	668.84 ± 78.64	652.89 ± 61.79	0.96	0.09
MH5	610.78 ± 74.13	609.94 ± 75.64	620.94 ± 73.53	600.31 ± 56.94	0.18	0.16
Big toe	558.57 ± 119.44	608.00 ± 108.67	560.21 ± 117.58	596.94 ± 107.42	0.89	0.31
Second toe	498.21 ± 94.52	529.05 ± 104.09	493.89 ± 97.81	509.78 ± 101.54	0.66	0.06
Toes 345	520.52 ± 131.30	542.73 ± 128.24	512.42 ± 137.91	513.42 ± 126.81	0.55	0.02*
Total object	843.36 ± 87.44	850.94 ± 92.19	836.26 ± 98.34	826.42 ± 92.99	0.45	0.01*

* statistical significance ($p < 0.05$)
* (L) – left foot
* (R) – right foot

DISCUSSION

Evaluation of COP parameters during the third trimester

In both pregnant groups it is possible to register a COP trajectory deviation what confirmed Mei, Gu a Fernandez (2018) as well. The main evidence of this change is COPI and COPEI which assess COP trajectory in the roll over process of the foot during the stance phase of gait (Diaz et al., 2018). According to Park et al. (2006) and Oeffinge et al. (2000) our values of the COPI (> 1) indicate more lateral weight shifting during the last trimester, as well as lower CPEI values that indicate a more pronated foot during gait, whereas in our case higher CPEI values indicate more supination in comparison pre/post measurement (Galica et al., 2013; Hagedorn et al., 2013). This finding is valid for both groups, but it is statistically significant for the experimental group in comparison of the pre/post measurements. Generally, many published studies indicate that medially shifted COP, thus pronating tendency is observed during pregnancy (Martínez-Martí et al., 2019; Mitternacht, Klement & Lampe, 2013; Vico Pardo et al., 2018). Also, similar studies show that foot pronation is a kinematic effect of gestation. According to Bertuit et al. (2015) and Osman et al. (2002) medio-lateral displacement of reaction forces is higher in late pregnancy. Lymbery et al. (2005) found that mediolateral ground reaction force tended to be increased in a medial direction. The centre of pressure moved more medially during pregnancy. Similarly, Mei et al. (2018) showed a medial shift of COP in the hindfoot area, which could be linked with foot pronation. It is possible that our outcomes were influenced by the use of the specific orthopaedic shoes by the experimental group. So, it could be that wearing these orthopaedic shoes causes changes in COP trajectory so that feet are more in supination during walking. This could bring positive health aspects for legs, because increased pronation of the foot results in internal rotation of the tibia caused by the increased calcaneal eversion angle, which can lead to discomfort, back pain or pain in other parts of the lower extremities during pregnancy (Martínez-Martí et al., 2019; Anselmo, Love, Tango & Robinson, 2017).

The length of COP is changed during the third trimester of pregnancy (Bertuit, Leyh, Rooze & Feipel, 2017), but we can register little difference between groups, where unlike the control group, women wearing orthopaedic shoes showed a tiny extension of COP trajectory, statistically significant only for the left foot ($p=0.04$). Further, we have registered an increase of MaV and MeV of COP for the experimental group (MaV increase 17%–18%, MeV increase 3%–7% for both feet) and control group (MaV increase 16%–18%, MeV increase 3%–7% for both feet). This finding may indicate that pregnant women increased their preferred velocity of gait. Paradoxically, other authors show that there is a decrease of COP velocity in late pregnancy (Bertuit, Leyh, Rooze & Feipel, 2017; Bertuit, Leyh & Feipel, 2018) and an overall decrease of gait speed (Bertuit, Feipel & Rooze, 2015; Bertuit, Leyh, Rooze & Feipel, 2017; Błaszczyk, Opala-Berdzik & Plewa, 2016). This difference may be due to individual development of biomechanics and physiology in pregnancy, where pregnant women establish very specific and individual gait strategies.

Evaluation of force-time parameters during the third trimester

Based on the evaluation of force-time parameters, we see a similar development of FTI and CT values in almost all cases for both feet. The development trend indicates an increase of FTI values and a decrease of contact time in comparison to pre/post measurements for both feet of both groups. Therefore, the size of the force impulse is probably formed more by force than by time during the gait. Varol et al. (2017) observed a general increase of FTI values during a pregnancy, especially in the midfoot area and this change could be related to increased foot pain.

A decrease of total contact time for both feet of both measured groups in late pregnancy support our COP results that show an increase of MaV and MeV. This opinion supports Ribeiro et al. (2013) who found that increased contact time indicates reduced gait speed. In an older study,

Ribeiro et al. (2011) also showed that contact time increased especially at the midfoot and medial and lateral forefoot from the first to the third trimester, but we can't confirm these results in our study. The total decrease of contact time also indicates the decrease of single support, which is observed in many studies (Bertuit, Feipel & Rooze, 2015; Forczek & Staszkiewicz, 2012; Błaszczyk, Opala-Berdzik & Plewa, 2016). On the other hand, Ramachandra et al. (2018) found that there is a single stance duration increase in the third trimester compared to the earlier trimesters.

LIMITATIONS

Our group of healthy pregnant women was measured only during the third trimester, so this study does not include data or analysis of kinematic and kinetic changes during the entire gestation period. Further, this study does not contain kinematic variables (gait velocity, stride length, step length, time of heel strike/toe off) because of cameras for motion caption was not a part of pressure platform for this measurement.

CONCLUSION

Over the last three months of pregnancy, observable significant changes can be found especially through COP parameters for both groups. We found out that specific orthopaedic shoes which were given to the experimental group especially influenced the trajectory of COP, which could have positive health aspects. Further, certain conflicting results in our study in comparison with other similar studies only confirm that individual biomechanics and physiology development in pregnancy affects the kinematic and kinetic aspects of walking differently.

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Correlation analysis of olympic-style weightlifting exercises and vertical jumps

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ABSTRACT

PURPOSE *Many types of vertical jumps (VJ) are commonly used to assess the development of the level of explosive strength of lower limbs achieved after a training period. This study is focused on comparing various parameters of different types of VJ with 1 RM in Olympic-style weightlifting, squat and deadlift with an Olympic bar.*

METHODS *Twelve elite weightlifters (men = 8; women = 4; age 26 ± 4 years, height = 173±8 cm; weight 93 ± 23 kg; weight category from 64 kg to +109 kg) were tested for 1 RM in the following exercises: snatch, clean and jerk, deadlift, squat and variations of VJ on dynamometric plates (Kistler Force Plate). The variations of VJ were: squat jump with the arm swing (SJA) and non-arm swing (SJ), countermovement jump with the arm swing (CMJA) and non-arm swing (CMJ). The parameters compared for each type of VJ were: jump height (m), relative force (% of body weight), relative power (W/kg of body weight) and average power (W). For statistical analysis, the parametric Pearsons correlation coefficient with α = 0.05 was used.*

RESULTS *The results show a significant correlation between 1 RM in exercises with an Olympic bar (snatch, clean and jerk, back squat and deadlift) and the CMJ, CMJA, SJ and SJA only in the average power output (W) parameter ($p < 0.05$). The significant correlation coefficients in the average power output (W) were for the CMJA and the snatch $r = 0.96$ $r^2 = 0.92$, clean and jerk $r = 0.96$ $r^2 = 0.92$, back squat $r = 0.97$ $r^2 = 0.94$ and deadlift $r = 0.93$ $r^2 = 0.86$; CMJ with hands on the hips and the snatch $r = 0.93$ $r^2 = 0.86$, clean and jerk $r = 0.93$ $r^2 = 0.86$, back squat $r = 0.95$ $r^2 = 0.90$ and deadlift $r = 0.94$ $r^2 = 0.88$; for the SJA and the snatch $r = 0.8$ $r^2 = 0.64$, clean and jerk $r = 0.81$ $r^2 = 0.65$, back squat $r = 0.82$ $r^2 = 0.67$ and deadlift $r = 0.78$ $r^2 = 0.60$; for the SJ with hands on the hips and the snatch $r = 0.76$ $r^2 = 0.57$, clean and jerk $r = 0.75$ $r^2 = 0.56$, back squat $r = 0.77$ $r^2 = 0.59$ and deadlift $r = 0.71$ $r^2 = 0.50$. Significant correlation coefficients were not found for 1 RM in the snatch, clean and jerk, back squat and deadlift and the CMJ or SJ with and without arm swing in any of the following parameters: jump height (m), relative force (% of body weight), relative power output (W/kg of body weight).*

CONCLUSION *The main finding is that the jump height (m) of the CMJ or SJ with or without arm swing did not correlate significantly with 1 RM in the snatch, clean and jerk, back squat and deadlift. Therefore, jump height measurement can be used as a motivation tool but not to predict maximum strength in Olympic bar exercises, or vice versa. We recommend using the average power output (W) parameter in the CMJ with using arms as a predictor of current performance level in exercises with an Olympic bar for men and women.*

Key words: *snatch, clean and jerk, squat, deadlift, countermovement jump, squat jump*

INTRODUCTION

Weightlifting is one of the few sports to have been featured at the 1896 Athens Games (Olympic.org, 2019), but nowadays it is fighting for its place. Taking into account that weightlifting in its various forms creates the potential of strength for all sports, we have to start asking how to train weightlifting efficiently and how it is reflected in other sports. One of these options is to refine testing methods, which provide metrics of current performance and motivate not only adults but also young athletes to stay dedicated to training. All this while respecting the principles of drug-free sport.

A very successful weightlifting coach named Bob Takano claims that jumping exercises (from a quarter and full squat) are the most helpful modalities for weightlifters in the general physical preparation phase for generating explosive force from the legs and hips (Takano, 2012). Explosive force is reflected primarily in the improvement of the power snatch and clean and jerk exercises in a classic weightlifting training. On the other hand, performing squats (loaded with 56% of 1 RM) or power cleans (loaded with 80% of 1 RM) could supplement jumping in the process of developing power, if we assume the theory that if an athlete jumps or runs with their own bodyweight it is considered power training (McGuigan, 2017). Many types of jumping exercises can be used to examine the level of explosive force development during the preparation training phase and the competition training phase.

Many researchers are focused on a possible positive effect of weightlifting and utilizing heavy squats on the performance in dynamic exercises including the vertical jump and vice versa. Positive results were found both in terms of a short-term (4–8 weeks) effect (Otto III, Coburn, Brown, & Spiering, 2012; Tricoli, Lamas, Carnevale, & Ugrinowitsch, 2005;) and an acute effect pre-workout (or post-activation potentiation effect) (Duthie, Young, & Aitken, 2002; Borba, Ferreira-Júnior, Santos, Carmo, & Coelho, 2017), although the success of the PAP effect depends on many factors (Robbins, 2005). To provide the best results in the explosive strength and vertical jump performance in general, it is commonly recommended to use a combination of traditional Olympic-style weightlifting exercises and plyometric drills (Fatouros, Jamurtas, Leontsini, Taxildaris, Aggelousis, Kostopoulos, & Buckenmeyer, 2000). Not all sports require training in only jumping high, but also in jumping as quickly as possible. For example, track and field athletes who want to jump high or jump far use their arms to reach the maximum jump height. Harman, Rosenstein, Frykman, & Rosenstein (1990) say that for these athletes it is more effective to train the countermovement jump with an arm swing in contrast to those who want to jump quickly – for blocking in volleyball with one's arms raised where it is better to train the countermovement jump without an arm swing.

Training halls in which weightlifting and sports training are mostly performed are not equipped with modern testing technology. For this reason, many coaches use the vertical jump height in centimeters as an indicator of the explosive force of the legs and hips. It is routinely tested in the vertical countermovement jump with an arm swing movement when jumping onto a stack of weight plates, which is made progressively higher. Coaches and athletes often place too much importance on the result of the vertical jump test, but we don't have enough research to link the result with actual weightlifting performance or vice versa. Only one study has examined the relationship between vertical jumps (CMJ and SJ) and weightlifting performance. The results of this study indicate that the Power Peak derived from the vertical jump (CMJ or SJ) can be a valuable tool in assessing weightlifting performance (Carlock, Smith, Hartman, Morris, Ciroslan, Pierce, ... & Stone, 2004). Unfortunately, this study compared weightlifting performance only to vertical jumps with hands on the hips. However, weightlifting involves complex movements, and it cannot be performed well without combining the explosive strength of the lower and upper limbs. We believe that it is necessary to include variants of vertical jumps with an arm swing in the comparison as well.

The purpose of our research was to examine the correlation between variations of VJ (squat jump with (SJA) and without (SJ) an arm swing; countermovement jumps with (CMJA) and without (CMJ) the arm swing), and the snatch, clean and jerk, back squat and deadlift.

METHODS

Twelve elite weightlifters (men = 8; women = 4; age 26 ± 4 years, height = 173 ± 8 cm; weight = 93 ± 23 kg (mean ± SD); weight categories from 64 kg to +109 kg) from the Czech Republic took part in a research that compared the results of exercises performed with the Olympic bar and different types of vertical jumps by means of a correlation analysis. Each of the weightlifters had competed at more than one international competition (World Championship or European Championship) in Olympic-style weightlifting and had been doing a focused weightlifting training for a minimum of six years.

All weightlifters were tested for their 1 RM in the following exercises: snatch, clean and jerk, deadlift, squat and variations of VJ on dynamometric plates (Kistler Force Plate) in the course of ten days. The results of the snatch and clean and jerk were taken from weightlifting competitions. For the correlation, the best result in the snatch and clean and jerk was considered. To minimize false testing of 1 RM in competition (without the possibility of multiple attempts), we also regarded the results that were not recognized by referees as "good attempts" due to movement in the elbows, but the weightlifter held the barbell over their head as 1 RM. The 1 RM testing was spread over several days of the week with the testing of vertical jumps being done a minimum of 48 hours after the 1 RM testing or before the 1 RM testing. The 1 RM testing was done in the traditional manner of 1 RM testing for weightlifters. After a basic warm-up and dynamic stretching, they warmed-up with the Olympic bar up to 60% of their 1 RM. Then they tried to reach their maximum in 8–12 series gradually with one repetition on each weight. The rest between the repetitions was usually 2–3 minutes between the attempts with the weight at 60–90% of their 1 RM, and usually 3–6 minutes between the attempts with the weight over 90% of their 1 RM as recommended by Bomba and Buzzichelli (2015). For the 1 RM testing of the back squat, the version used was the high bar position on the shoulders with the deepest range of motion possible but always under the parallel position of the tights, close to 50° at the knee joint.

The subjects jumped from the force platform with maximal effort in four different ways: squat jump with an arm swing (SJA) and squat jump without an arm swing (SJ), countermovement jump with an arm swing (CMJA) and countermovement jump without an arm swing (CMJ). The starting position for all countermovement jumps was an upright position with the hands on the hips or with the arms behind the back prepared for the arm swing. The starting position for the squat jumps was with the knee joints at 90° with the hands on the hips or with the arms behind the back prepared for the arm swing. The lowest position during the jumps was with the knee joints at 90°. The subjects performed three trials of each jump type for a total of 12 jumps and rested between the jumps, usually for 3-min. Each subject was carefully instructed in the proper technique of the different types of jumps. It took two to three practice jumps at submaximal effort before measuring to ensure that the jump-type was being performed correctly. No attempt was made to directly measure or control the degree of bending in the knee. The variations of VJ were: squat jump with an arm swing (SJA) and without an arm swing (SJ), countermovement jump with an arm swing (CMJA) and without an arm swing (CMJ). The parameters compared for each type of VJ were: jump height (m), relative force (% of body weight), relative power (W/kg of body weight) and average power (W).

For statistical analysis, after the expected normality of the data distribution according to the Shapiro-Wilk test was met, the data were analyzed with the parametric Pearsons correlation coefficient with $\alpha = 0.05$. The parameters of the Kistler Plates used: model dual Portable Force

Plate 600x500x50 mm type 9260AA6. Software MARS (Measurement, Analysis and Reporting Software).

All participants gave their written consent to participate in the research. The consents were consistent with the ethical standards in research at MU and approved.

RESULTS

The reported performance of all the weightlifters (women and men together) in the countermovement jumps (CMJ) with and without (hands on hips) an arm swing is shown in Table 1. Only the correlation coefficient for the average power output (W) parameter was statistically significant for both variants of the CMJ with all the 1RM test parameters in the exercises with an Olympic-bar.

Tab. 1: Pearsons correlation coefficients for countermovements jumps for both men and women together (n = 12)

	CMJ with arm swing (CMJA)				CMJ with hands on hips (CMJ)			
	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)
Snatch (kg)	0.563875	0.333178	0.448767	**0.962043***	0.399235	0.299596	0.417465	**0.939598***
Clean and jerk (kg)	0.540905	0.306653	0.429659	**0.963347***	0.363685	0.266328	0.385365	**0.934064***
Back squat (kg)	0.518168	0.326583	0.382336	**0.973714***	0.339815	0.322730	0.380403	**0.956430***
Deadlift (kg)	0.400937	0.180948	0.233943	**0.935190***	0.218970	0.152343	0.224558	0.942512*

*statistically significant ($p < 0.05$)

The reported performance of all the weightlifters (women and men together) in the squat jumps (SJ) with and without (hands on hips) an arm swing is shown in Table 2. Only the correlation coefficient for the average power output (W) parameter was statistically significant for both variants of the SJ with all the 1RM test parameters in the exercises with an Olympic-bar.

Tab. 2: Pearsons correlation coefficients for squat jumps for both men and women together (n = 12)

	SJ with arm swing (SJA)				SJ with the hands on hips (SJ)			
	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)
Snatch (kg)	0.567742	0.314079	0.433825	**0.802246***	0.492791	0.315427	0.282253	**0.761136***
Clean and jerk (kg)	0.534589	0.316329	0.422577	**0.811657***	0.455916	0.285934	0.251348	**0.758717***
Back squat (kg)	0.539559	0.346272	0.438173	**0.827792***	0.449647	0.323585	0.274748	**0.773848***
Deadlift (kg)	0.398124	0.283512	0.293510	**0.783064***	0.284477	0.163797	0.098859	0.719876*

*statistically significant ($p < 0.05$)

As can be seen from Table 1 and Table 2, the correlation coefficients between the 1RM exercises with an Olympic-bar and all types of vertical jumps used have higher statistically significant correlation coefficients in the CMJ and CMJA compared to the SJ and SJA.

The reported performance for men only (n = 8) in the countermovement jumps (CMJ) with and without (hands on hips) an arm swing is shown in Table 3. All the monitored parameters of the CMJ (without an arm swing) statistically significantly correlated with all the 1RM test parameters in the exercises with an Olympic-bar. Unlike the other monitored parameters, only the average power output parameter correlates significantly positively. The only parameters that have a significant correlation coefficient with the CMJA (with an arm swing) were the production of relative force (negative correlation coefficient) and the production of average power output (positive correlation coefficient).

Tab. 3: Pearsons correlation coefficients for the countermovement jumps for men (n = 8)

	CMJ with arm swing (CMJA)				**CMJ with hands on hips (CMJ)**			
	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)
Snatch (kg)	–0.573376	**–0.879680***	–0.618348	**0.828485***	**–0.829422***	**–0.880782***	**–0.736152***	**0.820774***
Clean and jerk (kg)	–0.565938	**–0.862002***	–0.579998	**0.871802***	**–0.808542***	**–0.847151***	**–0.708443***	**0.854790***
Back squat (kg)	–0.646068	**–0.786960***	**–0.736573***	**0.900732***	**–0.903932***	**–0.714265***	**–0.743880***	**0.903130***
Deadlift (kg)	–0.646366	**–0.846624***	**–0.777619***	**0.829092***	**–0.859801***	**–0.791277***	**–0.807195***	0.887157*

*statistically significant ($p < 0.05$)

The reported performance for men only (n = 8) in the squat jumps (SJ) with and without (hands on hips) an arm swing is shown in Table 4. No significant correlation coefficients were observed between the SJA and the 1RM in the exercises with an Olympic bar, not even for the average power output parameter (W). Significant correlation coefficients are generally lower in the SJ than in the CMJA and CMJ. Unfortunately, none of the SJA parameters correlated significantly positively with any of the 1RM tests in the exercises with an Olympic-bar.

Tab. 4: Pearsons correlation coefficients for the squat jumps for men (n = 8)

	SJ with arm swing (SJA)				SJ with hands on hips (SJ)			
	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)	Jump Height (m)	Relative Force (%BW)	Relative Power (W/kg)	Average Power (W)
Snatch (kg)	–0.609987	–0.681462	–0.548741	0.486529	–0.594691	–0.782088*	–0.592836	0.485422
Clean and jerk (kg)	–0.635081	–0.637116	–0.504150	0.530024	–0.590824	–0.763252*	–0.555892	0.532730
Back squat (kg)	–0.613839	–0.518869	–0.452827	0.572662	–0.640316	–0.663179	–0.525038	0.539215
Deadlift (kg)	–0.682372	–0.431406	–0.558064	0.484555	–0.743014*	–0.736194*	–0.671563	0.443945

*statistically significant ($p < 0.05$)

DISCUSSION

The limitation of this study is the very small number of participants, but it is caused by the fact that there are no more weightlifters at an elite level in the Czech Republic. In order to conduct further research, we would suggest obtaining more individuals for testing (men and women) from the field of Olympic weightlifting, and other sports to compare their performance with one another, or possibly add another intervention factor. Another limitation is the large body mass weight difference of the weightlifters. Due to the small number of tested persons overall, it was not possible to divided them into individual weight categories and then perform a corelation analysis.

In research like this, it is not common to evaluate the results of men and women together. And the fact that we compared parameters in women and men as one homogeneous group could be considered questionable. This methodological decision stems from the practical issue, that trainers test both men and women together and mostly record only the jump height parameter. Therefore, we decided to consider men and women as a single group to test whether it is possible to take at least one parameter as an indicator of performance across the board. That is why we performed a correlation analysis for men and women together and then one for men only. This subsequent verification of our results showed us that the results of the correlation analysis of the squat jump (SJA and SJ) for men and women together could be distorted by the number of participants, as the SJ and SJA do not correlate significantly with the results of a 1RM in the exercises with an Olympic-bar in the group of men only.

If we compare our results to other studies with a similar focus, we must consider the types of strength exercises with which they correlate each type of vertical jumps. In the study by Nuzzo, McBride, Cormie, & McCaulley (2008) significant correlations ($p \leq 0.05$) were found when comparing relative strength (1 RM/body mass) in both the squat and power clean to relative CMJ peak power, CMJ peak velocity, and CMJ height. In our study, it was shown that the squat (deep squat) correlated significantly with the CMJ jump height, but negatively. In the research by Carlock et al. (2004) the results showed that a maximum vertical jump performance in the CMJ or SJ in the power peak production is strongly associated with the 1RM of the weightlifting exercises (snatch, clean and jerk). And these types of vertical jumps can be a useful tool in achieving the best performance in Olympic weightlifting. However, this research, unlike ours, was performed on vertical jumps without an arm swing (CMJ and SJ) only and the data for the current weightlifting performance were taken from questionnaires given to both men and women. This study was also supported by Everett (2016) claiming that vertical jumps (countermovement and squat jumps) are useful exercises for explosiveness and elasticity during the second pull phase in the snatch and clean. The results of our research have shown that the snatch and clean and jerk in men correlate statistically significantly with the countermovement jump with an arm swing in the relative strength (negative correlation coefficient) and the average power output (positive correlation coefficient).

CONCLUSION

The main finding is that the jump height (m) of the CMJ or SJ with or without arm swing did not correlate significantly with 1 RM in the snatch, clean and jerk, back squat and deadlift. Therefore, jump height measurement can be used as a motivation tool but not to predict maximum strength in Olympic bar exercises, or vice versa. We recommend using the average power output (W) parameter in the CMJ with using an arm swing as a predictor of current performance level in exercises with an Olympic bar for men and women.

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Impact of a Strength Intervention Program on Change of Hamstrings: Quadriceps Ratio and on Change of 1 Repetition Maximum

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Abstract

The relationship between the muscular strength of hamstrings and quadriceps and their possible muscular imbalance is considered by many authors as one of the causes of knee joint injury. The aim of this work is to assess the exercise program including squat modifications both in terms of progression of lower limb strength and in terms of possible change of H: Q ratio. Probands were divided into five groups (one control, four experimental). The experimental groups practiced the intervention program twice a week for eight weeks (EX1: Barbell squat, EX2: Barbell half squat, EX3: Barbell half squat with countermovement). In one training session participants repeated the exercise five times in six series. All experimental groups exhibited significant differences in mean values ($p < 0.01$), indicating the progression of lower limb strength measured by 1 RM for barbell squat. The differences in the mean values of the H: Q ratio measured on an isokinetic dynamometer in the isokinetic test mode at angular velocities of 60 and 300 degrees per second do not show statistically significant differences ($p = 0.99338$). The established strength intervention program is suitable for the development of lower limb strength and does not show any changes in the H: Q ratio.

Key words: *Squat, Strength, Hamstrings, Quadriceps, 1 RM, ACL, Isokinetic dynamometer*

INTRODUCTION

Sports performances are constantly moving forward. Increasing demands are required from athletes. For all kind of sports, it is essential for athletes to be well prepared for any performance. Good physical condition is necessary not only to win, but also to prevent possible injuries. If an athlete needs to be musculous, it is necessary to include in their own training program also properly designed strength training. Possible muscle imbalances can cause injuries. In the case of lower limbs, the literature focuses on the ratio of hamstrings and quadriceps (H: Q).

We approach the H: Q ratio from two perspectives, depending on the type of muscle contraction during which maximum strength is produced. If both muscle groups work at concentric muscle contraction, it is the conventional H_{con}: Q_{con} ratio. If the hamstrings muscle group works in eccentric muscle contraction and the quadriceps muscle group in concentric muscle contraction, it is a functional H_{ecc}: Q_{con} ratio (Delextrat, Gregory, & Cohen 2010).

Both the strength of the quadriceps and the strength of the hamstrings are very important for the stability of the knee joint (Tsepis, Vagenas, Giakas, & Georgoulis, 2004). Low H: Q ratio can be considered as an indicator of hamstrings injury or anterior cruciate ligament (ACL) injury. For the conventional H_{con}: Q_{con} ratio, the critical value is set at 0.6. For the functional ratio H_{ecc}: Q_{con}, the critical value is set at 1.0. Data should be obtained from measurements at a rate of at least 120 degrees per second. If the athlete shows a lower H: Q ratio than the stated limit values, the specialist should create an exercise program to eliminate muscle imbalance as well as to establish proper cooperation of the agonist and antagonist. Women are more likely to have injuries, so their physical condition should be monitored more thoroughly. (Holcomb, Rubley, Lee, & Guadagnoli, 2007).

Squat is being considered a basic exercise for the development of lower limb strength (Cacek, & Grasgruber, 2008; Stoppani, 2008). Mausehund, Skard, & Krosshaug (2019) compared three types of lower limb strength exercises. Specifically, it was split squat (SS), rear foot elevated split squat (RFESS), and single-leg squat (SLS). The exercises show a strength increase in all selected muscle groups. Muscle strength of gluteus maximus and quadriceps increases similarly in all the applied exercises. The SLS achieves the highest power gain in the gluteus medius. It is convenient to include the RFESS in the exercise plan for hamstrings. The SS, SLS and especially RFESS should be included in the recovery program for injury or reconstruction of ACL.

For this work was developed a strength program aimed at strengthening muscle groups in the lower limbs, which includes only squats. We will investigate whether the program is effective in increasing strength and whether the conventional H: Q ratio will change significantly after its application. Selected modifications of squat exercises will be assigned to 4 experimental groups. These are the exercises: barbell squat, barbell half squat, barbell squat with countermovement and barbell half squat with countermovement. The load will also be manipulated. For exercises involving countermovement, the load will be around 30% 1RM, for exercises without countermovement around 95% 1RM.

METHODS

Subjects

Male students of Faculty of Sports Studies (Masaryk University) participated in the strength intervention. They were randomized into five homogeneous groups (four experimental, one control). Using One-Way ANOVA, we compared the mean values of the experimental groups (categorical factor: EX1-EX4) from several perspectives (dependent variables: H: Q ratio obtained from the dynamometer data at an angular speed of 60 as well as 300 degrees per second and 1RM of barbell squat). For all testing, we received $p > \alpha$. Before the subjects were chosen the following factors were considered: age, body weight, no rupture of the anterior cruciate ligament (ACL), no health complications. The experimental groups consisted of a total of 40 persons ($N = 40$) and their average age was 22.06 ± 2.17 years. Since the strength intervention involved squats (full squat and half squat), it was necessary to train all tested persons. The correct technique of squat is very important, which is why everybody was trained by an expert before the start of the intervention.

Study design

The purpose of the study was comparing the strength (through different parameters, e.g. measuring 1RM and data from isokinetic dynamometer) and values of hamstrings: quadriceps ratio before and after strength intervention program.

Participants were trained by Czech weightlifting team members in the correct technique of squat to ensure safety during both measurement and exercise part of the intervention program. We created appropriate exercises to warm up and stretch the muscles and we made sure that the participants followed them. All trainees had assistants at all time due to the safety reasons.

In the detection of 1RM of barbell squat, the test subjects did not exercise with the maximum load, but with the load they lifted e.g. four or five times in the barbell squat. The resulting values were consequently calculated according to the formulas by Brzycki and Baechle (Baechle, & Earle, 2008).

Knee joint muscles were diagnosed on a dynamometer (Humac Norm, CSMI, Stoughton, USA). Isokinetic testing, the range of motion was 0°–125° (0° is the maximum extension in the knee joint) at angular velocities of 60° per second and 300° per second. Testing of each person was carried out in a sitting position, with straps fixed over the shoulders, pelvis and quadriceps of the test leg exactly according to the manufacturer's recommendations. The software of this

instrument enables writing anatomical values to define the position of each testing person on the machine, the data were recorded and the same position was automatically set for each one during the post-tests. All the tested subjects were measured by an identical person. Since both tests were very demanding (1RM and dynamometer testing) it was essential to perform them forty-eight hours apart. The tests were performed before the intervention (pre-test), 1RM values were measured after four weeks when the participants' load was updated, and post-tests were made after eight-week intervention.

The protocol (Fig. 1) of this study includes a timing of measurements and a schedule of strength interventions for each of the experimental groups.

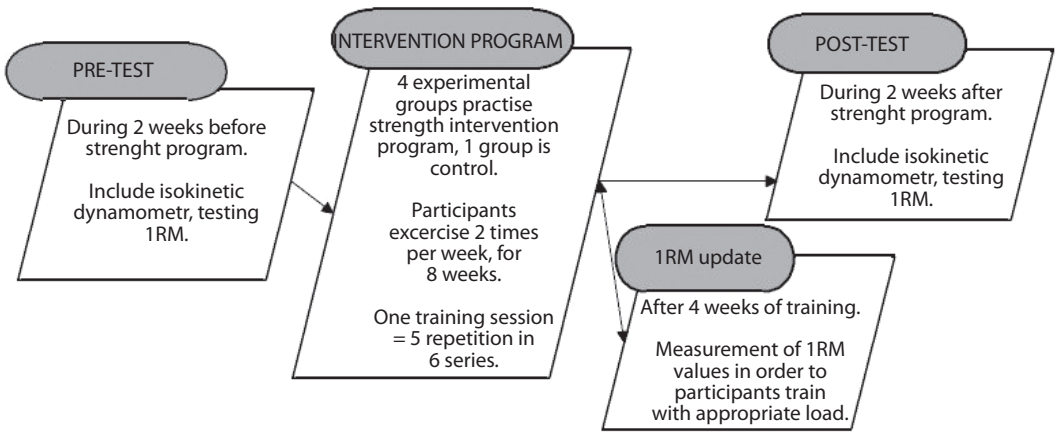

Fig. 1: *The protocol of timing of measurements and strength interventions schedule*

Participants were randomized into five groups, four experimental groups and one group was a control group. Participants in selected experimental groups underwent strength training equally twice a week, forty-eight hours apart for recovery. However, their program and load were different as shown in Tab. 1. Knee joint angle of 90 degrees became a critical point in determining the difference between a squat and a half squat (Chelly et al., 2010). Within one intervention, the test subjects practiced six series with five repetitions of the exercise (Tan, 1999).

Tab. 1: Type of squats and loads for all groups

Group	Type of squat	Load
Experimental group 1 (EX 1)	Barbell squat	95% 1RM
Experimental group 2 (EX 2)	Barbell half squat	95% 1RM
Experimental group 3 (EX 3)	Barbell squat with countermovement	30% 1RM
Experimental group 4 (EX 4)	Barbell half squat with countermovement	30% 1RM
Control group (CON)	–	–

Statistical analysis

Repeated measures analysis of variance with effect sizes and powers were used to compare the change in 1RM values before, during, and after the intervention. Evaluation of the H: Q ratio

before and after the intervention was performed with two-way ANOVA with repeated measures. Significance was accepted at the $p \leq 0.05$ level.

RESULTS

Results from measurements of 1RM

The comparison of the mean values of the experimental groups (EX1-EX4) obtained before the intervention, after four weeks of intervention and after eight weeks when the intervention was finished, can be observed in Fig. 2. Considering the value $p = 0.00489$ we can find a statistically significant difference of all mean values ($\eta_p^2 = 0{,}222$). Although we determine a significant difference between the mean values through ANOVA calculations, the post hoc test, resp. Bonferroni test confirming that statistically significant differences occur in each experimental group during measurement.

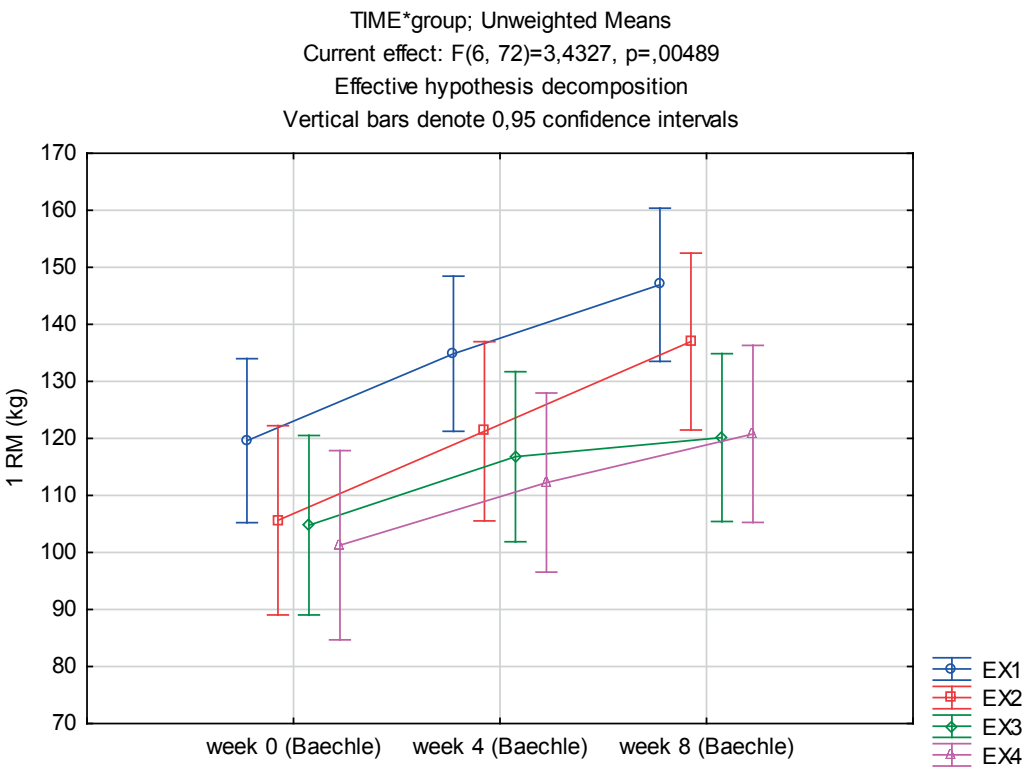

Fig. 2: The Changes of 1 RM values due to the intervention strength program

Results from measurements H_{con}: Q_{con} ratio

The data obtained from isokinetic testing of lower limb is suitable for calculating the conventional H_{con}: Q_{con} ratio. It can be seen from Fig. 3 that the H_{con}: Q_{con} ratio achieves on average higher values when measured at a higher angular velocity. After statistical data processing (two-way ANOVA with repeated measures), it is obvious that the mean values do not show statistically significant differences with a probability of p = 0.99338. The selected strength program does not increase or reduce the H_{con}: Q_{con} ratio. It can also be seen from the graph (Fig. 3) that the H_{con}: Q_{con} values

are very low. At an angular velocity of 60 degrees per second, the mean values of all groups (pre- and post-intervention) fall below the 0.60 level. Such a low value can cause ACL or hamstrings injuries (Hammerová, Králová, Cacek, Kalina, Hlavoňová, & Ondráček, 2018).

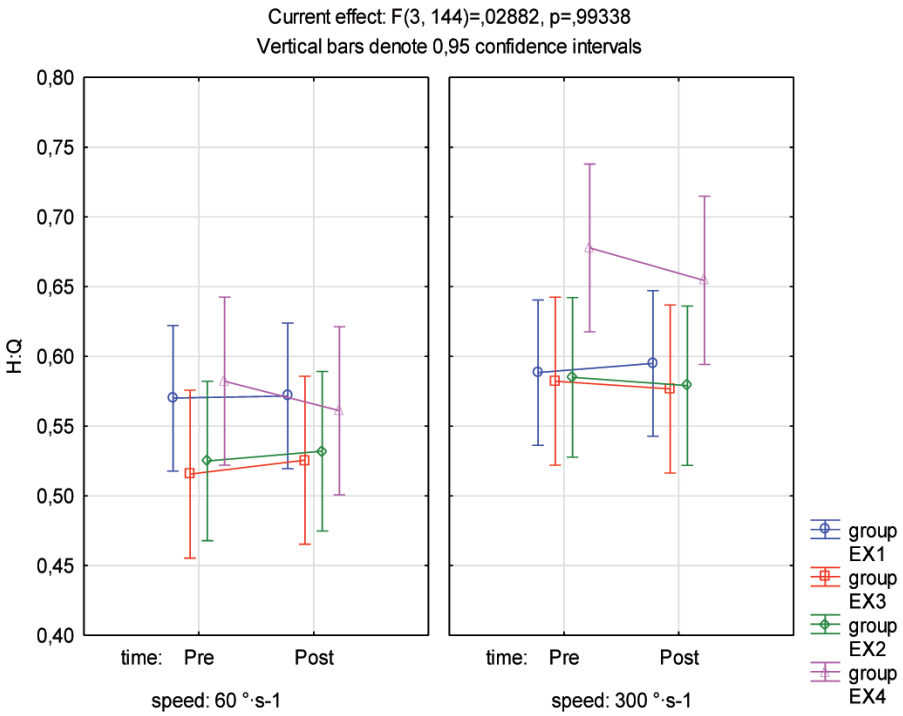

Fig. 3: The Changes of Hcon: Qcon ratio due to the intervention strength program

DISCUSSION

Many athletes use squats in their training programs. However, it is true that many athletes also have health problems with the knee joint or problems with selected muscle groups. Therefore, it is necessary to consider both the benefits and potential risks of selected exercises. Toutoungi, Lu, Leardini, Catani, & O'Connor (2000) report that squats should be safer for ACL than isokinetic or isometric extension to develop the strength of quadriceps. At the same time, they say that isokinetic and isometric flexion can be safely used to develop the strength of hamstrings. Considering the forces exerted on the knee joint and all its structures, the inclusion of a squat in the training program should not be harmful to the ACL.

Also, the results of our research show that although there was a statistically significant increase in lower limb strength (values of 1RM) in all experimental groups, they did not decrease the H: Q ratio values. Therefore, it can be said that even from this point of view, while keeping the right technique, squat exercise is suitable. There was probably no significant change in the H: Q ratio for several reasons. First, we compare the change in 1RM (specific exercise) with the change in the H: Q ratio (non-specific exercise), which was measured by an isokinetic dynamometer. For squatting (1RM), there was an average improvement of 21,62% for all participants; for dynamometer measurements, hamstring strength improved by 2,67%, quadriceps strength by 1,86% at an angular speed of 60 degrees per second and 5,89% for hamstrings and 6,64% for quadriceps at

an angular speed of 300 degrees per second. While squatting (specific exercise) is a multi-joint exercise within an open kinematic chain, dynamometer testing is a non-specific exercise within a closed kinematic chain. Another factor may be the fact that the strength of hamstrings and quadriceps was measured at concentric contraction.

Individual measurements (1RM and dynamometer) do not show similar results precisely because of the specificity and non-specificity of the exercise to the measurement. Baker, Wilson, & Carlyon (1994) confirm that the principle of specificity (motion structure, type of contraction, rate of contraction, resistance size, etc.) should be followed during testing.

Croix, ElNagar, Iga, Ayala, & James (2017), as some of many authors, show that women achieve lower H: Q ratio. Specifically, in their research, it was a H_{ecc}: Q_{con} ratio where women achieved lower values at angular speeds of 120 and 240 degrees per second, but not at 60 degrees per second. At the same time, in their study, participants achieved a higher H: Q ratio at higher angular speeds, which corresponds to our results.

In this research, we can point out following limitations. One of the inconvenience was low number of trained subjects. It would be nearly impossible to use in this research more subjects due to insufficient equipment, lack of time and finances provided. It is also important to consider the fact that all trained and measured subjects were male students of Faculty of Sports Studies. We could get more relevant results in case of inclusion of common population. It would be interesting to measure also female subjects to compare final results for both sexes. Finally, it would be more efficient if we measured the strength of hamstrings during eccentric contractions and according to this measurement we might have work with functional H: Q ratio (H_{ecc}: Q_{con}), which would be more applicable. These limitations can be considered as recommendations for future researches.

CONCLUSION

In summary, we found out that the chosen strength training program had caused statistically significant progress in increase strength of lower limbs given 1RM values. The same training program didn't cause statistically significant changes of H_{con}: Q_{con} ratio. To sum up, squats and their modifications are suitable exercises, but each subject's health condition needs to be considered.

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SOCIAL SCIENCES

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Trends in Body Mass Index among Children with Mild and Moderate Intellectual Disabilities

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Abstract

In recent years, worldwide obesity has increased both in the adult as well as childhood populations. Research shows that obesity nowadays is associated with still younger age. What is currently becoming the focal point of attention is the prevalence of obesity in people with intellectual disabilities whose physical and mental limitations affect, to a certain degree, their daily lives. Nevertheless, there is a lack of data for the childhood population with intellectual disabilities.

This research seeks to compare trends in BMI indicators and eating habits among children with mild and moderate intellectual disabilities who live with their families as opposed to those who are provided for at Children's home in region Zlín in the Czech Republic.

The research method used was quantitative and comparative research approached deductively and using correlation. BMI indicators were determined by means of InBody analyser. Eating habits data were collected through a questionnaire of our own design which is standardly used in the Special Olympics Healthy Athlete Project. The BMI trends were observed in twelve children from two primary schools.

We have concluded that children with mild ID who are provided for at the children's home do not tend to be obesity, rather they have a proclivity to overweight or normal BMI and children with moderate ID have a proclivity to normal BMI or underweight. As emerged from case histories, only children with moderate ID living with their own families tend to have obesity or normal BMI but children with mild ID living with their own families tend to have overweight or normal BMI. Obesity and overweight are connected only with boys.

Children's weight remained the same within the existing BMI ranges. Summer holidays in children with mild ID and moderate ID living in children's home had no verifiable effect on the BMI indicators. Children living in their own families had a subsequent weight rise before summer holiday (June 2017, June 2018) and a weight loss after holiday (September 2017, September 2018). Summer holiday influences the BMI indicators in children with mild ID and moderate ID living in their families.

The research further shows that children with mild ID and moderate ID being cared for in the institutional environment have a healthier diet than children with mild ID and moderate ID living with their families.

The direct mean correlation force is between dietary habits and muscles in children with moderate ID living in their family. The indirect mean correlation force is between dietary habits and fat in children with moderate ID living in residential care.

The conclusions of the research may serve as a recommendation for parents to pay more attention to their children's diet as well as their physical activity.

Key words: *children with intellectual disabilities, mild level of intellectual disability, moderate level of intellectual disability, BMI indicator, obesity, eating habits.*

INTRODUCTION

Childhood obesity is considered one of the most pressing public health issues of today. Its prevalence is continuously rising. Unfortunately, no consensus as to how this problem should be resolved has been reached yet. Obesity has mostly been regarded as a matter of personal and parental responsibility. The intervention of governments usually lies in laying down normative regulations as to what constitutes a healthy diet and what food should be prepared in schools. (Duramy, 2018). It has been found out that childhood obesity is more prevalent in children who have been exposed to high levels of stress and as a result suffer from behavioural issues, learning difficulties, emotional problems and somatization (Tanu et al., 2018). In the Czech Republic, the number of obese children in primary schools is on the increase. Whilst 20 years ago, only 4 % of children were obese, nowadays the percentage is 14 % for obesity and 25 % for overweigh. The most common factors are a bad lifestyle and poor eating habits (Eurozprávy.cz, 2008).

Intellectual disability (ID) is an umbrella term for congenital handicap of intellectual abilities which are manifested as an inability to understand and adapt to one's surroundings (Vágnerová, 2004, p. 289). Intellectual disability in an individual is seen as a limitation in intellectual functioning and adaptive behaviours (Švarcová, 2000, p. 28). According to Valenta and Müller (2003, p. 10), intellectual disability is a developmental mental disorder manifesting in lower intelligence. It is demonstrated especially as a deficit in cognitive, speech, motor and social abilities. In terms of IQ, intellectual disabilities can be divided into mild (50–69), moderate (35–49), severe (20–34) and profound (below 20) (NICM, 2014).

Individuals with mild ID are comparable with children at the age of 9 to 12. They can be educated at special needs primary schools. Speech is used functionally in day-to-day situations. Individuals with mild ID are able to hold a conversation and respond in a clinical interview despite the delay in speech development. Most of them manage to master self-care, i.e. eating, getting dressed, hygiene, bladder and bowel control and practical household chores.

Individuals with moderate ID are comparable with children of pre-school age, i. e. 3–6 years old. The development of cognitive and language skills is considerably delayed. Learning occurs solely on the practical level and includes mastering self-care activities and basic skills (Kocourová, 2014). Some pupils are able to attain the grounding in reading, writing and maths under the tutelage of a qualified teacher. Self-care and fine motor skills also develop with delay. Adults with moderate ID are able to carry out simple manual work under supervision. They are not able to live a life completely independent of support and instruction. This degree of disability is characteristic of noticeable differences. Some individuals attain a higher level of sensory motor skills or are capable of social interaction, for example a simple conversation, whilst others are not able to communicate their basic needs (Švarcová, 2000, pp. 28–29).

School-age child development comprises the period of ages between 8 and 11. Children in this age group exhibit a change in physical proportions, i.e. the growth of extremities and trunk as compared to the head which appears to be smaller. Physical form appears more rounded and first adult teeth are beginning to grow. Children are exposed to life-changing events. They start attending school and take part in different social interactions. Further characteristics include cooperation, competition, accepting objective reality at face value and dependence on the leadership of parents and teachers. The development of physical characteristics in children with ID corresponds to that of the general childhood population unless there is a combination with, for instance, Down syndrome, cerebral palsy or organic brain damage.

Puberty is a developmental stage which covers the ages between 12 and 15 and is characteristic of the development of secondary sex characteristics and growth spurt initiated by the production of sex hormones. A child gradually becomes an adult physically as well as mentally. Due to hormonal changes, emotional stability is compromised; there is a heightened sense of anxiety,

insecurity and low self-esteem. Group identity and first interactions with the opposite sex gain on importance. (Studium Psychologie, 2016).

People with intellectual disabilities have a shorter lifespan and a higher mortality in comparison with the general population (Bittles et al., 2002). This observation is also supported by Patja, Iivanainen, Vesela, Oksanen & Ruoppila (2000). Conditions such as epilepsy, osteoporosis, motion disorders, obesity, intestinal motility disorders and hyperlipidemia are more often found in people with intellectual disabilities (Tyler, Schramm, Karafa, Tang & Jain, 2010). According to Havercamp, Scandline & Roth (2004, pp. 418–426) and Cooper, Melville & Morrison (2004, pp. 414–415), this population also has a worse state of health and concurrently difficult access to primary healthcare. Consequently, Special Olympics International (SOI) supported The Healthy Community Project, whose project partners between 2016 and 2019 were The Czech Association of Special Olympics and The Faculty of Sports Studies (Válková, 2016); (Válková & Krejčí, 2016, p. 47).

An increased body weight, which is more common in people with intellectual disabilities, is a significant risk factor for the onset of certain diseases (Melville, Hamilton, Miller & Boyle, 2007); (Rimmer & Yamaki, 2006). According to Melville, Hamilton, Miller & Boyle (2007), the prevalence of obesity is 15–50 % for women and 2–45 % for men (pp. 223–230). The risk of obesity appears to be especially high in women, people with Down syndrome and people with mild ID (Melville, Hamilton, Miller & Boyle, 2007); (Hsieh, Rimmer & Heller, 2014). Svačina & Bretšnajdrová (2003, p. 35) also indicate the significance of gender as a factor in obesity: women tend to be more obese then men in all populations. Other factors include education, in relation to which higher income means a lower BMI, and alcoholism which leads to an increase in weight.

Stancliffe et al. (2011) underscores the need to assess living arrangements during the obesity risk factor analysis (pp. 401–418). People living in institutional environments have the lowest prevalence of obesity and people living in their own homes experience the highest prevalence of obesity (Melville, Hamilton, Miller & Boyle, 2007); (Stancliffe et al., 2011).

All cited authors reference to the BMI scale of the World Health Organization (WHO). The BMI was developed as a tool for estimating the risk of disease. The higher the BMI, the higher the risk for certain medical conditions. Being overweight or obese means a higher risk of premature death, cardiovascular disease, high blood pressure, arthrosis, certain kinds of cancer and diabetes (WHO, 2018).

The aim of the presented study, which is part of the Special Olympics Healthy Community project (HC-ZAS), is to compare BMI trends and diets in children with mild ID and moderate ID who live in their own home with children living in a children's home in the region of Zlín.

METHODOLOGY

Participants

The study participants were pupils of Primary school Otrokovice and the Special Needs and Practical School in Zlín. The criteria for their selection was mild ID and moderate ID and the address of their home. Six children were selected from Otrokovice Primary School who live in their families (three children with mild ID and three children with moderate ID), and six other participants (three children with mild ID and three children with moderate ID), who live in residential care, were chosen from Zlín Special Needs and Practical School. In total, 12 pupils were selected for the BMI trends evaluation, of which 11 have ID with no further impairment, whereas 1 pupil has Down Syndrome. The ages of the participants range between 8 and 15 years, which covers two developmental stages: early school age and puberty (Table 1). The data collection was conducted in four instances throughout the period of 2 years, always in June and September, to find out whether the summer holiday affect BMI indicators. The ethical consensus was guaranteed.

Tab. 1: The characteristics of participants

Periodization	June 2017		September 2017		June 2018		September 2018	
	boys	girls	boys	girls	boys	girls	boys	girls
Younger school age 8–11 age	4	4	4	4	4	2	3	2
Pubescence 12–15 age	2	2	2	2	2	4	3	4
Total	6	6	6	6	6	6	6	6

Data acquisition and analysis

The InBody 230 analyser, which provides accurate results of body composition (fat, active body mass and water), was used for the detection of obesity. InBody uses the method of 8-point tactile electrodes which enable to measure the body in segments. The data collection took place in the schools' gym and was carried out within the space of two days at two different schools, one day each. In the picture below (Figure 1), we can see the example of the BMI scanning taken at one of the special needs primary schools. Measurements were always taken in the morning from the youngest to the oldest children.

Fig. 1: BMI scanning with InBody230

Detailed analysis of participants using InBody is shown in the table (Table 2). Muscles and fat are given in kilograms.

Tab. 2: Characteristics of participants in terms of body composition

Participants/Period		June 2017	September 2017	June 2018	September 2018	Parameter
Girl 11–12 age	BMI	15,1	14,3	15,3	14,7	Children with mild ID living in their families
	Muscles	13,5	14,4	15,6	19,2	
	Fat	4,6	3,3	5,1	2,5	
Boy 12–13 age	BMI	21,2	21,0	22,9	22,2	
	Muscles	22,3	25,1	29,7	31,1	
	Fat	15,4	13,3	15,8	13,8	
Boy 14–15 age	BMI	16,1	17,3	16,8	16,5	
	Muscles	24,2	21,7	26,2	26,2	
	Fat	3,9	7,0	4,2	3,6	
Boy 11–12 age	BMI	23,4	23,6	24,6	25,4	Children with moderate ID living in their families
	Muscles	8,6	9,3	15,4	14,4	
	Fat	20,3	23,7	18,0	21,1	
Girl 9–10 age	BMI	15,6	13,9	15,2	15,2	
	Muscles	9,3	9,7	11,0	11,1	
	Fat	6,0	4,3	6,1	6,1	
Boy 9–10 age	BMI	18,2	19,6	18,5	19,1	Children with mild ID living in residential care
	Muscles	15,4	14,5	18,9	19,2	
	Fat	8,1	11,8	8,2	10,4	
Boy 10–11 age	BMI	15,8	14,7	15,2	15,2	
	Muscles	10,0	15,6	17,7	18,5	
	Fat	14,3	5,3	5,3	5,7	
Girl 8–9 age	BMI	16,4	15,7	14,9	16,5	
	Muscles	13,9	9,4	11,3	11,5	
	Fat	2,7	3,3	3,6	3,9	
Girl 14–15 age	BMI	19,1	17,7	20,4	21,8	Children with moderate ID living in residential care
	Muscles	19,4	19,3	18,1	18,5	
	Fat	9,2	9,0	16,7	18,8	
Girl 11–12 age	BMI	14,3	13,1	13,7	14,1	
	Muscles	5,0	9,5	10,6	10,7	
	Fat	11,6	2,7	3,5	4,4	
Boy 8–9 age	BMI	15,7	15,1	15,4	15,9	
	Muscles	8,1	11,4	12,0	12,6	
	Fat	8,8	7,9	10,2	4,5	

To describe trends, Švancara's model for types of development was employed (Švancara, 1980, p. 20). For 3 to 4 subsequent measuring sessions only 4 types were used: stable, positive, negative and unstable (Válková, 1989).

BMI is an index of body weight which is commonly used to indicate underweight, normal weight and obesity. There are universal BMI ranges for the adult population which are not age- or gender-specific. However, there are no standardized ranges for children between the ages 5 and

19. In children, BMI changes with sex and age. Based on the measured BMI value, one of five categories is allotted by age and sex. The categories are as follows obesity, overweight, normal, thinness and severe thinness. The child then can be assigned to one of these groups. BMI is defined as a person's weight in kg divided by the person's height in meters (kg/m^2). The ratio is expressed by the following formula

$$BMI = \frac{weight\ in\ kilograms}{(height\ in\ metres)^2}$$, (WHO, 2018).

For dietary data collection a simple questionnaire of 5 questions to inquire about drinking and dietary habits was compiled. The method of communication during the data collection had been tried and tested in practise previously (Válková, 2014) and in the presented research included face-to-face communication with the children by means of pictures or samples of authentic foods. Teachers were available for support in case of need. In view of the children's cognitive capacity, the Likert scale was reduced to 3 options: "no", "sometimes", and "often". "Often" was evaluated as the most positive and assigned 3 points; "sometimes" was allotted 2 points and "never", indicating that the child never consumed the presented food, was ascribed 1 point. These options determine at what frequency the person consumes the food or drink The minimum score, i.e. the least healthy diet, amounted to 5 and the maximum, i.e. "the healthiest" diet, totalled 15 (Figure 2). Unsweetened drinks mean drinks without refined sugars.

The data collection was conducted in person and was repeated four times within space of 2 years as part of the entire survey. All 4 interviews were done by the same person who was well versed in the child's communication specifics and with whom the child was familiar.

Dependence between correlation and body composition was determined by correlation coefficient.

	Eating habits questionnaire
	The minimum is 5 points and maximum is 15 points (the healthiest diet).
	It is always possible to select only 1 variant.
1. Drinks:	
	1) unsweetened – often: 3 points
	2) sweetened – sometimes: 2 points
	3) sweetened – often: 1 point
2. Milk:	
	1) no: 1 point
	2) sometimes: 2 points
	3) often: 3 points
3. Milk products:	
	1) no: 1 point
	2) sometimes: 2 points
	3) often: 3 points
4. Fruit:	
	1) no: 1 point
	2) sometimes: 2 points
	3) often: 3 points
5. Vegetable:	
	1) no: 1 point
	2) sometimes: 2 points
	3) often: 3 points

Fig. 2: Eating habits questionnaire
(Source: Healthy Community Project)

RESULTS

BMI trends among children living in their own home and residential care

Figure 3 shows BMI trends among children with mild intellectual disability attending Otrokovice Primary School and living in their families. As can be seen, the weight of elderly boy and girl remained within norm, whereas the other boy was overweight for the whole research period.

One of the boys aged 12 to 13 and the girl tend to have a lower BMI following the period of the summer holiday (September 2017 and September 2018). The other boy aged 14 to 15 shows the similar tendency but with increase period of the summer holiday (September 2017).

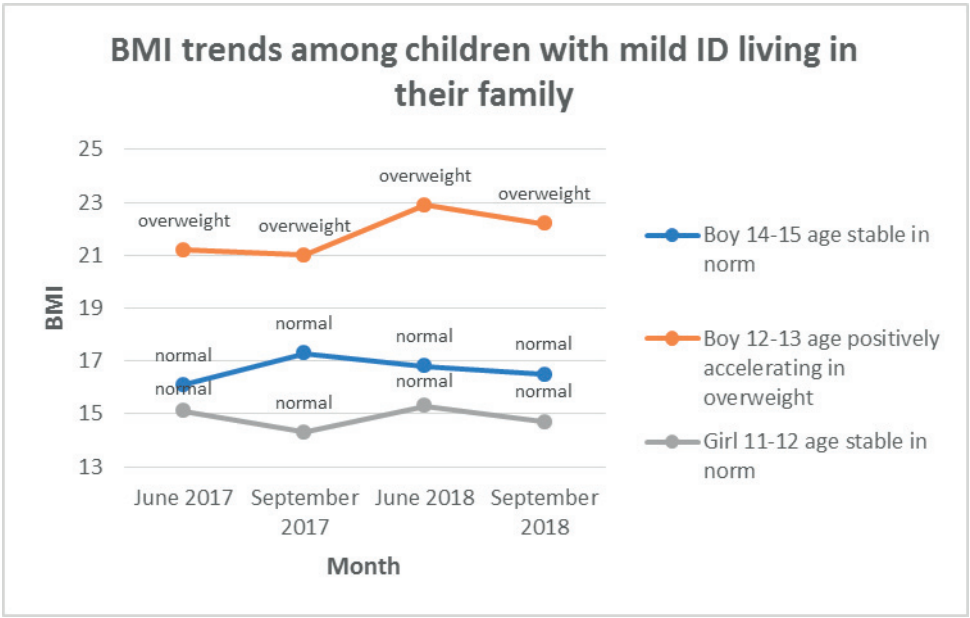

Fig. 3: BMI trends in children with mild intellectual disability attending Otrokovice Primary School

Figure 4 shows BMI trends among children with moderate intellectual disability attending Otrokovice Primary School and living in their families. As can be seen, the weight of both girls remained within norm, whereas the boy was obese for the whole research period.

One of the girls aged 13 to 14 tends to have a lower BMI following the period of the summer holiday (September 2017 and September 2018) and an increased BMI towards the end of the school year. The other girl aged 9 to 10 shows the same tendency. However, no changes in BMI were identified in 2018. The boy is associated with a continuous mild increase in weight.

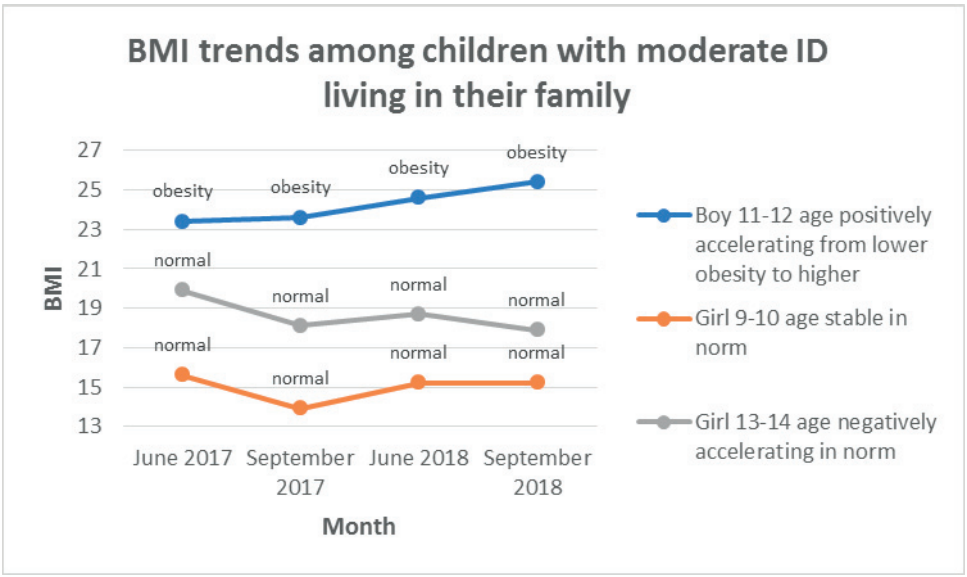

Fig. 4: BMI trends in children attending Otrokovice Primary School

Figure 5 demonstrates BMI trends in children with mild intellectual disability attending Zlín Primary School and living in a children's home. As can be seen, one of the boys aged 9 to 10 is overweight, whereas the other boy aged 10 to 11 and girl are in normal weight and do not show any change in weight during the whole research period.

It can be further concluded that all three children irrespective of their gender are associated with the same tendency which is apparent in a weight loss before the summer holiday (June 2018) and subsequently a mild weight gain after summer holiday (September 2018).

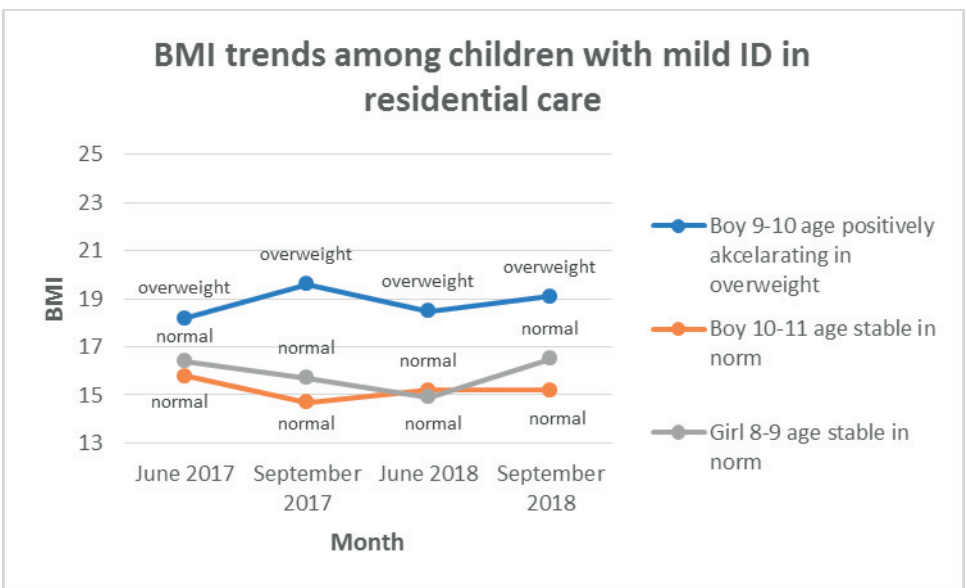

Fig. 5: Trends in children with mild intellectual disability attending Primary School Zlín

Figure 6 demonstrates BMI trends in children with moderate intellectual disability attending Zlín Primary School and living in a children's home. As can be seen, one of the girls aged 11 to 12 is underweight, whereas the other aged 14 to 15 does not show any change in weight during the whole research period.

It can be further concluded that all three children irrespective of their gender are associated with the same tendency which is apparent in a weight loss following the summer holiday of 2017 and subsequently a continuous mild weight gain. Within the research period, the BMI of none of the respondents was affected by the summer holiday.

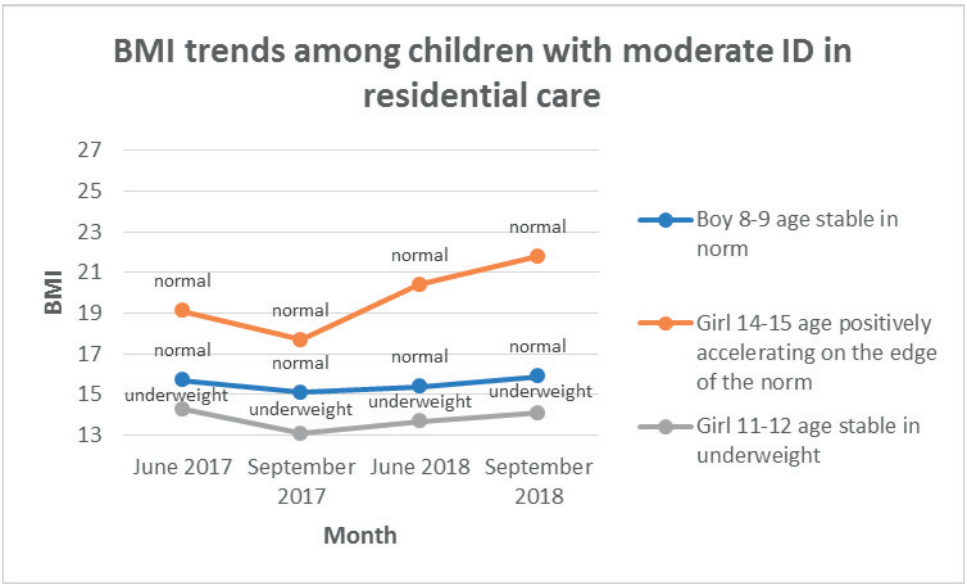

Fig. 6: Trends in children attending Primary School Zlín

Dietary habits in children living in their own family and in a children's home

By comparing questionnaire results of children living in their own home with mild ID and children with moderate ID (Table 3), it can be seen that children with moderate ID have better dietary habits by 0.17 points. The mean values among children with mild ID range between 9.25 and 12.50. The mean values among children with moderate ID vary between 10.25 and 12.75 out of the total score of 15 points.

Tab. 3: Dietary habits scores among children living in their own home

Children with mild ID	Average score in questionnaire	Children with moderate ID	Average score in questionnaire
Boy 14–15 age	9.25	Boy 11–12 age	10.25
Boy 12–13 age	11.25	Girl 9–10 age	10.50
Girl 11–12 age	12.50	Girl 13–14 age	12.75
All children	**11.00**	All children	**11.17**

By comparing questionnaire results of children living in in residential care with mild ID and children with moderate ID (Table 4), it can be seen that children with moderate ID have better dietary habits by 0.50 points. The mean values among children with mild ID range between 11.50 and 13.00. The mean values among children with moderate ID vary between 11.75 and 13.75 out of the total score of 15 points.

Tab. 4: Dietary habits scores among children living in residential care

Children with mild ID	Average score in questionnaire	Children with moderate ID	Average score in questionnaire
Boy 9–10 age	12.25	Girl 14–15 age	11.75
Boy 10–11 age	11.50	Girl 11–12 age	13.75
Girl 8–9 age	13.00	Boy 8–9 age	12.75
All children	**12.25**	All children	**12.75**

By comparing dietary habits of children living in their own families and children living in a home in both categories ID (Table 5), it can be seen the diet of children in residential care is healthier by 1.25 points in mild ID and by 1.58 points in moderate ID. This difference is more significant than the difference within the same degree of ID.

Tab. 5: Dietary habits scores among children living in their own home and in residential care

	Average score in questionnaire	Difference
Children in family with mild ID	11,00	**1,25**
Children in residential care with mild ID	12,25	
Children in family with moderate ID	11,17	**1,58**
Children in residential care with moderate ID	12,75	

We can also see the healthiest diet have children with moderate ID living in residential care (12.75 points). The worst diet children have with mild ID living in their families (11.00 points).

Correlation between eating habits and body composition

The following table (Table 6) shows the correlation values. The direct mean correlation force is between dietary habits and muscles (r = 0,606) in children with moderate ID living in their family. The indirect mean correlation force is between dietary habits and fat (r = –0,517) in children with moderate ID living in residential care. BMI has the closest dependence on the eating habits of children with moderate ID living in residential care (r = 0,253).

Tab. 6: Correlation between dietary habits and body composition

Dietary habits	BMI	Muscles	Fat
Children with mild ID in family	r = –0,115	r = 0,293	r = 0,225
Children with moderate ID in family	r = –0,109	**r = 0,606**	r = –0,172
Children with mild ID in residential care	r = –0,002	r = –0,129	r = –0,223
Children with moderate ID in residential care	r = 0,253	r = –0,191	**r = –0,517**

DISCUSSION

Within the presented research, only one boy with Down syndrome, living in his own home, was obese. Melville, Hamilton, Miller & Boyle (2007), who studied adult population, arrived at the same conclusion: people with Down syndrome are prone to obesity. Stancliffe et al. (2011) found out that there is a connection between obesity and living arrangements. There was a higher prevalence of obesity among people with ID living in their own home than in residential care. Within the presented research, this was confirmed in children with moderate ID living in their families. In children with mild ID living in the families, an overweight relationship was found.

It is noteworthy that prevalence of obesity among girls was not confirmed in any category. For instance, Hsieh, Rimmer & Heller (2004) or Melville, Hamilton, Miller & Boyle (2007) discovered a link between obesity and gender in adult population. Furthermore, many studies proved a connection between prevalence of obesity and intellectual disabilities in the adult population, for instance (Rimmer & Yamaki, 2006), which was not true for the childhood population in our research. Eight out of twelve children have their BMI within norm, one child is underweight, two children are overweight, and only one child is obese. It is interesting that only boys are overweight and obese. It is highly likely that children with ID are physically more active than adults with ID. As a result, obesity is more prevalent in adulthood. All the research participants had the opportunity to attend one class of sports after-school activities in addition to the two weekly compulsory classes of Physical education as part of their school curricula. There is a wider range of after-school activities for children living in residential care.

One of the reasons may be the fact that children in residential care are attended by professionals, who are available for them in the children's free time and arrange various after-school activities for them, whereas children living in their own home depend on their parents' interest and free time. For instance, their parents may go cycling with them or drive them to an after-school sports club.

Furthermore, it is interesting to note that summer holiday (which in the Czech Republic are 2 months and children are at home during them) has effect on the BMI indicators in children living in their families and has little effect on the BMI indicators in children living in residential care as every child shows a different trend in peaks and falls in their BMI values. This is not true, however, for the year 2017 as the BMI indicator were higher in June 2017 in 9 out of 12 children than in September 2017. It may be safe to conclude that summer holiday meant more physical activity.

In 4 out of 6 children living in their families the BMI indicator were higher in June 2017 than in September 2017 and the BMI indicator were higher in June 2018 than in September 2018. It may be safe to conclude that summer holiday meant more physical activity than during the school year.

In 4 out of 6 children living in residential care the BMI indicator were higher in June 2017 than in September 2017, but the BMI indicator were lower in June 2018 than in September 2018. It may be safe to conclude that children have during summer holiday 2017 more physical activity than during the school year but that summer holiday 2018 meant less physical activity.

It is not surprising that children in residential care have a better diet than children living in their own home. Parents would have to pay more attention to their children's dietary needs and be instrumental in forming their children's healthy eating habits, i.e. offer more fruit and vegetables. Many parents do not feel comfortable refusing their children's cravings for sweets. This phenomenon can be linked to protectionist parenting and economic status. Children's diets in institutions, e.g. children's homes and schools, are subject to strict regulations. The staff are responsible for adhering to technological procedures and daily food portions in accordance with regulation No. 110/2005 Sb. on School Catering. There is also regular monitoring to ensure that these regulations are observed. Consequently, children in residential have a more limited choice within their dietary options.

CONCLUSION

Research into BMI trends was conducted in space of two years in six children with mild ID and in six children with moderate ID at early school age and puberty. A half of these children lived in their own families and the other half in the Children's home in the Zlín region in the Czech Republic.

Only children with moderate ID living in their families are associated with obesity and tend to normal weight. Children with mild ID living in their family tend to overweight and normal weight. Children with mild ID living in residential care are not associated with obesity and tend to normal weight or overweight also children with moderate ID living in residential care are associated with normal weight or underweight. Obesity and overweight are connected only with boys.

Two thirds of children with mild ID and moderate ID living in their families follow the same pattern of BMI: a subsequent weight rise in June 2017 and 2018 but the holiday period is associated with a weight loss in September 2017 and 2018. Summer holiday influences the BMI indicators. Almost all children with mild ID and moderate ID living in residential care follow also the same pattern of BMI: the holiday period is associated with a weight loss in September 2017 and a subsequent weight rise in June 2018 which continues its upward trend in September 2018. There is no conclusive evidence that summer holiday influences the BMI indicators.

Children tend to remain in their BMI category, i.e. normal weight, underweight, overweight or obesity. No child manifested any changes in weight during the research period. With growing age, half of children have demonstrated a weight gain.

Children with moderate ID living in their families are provided a healthier diet than children with mild ID living in their families. As well as children with moderate ID living in residential care are provided a healthier diet than children with mild ID living in residential care. Children with mild ID and moderate ID in residential care are provided a healthier diet than children with mild ID and moderate ID living in their families, which means they consume fewer sweet drinks, more dairy products and fruit and vegetables.

The direct mean correlation force is between dietary habits and muscles in children with moderate ID living in their family. The indirect mean correlation force is between dietary habits and fat in children with moderate ID living in residential care.

It has been concluded that parents should consider arranging sports activities for their children provided they are not willing or able to do sport with them themselves. It would also be advisable to extend the range of sports activities in the vicinity of their homes and promote the importance of sport in children with ID. Parents are further recommended to pay more attention to their children's diets and prepare homemade food from healthy ingredients. More portions of fruit and vegetables should also be included in the diet. A workshop focusing on a healthy diet and food could be organised to increase parents' awareness in this area.

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The Determinants of Motivation Regarding Top Competitive Basketball of Juniors

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Abstract

The motivation plays an essential role in carrying out any activity in people's lives. It is a critical aspect between individual stages of career transitions and its goals. The purpose is to describe the determinants of the motivation and adherence of junior basketball players. The research interviews 40 players who wish to continue at the professional stage. The Career Transition theory (Alfermann & Stambulova, 2007) is a scope for the research. The research is qualitative, using The Grounded Theory by Strauss and Corbin (1990). The chosen research instrument was a semi-structured interview. The sample consists of twenty girls and twenty boys between ages 15–18. The results illustrate eight determinants of motivation and adherence. 1. lifestyle, 2. the perception of competencies, 3. specifics of basketball, 4. bio-psychosocial health. 5. enjoyment, 6. team spirit, 7. society, 8. time management. Time management is the most occurring reason for termination of the basketball career.

Keywords: *motivation; transition; time management; determinants of motivation; basketball, juniors, skills; career transition; lifestyle; adherence; passion; health; team spirit, coach.*

INTRODUCTION

The concept of motivation falls within the sphere of psychology terminology. It interferes with the life of a person in every aspect of life. The determinants of motivation are present in several areas. Those represent individual characteristics and personal potential. Social and biological factors determine psychological factors. These three areas cannot exist in isolation. The development of human psyche depends on biological factors within the nervous system. Social determinants refer to a person as part of society. It develops, influences, and shapes the person with specific social standards, culture, and civilization (Čechová & Rozsypalová, 1992). Since psychology is a discipline with many theoretical frameworks, many of the theories mentioned are of the older date. It is my preference to work with original works that the new theories built upon.

Motivation has been repeatedly reported as one of the most important contributors to high-level performance. For instance, in sport, athletes' success is often explained as a function of motivation (Gould et al. 2002).

Sport is a specific environment with precise requirements for its participants. If the motivation of participants is low, there is a weak incentive for hard work. They may get further from reaching a professional level in one's career. Motivation is the foundation of sports performance and success. It relates to experiences the athlete undergoes. Sportsperson then responds to the sport in their individual way (Duda & Treasure, 2010). We can distinguish three basic types – amotivation, internal and external motivation. 1. External motivation builds on external rewards. Trophies, prizes, praise, status, and a pay check. 2. Internal motivation comes from the inside of a person: enjoyment, fun, enthusiasm for action, demonstration or improvement of abilities. Amotivation means a lack of internal and external motivation for sporting activities (Jarvis, 2006).

The need for achievement is a theory focusing on actual sporting activity. Need for achievement describes the process of mastering the top competitive sport. It includes high sporting performances and diverse activities of life. This embodies the creative self-image of an athlete's

personality. To construct the consistency of the general and specific objectives of society and the individual is imperative. Need for achievement has resources in the long-term learning process and various motives prevailing at different levels. Top sporting performance is the result of the complexity of motives that energize, maintain, create and strengthen the stages of motivation. It is the foundation of the activity and the result of sporting performance (Vaňek, Hošek & Man, 1989).

Self-determination theory (Ryan & Deci, 2002) was initially developed by Edward L. Deci and Richard M. Ryan and has been elaborated and refined by scholars from many countries. Sport is a specific environment with specific requirements for the participants. Without motivation, the pillars for continuation on an elite level are weak. Motivation represents the fundamentals for sports performance and success. (Duda & Treasure, 2010). Sports psychologist Gurský (2005) describes motivation as a process of managing, maintaining and energising behaviour. Motivation can be seen in more ways than one. Self-determination theory (Ryan & Deci, 2002) propositions focus on how social and cultural factors facilitate or undermine people's sense of volition and initiative, in addition to their well-being and the quality of their performance. The theory makes distinctions between different types of motivation and the consequences of them. *1. Intrinsic motivation* is the natural, inherent drive to seek out challenges and new possibilities associated with cognitive and social development. *2. Extrinsic motivation* comes from external sources. The different forms of extrinsic motivation and the contexts in which they come about, these contexts affect whether the motivations are internalised and so integrated into the sense of self. Four different types of extrinsic motivations often vary in terms of their relative autonomy:

Externally regulated behaviour: Is the least autonomous, it is performed because of external demand or possible reward. Such actions can be seen to have an externally perceived locus of causality.

1. **Introjected regulation of behaviour**: describes taking on regulations to behaviour but not fully accepting said regulations as your own. Deci and Ryan claim such behaviour normally represents regulation by contingent self-esteem, citing ego involvement as a classic form of introjections. This is the kind of behaviour where people feel motivated to demonstrate the ability to maintain self-worth. While this is internally driven, introjected behaviour has an external perceived locus of causality or not coming from one's self. Since the causality of the behaviour is perceived as external, the behaviour is considered non-self-determined.
2. **Regulation through identification**: a more autonomously driven form of extrinsic motivation. It involves consciously valuing a goal or regulation, so that said action is accepted as personally important.
3. **Integrated Regulation**: Is the most autonomous kind of extrinsic motivation. They are occurring when regulations are fully assimilated with self, so they are included in a person's self-evaluations and beliefs on personal needs. Because of this, integrated motivations share qualities with intrinsic motivation but are still classified as extrinsic because the goals that are trying to be achieved are for reasons extrinsic to the self, rather than the inherent enjoyment or interest in the task.

The third type is called **amotivation** – internal or external motivation is missing (Jarvis, 2006). Another view regards differences in *quantity and quality of motivation*. Quantity – frequency of engagement in sport "here and now", achieved success. Quality refers to the positive enjoyment with the sport (Duda & Treasure, 2010). The actual sporting activity creates both the short-term and the long-term process of exceptional performance – achievement motivation (Vaňek & Hošek, 1989).

In Study with French junior national tennis players and fencers, results revealed the presence of different levels of autonomous and controlled motivations. Results show that athletes with the least self-determined motivational profile obtained lower levels of subsequent tennis performance than those with more self-determined motivation. The least self-determined motivational profile led to the lowest level of performance. They used cluster analysis, which siggests that this way

of analysis is useful in the understanding of the complex relationship between motivation and performance in elite sport (Gillet, et al. 2009).

Achievement goal theory (Nicholls, 1984; Duda, 1992) falls under the concept of the need for achievement. The theory distinguishes two types of motivation depending on the orientation of sportsperson. 1. Task orientation and 2. Ego orientation. The orientation influences the structure of the goal in sports. The process creates a specific motivational climate. We distinguish two dimensions. The mastery and the performance; both based on the orientations either on the task or the ego (Ames, 1992). The motivational climate is a result of the coach's educational approach and the experience gained through the implementation of the activity.

The mastery (task-orientation) refers to a structure of climate that encourages effort, cooperation, has emphasis on learning and mastering the task. The task-oriented motivational climate shaped by the coach helps to increase internal motivation and adherence to the sport. Coach uses the training environment as a place of education and knowledge about more than the sports (Almagro et al., 2009). Task-oriented athletes usually have a higher motivation than ego-oriented athletes. It is essential to consider a personal improvement, individual mastery, and improvement since the last performance. Success is assessed by self-performance and personal development (Lochbaum & Roberts, 1993). Greater autonomy is another factor considered a solid motive. More mature individuals can make decisions according to their will. They should be free to choose if they wish to continue further. If the adolescents get to decide the use of their time, their motivation may increase (Dawes et al., 2013). Performance (ego-orientation) refers to situations that lead to normative comparisons and higher competition between teammates. Teachers and coaches usually penalize participants for their mistakes (Ames, 1992). The coach emphasizes processing of the information in a normative manner. Comparison with the chosen standard, which reduces the athlete's sense of control over their activities and the consequent results in sport (Duda & Hall, 2001). Ego-oriented individuals value the demonstration of their abilities (Vallerand & Losier, 1999). They evaluate their success or failure by comparing their performance with that of the others (Lochbaum & Roberts, 1993). The task-oriented youth is motivated more internally. They experience a lot of enjoyment and successes than ego-oriented individuals (Gómez-López, 2013). Positive experiences in sports are a great predictor of further sports engagement. They help to expand the motivation to continue. Dworkin et al. (2003) describe six key areas of experience: 1. exploration and identity; 2. initiative; 3. self-regulation; 4. peer relations; 5. teamwork and social skills, 6. social networks with adults. The specific model of the motivational structure defines the level of all the stages in the motivational structure, the level of one's sporting performance, the level of the competition in which the athlete has the opportunity to realize their self. 1. Biological motivation: status, needs, expressions of the athlete's organism. 2. Material motivation: the relationship between life and sport, prizes, rewards, the study of sport, a profession in sport, the realization of self in the sport. 3. Educational motivation: development of learning, the influence of a coach, self-educating, self-improvement, sports performance, goals in sport and life. 4. Psychological motivation: a manifestation of personality, abilities, and skills, characteristics, will, overcoming psychological burdens, hardiness and resilience 5. Social motivation: competition in sport, relationships with teammates, social learning, role models, handling the social status of the top athlete, the influence of the specific and global environment of sport and society. 6. Political motivation: peace as a product of sport and policy of peace, gaining knowledge about people, establishing opinions, getting to know the world, engagement and all-round growth of the athlete's personality (Macák & Hošek, 1989).

Passion and adherence

Motivation overlaps with passion. It is a catalyst, an energy supplier that is persistent and strategic in high-demanding activities. The passion has two dimensions - harmonious and obsessive (Vallerand et al., 2003). Harmonious passion is a predictor of mastery goals, based on autonomous internalization. Individuals are not compelled to do the activity; they freely choose to do so. Other areas of life coexist with performing the selected pursuit. Elite performance is achieved through the obsessive passion of athletes who concentrate exclusively on their sport at the cost of other areas of life. It is the result of controlled internalization. The inner impulse forces a person to execute the activity even at inappropriate moments (Vallerand et al., 2008). Adherence means 'loyalty' to the given program of chosen activity. It is found in activities that are the result of free choice. Another aspects are the efficacy of a program and social support, interpersonal relationships, whether positive or negative (Slepička & Hošek & Hátlová, 2009).

Career Transition theory

The Career Transition Theory (Alfermann & Stambulova, 2007) focuses on the different stages of a professional sports career. A transition is an event that results in a change in thinking about oneself and the world in which the individual lives. It requires an adequate behavioural change. Athletes must meet the specific requirements of adjustment (practice, competition, communication, lifestyle). Several authors describe specific stages with similar content: 1. Preparatory stage; development of movement and motor skills filled with a wide range of sports activities to which the child dedicates its time. The critical aspect is to present and develop a good atmosphere, especially during periods when parents play a significant role as a principal socializing agent. 2. Start of sports specialization or initiation stage (Salmela 1994, Bloom 1985). Sport is rather a game, the individual may try many activities to clarify which one is best for them. 3. Intensive training in selected sports or specialization years (Cote, 1999) / development stage. The focus is on 2 to 3 sports; individuals devote their time to them. Activities require specific knowledge of the chosen sport, they develop skills and abilities and create an emotional relationship with the given activity. 4. Cultivation stage or stage of perfection/investment years; the athlete becomes an expert in selected sport, reaches an elite level, or a senior level in the sports profession. They achieve their highest performances. 5. Final stage or maintenance years is preparation for career termination. Sporting performances still hold a certain level, but there are no significant records. Athletes have enough strength to sustain a professional sports career. Their engagement is gradually decreasing. Some authors describe the stage as an interruption of sports career (Wylleman & Lavallee, 2004) or recreational years. Athletes cease to participate in a high a level of sport but may continue recreationally.

Junior athletes are at the developmental stage (specialization years or intensive training in selected sport). Athletes narrow their attention and engagement to one or two sporting disciplines that interest them (Alfermann & Stambulova, 2007). Sports engagement means the extent to which young people perceive activities as entertaining, exciting and challenging (Vallerand & Losier, 1999). Sports engagement and sports career of an adolescent is distinguished by intensity – the frequency with which they participate in a chosen activity; and length – how many years they have participated in chosen activity (Bohnert et al. 2010).

The model of four stages of the motivational structure by Vaněk and Hošek (the first one to mention three main phases is Stránsky) describes the primary motives of different age categories. 1. Stage of the first expansion of movement (biological motives, need for movement, positive excitement, parents as role models, and other athletes). The participants are around ten years old; performed activities are diverse, performance is based on entertainment and playing. The critical role of the coach is to create a positive attitude towards sports, to teach the basic principles of movement and skills. There is a possibility of an early specialization of the individual. 2. Stage of

selective self-realization – youth and adolescents (motives are a social claim, performance, success in conjunction with a positive experience). The incentive is a gradual sports specialization, specific training, and moderately high performance. The key role of the coach is 'to have good luck with the personality type the coach will be.' He should be able to push the player forward, give him the knowledge and values about sport and life itself. 3. Stage of sports mastery – adulthood (the motivational structure is differentiated, importance is on personal success, social prestige, economic status). Specialization in a specific sport is high. The key role of the coach is to create cohesiveness in the team and to maintain high performance. 4. Involution of the motivational structure (the involution of elite performance, socio-psychological problems for leaving the 'glory' stage, changes in economic status). It involves a period of higher maturity, specialization in a chosen sport, keeping advanced performance. The role of the coach is to maintain the team harmony. He should represent an adequate example for children and youth. Each stage is full of internal and external influences that are interconnected. Together they shape the athlete's personality, their system of values, characteristics and structure of sports motivation (Votík, 2011). Career Transition theory and the model of motivational structure is the framework of this research.

Transitions

Transitions between stages can be predictable (normative) organizationally or structurally. They may be associated with changes in sports achievements or with changes in age (initiation of the competitive sport, transition from high school to college). Unpredictable transitions (non-normative) occur unexpectedly or do not occur at all. They are also called non-events which points to changes when the transition is expected but does not ensure for specific reasons (Petitpas et al., 1997). *The motivation for the transition* can be socialization and the influence of important people (family and peers); behaviour related to the transition period (work ethics, maximizing options of sports selection, focus on transition); internal motivation (love for the sport, love for a particular activity, voluntary sports sacrifices). *Perception of the transition* may raise uncertainty of new experiences (perception of increased standards, lack of control); emotional reactions associated with the transition (stress levels, negative experiences, positive transition experiences). *Sources of stress associated with transition* are external and internal pressures; lack of support from the institution, organizational pressures, lack of school support; the pressure of sports careers and lifestyle (conflicts between the sport and education. *Support for sports development* associated with sport is support from a coach, informational support; material support, emotional support and support of self-confidence; institutional support – school support for sports participation, organizational support. *Changes associated with ending of the transition* may be: changes associated with sport – increased technical skills and knowledge, increased importance of sport; psychological development – identity-related changes, psychological changes – coping, self-confidence, nervousness; changes associated with socialization – benefits of transition (friendships); negative impacts (lack of time for friends), loss of contact (Pummell, Harwood & Lavallee, 2008).

Dual career, defined as a career with the major foci on sport and studies or work (Stambulova & Wylleman, 2014), also consists of dual career transitions which are athletes' simultaneous transitions in sport and education or work.

The transition from junior to senior plays the most critical role in the overall sports career. Athletes themselves often describe this stage transition as the most difficult. Many sportspeople have admitted they have failed to cope with the demands. Some athletes do not manage the transition. They stagnate, stay with the sport recreationally or terminate sporting activities completely. They may feel tense, observe lack of progress, or have alternative goals. Other complications could be interpersonal conflicts with the coach and training environment, lack of leadership and personnel management in sports (Hollings et al., 2014).

Characteristics of the adolescence and the stage of selective self-realization

Adolescence is a crucial period for young athletes to become regular participants of physical activity, or to omit it altogether. Youth participation in sport accounts for the highest percentage of time dedicated to the activity if it is structured and voluntary (Czikszentmihalyi & Larson, 1984; Larson & Verma, 1999). The motivation during training and competitions is a determinant for youth's sports engagement (Almagro et al., 2009).

One of the most critical factors is the culture and environment in which an individual grows, studies and develops their professional focus. Few studies explore cultural factors that may have an emphasis on development of the specific motivational goals among youth. Their perception may be different from the cultural perspective (Ryska, 2001). Maehr and Nicholls (1980) have pointed out the importance of the perceived cultural context and its impact on the type of motivational orientation of the individual growing in it. Physical culture reflects cultural values, needs, activities, norms, and relationships. There is a connection with material and spiritual culture, thus modelling concepts such as physical exercise, mass recreation, or sport. The basic function of physical culture is the satisfaction and cultivation of the natural need for motion, the renewal of physical and mental forces (Charvát, 2002).

Purpose

There is a need to comprehend how youth basketball players perceive their career and participation in sporting activities. The benefit is to understand why basketball youth choose basketball as a professional career, which facets of sports they might maintain in recreational sports. The research strategy is qualitative, focused on the environment of the Slovak Republic with its specifics. The research aims to formulate determinants of motivation that relate to the stage of selective self-realization of junior basketball players, leading them to continue playing professional basketball.

Research question

(1). Which determinants relate to the motivation of basketball juniors players?

(2). Are there gender differences relating to the determinants of the motivation?

METHODS

Research design

Qualitative research can capture the multidimensionality of meanings, contexts, unexpected phenomena, processes and explanations found in the world of sport, games and physical activity (Stelter, Sparkes and Hunger, 2003). The number of such research designs has increased in recent years. Sports psychology has a room for further qualitative studies (Munroe-Chandler, 2005).

Grounded theory is a research methodology which operates inductively. A study using grounded theory is likely to begin with the collection of qualitative data. Researchers review the collected data with one goal in mind. They look for repeated ideas, concepts or elements which become apparent. These are tagged with codes, extracted from the data. As more data is collected, and re-reviewed, codes can be grouped into concepts, and then into categories.

The analysis according to the Grounded Theory is carried out in three main steps (open coding, axial coding, selective coding). Opening coding identifies anchors that allow the key points of the data to be gathered. Everything is conceptualized line by line. Axial coding collects codes of similar content into the groups, which are later grouped in broader, similar concepts to create categories. Axial coding uses paradigm consistent of phenomena, direct causes, intervening causes, actions/interactions, consequences, and context. Selective coding is done after having found the core variable. The core explains the behaviour of the participants in resolving their main concern. After the core variable is chosen, researchers selectively code data with the core guiding their coding, not bothering about concepts with little importance to the core and its subcores.

Research instrument

The data were collected via semi-structured interview. Questions were divided into three main parts regarding time – past and first experiences with sport and basketball, transition to the current junior stage and its difficulties; the presence and the dreams of the future. These three parts then focused on physical, social and psychological aspects of playing sports which were asked only if the participants had problems to talk about their experiences. The collection, analysis and interpretation process was conducted according to Strauss and Corbin's approach to Grounded theory (1999). The analysis was done using the software Atlas.ti, a program for the transparent processing of results, codes, subcategories, categories, and final paradigms.

The number of interviews differed from person to person – some recordings were about 30 minutes long, some took a bit over an hour. According to this, the transcribed pages ranged from 5 to 20 pages long.

Participants

The research group consists of 40 junior basketball players with an age range of 15–18. The choice of participants intended to have a uniform gender distribution of twenty boys and twenty girls. The main criteria are the age (15–18), the interest in continuing the basketball career professionally. The sample of players is from every part of Slovakia where the participation is the highest.

The interviews were obtained with players residing in five cities. Boys are from Bratislava, Prievidza, Žilina, Nitra, Košice, Poprad, Komárno / Trnava. Girls are from Banská Bystrica, Prievidza, Nitra, Košice, Ružomberok, Stará Turá / Piešťany.

The course of research and analysis

Each participant signed the informed consent; educating them about the research and its purpose with contact information. They had the right to withdraw from the interview or to keep silent about specific questions. Every interviewee agreed to recording on the audio. All audio recordings have transcriptions. Names and identifying markers were omitted to keep the anonymity.

Triangulation was provided through feedback of the coaches from the areas and places where the respondent's practice. Feedback was positive. The coaches discussed the importance of the determinants which appear in the results.

Limits and positives

Limitations were difficulties in time management, geographical extent and gathering the right amount of sufficient respondents to meet the criteria. One of the limitations is also the age and need for informed consent given by their parents or legal guardians who might refuse.

An intimate atmosphere regarding safety and space for an in-depth interview is one of the positives. This type of research gives the opportunity for young people to express themselves freely. They are allowed to speak about any topics that may be unknown by coaches, parents or friends about the motivation phenomena.

RESULTS

Basketball players in this age category have a solid idea of whether to continue their basketball career professionally, recreationally or leave the sport altogether. The paradigmatic model of the grounded theory demonstrates the complexity of youth motivation:

Phenomena: basketball and sport as a lifestyle; perceived own competencies; the game itself (collective sport, dynamics – action, technique, connecting with the ball, basket throws); balance

(study – dual career). These are the main determinants of motivation, which plays an active role during the stage of selective self-realization.

Direct causes: coach; training process; support. These determinants are in close association with the phenomena described above. They determine the choice of a future career in sport, especially if the cohesiveness between the phenomenon and the causal conditions is disturbed.

Intervening causes (remote impacts): people outside the sporting environment; winning; physiology; first experiences with sports.

Context: environment and conditions, enthusiasm (love and joy of sport). These determinants exist somewhere between the thin lines of basketball as a sports discipline, coach and team, and perspective of the future.

Actions / Interaction: first experiences (strong memories); career self-reflection; sacrifices for sport; the benefits of sport.

Consequences: Future Prospects (Professional Sport + Study Selection + Recreational Engagement).

The apparent eight areas of determinants of motivation answer the first research question: *1. Which determinants relate to the motivation of basketball juniors players?*

Lifestyle

Sport and basketball represent a lifestyle, a part of the player's identity. "Especially because of that sport, when I am doing it my whole life or at least most of my life, I can see it in myself, in my health, it is reflected in my life." They spend their spare time playing basketball, as a hobby and as a habit. "It's a daily thing, as I go to school every day, I am going to train every day." They cannot imagine life without a sport or training. Otherwise, they become bored and begin searching for another physical activity. It embodies an active engagement and passive engagement (as a fan, researching information via the media and internet). "My dad took me to see men's league, and I fell in love with basketball, I created a close relationship with it."

Everything is affected by their first experiences with the sport. Positive experiences are about seeing the worth in basketball. Negative ones are overcoming obstacles and proving themselves. "As a little boy I larked with my friends, leaped over the trees, climbed the constructions, so I was used to the intensity, I played with my brother, and with his help, I performed better." The perceived benefits of sports influence the lifestyle led at a younger age. They are called mental skills. Taking responsibility for themselves and others, developing their abilities, feeling their leisure time is profitable for themselves both mentally and physically, avoiding unhealthy habits and activities.

Perception of one's competencies

Adolescence is a time when youth realizes their abilities through organized sporting activities and learned basketball skills. Goals and goal setting lead them to constant improvement. They resist stagnation and are in constant pursuit of new goals even beyond their performance. "I know my goal, I know what I want to achieve, and I am going after that."

Improvement accompanies a sense of success, refining basketball skills – physical, mental and social. "Day to day, you suffer at the training, sweat the soul out, you come here to fight. You know you are ready for it, you see your everyday process and progress, you move on from match to match which motivates you to continue. This is what I learned, and I can learn something new when I go further."

High performance means more than winning. The perception of their potential shows them how far they can proceed when working hard. They aspire to ensure their basketball or sports career; they want to improve with a focus on the term – I WANT. "I want to make my money, play

professionally, I want to play abroad, I want to feel it – WANT. I want to belong at the top. I want to play in (foreign country) because they are the second best in the world right after America and I think I can do it."

Coach contributes to the perception of their competences, as long as players get enough freedom to prove themselves on the court – both as a team and as an individual. Every player who works hard to get on the court should be treated fairly according to their skills. The coach should teach new things, not only about basketball but life as well. They need to be specific about what is done wrong and how to do it better, how to overcome obstacles. Unwavering position in the team confirms their competence. Players motivate each other to move forward. Another important aspect is support – material support from parents, informational support from the coach, emotional support from family, coach, team, friends. "Certainly, my parents motivated me to go to training because we do not live in the (city). They drive me twice every day. My parents are also entangled in it." "Probably my mom. She goes to my matches. She supports me; she encourages me."

None of this is possible without the respect and honor towards the people around them, against the opponents and their game, which improves the player himself and increases their competencies. "At the moment, probably the most that I have the chance to get to represent my country, Slovakia."

Basketball specifics

Basketball as a collective sport is a major reason why young people begin with practice. The collectivism is also a reason why they stayed with it for such a long time and wish to continue. "In time I found out that I enjoy it as a team. When we won together, we had to pull our weight as a team, it's about a shared experience."

As a team sport, it helps to establish strong relationships inside and outside of the court. The need to cooperate with others teaches tolerance and respect. Getting along with different personalities can lead to a further increase of social competencies. Dynamics and action of basketball (speed of the game, thought processes, tactics, quick decisions, reading teammates and opponents). "There is always something happening, observing the attack and defence at once. Other sports don't have that. There is always something interesting to see; something is still going on." "It's more gripping; you have to think, to have that players logic or something like that."

The considerable importance is connecting with the ball. The touch of a ball recalls the passion for basketball. The basketball is an extension of the body; it becomes the one with the player. It may associate with past experiences of the moment they touched the ball for the first time. This often helps to manage sports crisis. "I enjoyed it since childhood, to throw a basket, it's made for me. I was in preschool, threw a basket even when I had no idea what a ball is."

The training process plays a role in understanding the team as a whole and understanding individual members. Coach has to be a part of the team as a partner. He should be willing to try new things, be forward thinking, use the help of media, design suitable training sessions for their players based on their needs collectively and individually. Basketball builds the player physically, which includes the importance of strength and endurance, accuracy, balancing their life and plays part creatively. "Physical condition, we are keeping healthy, we are sportspeople, and we are fit. We have better health than people who sit on a couch at home, for sure."

Last but not least, the passive participation and patterns mentioned are watching basketball on TV, reading books, searching for inspiration in the world. "They motivated me, the big payers of the NBA."

Time management

This determinant is often the biggest reason for terminating the basketball career. It is important when balancing school with sports and personal life with sport.

Balancing the school and sport means to find time for both parts. The importance lays on the tolerance of teachers and coaches. Their cooperation should create conditions for players to meet the requirements of both sides. "I am starting college soon, and it would be nice to earn money by doing something I love. However, I know it's hard to do that, one injury and you are done."

Balancing personal life and sport focuses on enough time for friends and family, often on the sidelines. Their families display understanding providing huge support. This determinant may influence setting up player's future potential family. 'I am not sure how to say this. Yes, I would go for it if I had time for everything I want to do.'

Health – the biopsychosocial point of view

From a biological point of view, the sport is significant for health (good physical condition, stamina, endurance, keeping high performance at an older age). "I won't be sitting at home; I do something for my body. Then I feel better about myself."

From the social point of view, sport provides specific socialization. The athletes belong to a certain group of people with whom they have at least one thing in common. "That is what's so amazing about the sport, about the collective. Even if someone turns their back on you, teammates will be there for you."

They learn communication and interaction through problem-solving, verbal and nonverbal communication, openness and honesty. Those are factors without which the team cannot function as a cohesive unit. "He taught us when there's a problem we should say it right away so it won't suffocate us. They taught us to communicate."

From the psychological point of view, it helps to relax and to gain the psychological well-being. By training and playing, they exhaust themselves physically but energize mentally. "... that I can relax on the court. Not physically, but mentally. When I go there, I throw away all the bad thoughts or things that happened through the day."

Basketball is often described as entering another dimension of life. Young players go through self-development when gaining knowledge about different cultures, different environment, and personalities. "We visit many cities; we have many experiences as a team. We get to know new people, that sport gives me a lot for my life. I am growing up with it."

Basketball can provide a sense of life. A fulfilling activity with many future possible achievements when setting direct and indirect goals. "I like when the match shows it has a sense, that we move forward."

Enjoyment

Enjoyment combines all the determinants mentioned so far. It is imperative to keep enthusiasm in the various transitions through different career periods. Many individuals are afraid of moving to a professional level to not to lose the passion. Thus, it is vital for the other determinants to be present to maintain the zeal of basketball and sport as such. "It fulfills me, that is what pulls me to it, I enjoy it so much. For me, basketball is a sport that I relish in."

Environment

The conditions and options of clubs and countries affect the quality of the game. Physical regeneration and psychological assistance in setting other goals for the prospective elite level plays a vital role in material support. Training conditions – halls and sports facilities, traveling to different cities, many clubs and teams have unalike opportunities for training, many individuals have to travel too far which is time-consuming and tiring. Prospects of the country – engaging in the

first league of men and women; going abroad; salary conditions; support for basketball by the state. Staff members – masseurs, doctors, sports psychologists who do not appear in the youth basketball in Slovakia.

The potential for the future relates to the environment. It is a vision of a certain status if youth stays on a basketball track, often due to their positive experience. Many players search for an opportunity abroad. Unfortunately, many see it as a risk in comparing their abilities with players from other, more evolved countries, so they choose to end their career early. Nevertheless, they want to keep doing sport, mainly basketball recreationally, or to get another sports-related profession – coach, referee, or physiotherapist. "I cannot be happier about the care our youth sport gets. However, I know it might be a problem if I won't get any offer from abroad when it comes to the transition from juniors to the men's league. I know that on the professional level it's not the best, but I do believe it'll be okay. Fingers crossed for me and other guys, for everyone."

Atmosphere – team spirit

Emphasis is placed on cooperation between teammates "... that we can hold each other up. We are friends even outside of the court; we trust each other everywhere." and moreover, coaches. "Coach cannot always be, like, shouting at us. We wouldn't enjoy playing in an atmosphere like that; we would stop. The atmosphere at the training and in the team, it has to work."

The dual relationship is vital in establishing a relationship as coach-trainee, person to person. Equivalence and justice – every player should be treated equally. Even the weaker ones should be a proper part of the team, they should see and feel their value. "One for all, all for one. Charisma. To have respect from the players. That's the most important because if players start to make fun of their coach, it's the worst."

Players should trust their coach to lead them adequately, to take care of them, give them the opportunity to play, "to show off." They need to have the confidence that coach will take care of them, will trust them and help them. "Trust in one another, that's the most important aspect." "It's good when the training sessions are freer, there's not too much tension. Then we go there full of joy; we work a lot harder because we love it. Of course, the coach should be strict but not in a way we would be scared of him."

The basketball and its cohesiveness guarantee a common emotional experience. Players enjoy their participation fully or suffer together when they lose. This experience adds to the value of basketball and sport itself. "If something goes wrong, guys don't blame anyone. They start to shout, start to chant for us, that's the best when we root for each other."

"It's the most beautiful sport existing."
"Those who were able to build themselves in it, stay in it."

2. Are there gender differences relating to the determinants of the motivation?

Regarding the genders, their answers were very similar. One of the reasons for terminating their basketball career is education and necessity to get an offer from abroad which results in subjective feelings of inadequacy. Nevertheless, it is clear that this age group already decided for or against continuing with professional sports career. The decision is influenced by the complex process of determinants starting in their childhood and is ongoing to their present day.

DISCUSSION

Motivation and adherence are elements linked to passion interconnected with the professional sport. The results and their application to existing theories point to the importance of a sufficient educational environment in the sporting process. This process is formed and should be formed by the coach with the help of specialists such as sports psychologist.

Described determinants show the meaning of terms self-realization and sense of life. They represent enrichment for the age of adolescence. They can help the so-called anchoring of youth to a specific action that leads to a healthy lifestyle if applying the right approach. At the same time, they represent a potential for the future career in something they enjoy. Youth has a unique space where they may mentally unwind, find the group they belong to; they can figure out their own identity. Young basketball players see this sport as a purposeful activity with a meaning. Self-realization in basketball offers a room for enrichment, even creativity which connects with Maslow's (2000) theory of pyramid of needs. Before a person can fully develop their potential, they must meet the basic needs. Material support from parents assists with physiological needs and the need for security and safety. Emotional support fulfils the need for love and compassion. Informational support assists them to meet the needs of reaching firm competencies. Athletes aged 15–18 will develop their individual needs even after entering the professional sport. They will have to secure themselves, find new friends, set up their own families, and gain other specific competencies.

Motivation to play basketball professionally connects with experiencing the passion. This sport is regarded as meaningful and gives youth a sense of life – they demonstrate their capabilities to their selves and others. Basketball lets them find "asylum," the safe space where they can reach their potential goals if they attain the elite level. In the case of involuntary career termination or loss of enthusiasm, they may experience an existential crisis when they do not know where to go next (Frankl, 1999). For this age period, any crisis is intense. Youth encounters many crises and obstacles (changes in the body, transitioning from high school to college, choosing and planning for another potential occupation).

An overview of the options in self-realization provides a specific model of the motivational structure (Macák & Hošek, 1989). It monitors the level of one's sporting performance and the level of competition. The first stage is biological motivation: the determinants associated with the need to move or with hyperactivity, feeling good about physical health. In the second stage stands a material motivation: athletes see the rewards of their work, they are interested in the specific sport, they form a relationship with it even when losing, they can achieve self-realization which leads them to choose the basketball as a profession. Pedagogical motivation: the coach plays a vital role at the younger age (teaching the technique or life values in later life). Young basketball players learn through the challenges that sport conveys, their performance improves, and they try to achieve their goals. Psychological motivation involves demonstration of personality, abilities, characteristics, will, resilience presented at the junior level. Young basketball players notice everything basketball has taught them and developed in them (endurance, purposefulness, independence). They have enough willpower to move further despite possible obstacles. Basketball as a team sport puts a strong emphasis on social motivation. They seek good relationships with teammates and coaches, even with opponents. Sport influences their socialization. Political motivation is the last stage where sportsperson grows into a versatile individual if there are right conditions present.

Basketball players get a chance to introduce themselves to new people, cultures which can provide a healthy development of their opinions and values, their worldview grows. If they internalize them, they may transfer them into their future life and profession. Travelling and exposure to many new things is not only an enriching aspect but also a stress factor which should be adequately addressed (Cosh & Tully, 2015).

The approach of coaches and teachers means a significant result. Their cooperation may reduce organizational demands on players (not reducing the demands of education and sports training). It could help with the sufficient time management allowing the athlete to succeed in both areas and work on their dual career (Stambulova & Wylleman, 2014). Focusing on the mastery goals is an essential element confirmed by the feedback from the coaches. As long as the youth enjoys the practice and the matches, basketball keeps being the source of joy which results in young players to wish to stay in sports and to give an ample performance.

Coach needs to possess enough skills for creating cohesion within the team, to know how to approach their players as one unit and as individuals. They should be able to balance emotions and rationality, to create an exciting training plan, to actively listen, and be careful in the early specialization of their players. If a coach starts with a sportsperson's specialization early and the young player is not ready (mentally or physically), it can discourage them. If they create an adequate environment, the youth will have the safe space to enjoy basketball and connection with the ball, to mentally relax from the difficulties of other areas of life. If they leave the professional sport, they will remain in recreational sport relishing it thoroughly. Faith in a young athlete gives them the opportunity to develop as a person and as a player, to perceive their competencies, which brings a desire to improve and achieve higher goals.

CONCLUSIONS

We identified eight main determinants of motivation at the stage of selective self-realization: lifestyle, own perception skills, basketball specifics, time management, and health from a bio-opsychosocial point of view, enjoyment, environment and team spirit (team atmosphere). These determinants entwine with the passion that brings and maintains the motivation of basketball player. The motivation and passion result in adherence to the basketball which points to the dedication for the chosen sport even under challenging conditions. Results show that sport can bring a certain meaning, sense of life to an individual; basketball helps to fulfil physical and mental needs. In conclusion, it is imperative to create and maintain orientation on task. Sport should be a source of fun which should be reflected in a professional sport also. Not everyone can win, it is essential to get a good feeling of achieving high performance, satisfaction with oneself. It is necessary to nourish the passion in the youth so they may adhere to the sport, either professionally or recreationally.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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STUDENT SECTION

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Monitoring of Physical Activity of Soldiers of the Army of the Czech Republic

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Abstract

Aim: This research is aimed at the possibilities of physical training of Army of the Czech Republic personnel (soldiers of the 7th mechanised brigade) during a routine week spent in garrison and the follow-up analysis of the amount of their physical activity.

Methodology: The observed group was made up of 52 professional soldier volunteers in the age range of 29.9 ± 4.5 years. The measurement has been performed continuously during the time span of one week. Physical activity has been measured with the utilization of the ActiGraph GT1M accelerometers supplemented with the use of a weekly physical activity protocol.

Results: Based on the results it is possible to infer that the average daily physical activity (7.66 hours) has been greater than the average daily physical inactivity (5.89 hours). No difference in the amount of weekly physical activity of professional soldiers in relation to age (≤ 30 years and > 30 years) has been found, nor in relation to being a smoker/non-smoker, nor in relation to BMI (< 24.9 kg/m² and ≥ 24.9 kg/m²).

Conclusion: With an average daily step count of 10169.84 the amount of physical activity of the soldiers is sufficient and meets the health recommendation for the daily step count (Aoyagi & Shephard, 2009).

Key words: *ActiGraph, motion, physical activity, BMI, monitoring.*

INTRODUCTION

There are multiple types of professional specialisation of the personnel in the military environment. The most basic division is the split between personnel of combat units and of supporting units, alternatively staff personnel. Physical training is conducted with dissimilar intensity and objectives on different organisational levels as there is usually a higher level of physical fitness requirements for combat units in comparison to other units. Apart from their expert and psychological preparedness, physical fitness is especially important for military personnel to successfully manage set tasks, functions and situations related to military life. Physical fitness is the objective of physical training which is aimed at providing physical fitness of the soldiers via a pedagogically controlled process to secure the ability of the soldiers to properly perform the tasks arising from their assigned military functions (Ministry of Defence, 2011). The amount of training hours spent on different types of training – basic ability and skill development, obstacle course, endurance development, self-defence techniques, swimming, sport games – is firmly set in military regulations (Prog-1-3, 2005).

Good physical fitness of Army personnel is considered a necessary requirement for the effective performance of their duties, be it during ordinary activities in garrison (specialist training, guard duty, vehicle maintenance and repair, etc.), during continuous field training and exercises, during several months long military operations abroad, during nature catastrophe relief and humanitarian tasks, tasks in assistance of the Police of the Czech Republic as part of the Integrated Rescue System or during public presentations of military capabilities – combat training presentations, sporting events and others (Zemánek, 2015).

Knowledge of the current state of a soldier's physical fitness is regarded as a necessary requirement for effective job assignment of professional soldiers (it is also a necessary requirement for constructing an appropriate training programme) and data about its development represent a valuable feedback information in relation to the quality of the training.

METHODOLOGY

The observed set was made up of 52 professional soldier volunteers, members of the 73th tank battalion, 7th mechanized brigade. Measurement of weekly physical activity was based on voluntariness and has been conducted with consent of the participants. The measurement has been conducted during an ordinary week (Mon–Sun) spent in the garrison. 52 participants (male) of the age of 29.9 ± 4.5 years took part in the monitoring. The weather during the week (in April) has been sunny to partly cloudy with temperatures during the day 11–16 degree of Celsius. Working hours of soldiers are 40 hours a week (Monday-Thursday from 7:00 AM to 4:00 PM, Friday from 7:00 AM to 1:30 PM, free weekends). Somatic parameters of the monitored group are in Table 1.

Tab. 1: Somatic parameters of the monitored group

Nr.	Variable	M	SD	Min	Max
1	Weight [kg]	81.8	9.6	64.0	110.0
2	Height [cm]	179.4	7.1	161.0	193.0
3	Age [years]	29.9	4.5	22.3	42.5
4	BMI [kg/m^2]	25.5	3.1	19.4	32.1

The average BMI value of the group is 25.5. According to Vítek (2008) this value corresponds to the overweight category, but for 80 % of the group, who had a BMI value greater than 24.9 kg/m^2, this was caused by a higher ratio of muscle mass resulting in a higher body weight and thus in a higher BMI value. None of the group had a BMI value smaller than 18.5 kg/m^2, which would correspond to malnutrition.

In accordance with the Military Personnel Law (Law no. 221/1999 Collection) it is necessary to consider physical fitness a basic obligation of a professional soldier. Physical training is a controlled physical education activity in accordance with internal normative acts and is obligatory for all military personnel fit for duty. The aim of physical training is to secure the ability of the soldiers to properly perform the tasks arising from their assigned military functions via a pedagogically controlled process. It is realised via practical training which is being conducted based on an approved training schedule in accordance with training programmes and other training regulations. It is being methodically directed by the Physical Training Chief of the Ministry of Defence via physical training specialists or via personnel designated to direct physical training. The scheme of physical training is shown in Figure 1 (Ministry of Defence, 2011).

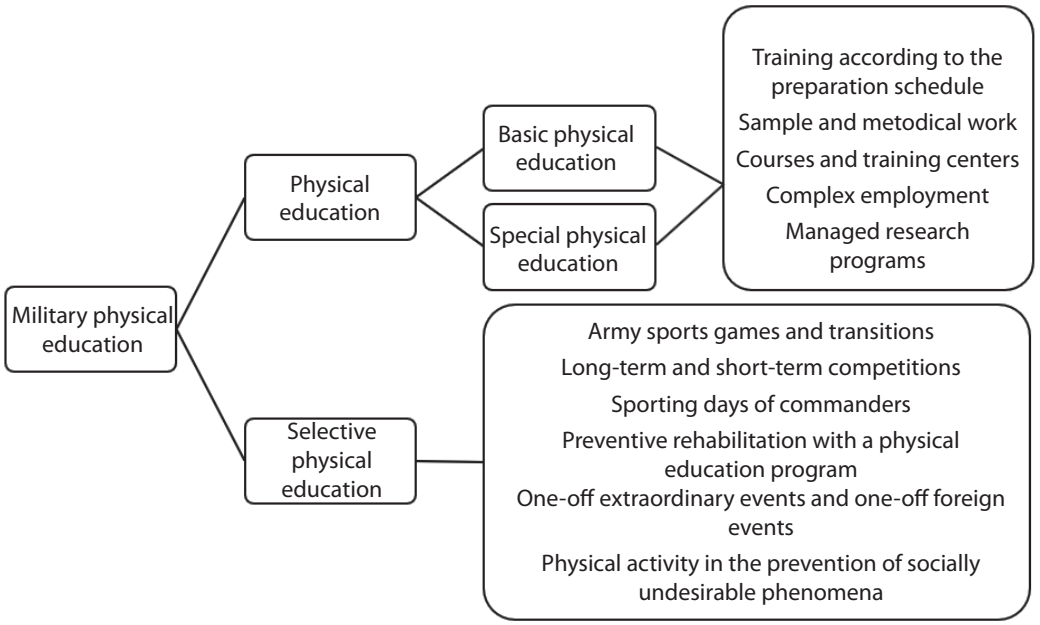


Fig. 1: Scheme of physical training (Ministry of Defence, 2011)

Physical training is one the main types of military training. Its aim is to provide physical fitness of military personnel in order to manage their duties and strain during all situations.

To provide for the needs of organised and individual physical training of the personnel of the 73th tank battalion there is a 333 metres long running course available in the garrison and paved and unpaved running courses in the vicinity of the garrison (lengths of 1500 metres to 20 kilometres). A collective activity of the 73th tank battalion is the battalion run which is being organised once per week. Its main objective is the increase of individual physical fitness and the increase of collective cohesiveness of the battalion personnel. During unfavourable climatic conditions (< –15 degree of Celsius) the battalion run is substituted by the battalion march (with or without load). The objective of the march is the development of individual physical and psychological endurance of battalion personnel. Another means used for physical fitness development is the NATO obstacle course, located in the 15 kilometres distant Vyškov garrison. 15 kilometres distant from the Přáslavice garrison, in MTA (military training area) Libavá, a combat obstacle course is located, offering multiple technical sections – for example water surface crossings using a rope, two-storeyed building rope climbing with a subsequent down-jump, movement in restricted space and others. The Přáslavice garrison itself also offers a climbing facility.

Monitoring of physical activity has been conducted using the uniaxial accelerometer ActiGraph GT1M, which has provided continuous week-long monitoring of physical activity. The accelerometer ActiGraph GT1M measures the frequency, time and intensity of motion and provides an objective monitoring of the physical activity of the volunteers without age restriction.

Based on the time the device has been worn and the measured physical activity it is possible to calculate also the physical inactivity of the volunteers, which represents a state of the organism with minimal body movement with energy requirements approximately equal to those of basal metabolism. We get the average active energy output performance as the ration of the active energy output and the time during which the accelerometer has been measuring the motion activity. Despite its simple construction, the accelerometer is considered a valid and dependable device for motion activity monitoring, particularly during multiple day or weekly-long use (Aadland et al., 2015; Abel et al., 2008; Rohtney et al., 2008). It has no negative effects on the wearer's health

and does not produce any kind of EM radiation (Mitáš et al., 2007). The device has always been worn during the whole day, with the exception of showering, bathing and swimming since it is not waterproof. The ActiGraphGT1M is storing average data over minute long intervals with the possibility to ascertain how many minutes have been spent with light, average or intensive physical activity during days and weeks (Mitáš et al., 2007).

Uniaxial accelerometers like the ActiGraph provide acceleration measurement only in the vertical plane resulting in a possible lower validity of the measurement during higher velocities of running locomotion in the sense of underestimating the energetic output (Brage et al., 2003). The device is able to monitor and store temporary data on the activity in relatively short time intervals for the time of days up to weeks (Montoye et al., 1996). Accelerometer ActiGraph GT1M is shown in Figure 2. Figure 3 shows the correct way of wearing the device.

Fig. 2: ActiGraph GT1M (Mitáš et al., 2007)

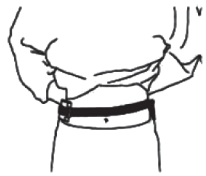


Fig. 3: Correct wearing of the ActiGraph GT1M (Mitáš et al., 2007)

The measured data has been processed using the ActiPA2006 software developed for research purposes of the Centre of Kinantropology Research of the Faculty of Physical Culture, Palacký University, Olomouc (Chytil, 2006). All statistical calculations have been made with STATISTICA 8.0. The descriptive characteristic has been expressed as medians, arithmetic averages, interquartile ranges and maximal and minimal values.

The t-test and Kruskal-Wallis test have been used for inter-group variable comparison. Statistical significance has been determined at a level of $p < 0.05$.

RESULTS

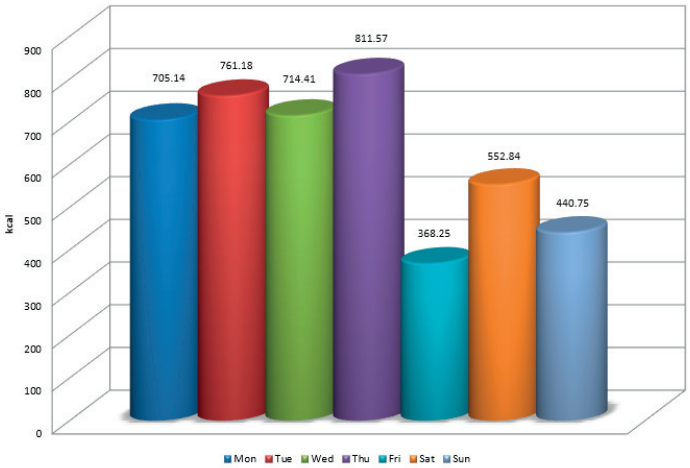
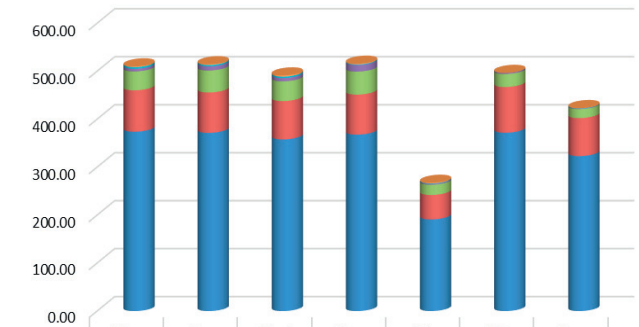


Fig. 3: Active energy output [kcal] during days of the week

Figure 3 shows the values of active energy output [kcal] during separate days of the week, which have been approximately at the same level during the week with the exception of Fridays when the output has been at its minimum. This corresponds to the average step count during this day, when this value has also been minimal.



	Mon	Tue	Wed	Thu	Fri	Sat	Sun
> 12 METs	1.11	1.18	2.07	1.11	1.00	0.02	0.39
9-12 METs	3.68	2.93	3.18	1.41	1.12	0.07	0.89
6-9 METs	5.52	8.70	6.82	13.72	1.68	2.00	0.64
3-6 METs	39.45	45.95	41.25	48.07	21.45	27.25	18.77
1-3 METs	86.23	84.04	79.82	83.36	50.89	95.23	79.09
< 1 MET	374.00	371.62	357.98	367.89	191.14	371.86	323.23

Fig. 4: Structure of physical activity [min] during the week based on average intensity of physical [MET]

Figure 4 shows the structure of physical activity in separate days during the week and during the whole week. The structure is given by the time duration [min] of different intensity of physical activity, from activity intensity < 1 MET to > 12 METs.

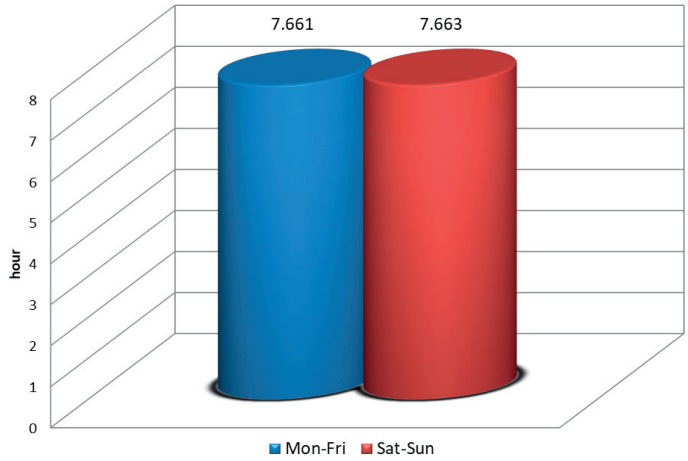


Fig. 5: Average physical activity [hours]

The graph shown in Figure 5 implies a higher average physical activity during the weekend, but the difference is not large enough to be statistically significant (p = 0.997).

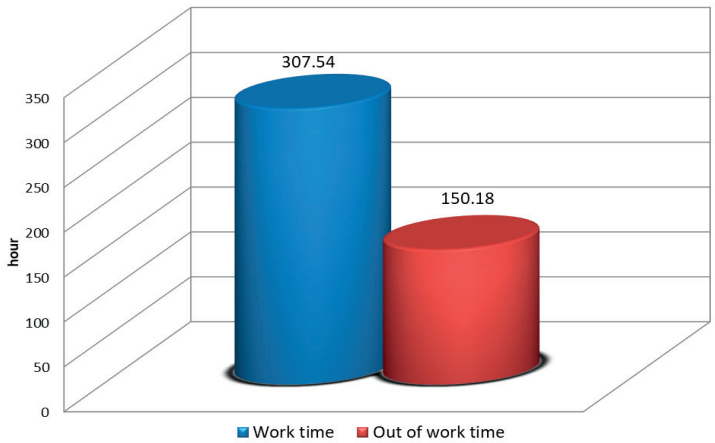


Fig. 6: Average physical activity [min] during working hours vs off-duty time

The average physical activity [min] during working hours has been more than double the average physical activity during off-duty time as shown in Figure 6. The difference is statistically significant (p = 0.000).

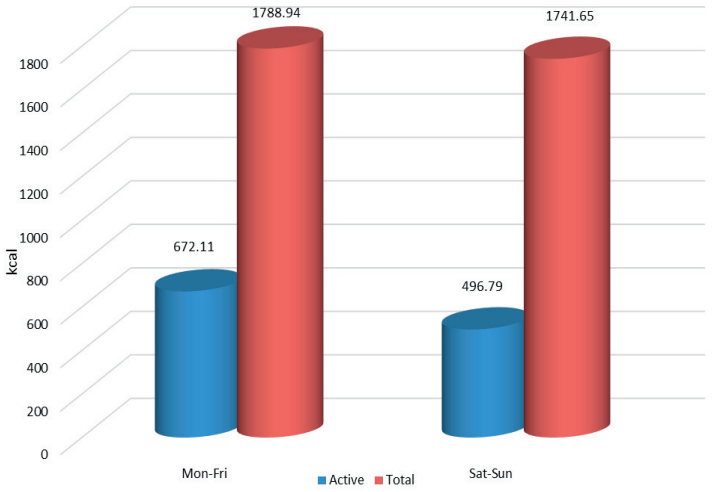


Fig. 7: Average energy output [kcal]

The graph shown in Figure 7 implies that the average active energy output value [kcal] calculated for one day, as well as the overall energy output [kcal] calculated for one day, was higher during the weekdays than during the weekend.

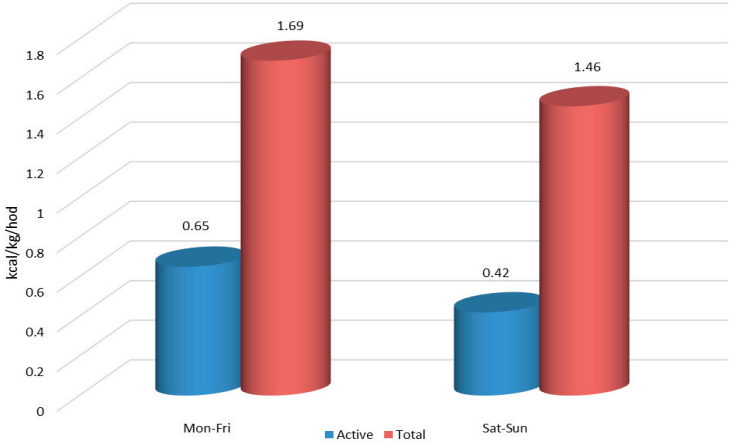


Fig. 8: Average relative output [kcal/kg/hour]

The difference between weekdays and weekends is evident from the graph shown in Figure 8 for these values:

Average active relative output [kcal/kg/hour] calculated for one day and overall relative output calculated for one day. These were higher on weekdays than on the weekends with the difference being statistically significant ($p = 0.000$).

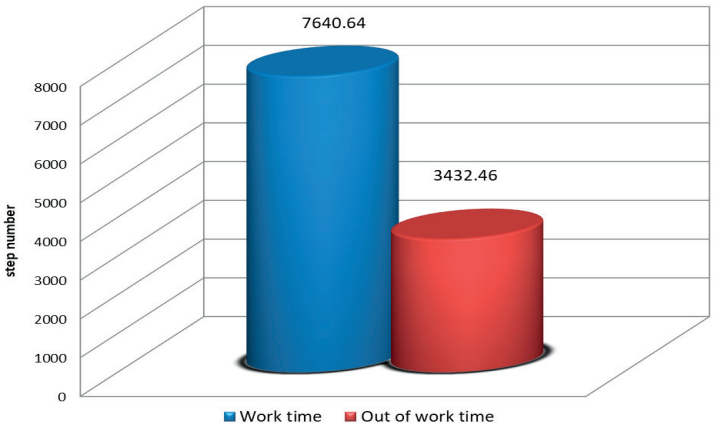


Fig. 9: Average step count during working hours vs off-duty time

The average step count during working hours, as shown in the graph in Figure 9, has been more than double in comparison to off-duty time with the difference being statistically significant ($p = 0.000$).

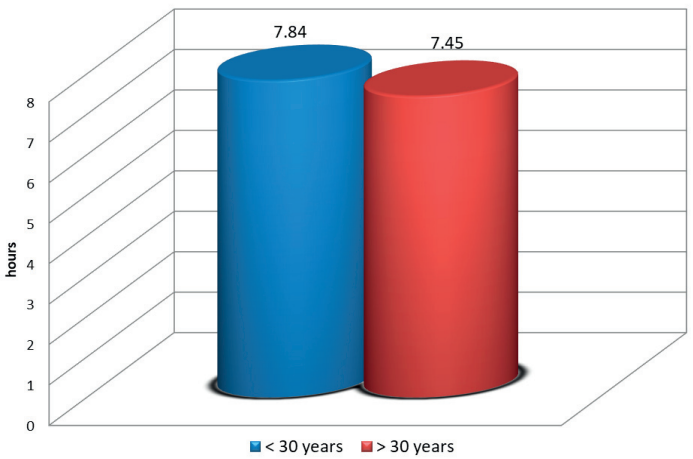


Fig. 10: Average weekly physical activity [hours], calculated for one day, in relation to age

The value of average weekly physical activity [hours], shown in Figure 10, is higher for the ages ≤ 30 years in comparison to ages > 30 years, but the difference is not statistically significant ($p = 0.442$).

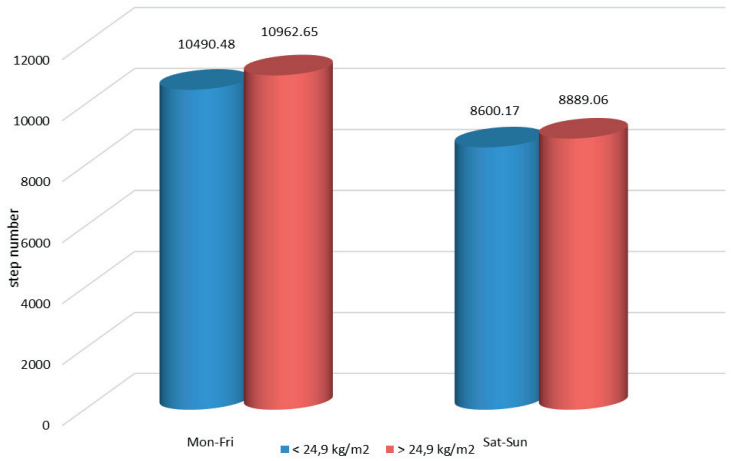


Fig. 11: Average step count calculated for one day

The graph in Figure 11 shows the comparison of number of steps during the weekdays and on weekends in relation to BMI. Individuals with a BMI value ≥ 24.9 kg/m^2 have had a higher step count both during weekdays and weekends in comparison to individuals with values < 24.9 kg/m^2, namely a step count value higher by 536.4 during the week and by 289 during the weekend. Yet this difference is not statistically significant ($p = 0.562$).

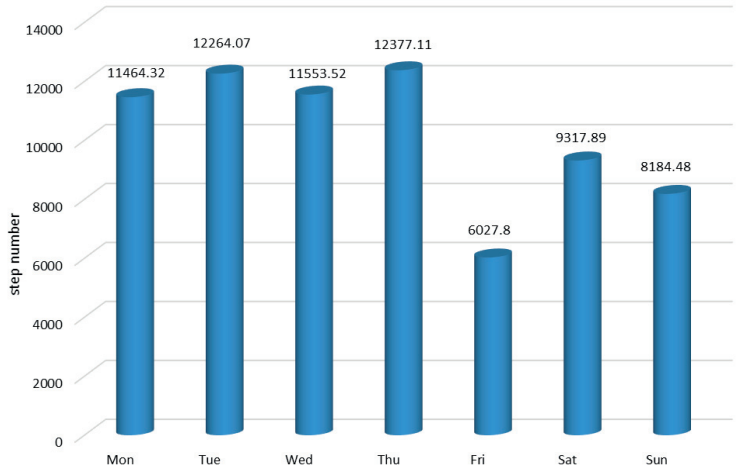
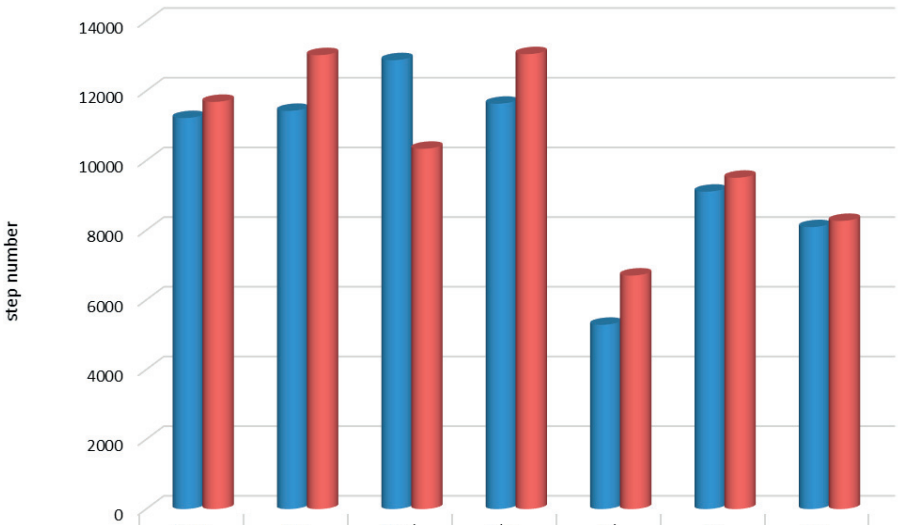


Fig. 12: Average count of steps, leaps and position changes during days of the week

It is evident from the graph shown in Figure 12 that the minimal number of steps, leaps and position changes has been measured on Fridays. The reason behind this is possibly the fact that the working hours on Fridays are 2.5 hours shorter than on the other days (working hours on Mondays to Thursdays being 8.5 hours, on Fridays 6 hours). A more probable reason is that only a smaller part of the monitored individuals is conducting physical training on Fridays.



	Mon	Tue	Wed	Thu	Fri	Sat	Sun
< 24,9 kg/m2	11221.6	11427.4	12882.3	11632.7	5288.33	9108.95	8091.38
> 24,9 kg/m2	11685.9	13027.9	10340.2	13056.7	6702.35	9508.65	8269.48

Fig. 13: Average step count during the days of the week in relation to BMI

The graph in Figure 13 shows the of average step count during separate days of the week in comparison to the individuals BMI. The only day during which the individuals with BMI value < 24.9 kg/m2 had better results in average step count, with a difference of 2542 steps, is Wednesday. On other days of the week individuals with BMI values ≥ 24.9 kg/m2 had the better results, with the differences in step counts being 464.3 on Monday, 1600.53 on Tuesday, 1424 on Thursday, 1414 son Friday, 399.7 on Saturday and 178 on Sunday.

DISCUSSION

The average value of weekly physical activity (PA) calculated for one day has been 7.66 hours. In contrast the average value of weekly inactivity calculated for one day has been 5.89 hours. It is apparent from these values that the monitored individuals have been active for a larger part of the day than inactive. 9 individuals out of the monitored group have been physically active for more than 9 hours a day on average and 3 physically inactive for more than 9 hours a day on average. The highest average value of physical activity has been 11.71 hours and the highest value of average inactivity 10.28 hours. The measured values of physical activity and inactivity can be compared, for example, with the military police of the Armed Forces of The Czech Republic, where physical activity was measured 7.74 hours and physical inactivity 5.59 hours (Štégner, 2014). The average time of measurement for one day has been 13.55 hours. This value influences the accuracy of the measurement since the measurement accuracy is proportional to the time-span of the measurement. It is evident that the monitored individuals have been wearing the device for most of the day.

The average BMI value of the group – 25.5 can be compared with Czech Combat troops – 26.0 or Logistic troops – 24.9 (Soumar & Oberman, 2010). The World Health Organisation recommendation for health sustainment (WHO, 2012) is to conduct medium intensity activity (3–6 METs) for at least 2.5 hours a week or conduct intensive physical activity for at least 75 minutes a week or to combine these variants appropriately.

The average time of medium intensity activity (3–6 METs) has been 34.6 min, which corresponds to 4 hours a week. It is evident that the monitored personnel have met the WHO recommendations. Out of the whole monitored group 79 % have met the parameters of the WHO recommendation for health sustainment. Average daily intensive activity (6–9 METs) has been conducted for a time of 5.59 minutes. The WHO recommendation of 75 minutes of intensive physical activity a week has been met by 10 of the monitored individuals. The highest value of the average intensity activity has been 19.43 minutes, thereby none of the monitored group has reached the value of 22 minutes a day.

Average daily intensity (9–12 METs) has been sustained for the time of 1.91 minutes, where 2 individuals reached a value over 15 minutes (16.86 and 21.14 minutes). 5 of the individuals have sustained an average daily activity of values higher than 12 METs for a time larger than 6 minutes with the longest time being 9.86 minutes.

The energy used for physical labour is expressed by a characteristic related to the active energy output. The average daily active energy output has been 622.02 kcal. Average active energy output per hour has been 49.05 kcal/hour. Average active relative energy output per day has been 0,59 kcal/kg/hour. This value can be compared, for example, with Sigmund et al. (2005) who is recommending a value of average daily active relative energy output of 6.5–10 kcal/kg/day, which corresponds to 0.27–0.42 kcal/kg/hour. From these values we can deduce that the measured average active relative energy output is more than sufficient.

Overall energy output values are composed of the sum of the active energy output and of the basal metabolism. The average value of the overall energy output per 24 hours has been 2654.59 kcal. This can be compared for example with Bunc (1990) who is recommending a value of 2200 kcal/day for physical fitness sustainment and a minimum value of 2600 kcal/day for physical fitness improvement or to members of the American army at CBRN (chemical, biological, radiological and nuclear) training – 2420 kcal (Goetz et al., 2011), members of fire brigade – 2585 ± 406 kcal (Heil, 2002), Malaysian soldiers – 2886 kcal (Ismail et al., 1996) or the American special operation forces – 3903.8 kcal (Margolis et al., 2014).

The values for physical fitness sustainment (2200 kcal/day) have been achieved by 38 individuals of the monitored group, the values for physical fitness improvement (2600 kcal/day) by 29.

Uniaxial accelerometers provide acceleration measurement only in one direction, usually the vertical direction. The principle of using accelerometers for approximating physical activity is based on the relationship of acceleration being directly proportionate to muscle work and thus related to energy output (Montoye et al., 1996). They also measure both the intensity of movement as well as the movement itself. However not all physical activity is manifested in the form of acceleration or deceleration.

The average daily step count (10186 ± 2738 steps) during a week of continuous field training in a military training area can be categorized as "regular medium intensity movement without competitive sport activity" and military personnel meet the recommended daily step count (Máček et al., 2010).

CONCLUSION

Although the values of average physical activity, average active relative energy output and recommended average strain intensity have been sufficient, and the healthy recommended average daily step count has been superseded, I recommend to adhere to the appointed time schedules for organised physical training of military personnel during working hours as well as to sustain committing of-duty time to physical activity. Military personnel also have the option to use the facilities and equipment in the garrison – for example the running course, gym, tennis courts,

squash and foot tennis courts, spinning, climbing facility, massage. Vouchers for downhill skiing, swimming pool and sport centres are available as well.

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The issue of sport specialization and the development of sport expertise

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Abstract

There are two different ways how to achieve sport expertise. First is called "early sport specialization" and second is called "early sport sampling". Although, early sport specialization is associated with negative physical, psychological and social development consequencies, researches claim that early specialized approach to sports training is necessary to achieve elite sport performance because of 10.000 hour rule and the theory of deliberate practice. On the other hand, experts who defend early sampling approach argue that sampling various sports during childhood and later start with special training is the basis for specialization in adolescence and adulthood and that athlete can benefit from such a transfer across sports.

The aim of this review is to discuss early sport specialization and early sport sampling approach in term of expertise development in sport.

Results suggest that despite a relatively high number of research in this area, it is still not clear which approach is more effective for attaining sport expertise. Conclusions of studies that examined the validity of the theory of deliberate practice and 10.000 hour rule in different sports are inconsistent. In addition, studies that dealt with early sampling approach examined mainly team sports and were conducted with retrospective design in which athletes do not have to recall their experiences or that the recall of experiences can be biased. Moreover, very few studies report early specialization of their athletes. Therefore, longitudinal studies are needed to reveal which approach is more effective to achieve expertise in sport.

Keywords: *early sport specialization, early sampling (diversification), sport expertise, deliberate practice, deliberate play*

INTRODUCTION

In the 1950s was early sport specialization considered the most effective way to achieve expertise in sport. It was expected that early specialized athletes will continue to improve their sport performance (Valik, 1974). However, this assumption was wrong. In the 1980s, research has shown that early sport specialization does not ensure elite sport performance (Matvejev, 1981).

Although, the issue of early sport specialization is discussed since 1970s (Valik, 1974), it is still current topic. This is evidenced by the number of published articles, especially review articles which deal with positive and negative aspects of early sport specialization (e.g. Sluder et al., 2017; Myer et al., 2015; Baker et al., 2009). These reviews generally concludes, that due to the number of negative physical and psychosocial consequences, early specialization in sport is inappropriate way to achieve elite sport performance.

However, researches who support the concept of early sport specialization have a strong argument for early sport specialization. They claim that early specialization is important for future success because the earlier one starts adhering to a strict training regime; the quicker one will attain desired level of skill. More specifically, someone starting a deliberate practice routine at a later age would be unable to "catch up" to a performer who started earlier, all other things being equal (Baker, Cobley & Fraser-Thomas, 2009).

On the other hand, researches introduced another approach to long-term athlete development. This approach is called early sport sampling or early diversification (Goodway & Robinson, 2015). In this approach, the so-called transfer of skills is highlighted because there is a general assumption that athletes can benefit from this transfer across sports (Williams & Ford, 2008).

In this review, we deal with the question of whether early sport specialization or early sport sampling is necessary for development of sport expertise. According to Starkes et al. (2003), we understand the concept of sport expertise as the result of four domains. These domains are physiological, technical, cognitive and emotional. While this article focuses mainly on the technical domain of sport expertise that is associated with skill acquisition in sport.

METHODS

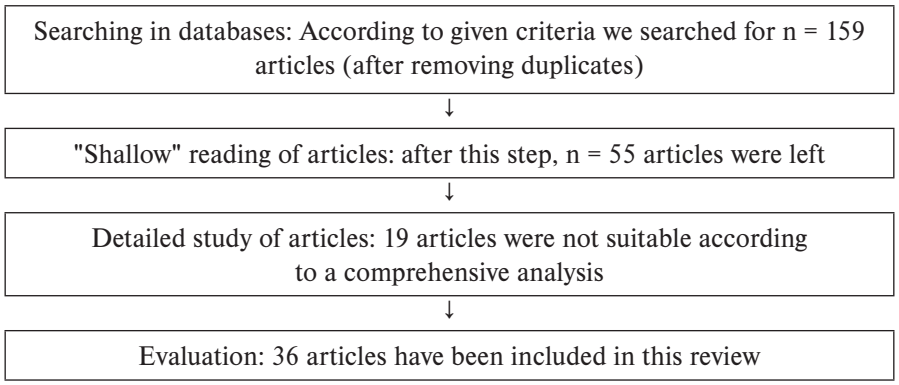
The aim of this review is to discuss early sport specialization and early sampling approach in term of expertise development in sport. We used PRISMA to create basic guidelines (Moher et al., 2011). The review methodology itself consists of four steps (see schema 1).

We searched articles in these databases: EBSCOhost (SPORTDiscus with Full Text), MEDLINE, and Google Scholar. We have included the literature published in the period 1990–2018.

We used following terms for the search: early sport specialization, late sport specialization, sport expertise. Articles were selected if they met these criteria: (1) the article was published in the years 1990–2018, (2) the article contained at least one reference to early or late sport specialization and expertise development in sport, either in the title or in abstract or in set of keywords, (4) the article was written in English.

These conditions met as of December 31, 2018 a total of 159 articles. Subsequently, the titles and abstracts of the articles were read. If the article did not meet the essential requirements, it was found to be inappropriate for this type of review. After this "shallow" reading, 55 articles were selected, both quantitative and qualitative studies.

These 55 articles went through a detailed study. 19 articles were removed for failing to meet the above criteria. Therefore, a total of 36 texts were used.



Schema 1: The article search procedure

RESULTS

Early sport specialization

Early sport specialization is usually described as athletes limiting participation to a single sport on a year-round basis at the exclusion of other sport or nonsport activities (Ericsson et al., 1993; Wiersma, 2000; Ferguson & Stern, 2014; Myer et al., 2016).

Côté, Lidor and Hackfort (2009) define early sport specialization as a focused involvement in one sport and a large number of hours of deliberate practice with the goal of improving sport skills and performance outcomes during childhood.

According to Baker, Cobley and Fraser-Thomas (2009) early sport specialization includes four specific parameters: early start age in sport; early involvement in one sport (as opposed to participating in several sports); early involvement in focused, high intensity training; and early involvement in competitive sport.

These definitions mentioned above are very similar. However, the main common point for those who defend early sport specialization is that early start of special and intense training distinguishes future professionals from amateurs (Côté, Lidor & Hackfort, 2009).

There are terms that are closely related to early sport specialization: 10.000 hour rule, the power law of practice and the theory of deliberate practice.

10.000 hour rule

Ericsson (1993) investigated what factors helped predict expert performance. His results stated that high volumes of deliberate practice (defined as specific, focused, skill based practice) at a very young age was the strongest predictor of becoming an expert performer.

This study leads to the famous "10.000 hour rule". Specifically, beginning a task at a very young age (before age 5–7) and acquiring high volumes of deliberate practice (5.000–10.000 hours) resulted in the likelihood of an individual becoming an expert (Ferguson & Stern, 2014). It means more than 3 hours of training or competing daily for ten years (Perič & Pecha, 2014).

The power law of practice

Research examining the accumulated effects of prolonged practice and the rate of learning has robustly indicated that performance increases monotonically according to a power function. The power law of practice states that learning occurs at a rapid rate after the onset of practice but that this rate of learning decreases over time as practice continues (Baker, 2003). In other words, the more time individuals devote to practice, the greater their level of achievement but the more difficult it becomes to make further improvements (Perič & Pecha, 2014).

Theory of deliberate practice

The theory of deliberate practice developed by Ericsson and colleagues (1993; Ericsson & Charness, 1994) advanced the general concept of expertise development through focused training over time with one major stipulation. They suggested that it was not simply any form of training that differentiated individual performance, but the engagement in a specific form of training they termed "deliberate practice".

By definition, this type of training involved practice activities that were effortful, low in inherent enjoyment, and purposefully designed to address current areas of weakness (Baker, Cobley & Fraser-Thomas, 2009).

The theory of deliberate practice postulates that experts are always made, not born. If we translate this theory to the youth-sport domain, it means that if athletes want to be high-level performers, they need to deliberately engage in practice during the specialization years, spend-

ing time wisely and always focus on tasks that challenge current performance (Gonçalves, Rama & Figueiredo, 2012).

Early sport specialization and development of sport expertise

However, the theory of deliberate practice according to Ericsson et al. (1993) is valid for other activities, especially for music. Therefore, researchers in the sports domain have been keen to examine the validity of deliberate practice theory and the 10.000 hour rule. Because the answer to the question of whether the high quantity and quality of deliberate practice at a young age is sufficient to achieve a peak performance level is of crucial importance for sports training and talent selection (Ward et al., 2004). The question of importance to performers and practitioners is whether practice alone is enough to attain expertise, and more specifically, to produce improvements in performance (Ward et al., 2004)?

Scientific evidence from different sports supports a positive relationship between practice hours and expertise level (e.g. Helsen et al., 1998; Hodges et al., 2004; Baker et al., 2005). However, the 10.000 hour rule and the theory of deliberate practice some studies in sport confirmed but others refuted. Starkes and colleagues (1996) were the first to undertake work on deliberate practice in sport. Athletes who participated in individual sports reported spending on average more than 10 years in practice before reaching an international level (Ward et al., 2004). Afterwords, Helsen et al. (1998) extended this initial work to team sport athletes by examining the practice histories of international, national, and provincial level soccer players from Belgium. And in a second team-sport domain, they examined the practice habits of players at similar levels of skill in field hockey. In both cases has been confirmed positive relationship between a number of sport-specific practices and the achievement of skill levels.

Nevertheless, some researches claim that 10.000 hours of deliberate practice may not be required to achieve elite performance. For example, Hodges et al. (2004) found that elite triathletes and swimmers trained for more than 10 years, but they did not acumulate 10,000 hour of deliberate practice. Also Baker et al. (2003b) found that elite basketball, football and hockey players did not accumulate 10,000 hours of deliberate practice, although they have been training in their sports for over 11 years as well. Interestingly, some studies confirm that for athletes is deliberate practice fun (Baker & Young, 2014; Deakin & Cobley, 2003). This is in contradiction with the definition of deliberate practice by Ericsson et al. (1993).

These findings suggest that the theory of deliberate practice and 10.000 hour rule may not be exactly the same for development of expertise in sport.

Early sampling

In contrast to early sport specialization, early sampling refers to engaging in a variety of different sports during the formative youth sport years with the ultimate goal of learning skills and having fun (Côté, Lidor & Hackfort, 2009). In this approach children should learn a broad base of fundamental motor skills before they start to specialize (Goodway & Robinson, 2015). It favours a focus on involvement in a number of different sports before specializing in later stages of development (Wiersma, 2000).

According to Goodway and Robinson (2015) is early sampling in the formative youth years clearly superior to early sport specialization. Côté, Lidor and Hackfort (2009) claim that early sampling years are considered as essential building blocks for self-regulated investment in elite sport during adolescence and adulthood.

Some authors also use the term “early diversification” as a synonym for “early sampling” (e.g. Baker et al., 2009; Baker, 2003; Côté, Lidor & Hackfort, 2009).

Nevertheless, in Eastern European literature is used term “age appropriate practice” (Perič & Pecha, 2014, Dovalil et al., 2002) instead of “early sampling”. “Age appropriate practice” is in the formative youth sport years characterized by high amount of so-called “multiside develop-

ment" which also means that children should engage in a variety of different sports in early stages of sport development.

Deliberate play

For sampling years is characteristic sampling various sports and also engaging in deliberate play (Côté & Fraser-Thomas, 2007). Deliberate play is described as engaging in an activity primarily for intrinsic enjoyment, although the activity may still contribute to skill learning (Côté et al., 2007).

According to Baker and Côté (2006), deliberate play is defined as sport activities that are intrinsically motivating and provide gratification and enjoyment, as well as sampling in early years of sport participation may lead to more enjoyment and a lower frequency of dropout, which indirectly contribute to the attainment of a high level of performance in adult years.

The informality of deliberate play allows children to engage in sports with minimal equipment, in any kind of space, with any number of players, and with players of different ages and sizes. This kind of environment is easily created and does not necessarily require characteristics of formal organized sport and structured practice, such as adult supervision, coaches, officials, specialized equipment, time limits, or uniforms (Côté, Lidor & Hackfort, 2009).

Transfer of skills

It is hypothesized that experiences in different sports provide the young athlete with important abilities. These abilities prove beneficial in the development of sport-specific skills required to reach elite performance in the main sport at a later stage in the career. Therefore, there is a general assumption that talented athletes can benefit from such a transfer across sports (Williams & Ford, 2008).

Baker et al. (2003) claim that transfer of learning occurs from one sport to another, including both cognitive and physical abilities. Further, Schmidt and Wrisberg (2000) suggest that the effect of such a transfer is most pronounced during early stages of involvement, which corresponds to the timeframe of the sampling years in the "Developmental Model of Sport Participation" (Côté, Baker & Abernethy, 2007). Based on these considerations, it can be hypothesized that involvement in different sports, during at least the early stage of the career, may be beneficial for reaching elite performance in certain sports.

Baker, Côté & Abernethy (2003b) indicated that participation in other relevant activities (e.g. other sports where dynamic decision-making is necessary) during early phases of development augmented the physical and cognitive skills necessary in their primary sport. They have shown that world-class team players that demonstrated greater diversity across several domains had also accrued less practice hours within the specialist domain prior to national selection compared to those who exhibited a less diverse participation profile and were not of world class standing.

Acquired sport skills and physiological changes achieved during early sampling years can transfer to later sport specialization of an athlete. More specifically, athletes gain ancillary benefits via some mechanism of transfer from engagement in nondomain activities requiring similar skills (or at least possessing relevant physical and/or cognitive attributes), to those in their domain of expertise (Baker, Côté & Abernethy, 2003a).

Greater diversity across sports at an earlier age may manifest itself in more flexible perceptual-motor and perceptual-cognitive solutions to a broader range of existing, as well as novel problems and ultimately, to the attainment of adaptive expertise (Hatano & Inagaki, 1986).

Current research confirms that the transfer effect is the most significant in early stages of sports training (Schmidt, Wrisberg, 2000; Côté et al., 2012). Therefore, a broad base of fundamental motor skill development that is learned through sport sampling is necessary and important before sport specialization. Thus, sport sampling in the formative youth years is clearly superior

to early sport specialization (Goodway & Robinson, 2015). The transfer effect can be considered as the basic principle of early sampling (diversification) approach (Baker et al., 2009).

Early sampling and development of sport expertise

The "sampling years" were proposed to be a period where deliberate play and diversity were both encouraged and beneficial to the development of skilled performance (Côté, 1999; Côté & Hay, 2002). A high amount of deliberate play during sampling years establishes a range of motor and cognitive experiences that children can ultimately bring to their principal sport of interest (Côté, Lidor & Hackfort, 2009).

Several studies of elite athletes have found that elite performance is usually preceded by a period of sampling various sports. Baker, Côté and Abernethy (2003b) through a process of semi-structured interviews, retrospectively examined the participation histories of elite players who held an international or world-class ranking in a variety of different team sports. These authors found that expert and world-class athletes engaged in considerably more "deliberate play" during the sampling years (i. e., 7 to 12 years) than non-experts. Vaeyens et. al. (2009) revealed that a higher proportion of the world-class athletes trained and competed in other sports beyond their current individual main sport and they invested significantly more training time in other sports. Ginsburg et al. (2014) found that only 25% of professional baseball players had specialized in one sport before the age of 12. Bridge and Toms (2013) found that significantly more high performance athletes in the United Kingdom had competed in multiple sports during their early teens rather than having specialized in only one sport.

Evidence suggests a beneficial effect of early diversification not only on the sport performance but also on other variables. Children who sample multiple sports in early years are more likely to develop competence in the type of object control and locomotor skills that make up many different sports. Therefore, these children will have many different sports available to them across the lifespan (Goodway & Robinson, 2015).

Because limited skill acquisition during early sport specialization may limit the acquisition of fundamental motor skills. This can negatively affect engaging in sport activities later in adulthood (Wiersma, 2000; Branta, 2010). For example, young children who specialize early in gymnastics will not necessarily develop competence in object control skills (e.g. catching, throwing) and thus they will be less likely to find enjoyment in lifetime sports such as basketball, softball, and tennis (Goodway & Robinson, 2015). If children develop fundamental motor skill competence through sport sampling, they will be able to apply these fundamental motor skills to many physical activities later in life (Clark & Metcalfe, 2002).

Further, during early phases of growth and maturation, early sampling may stimulate generic physiological and cognitive adaptations, which lay the groundwork for specialized physical and cognitive capacities necessary for later expertise. Moreover, athletes who sample and diversify in their young years may be at less risk for injuries than their peers that specialized early (Baker & Côté, 2006).

DISCUSSION

When discussing early sport specialization and early sport sampling (diversification) in term of expertise development in sport we need to realize, that these approaches are applicable in sports, where peak performance is achieved before adulthood, such us gymnastics or figure skating (Balyi & Hamilton, 2004) and also in sports where peak performance is achieved in adulthood, such us track and field or sport games (Balyi & Hamilton, 2004).

However, it is not still clear if early sampling (diversification) approach is beneficial for all these sports. Côté et al. (2009) conclude that early diversification is not beneficial for athletes

in sports where peak performance occurs before full maturation, as already mentioned above gymnastics. Also Côté, Lidor & Hackfort (2009) claim that early sampling (diversification) does not hinder elite sport participation in sports where peak performance is reached after maturation. From this, it follows that sports with a focus on different capabilities (physical, technical, tactical) are unique in their career development and should be analyzed separately.

Many studies which dealt with question, which of these two approaches to long term athlete development is more appropriate for acquiring expertise in sport have been conducted with a retrospective design (e.g. Baker, Côté & Abernethy 2003b; Vaeyens et. al., 2009; Ginsburg et al., 2014). Common for this design is that face methodological risks, namely that athletes cannot recall their experiences or that the recall of experiences could be biased (Moesch et al., 2013). Therefore, we need more longitudinal empirical studies to reveal which approach is more effective to achieve expertise in sport.

Further, there are also practical issues related to early sport specialization and early sampling. Nowadays, children's sport is associated with financial resources as well as family support. If child is engaged in more sport activities, it requires purchase of sports equipment for every sport and payment of membership fees in each sport. Further, it often requires parents' time to bring children to training, wait for them to finish training and then take them home. Therefore, from a financial and time point of view, early sampling (diversification) could be more demanding than early sport specialization.

CONCLUSION

The purpose of this review was to discuss early sport specialization and early sampling approach in term of expertise development in sport. According to 10.000 hour rule and the theory of deliberate practice (Ericsson et al., 1993; Ericsson & Charness, 1994) is early sport specialization necessary for development of sport expertise and is considered as a prerequisite for success. Therefore, early sport specialization has its supporters among athletes, coaches and other sport experts. For example, Smith (2015) presents that golfer Tiger Woods, swimmer Michael Phelps or tennis player Serena Williams as successful examples of this training approach. Nowadays, there are also popular books, which highlight the fact that with sufficient experience, patience, happiness and timing, anyone can become a professional athlete (e.g. Zacha, 2013).

However, our review shows that scientific research did not fully confirm the theory of deliberate practice and 10.000 hour rule in sport domain (Hodges et al., 2004; Baker et al., 2003). Moreover, studies confirm that early specialization approach to children sports training could have many negative consequencies in contrast to early sampling (diversification) (Sluder et al., 2017; Myer et al., 2015; Baker et al., 2009). Therefore, sampling various sports during childhood is reccomended as an alternative way to achieve elite sport performance (Goodway & Robinson, 2015).

As we have already mentioned in the discussion, although there are many studies that deal with early sport specialization or early sport sampling (diversification), we need more longitudinal empirical studies to reveal positive or negative aspects of early specialization or early sampling (diversification).

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REPORTS

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Educational Activities of the International Fencing Federation (FIE) "FIE Budapest Coaching Academy"

Michal Roček

The International Fencing Federation (FIE – La Fédération internationale d'escrime) became a central, umbrella organisation in fencing after being established in 1913. Currently it is represented by 153 national fencing federations worldwide[1]. Through developmental projects in various areas the FIE actively promotes fencing to strengthen its position as a global sport. For example, it provides material help to smaller federations, supports veteran fencers, international fencing training camps, fosters anti-doping campaigns, promotes the principles of Fair Play. FIE activities also reflect gender issues. To be specific, the federation held *FIE International Women's Referee Training Session* and also *All Women Coaching Course in Foil* (Asia & Oceania). Namely the latter project of coach education in fencing is one of the key points in the strategy of development over the last years. The FIE had organised a number of official international coaching camps (academies), however, it failed to realise its vision of a permanent coaching school.

A permanent coach academy was first established in Africa. The effort to popularise and promote fencing to make it a global sport led to the opening of the *International School for Fencing Masters* (EIMA) in Dakar, Senegal in 1999. By 17 Jun 2016 as many as 111 students had graduated from the school[2].

2016 represents another milestone in the educational activities organised by the FIE. After almost three years of negotiations that preceded the opening of a permanent FIE Coaching Academy in Budapest, the educational programme was opened for first students in 2016. In contrast to the *International School for Fencing Masters* (EIMA) in Dakar, Senegal, which operated in the mode of 18-week intensive course (4.5 months), the Budapest coaching academy usually lasts 3 months (12 weeks although one course in its history took as long as 4 months).

In Budapest Corner Hotel Angyalföld was chosen as the centre of educational activities of the FIE. It is a multifunctional object whose founder is the 13th district of Budapest. The complex is placed in the proximity of the Danube and Margaret Island in 45 Lomb street, Budapest 1139. The facility has everything that is needed for lessons: the gym, where the fencing lessons take place, is equipped with fencing apparatus, there is also accommodation, catering, and a conference room for theoretical classes. The place is conveniently placed near underground stations and public transport stops which makes commuting easy.

FIE coaching academy is an intensive programme with highly structured teaching comprising 360 lessons. At the end of the course the students take a final exam consisting of a written test on theoretical subjects and a practical exam from fencing. In terms of organisation the academy is divided into two strands. The strand of practical lessons is provided by FIE experts (renowned coaches): sabre – Ioan Pop (Romanian member of the FIE Hall of Fame, Olympic medalist), since 2019 Ákos Bodoky (Hungary) took over from him, Béla Kopetka (Hungary) responsible for épée and Zoltán Bernát (Hungary) for foil coaching.

The theoretical lessons are provided in cooperation with the FIE by the University of Physical Education, whereby the instructors, academic staff of the university, come to the coaching academy to teach theoretical subjects to the trainees. The staff of the University of Physical Education

[1] https://fie.org/fie/structure accessed on 16th Nov 2019

[2] Creating coaches to develop fencing in Africa, https://fie.org/articles/380, accessed on 5th Aug 2019

have considerable experience in training fencing coaches, providing three types of formal programmes of education for fencing coaches. The first one is an accredited bachelor programme for fencing coaches. The second one is the prestigious International Coaching Course (ICC), whose strategic partner is also the Olympic Solidarity. The International Coaching Course (ICC) is a 3-month full-time course in English. The third programme in the education of coaches is FIE Budapest Coaching Academy. The cooperation between FIE Budapest Coaching Academy and the University of Physical Education is officially recognised by the Ministry of Education, whereby an internationally recognised, legally approved programme for the graduates of the coaching academy is created. There are in total 60 lessons of theoretical subjects. For 2019 the following subjects have been put forward: psychology, physiology, sport theory, biomechanics[3], pedagogy. It is noteworthy that in 2016 and 2017 the academy included a subject called "strategic management" in place of biomechanics.

As mentioned above, practical lessons are taught by FIE experts. Despite the effort to clearly determine the competences of the trainees (hold a level-3 coaching diploma, have at least seven years' experience of coaching, hold an FIE or national licence, be in good physical health), there are significant differences in technical and tactical abilities of the participating coaches[4] and that is why there are extremely demanding requirements on precise mastery of the basic fencing technique (methodology of footwork, bladework, basic tactic). Significant attention is also paid to the training of coordination skills that are indispensable to fencing. Last but not least, in terms of content the course aims to enrich the arsenal of games and training exercises which develop specific qualities of young fencers such as the sense of distance, rhythm and timing in a playful, enjoyable way.

Apart from the written test the applicants have to take a practical exam. It is conceived as a presentation showcasing practical skills in the form of an individual fencing lesson on an assigned topic ranging between 15–20 minutes, supervised by the examination committee. The committee is composed of FIE experts (teachers at the FIE Coaching Academy) and guests, such as former elite athletes, officials of the fencing federation, representatives of the National Olympic Committee (NOC) or University of Physical Education[5].

In conclusion, I would like to shortly describe the application procedures. The International Fencing Federation (FIE) addresses the individual national federation in an informative letter, they then inform potential applicants in the coaching community who meet the requirements of the FIE. Based on national selections applicants have then officially applied and the FIE conducts the final selection of the participants. The courses in 2019 were divided according to individual weapons (sabre, foil and épée), and the format of the course was following: 8 students per weapon, 6 from Europe, 2 from Panamerica/Asia-Oceania. To be specific, for foil held from July 22 to October 21, 2019, the participants were 6 male and 2 female coaches from these countries: Scotland, USA, Croatia, Turkey, Serbia, Lebanon, the Czech Republic and Hungary. Apart from the FIE requirements mentioned above, the application form for this year also included a provision that after graduation from the FIE Coaching Academy a successful applicant will be a fencing coach at her/his National Federation for two years. The whole course is taught in English, so it is essential that the participants speak and understand English. Successful applicants from the national rounds also had to undergo a medical check-up. From the obligatory

[3] The lecturer of the subject was József Tihanyi, PhD, DSc., scientist, member of the national team in high jump, Olympic athlete, legendary coach of Hungarian high jumpers.

[4] E.g. the participation of an Olympic medalist the the OG in Athens – Zsolt Nemcik (2016), world champion medalist – Cosmin Hancenau (2017), Olympic medalist from the OG in Sydney – Wiradech Kothny (2019).

[5] Members of the examination committee were: József Navarrete – Olympic medalist, World and European Championship medalist, the current coach of Hungarian junior national sabre team. Bence Szabó – member of FIE Hall of Fame, Olympic gold medalist. Dr. Krisztián Kulcsár – the chair of the *National Olympic Committe* (NOC), Olympic medalist, world champion in épée.

documents provided for the application procedure the FIE requested the following: passport or ID copy, recent colour photo, university diploma/enrolment copy, doctor's certificate proving the candidate is in good health, short biography (experience in a weapon, name and location of the club, name of the coach), reference letter from the national federation, stamped and signed by the federation's president.

The strategic plan of the FIE contains further development of educational activities and aims at fostering fencing education worldwide. The plan proposes the establishment of a new coaching educational centre, similar to the one in Budapest[6], in each continent. These activities are provided by the FIE free of charge. The financial report for 2017 implies that the FIE invested 597,162 CHF[7] in Schools and training for Fencing Masters International Fencing Federation. From that 68 participants attended the Coaching Academy in Budapest[8]. However, this number decreased in the following years due to a modification in the format of the course whereby the participants in individual weapons were divided and the number of times the course was run was also reduced from the initial three to two or even one in 2019.

[6] FIE Budapest coaching academy, https://fie.org/development/courses/31, accessed 5th July 2019

[7] https://static.fie.org/uploads/20/100188-6.%20documents%20financiers%202017%20ang.pdf, accessed 19th Nov 2019

[8] https://static.fie.org/uploads/20/100286-100264-5.%20Rapport%20Annuel%202017%20ang.pdf, accessed 19th Nov 2019

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