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Dear Readers,

The Montenegrin Journal of Sports Science and Medicine (MJSSM) continues reaching highest impact ever. We are proud to announce that Scopus has promoted CiteScore for 2017 (0.60), SJR for 2017 (0.167) and SNIPE for 2017 (0.634), while CiteScoreTracker 2018 is already 0.50 that was updated on 08 July, 2018. On the other hand, Clarivate Analitics did not arrange the impact factor yet and this task will be the main our goal in the upcoming years.

We would also highlight that our journal will continue working on growing academic publication in the fields of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side, in various formats: original papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers, as well as promote all other academic activities of Montenegrin Sports Academy and Faculty for sport and Physical Education at University of Montenegro, such as publishing of academic books, conference proceedings, brochures etc.

Our great gratitude goes to the Montenegrin Sports Academy, Faculty for Sport and Physical Education, and the University of Montenegro, that is, to the Rector, Professor Danilo Nikolic, who supports selflessly our Journal and help us to reach all above mentioned successes. Also, from time to time, Montenegrin relevant ministries provide their support so we would like to thank the Ministry of Science and Ministry of Education, especially the first one that supports us constantly in 2018.

At the end, we would like to thank our authors for choosing our Journal to publish their scientific papers and invite them to continue our cooperation in the future. However, we would also like to thank our editorial team as well as all reviewers who develop our Journal on the voluntary bases.

Thank you for reading us and we hope you will find this issue of MJSSM informative enough.

Editors-in-Chief,
Prof. Dusko Bjelica, PhD
Assist. Prof. Stevo Popovic, PhD

ORIGINAL SCIENTIFIC PAPER

Interval Training with Blood Flow Restriction on Aerobic Performance among Young Soccer Players at Transition Phase

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ABSTRACT The purpose of current study is investigating effect of Blood Flow Restriction Interval Training on aerobic performance among young football players during transition phase of periodization. Twenty eight young male football players were recruited in this study. Subjects were randomly divided into three groups: control, Normal Interval without Kaatsu, and Interval with Kaatsu. Exercise protocol was based on aerobic interval at 400 meters with maximum effort for 3 sets in per sessions (First week) and 4 set (Second week). The results shown that there is a significant difference in aerobic power between groups $p<0.05$. Post hoc comparisons indicated that the mean of aerobic power was significantly different between all three groups. It has been shown, there is a significant difference in rate of perceived exertion between groups at the $p<0.05$. Post hoc comparisons indicated that the mean of RPE was significantly different between groups. This study has been shown that aerobic power and RPE was improved by both normal and BFR interval method. We also found that there is not significantly difference in NIWK and IWK group at rate of perceived exertion. This results may be explained by reducing intensity of exercise by subjects during exercise with BFR in cause of pain in their legs during exercise. The result of current study suggest that Intermediate-intensity, interval training with BFR improves aerobic capacity and RPE concurrently in young football players and prevent decline of VO2max at result of retraining at transition phase.

KEY WORDS aerobic power, maximum oxygen uptake, blood flow restriction training, interval training

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Introduction

Endurance performance is one of the most important aspect of successfully at football (Helgerud, Engen, Wisløff, & Hoff, 2001). Players with high level of aerobic and endurance ability may cover tactics and techniques tasks for achieve the best results during competitions (Clemente et al., 2013). Ability to run more for players or at the other hand distance cover during each full time competition significantly influenced by aerobic capacity and endurance performance. Results of several investigations regarding to aerobic performance and its important variables as well as maximum oxygen uptake it has been shown that aerobic capacity may enhance by the several methods by using aerobic energy system training such as interval training, high intensity interval training and also long slow distance training (LSD)(Gibala et al., 2006; Helgerud et al., 2007; Weston et al., 1996). Lack of aerobic performance during transition phase at football player could be with less acceleration by some exercise routines as well as long slow distance or aerobic interval training. However, a major problem with this kind of exercise routines is long duration of exercise protocol. Traditionally load of interval training could be adjusting by variables as well as time (speed) and distance at per repetition, number of sets, intensity of training base of heart rate, recovery time and frequencies of training sessions (Bangsbo, 2003). Several adaptation influences on human body to improve ability of aerobic energy system as well as mitochondria density, respiratory capacity, capillary densities and etc. (Rivera-Brown & Frontera, 2012). Aerobic training at any target heart rate maybe improve variables influenced on aerobic capacity. Level of

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adaptations and time to reach at degree of adaptation according to training objectives are determining type of training which coaches and athletes may choose. For aiming cardiovascular improvement they choose low level of zone at target heart rate (below the 60% maximum heart rate) and for developing endurance performance they use normally high level zone at target heart rate (upper 80% maximum heart rate) (Benson & Connolly, 2011; Gilman, 1996). Blood flow restriction training (BFR) is a cutting-edge, exercise method that allow athletes to gain training objectives with low level of intensity (but most of time with increasing volume of training). This type of training normally called as KAATSU (means blood flow restriction training) training developed by Dr. Yoshiaki Sato (Cook, Clark, & Ploutz-Snyder, 2007).

Recently several studies have been shown restricting blood flow during resistance exercise termed KAATSU Training improved some aspects of body composition as well as muscle mass and strength significantly (Abe et al., 2010). Increasing one repetition maximum and muscle size by using KAATSU training method have been reported by several researches (Cook et al., 2007). The main mechanisms by the blood restriction training is thought to stimulate improving muscle mass is stimulates of fast-twitch fiber recruitment (FT), and increased protein synthesis (mTOR) pathway and stimulate of growth factors at anabolic pathways (Loenneke, Wilson, & Wilson, 2010) and increased protein synthesis through the GH–IGF–1 axis. Improving anaerobic energy system at result by this type of training combined with high intensity interval training has been reported by the new study (Behi, Fahey, Afsharnezhad, & Amani, 2017) increasing glycogen content of muscle cells, increasing creatin phosphate synthesis and improving muscle function are the main reasons to improving anaerobic performance. Improving aerobic and anaerobic performance at the same time with the same type of exercise or least reducing conflict effect by these type of training is important. In parallel with muscular fitness at result by KAATSU training in combined with aerobic exercises has been shown significant improvement at maximum oxygen uptake and maximum heart rate. Ischemia enhanced adaptation to aerobic and endurance exercise by increasing muscle glycogen content and variables related to maximum oxygen uptake (Park et al., 2010).

Increasing muscle capillary density at resulted by blood restriction training has been shown at recent researches. Increasing capillary density will increase ability of muscle cells to receive more oxygen (Kirkendall & Garrett, 1998) and then increasing aerobic metabolism. Increasing vascular endothelial growth factor (VEGF) and angiogenesis has been reported at recent studies. VEGF and angiogenesis increase by result of traditional interval training but has been shown significant increase by result of VEGF and angiogenesis by blood restriction training (Evans, Vance, & Brown, 2010; Presta et al., 2005). Rate of perceived exertion is one of the variables that may effect on endurance performance. At the workload with same intensity athletes with high level of aerobic fitness reported with lower points of RPE (Lower point means reducing fatigue at the same situation) (Scherr et al., 2013).

Debate continues about the best strategies for improving aerobic performance after competition phase at football players. Blood restriction method was applied at several research regarding to strength and muscular hypertrophy but so far this method has only been applied at the current research to improve aerobic performance. Researchers at the following study hypothesis that blood restriction training may influence on human performance over the anaerobic and strength variables. This type of training may effect on aerobic performance for developing aerobic energy system at short and limited duration of time. Developing aerobic and endurance capacity at short duration of time and also reducing confliction effect by the aerobic-strength training at the same time is vital aspect of athletes conditioning program. Thus, the purpose of the current study was to investigate the influence of Blood Restriction Aerobic Interval Training on aerobic performance and rate of perceived exertion among football players.

Methods

Participation and design of study

This study was an experimental research design. This study was in agreement with the principle of Helsinki Declaration and approved by the ethical committee in the Somal Medical University, Iran. Twenty eight young male soccer players were recruited in this experimental research (age: 23.89±2.26 years; weight: 73.04±3.90; height: 176.1±4.05). All subjects fill up informed consent form before participants to study. The inclusion criteria of participants were: football player, able to do interval exercise, has at least 7 year football experience. And the exclusion criteria also were: football player with chronic injury, player who stop football player since 6 month ago. Subjects were randomly divided into three groups: control (CTL; n=9), Normal Interval without Kaatsu (NIWK; n=9), and Interval with Kaatsu (IWK; n=10). Pre-tests were measured at beginning of exercise protocol. Subjects of current research were well trained football player and without chronic injuries.

Seven steps Bruce protocol was used for determining of aerobic capacity and maximum oxygen uptake (Sarma & Levine, 2016). Participants on this study spent minimum 10 minutes warm-up before start the test. Speed and slope of treadmill gradually increased. Participants were allowed to stop test when they could not continue test (Time to exhaustion was recorede). Metalyzer 3B device (Meyer, Georg, Becker, & Kindermann, 2001), Metasoft Studio software and COSMOD treadmill were applied for aerobic test protocol. Devices were calibrated prior data collection and before post-test. Volume of Vo2 and Vco2 was measured directly by device. Heart rate was monitored by Polar chest belt which was connected to Metalyzer. All tests were performed at laboratory of Shomal University with standard temperature.

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Rate of Perceived Exertion (RPE) were determined by 15 point Borg Scale at the end of step 3 during Bruce protocol (Ciolac et al., 2015). Subjects were participated at familiar session 48 hours before start the test. All subjects were familiar with procedure of Bruce Protocol prior the experimental began.

In the first session of the exercise for the purpose of body adaptation and avoiding any injuries, the imposed pressure was 140 mmHG and to reach the aimed pressure, from the second session the pressure was increased to 180 mmHG (Scott, Loenneke, Slattery, & Dascombe, 2015). Adjustable cuff was applied for blood restriction protocols. The cuffs were applied tightly around the upper section of thigh (One cuff was used for per subjects during exercise protocols).

TABLE 1 Exercise Protocol

Week	Session	Set	Intensity	Distance
First	4	3	60-65% MHRR	400m
Second	4	4	65-70% MHRR	400m

Intermediate intensity interval training (aerobic energy system exercise) was applied for exercise protocol. Three set at 400m for the first week and 4 set (400m) for the second week including 60-80 seconds rest between sets were applied in this experimental. Warm-up and cool-down were done at initial and end of each training session. Training intensity was monitored by Polar base chest belt and windows client software. Intensity of training was selected at 60-70% maximum heart rate reserve (MHRR).

Statistical analysis

Analyses of variance with one-way ANOVA was applied to determination of between groups' differences and in the case of significant F value, a post hoc test using Bonferroni identified significant differences among mean values between groups. Paired t-test was used to determination of variables changes within the groups from pre to post test. Kolmogorov-Smirnov was applied for determination of normality of the groups. The level of significance was established a priori as $p \leq 0.05$. SPSS software was employed to analyze the data.

Results

The result of statistical analysis has been shown there was a significant differences of rate of perceive exertion at the $p<.05$ level for the three groups [$F(2, 25) = 7.243$, $p = 0.003$]. Post hoc comparison using by bonferroni indicated that the score of RPE at control group was significantly different that the IWK and NIWK group.

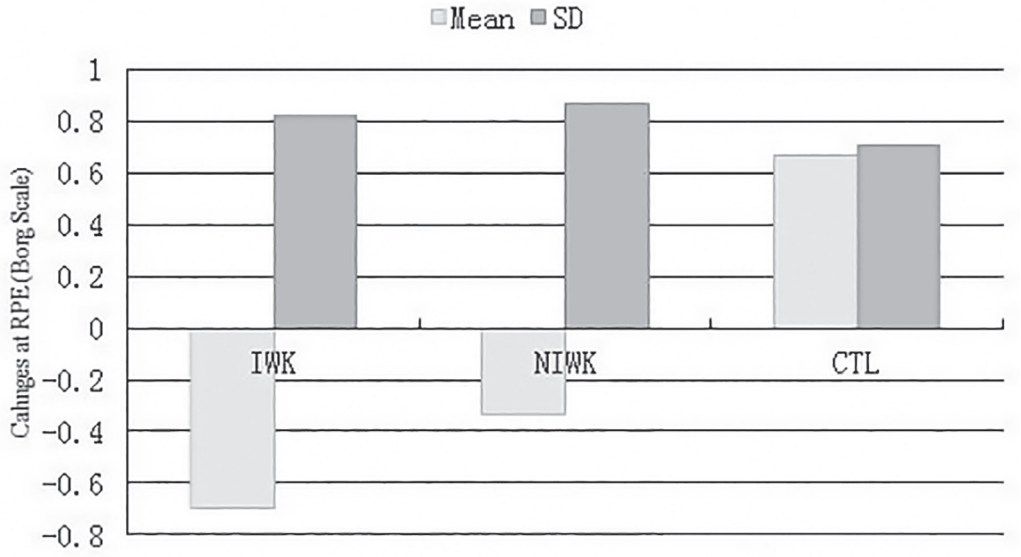

FIGURE 1 Rate of received exertion (pre to post) between groups

Did not significantly differ from the NIWK and IWK groups. Analyzing data from pre to posttest using by paired T test has been shown a significant differences in the score of RPE from pre to post test at IWK group; $t(9)= 2.689$, $p=0.025$ and CTL group; $t(9)=-2.828$, $p=0.022$. Not any significant differences reported at NIWK group (Figure 1).

TABLE 2 Deceptive Data for Pre to Post Tests

Variable	Control group		Kaatsu group		Normal Interval	
	pretest	post test	pretest	post test	pretest	post test
RPE	15.88 ± 1.26	16.55 ± 1.23	15.2 ± 1.75	14.5 ± 1.08	15.0 ± 1.87	14.66 ± 1.5
VO2max	52.22 ± 5.04	50.22 ± 5.4	54.6 ± 6.99	56.6 ± 7.74	54.11 ± 5.66	54.88 ± 5.68

The result of statistical analysis has been shown there was a significant differences of maximum oxygen uptake (VO_2max) at the p<.05 level for the three groups [F(2, 25) = 13.349, p = 0.000]. Post hoc comparison using by bonferroni indicated that the score of VO_2max at control group was significantly different that the IWK and NIWK group. Did not significantly differ from the NIWK and IWK groups. Analyzing data from pre to posttest using by paired T test has been shown a significant differences in the score of maximum oxygen uptake from pre to post test at IWK group; t(9)= -3.721 , p=0.005 and CTL group; t(9)= 3.464, p=0.009. Not any significant differences reported at NIWK group (Figure 2).

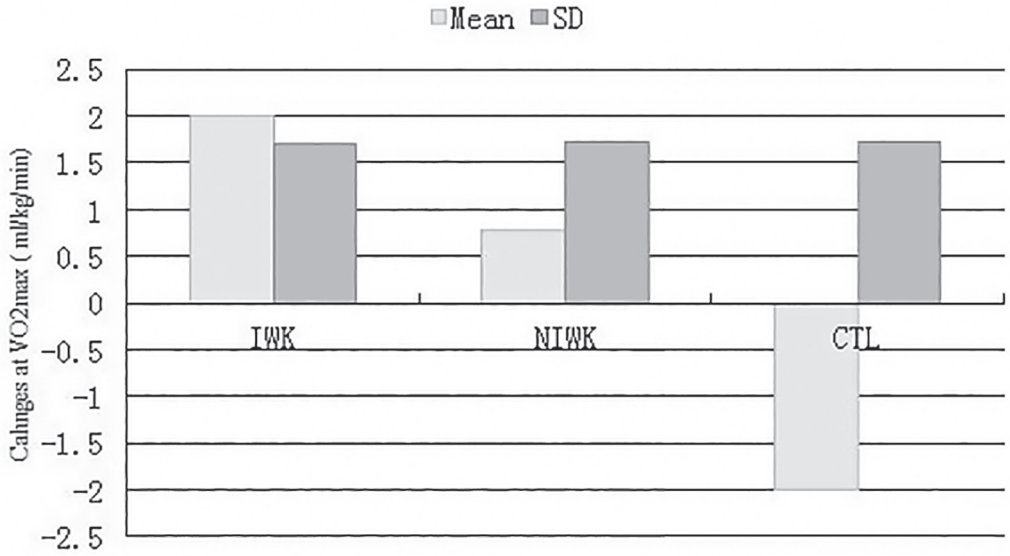

FIGURE 2 Comparison of change at VO2max (pre to post) between groups

Discussion

The strong relationship between training intensity maximum oxygen uptake reported at the several studies. It has been shown that any reducing at training intensity my lead the maximum oxygen uptake to lower than normal (Kenney, Wilmore, & Costill, 2015). It has been reported decreasing at maximum oxygen uptake by result of reducing training intensity and volume at the transition phases of periodization in football. Increasing intensity of aerobic energy system training with some other way without manipulating actual volume and intensity factors such as distance and speed with minimum side effect on recovery and fatigue by result of completion phase may help researcher to minimizing at VO_2max reduction (Shepley et al., 1992). This study investigated effect of interval training (moderate intensity-aerobic energy system) with blood flow restriction on the aerobic performance and rate of perceived exertion. Cuff pressure between 140-180mHg was applied at this research. Several investigation previously reported benefits of KATTSU training on the strength training by increasing muscle mass and one repetition maximum but still effect of this type of training on the aerobic performance and related variables is not clear yet. The result of this research has been shown improving maximum oxygen uptake by result of blood restriction training. The present study has been shown significant differences at maximum oxygen uptake between groups. It has been estimated increasing 3.66% at VO_2max in interval groups under blood restriction while has been shown only 1.43% increasing at maximum oxygen uptake in interval groups without blood restriction. In additional to the control groups -3.82% decreasing of VO_2max has been reported (reported by paired t test for within group differences). The magnitude of increases in VO_2max at KAATSU group in current study is also similar to those reported by Park et al., that they investigated walking training with blood flow restriction (Park et al., 2010). It Has been reported increasing 2.5% at aerobic capacity after two weeks walking training. The similar finding has been

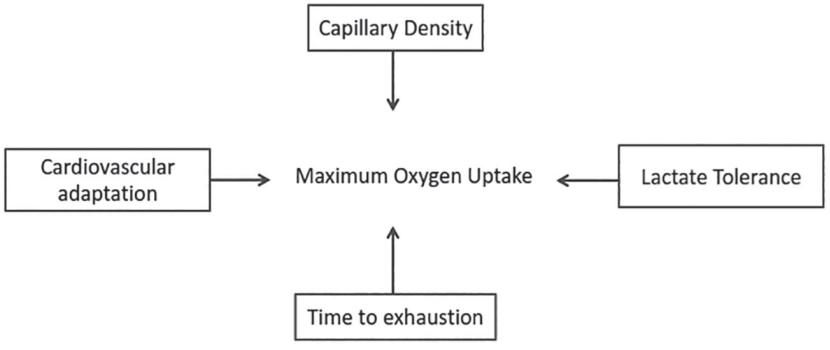

FIGURE 3 Suggested model in variables relationship with maximum oxygen uptake

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reported by Takashi et al. They has been reported improving by 6.4% at VO_2max after 8 weeks training with intensity of 40% of VO_2max (Abe et al., 2010). Result of current research also has been shown improving time to exhaustion among kaatsu groups and rate of perceived exertion. Rate of perceived exertion is effective variable for endurance and aerobic performance. Improving capillary density (Patterson & Ferguson, 2010), developing time to fatigue, improving cardiovascular function (Ozaki et al., 2010), respiratory function and muscular performance may are the main factors by resulted by blood restriction training to improving maximum oxygen uptake and aerobic performance. This research suggested model of improving aerobic performance by blood flow restriction (Figure 3) which need more research at feature to show all aspects by details. The findings from this study make several contributions to the current literature. First, improving maximum oxygen uptake without manipulating of distance and speed of training (factors of Intensity during aerobic energy system training) with blood flow restriction method. This is the first time report at this area.

The major limitation of this study was small sample of participants, and future study might explore in larger sample. The second limitation was level of participants of the current study.

In conclusion, our investigation in the current research suggests that moderate-intensity aerobic exercise (running) may improve aerobic performance in combined with blood flow restriction method by improving rate of perceived exertion and maximum oxygen uptake at comparison with traditional training.

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ORIGINAL SCIENTIFIC PAPER

The Relationship between Objectively Measured Physical Activity and Fundamental Motor Skills in 8 to 11 Years Old Children from the Czech Republic

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ABSTRACT The aim of this research was to explore the relationship between objectively measured physical activity and fundamental motor skills in 8-to-11-year-old children from the Czech Republic. The research sample consisted of 201 children (108 boys and 93 girls) aged 8-11 from Olomouc, Czech Republic. The Test of Gross Motor Development 2 was used to assess the level of children's fundamental motor skills. Furthermore, an ActiGraph GTX3 device accelerometer was used for the objective measurement of physical activity levels. The results have shown a low-to-medium correlation between moderate to vigorous physical activity and locomotor motor skills among the total sample, as well as between vigorous physical activity and object control skills in the sample of boys. Fundamental motor skills are essential factors for children's participation in organized and free-time physical activities. There is a commitment to develop fundamental motor skills in children, especially object control motor skills in girls.

KEY WORDS motor development, accelerometers, primary school children

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Introduction

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985). Participation in regular PA could bring significant short- and long-term benefits for youth's health, especially in children's physical, social, cognitive, and psychological development (Janssen & LeBlanc, 2010) e.g., improving children's health-related physical fitness (cardiorespiratory fitness and muscular strength) (Morrow, Tucker, Jackson, Martin, Greenleaf, & Petrie, 2013); reducing body fat, improving bone health, reducing anxiety, and depression symptoms are related with higher levels of PA (Janssen & LeBlanc, 2010). Despite these health benefits, many children and youngsters are not sufficiently physically active (Hallal et al., 2012). In contrast, physical inactivity (PI) is linked to an increased risk of several diseases: cardiovascular disease (CVD), hypertension, diabetes mellitus type 2, obesity, osteoporosis, depression, and colon cancer (U. S. Department of Health and Human Services [USDHHS], 1996). However, important factors for the determination of PA/PI among children are fundamental motor skills (FMS). In their conceptual model, Stodden et al. (2008) offered a system of relationships between motor competencies (MC), PA, and the risk of obesity. This model proposes a reciprocal relationship between MC and PA and their influence on obesity. A positive spiral of engagement explains the lower risk of obesity within higher levels of PA and motor competence. Nevertheless, a negative spiral of disengagement causes a higher risk of obesity within lower levels of PA and motor competence. Children and youth who are better in terms of motor proficiency are more likely to participate in organized and free-time PA and build a healthy lifestyle later in their adult age (Stodden et al., 2008). Additionally, sedentary lifestyles appear more often among children with lower levels of motor proficiency; in adulthood, these children are more likely to avoid difficult movement patterns (Stodden & Goodway, 2007).

FMS do not occur naturally with aging, and they must be learned as movement patterns (Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012). FMS are the foundation for more complex types of PA and sports.

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FMS are mainly classified into two groups (Ulrich, 2000): 1) locomotor skills (i.e. run, jump, hop, leap, and slides); 2) object control skills (i.e. dribble, catch and kick the ball). Some studies that dealt with health benefits connected with FMS have discovered a strong evidence of positive dependence between FMS and PA among children (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Some of these studies used a self-report method to display PA levels (Erwin & Castelli, 2008). However, another systematic review study pointed out the absence of studies focused on the relationship between objectively measured PA and FMS through TGMD-2 among children in their middle childhood, especially in the age range from 8 to 11 years (Logan, Webster, Getchell, Pfeiffer, & Robinson, 2015).

The aim of the research.

The aim of the present study is to discover the relationship between objectively measured PA and FMS among children in middle childhood from the Czech Republic. The present study also offers rare findings for this age group.

Methods

Sample characteristics

Data were collected from a convenient sample of 201 children: 108 boys and 93 girls (their average age 9.22±1.04 years), without any health problems, physical or mental disability, attending three local primary schools in Olomouc, Czech Republic. The participation in the research was voluntary. From the participants and their parents/legal representatives, written permission prior to children's involvement in the research was obtained. Data collection was performed from December 2013 to March 2014. The study was approved by the Ethical Committee of the Faculty of Physical Culture, Palacký University, Olomouc (22/2014).

Physical activity measurement

An ActiGraph GT3X device accelerometer (Pensacola, FL, USA) was used to objectively measure children's daily PA. An accelerometer is very often taken as the "gold standard" for the objective tracking of field-based PA. It is a non-invasive method for children and eliminates the possibility of self-report biases (Bassett, Troiano, McClain, & Wolff, 2015). The accelerometer provides detailed information about the time spent at different intensity levels, estimation of energy expenditure (EE) and the number of steps per unit of time (Cain, Conway, Adams, Husak, & Sallis, 2013). The ActiGraph accelerometer generates output presented as activity counts per unit of time. For this study, the accelerometer data were recorded in 60s intervals. Based on the count of thresholds, it is possible to estimate the total time spent in PA of various intensity. For this study, the cut-off points (CoP) proposed by Freedson, Pober and Janz (2005) were applied. According to these authors, the intensity of PA is divided into: sedentary PA (SPA): 0–149 counts/min (cpm); light PA (LPA): 150–499 cpm; moderate (MPA): 500–3999 cpm; vigorous PA (VPA): 4000–7599 cpm; and very vigorous PA (VVPA): ≥7600 cpm. Tracking of children's PA with ActiGraph accelerometers has a proper validity and reliability (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006). For the present study, the ActiGraph GT3X was placed in a pouch which was attached to a belt that children wore around their waists. Children were asked to wear the devices from their waking up and throughout the day and to take it off only when swimming, bathing, and sleeping. Children wore the devices for three weekdays and one weekend day (Puyau, Adolph, Vohra, & Butte, 2002). The period of 10 or more hours of wearing the ActiGraph GT3X device was used for further data analysis (Troiano, Berrigani, Dodd, Masse, Tilert, & McDowell, 2008).

FMS assessment

For the assessment of children's FMS, the Test of Gross Motor Development-2 (TGMD-2) was used. The TGMD-2 was designed to assess 12 FMS, and it is further divided into two subtests: the test of locomotor skills (run, gallop, hop, leap, jump, and slide) and test of object control skills (two-hand strike, stationary dribble, catch, kick, throw, and underhand roll). Every child performs each skill twice, and their performance is evaluated based on the performance criteria. An observer evaluates the performance of every skill according to four to six skill criteria. Skills are scored with units 0 or 1, which indicates the absence or presence of the tested criteria. The highest total raw score for each subtest (locomotor and object control skills) is 48 points. Raw scores for two subtests are added and converted to percentiles and to gross motor quotient (GMQ) for each child. Reliability and validity of the TGMD-2 among young children have been documented (Ulrich, 2000). Data used for analysis included the locomotor (LM) subtest raw score, the object control (OC) skills, LM and OC skills overall (i.e., LM subtest raw score + OC subtest raw score) and GMQ.

Statistical analysis

All statistical analyses were processed in STATISTICA 12 (StatSoft, Prague, Czech Republic). The results of each sub-test were presented by means and standard deviations. The relationship between volume and intensity of PA and FMS were quantified using Pearson's correlation coefficient r. The relationship between the monitored variables was interpreted by Cohen (1992): $r = 0$ – complete independence; $0.00<r<0.20$ – very weak dependence; $0.20\leq r<0.40$ – low dependence; $0.40\leq r<0.70$ – medium dependence; $0.70\leq r<0.90$ – high dependence; $0.90\leq r<1.00$ – very high dependence; $r = 1$ – total dependence. Significance was set at $p<0.05$ for all tests.

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Results

The average GMQ score for total sample regardless of gender shows that approximately half of children (52%) have average developed FMS. Above average developed FMS occurred in 32% of the entire sample. A low level of motor development is present in 5% of the sample, and 3% of the sample has superior motor development. Boys performed better on the OC skills and LM and OC skills overall. In contrast, girls performed better in LM skills and GMQ (Table 1).

TABLE 1 Results of FMS and PA levels (N = 201)

	Boys (*n*=108) 8.00–11.99 yrs.		Girls (*n*=93) 8.00–11.99 yrs.		All (*N*=201) 8.00–11.99 yrs.	
	M	***SD***	***M***	***SD***	***M***	***SD***
LM skills [points]	46.29	3.19	46.68	1.69	46.47	2.90
OC skills [points]	42.64	5.38	39.58	5.38	41.22	5.47
LM and OC skills overall [points]	89.06	6.90	86.09	6.47	87.68	6.85
GMQ [points]	104.28	12.03	104.96	11.71	104.59	11.90
SPA [min/day]	1 038.68	96.21	1 019.23	185.02	1 029.68	144.20
LPA [min/day]	138.78	27.31	138.14	24.48	138.48	25.79
MPA [min/day]	206.81	54.01	197.82	44.25	202.66	49.82
MVPA [min/day]	220.32	57.31	210.65	49.90	215.85	54.09
VPA [min/day]	11.77	9.54	9.69	7.45	10.81	8.67
VVPA [min/day]	1.24	4.53	1.46	3.03	1.34	3.90
Steps [steps/day]	10 456	2 931.14	9 664	2 592.57	10 090.21	2 800.90

Note. n = the sample size; M = mean; SD = standard deviation, LM skills = Locomotor skills, OC skills = Object Control skills, LM and OC skills overall = Locomotor and Object control skills overall, GMQ = Gross Motor Quotient, SPA = sedentary PA, LPA = light intensity of PA, MPA = moderate intensity of PA, MVPA = moderate to vigorous intensity of PA, VPA = vigorous intensity of PA, VVPA = very vigorous intensity of PA.

According to ActiGraph GT3X data, the children's sample, regardless of gender, spent 60% of the monitored time in SPA. In the zone of MVPA children spent 13.25% of the monitored time. A similar amount of time was spent in LPA (12.50%) and MPA (12.44%). Children spent the shortest time in VPA (0.66%) and VVPA (0.08%) (Table 1). A Pearson product-moment correlation coefficient was computed to assess the relationship between PA levels and indicators of FMS. In the total sample, regardless of gender, very weak positive correlation between the following variables was found: VPA correlated with LM skills ($r=0.17$; $p<0.05$), with LM and OC skills overall ($r=0.17$; $p<0.05$), with OC skills ($r=0.16$; $p<0.05$) and with GMQ ($r=0.16$; $p<0.05$). Number of steps/day correlated with OC skills ($r=0.19$; $p<0.01$), with LM and OC skills overall ($r=0.17$; $p<0.05$) and finally with GMQ ($r=0.15$; $p<0.05$). In the boys' sample, statistically significant positive correlation was found between VPA and all indicators of FMS: LM skills ($r=0.19$; $p<0.05$), OC skills ($r=0.24$; $p<0.05$), LM and OC skills overall ($r=0.28$; $p<0.01$) and GMQ ($r=0.30$; $p<0.01$). Similar weak correlation was four between the number of steps/day and OC skills ($r=0.22$; $p<0.05$), LM and OC skills overall ($r=0.21$; $p<0.05$), and GMQ ($r=0.23$; $p<0.05$). There were no significant correlations in the sample of girls.

Discussion

There is a problem of decreasing PA among children and adolescents in the Czech Republic. The present study indicates that boys (♂) were more physically active than girls (♀) in all levels of PA intensity except the VVPA. If we consider the recommendations from Tudor-Locke et al. (2011), 80% of the boys from our sample met these recommendations (13,000 steps/day for ♂). Regarding the girls' sample, recommendations are found in an even larger percentage (88%: 11,000 steps/day for ♀). According to data from 2010, children aged 6–11 years, achieved average 10,128 steps/day (♀) and 10,600 steps/day (♂) (Sigmundová & Sigmund, 2015), which is an average of 600 steps/day (for ♀) and 144 steps/day (for ♂) more than in the present study. This finding corresponds with the previous study conducted by Cameron, Craig, Bauman, and Tudor-Locke (2016). These authors in their longitudinal study of Canadian children (regardless of gender) aged from 6 to 11 years of age have found a significantly negative trend in the number of steps/day (10,997 steps/day from 2005 to 2006 versus 10,331 steps/day from 2012 to 2014). Because 12,000 steps/day correspond to approximately 60 min/day MVPA (Colley, Janssen, & Tremblay, 2012), it may be stated that 84% of the total sample met a recommendation for at least 60 min/day of MVPA. The recommended 90 min/day of MVPA (Sigmund, El Ansari, & Sigmundová, 2012) based on the number of steps/day, were performed by approximately 56% of children from the present study. Based on the results of the cpm of the accelerometer and their distribution by the CoP from Freedson et al. (2005), we can say that 100% of our sample met the recommended 90 min/day of MVPA (Sigmund et al., 2012). With a sample of 288 children from the US (aged 6 to 11 years), in their study, Troiano et al. (2008) showed that 42% of children (48.90% of boys and 34.70% of girls) met a recommendation for 60 min/day MVPA. The average time spent in the MVPA zone was 84.90 min/day (95.40 min/day for ♂ and 75.20 for ♀). A sample from another study, consisting of 169 children from Olomouc (M = 9.92 years), spent an average of 43.28 min/day of MVPA (Šnoblová, Jakubec, Sigmund, & Sigmundová, 2015).

We assume that the reason for the large difference between the time spent in the MVPA is caused by different devices used for the objective monitoring of PA and, consequently, by selecting the CoP for the PA intensity zones. These findings are in accordance with Vanderloo, Di Cristofaro, Proudfoot, Tucker, and Timmons (2016) who underscore the difficulties in evaluating the results of the objective monitoring of PA measured for the same children's sample with different devices. Additionally, some studies have proven that the selection of CoP could notably change an average of MVPA and the percentage of children who met PA recommendations (Beets, Bornstein, Dowda, & Pate, 2011). An average GMQ score of the total sample has shown that approximately half of children (52%) have average-developed FMS. Above average FMS occurred in 32% of the total sample. Low levels of motor development are present in 5% of the sample while superior motor development occurred in 3% of the sample.

The results of the present study indicate that boys achieved higher results in OC skills and the LM and OC skills overall. In contrast, girls achieved higher results from the LM skills and GMQ. These results confirm the trends from other studies, in which, with regard to gender, boys have shown significantly higher scores in OC skills and LM and OC skills overall (Burns, Brusseau, & Hannon, 2017). Girls have shown better scores in LM skills (Burns et al., 2017; Slykerman, Ridgers, Stevenson, & Barnett, 2016). The OC skills tested in the present study are typical skills included in many ball games, which are more popular among boys than among girls. However, some LM skills are mostly taught during dance classes, which are more popular among girls. The relationships between PA and OC skills were more powerful than the relationships between PA and LM skills. Similar results were presented by Hume et al. (2008). Relations between the levels of PA and levels of FMS in the total sample regardless of gender are partially in alignment with the results of the research conducted by Lopes, Maia, Rodrigues, and Malina (2012), especially in the relationship between VPA and LM and OC skills overall (r=0.18) among children aged from 8 to 10 years. The same authors presented a weak dependence (r=0.22) between the total level of FMS and MVPA (r=0.30). In the present study, no significant correlations were found between these two variables. In contrast to the boys' sample from the present study, Hume et al. (2008) reported a weak correlation between the total level of FMS and MPA (r=0.21), VPA (r=0.25) and MVPA (r=0.24). In comparison with those results, the boys' sample from the present study demonstrated a significantly weak correlation between the VPA and LM and OC skills overall and between VPA and OC skills. Hume et al. (2008) also presented low dependence in the girls' sample between VPA and LM skills (r=0.29) and between VPA and LM and OC skills overall (r=0.21). However, in the girls' sample from the present study, there were no significant correlations between any component of FMS and any level of PA intensity. The absence of significantly positive correlation between the levels of PA and the levels of FMS in the present study is unexpected, considering previous findings indicating that these skills are related to PA in girls (Burns et al., 2017; Castelli & Valley, 2007).

Findings from the present study did not support a strong relationship as other studies did. We believe that the difference was shown, because in the research conducted by Hume et al. (2008) only five items for the evaluation of the level of FMS (three subtests for OC skills and two subtests for LM skills) were used, which could be explained with better results in the overall OC skills score in the sample from Hume et al. (2008) especially in the girls' sample. However, we agree with the statement of Wrotniak, Epstein, Dorn, Jones, and Kondilis (2006) that the children with better developed FMS choose to participate in a wider range of PA, which gives them the opportunity for plenty of movement experience. Over time, that leads to increasing amounts and intensities of PA.

Conclusion

With regard to gender, the study sample completely met the recommendations for PA set for primary school children (90 min/day MVPA) based on the cpm recorded by the ActiGraph GT3X device. In contrast, 80% of boys and 88% of girls met the recommendation based on the number of steps/day (13,000 steps/day for boys and 11,000 steps/day for girls). This difference could be explained by the selected CoP for individual PA intensity zones, where specific CoP can significantly distort the values on time spent in each of the PA intensity zones. The low level of PA can be explained by the results of the evaluation of the level of FMS. Based on the level of FMS assessed by TGMD-2, 52% of the total sample is at an average level of gross motor development (44% of the boys' and 58% of the girls' sample, respectively). In conclusion, it could be underlined that the promotion of FMS in both genders is a significant factor for increasing the levels of children's PA.

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Effect of the FIFA 11+ Programme on Vertical Jump Performance in Elite Male Youth Soccer Players

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ABSTRACT Despite the success of the FIFA 11+ programme in preventing injury, convincing coaches and players to do these exercises is difficult only in order to prevent injury, unless the programme can be shown to have a positive and direct impact on the performance. This study aims to investigate the effect of the FIFA 11+ programme on vertical jump performance in male elite-youth soccer players. Twenty-four male soccer players (mean ± SD: age = 16.79 ± 1.18 years, height = 174.17 ± 8.12 cm, mass = 62.45 ± 10.01 kg, experience = 6.96 ± 1.26 years) participated in this study and were randomly divided equally into two groups, FIFA 11+ and control. The experimental group performed the FIFA 11+ programme three times per week for eight weeks whereas the control group just performed their regular warm-up programme. The mixed-repeated measures ANOVA showed that there was a significant improvement in the vertical jump performance between groups in post-test (P=0.002) while no significant improvement was found between groups after 1-month of stopping the FIFA 11+ programme (P=0.076). It can be concluded that performing the eight-week FIFA 11+ programme can enhance the jump height in male elite youth soccer players. It seems that the FIFA 11+ programme could be incorporated into regular soccer practice as a warm-up programme instead of a conventional warm-up programme. However, due to the failure to maintain the long-term effectiveness of the FIFA 11+ programme on the jump height of soccer players, the continuation of performing this programme is necessary.

KEY WORDS vertical jump height, performance, soccer, the FIFA 11+

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Introduction

Soccer is the most popular sport in the world, with close to 270 million participants (FIFA, 2007). Like most sports, soccer has a risk of injury for both professional and amateur levels in all age grades (Junge & Dvorak, 2004). Ninety percent of all soccer players are male, and young players account for 54.7% of the total population of players (Daneshjoo, Mokhtar, Rahnama, & Yusof, 2013). The consequences related to injury are greater for those who are in the stages of growth and maturation (Read, Oliver, De Ste Croix, Myer, & Lloyd, 2015). Therefore, preventing injury in soccer is essential, especially for young male soccer players.

One effective factor in the success of a prevention programme is the high rate of compliance with it. If an injury prevention programme has a positive and direct impact on the performance, in addition to positive effects on the factors related to injury prevention, the programme is easier to accept by coaches and athletes (Nakase et al., 2013). Recent studies have shown that there is an inverse dose-response relationship between compliance with prevention programs and incidence of ACL injury (Sugimoto et al., 2012). Therefore, multi-

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purpose training programs have been designed in the form of warm-up programs aimed at preventing injury and improving athletic performance.

Although soccer is a more aerobic sport, it has been observed that non-aerobic fitness seen in muscle power actions is related to determining activities during a game, such as jumps (Faude, Koch, & Meyer, 2012). Attention should be paid to the vertical jump performance in a soccer game because of its role in momentum activities such as heading in attacking or defending situations (Fradkin, Zazryn, & Smoliga, 2010). Therefore, the ability to perform vertical jumps is one of the key components for the soccer players.

The first studies on the physical performance of soccer players used the FIFA 11 programme have been made (Kilding, Tunstall, & Kuzmic, 2008; Steffen, Bakka, Myklebust, & Bahr, 2008). Kilding et al. (2008) stated no changes in body mass, agility, and core stability. However, they observed a significant improvement in leg power (3-step jump and vertical jump) and 20m sprint of young soccer players following the 30 sessions of the FIFA 11 programme. However, Steffen et al. (2008) concluded that the 10-week performance of the FIFA 11 programme was not able to improve soccer skill tests including 40m sprint running, speed tests and vertical jump among adolescent female soccer players. These contradictory results are among the reasons behind the development of the FIFA 11+ programme that incorporates an increase in intensity and exercise components.

As a comprehensive warm-up programme, FIFA 11+ is one of the most successful injury prevention programs in soccer (Silvers-Granelli, Bizzini, Arundale, Mandelbaum, & Snyder-Mackler, 2017). It seems to have the essential components of improving the vertical jump of soccer players. To our knowledge, very few publications can be found in the literature that address the performance effects of the FIFA 11+ programme on leg power. Some studies (Bizzini et al., 2013; Daneshjoo, Mokhtar, Rahnama, & Yusof, 2013) have demonstrated that the use of the FIFA 11+ programme can improve the physical performance (e.g., vertical jump height), indicating that performance improvement may be possible with this programme. However, these outcomes have not been observed by other authors (Impellizzeri et al., 2013; Steffen et al., 2013). Regarding the conflicting results derived from the very few studies, the effect of FIFA 11+ on vertical jump height performance remains in doubt. In contrast, one of the limitations of the previous studies is that they did not take into account the effect sustainability of the FIFA 11+ programme on athletic performance. Thus, it is not yet possible to know how long the results of this programme can be maintained. Given the importance of compliance to the preventive training programs' success, understanding the performance effects of the FIFA 11+ programme and its sustainability will enable soccer coaches and trainers to choose it as a warm-up programme. Therefore, the primary purpose of our study was to examine whether the advanced version of the FIFA 11 programme (i.e., the FIFA 11+) can improve vertical jump performance, as an influencing factor in soccer. Our secondary purpose was to examine the follow-up results one month after halting the FIFA 11+ programme in male elite youth soccer players.

Method

We conducted a randomized controlled trial to assess the effect of FIFA 11+ versus the routine warm-up programme on vertical jump performance in male soccer players. Twenty-four male elite soccer players under 19 years (mean ± SD: age = 16.79 ± 1.18 years, height = 1.74 ± 8.12 m, mass = 62.45 ± 10.01 kg, experience = 6.96 ± 1.26 years) participated in this study. The inclusion and exclusion criteria were no lower extremity injury in the previous six months and no pain in the lower extremities. The participants were informed orally about the procedures they would undergo, and each of them voluntarily provided written informed consent before participating. Furthermore, we obtained written informed consent from parents or coaches, as caretakers, on behalf of the minors (for those under the age of 18) involved in this study. The study was approved by the Kerman University of Medical Sciences Ethics Committee (Reference number: Ir.kmu.rec.1395.352) and registered in the Iranian Registry of Clinical Trials (IRCT ID: IRCT2017010331754N1). Soccer players were randomly divided into two groups: intervention, and control (n = 12 per group). The FIFA 11+ group performed the programme 3 times a week for 8 weeks (24 sessions), whereas the control group just performed their regular warm-up programmes. Before data collection, a two-hour acquaintance meeting was held to explain the FIFA 11+ programme exercises. One of the researchers supervised all the training sessions to ensure that correct technique was used.

Participants were asked to wear minimal clothes (only spandex short) with their own soccer footwear. Before the performance assessment, the participants warmed up with a few dynamic stretching exercises, including slow jog, two-legged squat, and stretching exercises for hamstring, quadriceps, and calves.

Assessment of the maximum vertical jump: The subject stood beside a wall, started from a static standing position, reached up as high as possible with one hand and marks the wall with his fingertips. The jump was preceded by flexing the knees to approximately 90º; the subject jumped up with maximum effort as fast as he could and made a sign on the wall again with the same hand. The difference between these two marks in centimetres was considered as the maximum vertical jump height. The jump performance was monitored by one of the researchers. The mean of three vertical jump performance was calculated to analyse overall vertical jump height. The vertical jump test during pre-test, post-test and after one month were performed between 8 am and 1 pm. The vertical jump performance was assessed three days before and after intervention and also after one month without the FIFA 11+ training. The exercise programs were implemented during the 2016-2017 season.

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The FIFA 11+ is a comprehensive warm-up programme with six running exercises at the beginning and with three exercises to activate the cardiovascular system at the end, and six specific preventive exercises focusing on core and leg strength, balance and agility with three progressive levels for each exercise, as well as lower extremity and trunk alignment cues. It takes about 20-25 min to complete and requires a minimum of equipment (a set of cones and balls).

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 21. For data analysis and to compare the vertical jump performance between intervention programme (the FIFA 11+ vs routine warm-up) among the pre-intervention, post-intervention and one-month follow-up (times), a 2 × 3 (groups vs time) mixed repeated-measures ANOVA was used. If the interaction between time and group is significant, 'simple effects' analysis is used for exploring this relationship further. We screened the data to ensure that assumptions were met for statistical analysis. The Shapiro-Wilk, the Runs, and Levene's tests were used to assess the normality of data distribution, the hypothesis of independence and the homogeneity of variance between the groups, respectively ($p > 0.05$). Furthermore, homogeneity of variance-covariance was confirmed using Box's M table data ($p > 0.001$). The guidelines for interpreting the effect size value using eta squared data are: .01=small effect, .06=moderate effect, and 0.14=large effect (Cohen, 1988; Pallant, 2010). Significance was accepted at the 95% confidence level for all statistical parameters ($p<0.05$).

Results

There was no significant difference between the FIFA 11+ and control groups for height, weight, age, or pre-training vertical jump performance ($p>0.05$). Means (±SD) of vertical jump height in the subjects of the two groups in the pre-intervention and post-intervention are presented in Table 1.

TABLE 1 Vertical Jump Height Measures over Three Times Phases

Training groups	Pre-intervention	Post-intervention	After 1-month stopping the FIFA 11+ training
FIFA 11+	45.33±5.06	51.00±4.95	48.50±5.60
Routine warm-up	44.25±4.78	44.58±3.75	44.66±4.41

The table Tests of Within-Subjects Effects showed that the interaction between time and group with large effect size is significant ($F (2, 44) = 23.491$, $p<0.001$, $\eta^2= 0.51$). Since the interaction between time and group was obtained, "simple effects" analysis was used, which showed that the FIFA 11+ group had significantly more improvement in vertical jump performance after interventions ($p=0.002$) than the routine warm-up programme did, but there were no differences between groups one month after stopping the FIFA 11+ programme ($p = 0.076$).

As shown in Table 1 and also Figure 1, the vertical jump performance of soccer players in the pre-test was the same, but by performing the FIFA 11+ programme for the intervention group, the closer we come to the

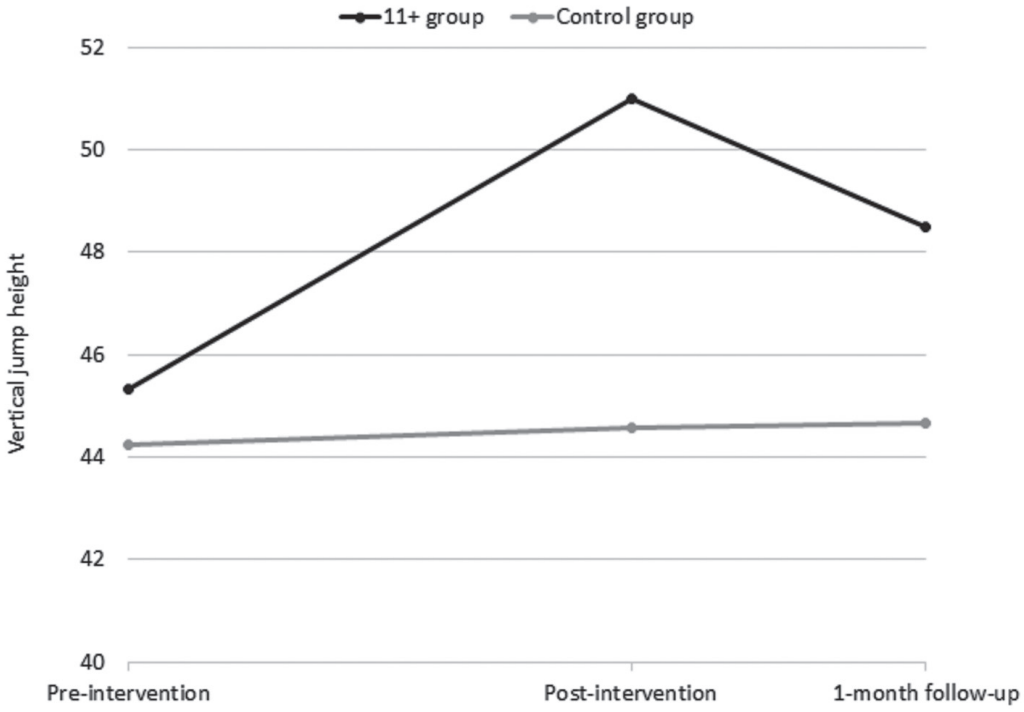

FIGURE 1 The Vertical Jump Height Performance of the Two Groups at Different Times

post test, the greater the difference between the two groups in terms of vertical jump height performance and also after the FIFA 11+ programme is stopped, the discrepancy will be lessened closer to the retention test.

Discussion

The current study aimed to compare the performance of the vertical jump height between the FIFA 11+ and the routine warm-up programme groups as well as the follow-up results obtained in terms of improving the jump height one month after stopping the FIFA 11+ programme. The findings of this study indicated that the effects of the FIFA 11+ programme exercises on the performance of soccer players' vertical jump were remarkable, and the vertical jump of the intervention group eight weeks after performing the FIFA 11+ programme exercises improved in comparison to the control group. Although this performance improved in the intervention group, one month after stopping the FIFA 11+ programme, it gradually lost its positive effects.

There are several possible explanations for this result. As a multicomponent training programme using a series of exercises such as bench, sideways bench, single-leg stance, squats and jumping, FIFA 11+ can induce the activity of core and hip muscles and thus improve neuromuscular control (Bizzini & Dvorak, 2015), which enhance functional performance efficiency of activities (Kibler, Press, & Sciascia, 2006). On the other hand, it could be mentioned that Nordic hamstring curl (the hamstring muscles are stretched during an eccentric contraction) and plyometric exercises of the FIFA 11+ programme are probably effective for improving the stretch-shortening cycle (SSC) function, which is one of the key factors for enhancing vertical jump performance (Kyröläinen & Komi, 1995). Similarly to the present study, Bizzini et al. (2013) studying on 20 amateur male soccer players (aged 25.5) and Daneshjoo et al. (2013) investigating 36 male elite soccer players (aged 17-20), reported significant improvements on the vertical jump performance of male soccer players because of performing the FIFA 11+ programme (Bizzini et al., 2013; Daneshjoo et al., 2013). A recent review study demonstrated that squats and plyometric exercises can improve vertical jump height (de Villarreal, Kellis, Kraemer, & Izquierdo, 2009). Furthermore, performing squat and walking lunge exercises can be effective in increasing vertical jump height (Jönhagen, Ackermann, & Saartok, 2009; Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004). Thus, the underlying effectiveness of the FIFA 11+ programme on vertical jump performance may be caused by using core, plyometric, and jump exercises.

However, Steffen et al. (2013) with 4.5 months of training with 226 tier 1–3 level female soccer players (aged 13-18) and Impellizzeri et al. (2013) with 9 weeks of training with 81 male amateur soccer players (aged 23.5) did not report significant differences in the vertical jump between the control and the FIFA 11+ groups, with male and female samples, respectively (Impellizzeri et al., 2013; Steffen et al., 2013). These differences in the results of studies can be attributed to factors such as gender, age, and the skill levels of the soccer players.

One of the factors that can be noted for the loss of training-induced performance adaptations for the vertical jump of soccer players is that the factors affecting vertical jump performance, such as strength, are likely to be retained for less than one month. The results of studies have shown that durability of strength is less than four weeks. For example, the ability to apply force to the water in trained swimmers was considerably reduced during four weeks of inactivity (Neufer, Costill, Fielding, Flynn, & Kirwan, 1987). Therefore, it can be concluded that by stopping the FIFA 11+ programme, the stimulating effective forces on vertical jump performance were reduced so that after one month there is no difference in terms of performance between groups.

As noted, improving the ability to jump vertically in a soccer game is critical for activities, such as heading in offense or defense situations. According to the results of this study, the FIFA 11+ programme has been effective in improving the vertical jump performance. This result is great for soccer coaches and trainers because the FIFA 11+ warm-up programme can be done without adding time as well as imposing additional financial costs compared to routine warm-up exercises. Given that our findings are based on a small sample size and that our results are related to young male soccer players aged between 16 and 19, the results from such analyses should thus be treated with considerable caution. The present results merely show the effect of the FIFA 11+ on the young grade, and additional studies on other grades, as well as female athletes, to fully realize the effect of the FIFA 11+ on vertical jump performance in other populations, are recommended.

The FIFA 11+ programme can improve the performance of male elite youth soccer players, but the maintaining of the training-induced performance adaptations is less than one month. Therefore, these findings suggest to soccer coaches and trainers that the inclusion of FIFA 11+ in the training routine would be beneficial to leg power and could improve the ability of vertical jump performance. However, the necessity of continuing to implement the FIFA 11+ programme exercises to maximize the benefits of this programme on the performance is noted.

What does this study add?

To date, because of few and contradictory studies, little is known about the effects of the FIFA 11+ programme on vertical jump performance. There is no study in this area to employ follow-up the results. Through this study, the database in this research area has been increased, and there is information on the

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effect of this programme on the vertical jump performance after a one-month follow-up. The results of this study indicated that FIFA 11+ improves performance in the vertical jump test, but the improvement was not maintained after one month of halting training. Data from this research can be helpful for soccer coaches and trainers in choosing the FIFA 11+ programme to enhance jump performance in elite male youth soccer players.

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ORIGINAL SCIENTIFIC PAPER

The Relationship between Previous Lower Extremity Injury, Body Weight and Bilateral Eccentric Hamstring Strength Imbalance in Young Soccer Players

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ABSTRACT This study aims to investigate the effect of lower extremity (LE) injuries on bilateral hamstring eccentric strength imbalance (HSI) and to determine the relationship between body weight (BW) and HSI in young male soccer players. Eighty-eight young soccer players aged 14-19 in Turkey voluntarily participated in this study. Eccentric hamstring strength measurements were taken using a NordBord® Hamstring Testing Device. To obtain the LE backgrounds of the participants, individual interviews were administered to the players, and the obtained data were verified through a review of previous injury records. While 22 (25%) out of 88 players reported LE injuries in the previous two years (injured players (IP)), the rest of them (75%) did not report any LE injuries (non-injured players (NP)). HSI values as peak forces were computed by extracting the weaker leg values from the stronger leg values. Both the Analysis of Variance (ANOVA) and the Analysis of Covariance (ANCOVA) were performed, controlling the BW effect in order to test the effects of LE injuries on HSI. Correlation analysis was also conducted, taking into consideration the previous research findings on the relationship between body weight and strength variables. There was significant relationship between BW and HSI (($p<0.05$) (0.04> r >0.02)) and non-significant results for HSI ($F(1.85) = 0.578$, $p>0.05$). However, the effect of BW was significant for HSI ($F(1.85) = 3.91$, $p<0.05$, $\eta 2 = 0.068$). This study supported the hypothesis that hamstring muscle strength imbalance is not affected by lower extremity injuries and that body weight is a factor that may affect strength imbalance.

KEY WORDS hamstring strength imbalance, body weight, soccer injuries

Introduction

Lower extremity (LE) injury is one of the most common sport injuries among soccer players (Hägglund, Waldén, & Ekstrand, 2013). Previous studies have shown that apart from internal factors such as age, gender, and being overweight, there are other factors, such as inflexibility, fatigue, shortened optimum muscle length, and strength imbalance, that may affect lower extremity injuries (Murphy, Connolly, & Beynnon, 2003). Recent studies have focused on strength imbalance and fatigue as significant factors of sports injuries (Liu, Garrett, Moorman, & Yu, 2012). Strength imbalance can be characterized by either side-to-side (right versus left) or front-to-back (agonist versus antagonist) differences in muscle length or strength. As a gold standard, isokinetic dynamometers have commonly been used over the years to measure strength and to assess muscle strength imbalance (Mijnarends et al., 2013), but these methods have some disadvantages, such as lack of portability and high cost of their widespread use (Opar, Piatkowski, Williams, & Shield, 2013). To overcome these limitations, a number of testing systems have been developed. One of the most recent ones is the "Nordbord": a hamstring strength testing device devised by Opar et al. (2013). After a reliability study, they

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argued that this testing device provides the right information at the right time. Current studies on the validity of this claim have revealed that the Nordbord testing method is a reliable field-based alternative (Buchheit, Cholley, Nagel, & Poulos, 2016).

The aims of this study were to examine the effect of previous lower extremity injuries (quadriceps and adductor muscle injuries) on hamstring eccentric strength imbalance and to determine the relationship between BW and hamstring eccentric strength imbalance using the Nordbord Nordic Hamstring Testing Device as the assessment tool. The majority of previous studies investigating the effects of strength imbalance on the risk of injury did not conduct follow-up about strength imbalance after repeated injuries. For this reason, it was not clearly underlined how sport injuries affect muscle imbalance ratios. Thus, this study aimed to examine the relationship between body weight (BW), muscle strength imbalance, and previous sports LE injuries.

Methods

Participants

This study consists of 88 young male soccer players who have played for first division teams in Turkey (U14, U15, U16, U17 and U19 teams). Prior to participation in the study, the players and their parents were informed of the possible risks of the study, and those who volunteered to participate gave their written informed consent. This study was approved by the Applied Ethics Research Center of the Middle East Technical University. The physical characteristics of the participants are presented in Table 1.

TABLE 1 Physical Characteristics of the participants

	LE injured (n=22)		LE non -injured (n=66)		Total(n=88)	
Variable	**M**	**SD**	**M**	**SD**	**M**	**SD**
Age (year)	15.95	1.59	16.29	1.85	16.20	1.78
Height (cm)	171.32	6.42	174.67	8.82	173.83	8.38
Weight (kg)	61.18	9.01	64.45	10.94	63.64	10.94

To gather data from the participants whose characteristics are given in Table 1, two data parameters were utilized: previous LE injury status and Eccentric Knee Flexor-Strength Testing, the details of which are provided below.

Previous Lower Extremity Injury Status

In a semi-structured interview, the participants were asked what kind of injuries they had experienced in the previous two years, and their injury records were obtained to verify the interview data from the club clinician. Both the data obtained from the players through the interviews and the data gathered from the club clinician involved the information of injury type, injury location, grade (grade1-2-3) and the injured limb (right or left legs). In addition to hamstring injuries, quadriceps and adductor muscle injuries (grade1-2 strains) were also identified as lower extremity injuries if they prevented the player from participating in a match or training for a period of one week or more.

Eccentric Knee-Flexor-Strength Testing

Before the strength test, players' routine musculoskeletal and cardiovascular evaluations were conducted. After a standardized warm-up (5-minute cycling at submaximal intensity, a combination of skipping, high-knees and butt-kicking drills, 10 forward lunges per leg, 10 weight-free deep squats, 30 seconds of dynamic stretching per leg, and 2 Nordic hamstring movements with low resistance), participants performed one set of three maximal repetitions of bilateral Nordic hamstring exercises while using a NordBord® Hamstring Testing device (Qutbluebox, Queensland, AUS) as previously described (Opar et al., 2013). During the performance, the participants were encouraged to make maximal effort. All the participants performed one set of three maximal repetitions of the bilateral Nordic hamstring exercise, with the greatest force value (N) used for the analysis.

Data Preparation and Statistical Analyses

To obtain strength imbalance values, side-to-side strength differences of hamstring eccentric strength value (Newton: N) were computed as follows:

$$\text{HSI} = \text{Stronger Leg (SL) value} - \text{Weaker leg (WL) value}$$

SPSS version 23 software was used for the statistical analysis. The 95% level of confidence was used for all statistical tests. Descriptive statistics (means, standard deviations and frequencies) pertaining to the characteristics of the participants (age, body weight and height) were given. To verify the relationship between the selected BW and strength differences (peak torques and peak forces), Pearson correlation analysis was employed. Data analysis to obtain the effects of lower extremity injuries on muscle strength imbalance was divided into two parts. In the first part, one-way analysis of variance (ANOVA) was performed to determine the mean differences of hamstring eccentric strength imbalance between the injured and non-injured players. In the second part, analysis of covariance (ANCOVA) was executed. This was done to eliminate the effect of BW on the results.

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Results

In the current study, 22 out of 88 players (25%) had previous lower extremity (LE) injuries in the previous 2 years (injured players - IP), and the rest of them (75%) did not report any LE injuries (non-injured players (NP)). The mean age (±SD) of the participants was 16.20 (±1.78); the mean height was 173.83 cm (±8.38), and the mean weight was 63.64 kg (±10.94 kg). Physical characteristics of participants are given in Table 1. There were no significant differences between the parameters pertaining to the LE non-injured and LE injured players ($p>0.05$). Additionally, there were no significant average differences in HSI between the LE injured (n=22) and LE non-injured (n=66) players (Table 2). HSI values as peak forces were computed by extracting weaker leg values from stronger leg values.

TABLE 2 Average mean (±SD) values for Injured and non-injured players in maximum eccentric peak force (N)

	LE injured (n=22)		LE non-injured (n=66)	
Variable	**M**	**SD**	**M**	**SD**
HSI	43.73	31.04	40.07	30.21

Note: * HSI = Maximum eccentric peak force differences between legs

One-way analysis of variance (ANOVA) was performed to determine the effect of LE injuries on HSI; the ANOVA results demonstrated that the effect of the previous LE is not significant for HSI ($F(1.86) = 0.239$, $p>0.05$, $\eta 2=0.003$). A Pearson correlation was performed to determine the relationship between BW and HSI (Figure 1), and a low (r=0.2-0.4) correlation was observed between BW and HSI variables (Cohen, 1988).

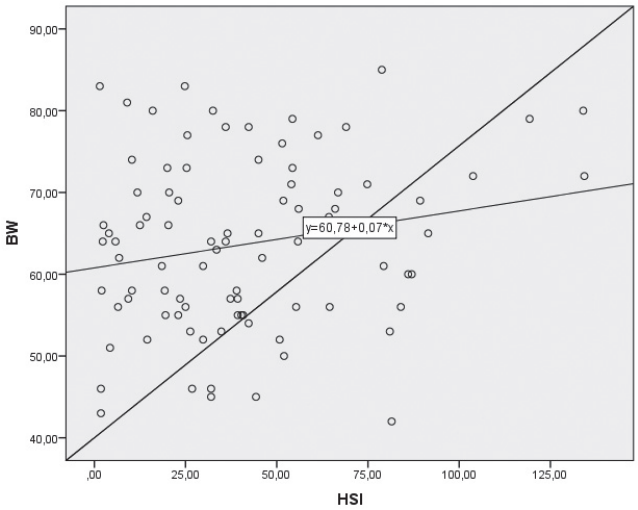

FIGURE 1 Correlation between BW and HSI in the total participants

In the literature, the possible effects of BW on strength parameters have been reported (Samson et al., 2000). In line with the literature, a positive correlation was found in this study between BW and HSI, which is a strength parameter; thus, the analysis continued with ANCOVA in the current study. A one-way ANCOVA was conducted to compare the effects of LE injury conditions (LE injured and non-injured) whilst controlling for BW. The results of ANCOVA indicated that although the BW effect was significant for HSI [$F(1.85) = 3.91$, $p<0.05$ $\eta 2 = 0.068$], there was no significant difference between groups with and without LE injury for HSI ($F(1.85) = 0.578$, $p>0.05$) (Table 3).

TABLE 3 Results of ANCOVA for the effect of LE injuries on HSI

	SS	df	MS	F	η^2
Injury Condition	516.97	1	516.97	0.578	.007
BW	3495.96	1	3495.96	3.91*	.44
Error	76060.85	85	894.83		
Corrected Total	227599.51	87			

Note: BW of participant's as covariate; *p < .05.

Most of the previous studies examined the effect of HSI on hamstring muscle strain rather than LE injury. However, in our study, as a part of LE, hamstring strain injury was also considered significant; thus, it was evaluated separately. A hamstring muscle strain was considered significant to the study separately. In this analysis, ANCOVA was computed to determine the effects of hamstring strain injury on HSI whilst LE injuries other than hamstring strain injuries were controlled together with BW.

TABLE 4 ANCOVA Results for the effects of Hamstring Strain Injury on HSI (BW and other "LE injuries other than H strain injuries" are controlled)

	SS	df	MS	F	η^2
Hamstring Strain Injury#	18.84	1	18.84	0.21	.00
BW	3332.21	1	3495.96	3.72*	.42
LE injuries without H strains	1263.38	1	1263.38	1.41	0.24
Error	75272.39	84	896.1		
Corrected Total	29778.09	87			

Note: *p < .05. BW= body weight (of participant's as covariate). SS= Sum of Squares, df= degrees of freedom, MS= mean square, F= effect size, η2= eta-squared #ten players suffered at least one hamstring strain injury and did not suffer any other LE injuries in the past two years.
Note: BW and other "LE injuries other than H strain injuries" are controlled

The findings pertaining to the effects of hamstring strain injuries on HSI revealed a non-significant relationship between hamstring strain injuries and HSI, as seen in Table 4. As in the ANCOVA results for the effect of LE injuries on HSI, the BW effect was significant ($p<0.05$) and the effect of hamstring strain injury on HSI by controlling BW and LE injuries other than hamstring strain injuries was not significant ($p>0.05$).

Discussion

Many studies have examined the relationship between strength imbalance and sports injuries (Croisier, Ganteaume, Binet, Genty, & Ferret, 2008; Grace, Sweetser, Nelson, Ydens, & Skipper, 1984; Nadler, Malanga, DePrince, Stitik, & Feinberg, 2000) and reported contradictory results. Some of these studies have revealed that bilateral strength imbalance has played a critical role in sports injury (Croisier, Forthomme, Namurois, Vanderthommen, & Crielaard, 2002; Newton et al., 2006). Conversely, other studies have argued that there is no relationship between strength imbalance and injury occurrence (Bennell et al., 1998; Brockett, Morgan, & Proske, 2004; Newton et al., 2006). The difference between the findings of the studies may be attributed to the differences in research design or to the influence of confounding variables. As a result, it remains unclear whether there is any effect of bilateral strength imbalance on sports injuries. Moreover, the previous studies did not investigate strength imbalance after injuries; thus, there is no evidence in the literature as to whether injuries cause imbalance or whether strength imbalance changes prior to injuries.

The present study aimed to focus on the effects of lower extremity injuries on strength imbalance rather than the effect of strength imbalance on any injury mechanism. The majority of the previous studies investigating the association between strength imbalance and sports injury did not consider in their analysis the role of other potentially significant factors, such as age, gender, body weight and previous injury status. In the statistical analysis of this study, the possible effects of body weight (due to increased muscle mass), which is one of the significant factors for strength, was also considered. It is clearly known that an increase in body weight is due to increased muscle mass or total body fat. In this respect, this study aimed to reveal more comprehensive statistical results.

Body weight (due to increased muscle mass) is one of the major determinants affecting muscular strength (Hasan, Kamal, & Hussein, 2016). Buchheit et al., (2016) have indicated the effect of body weight on eccentric peak torques in the soccer players using the Nordbord testing device and they developed a regression model to estimate players' expected strength taking their body weight into account. In light of that study and the present study, it can be said that it is appropriate to consider the effects of body weight on strength imbalance in further studies.

Bilateral strength imbalance can be calculated as side-to-side strength difference or the ratio of right and left limbs or between stronger and weaker limbs. It was stated in the literature that using ratios has some disadvantages (Impellizzeri, Bizzini, Rampinini, Cereda, & Maffiuletti, 2008). In this study, instead of ratios, side-to-side strength differences were preferred to obtain strength imbalance values. Nadler et al., (2000) evaluated side-to-side strength differences in their participants' abductor and extensor muscles to obtain strength imbalance data. They have indicated that there were no significant differences between athletes with and without reported lower extremity injuries in terms of strength imbalance (side-to-side strength differences of abductors or extensors) considering the participant's body weight. In a similar way, absolute strength difference values between legs were calculated to utilize the strength imbalance values in this study.

In the study of Yamamoto, (1993), which is one of the first studies on the effect of HSI on injuries, the players who reported hamstring strain injuries in the previous two years had more strength imbalance of the bilateral legs in comparison to the players who reported no hamstring strain injuries. More recently, Bourne, Opar, Williams and Shield, (2015) found that eccentric knee-flexor strength and previous hamstring strain injury are linked with an increased risk of future hamstring strain injury. Many other studies have also demonstrated that bilateral strength imbalance may be related to the occurrence of hamstring strain injury (Cameron, Adams, & Maher, 2003; Yeung, Suen, & Yeung, 2009). Contrary to the previous findings in elite soccer, bilateral strength imbalance was not associated with lower extremity injuries in the current study. Our

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findings corroborate the results of some previous studies indicating that bilateral strength imbalance is not associated with the incidence of sports injury (Bennell et al., 1998; Opar et al., 2014; Zvijac, Toriscelli, Merrick, & Kiebzak, 2013). Zvijac et al. (2013) found recently that there is no relationship between knee concentric strength imbalance and hamstring strain injury. Nadler et al. (2000) reported that there is no significant side-to-side percentage difference of the gluteus maximus strength between athletes with and without lower extremity injury. Our findings are consistent with these reports and do not support prior hamstring injuries as a risk factor for re-injury.

Conclusion

In this study, young soccer players with reported lower extremity injuries in the previous two years had similar eccentric hamstring strength imbalance in comparison to non-injured soccer players. While many studies have indicated hamstring strength imbalance as a risk factor for lower extremity injury especially in the hamstring, several other studies have reported contrary findings. The finding of this study supported the null hypothesis that hamstring muscle strength imbalance is not affected by either lower extremity injuries or hamstring strain injuries and that body weight is a factor affecting strength imbalance. Future studies are needed to better understand the relationship between the risk of sport injury and strength imbalance considering multiple factors such as body weight, muscle flexibility and age.

There are some limitations that should be acknowledged. Firstly, the measurement of strength and assessment of imbalance were only performed at a single time point after the injuries. It is important to consider that strength may change over time and a pre-test /post-test experimental design in which participant's strength is measured twice, once before and after a period may lead to more robust inferences. To eliminate the effect of body weight, previous studies generally have utilized relative strength values (Nadler et al., 2000). Rather than using relative strength values, the body weight effect was controlled using ANCOVA analysis in the present study. Although body weight mainly has positive effects on strength, it can also have negative effects depending on the body fat percentage. The body weight percentage of participants was not measured in this study. It was not possible to obtain homogeneous groups regarding body weight or body mass index as consequences of the age range factor in the population of this study. Stratified random sampling can be used to obtain more homogeneous groups for further studies.

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ORIGINAL SCIENTIFIC PAPER

Is Social Capital Associated with Academic Achievement in Lithuanian High-school Students? A Population-based Study

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ABSTRACT The present study aims to determine the associations between family, neighbourhood, and school social capital with academic achievement among Lithuanian high-school students. The study included 1854 high-school students (901 males and 953 females) aged 16-18 years. At the end of the school year, the students' achievements were measured as an average grade. Family, neighbourhood, and school social capital were identified, indicating trust and understanding perceived from those social settings. Gender, body-mass index, self-perceived socioeconomic status, self-rated health, psychological distress and physical activity were also measured and used as covariates. Academic achievement was associated with family social capital, horizontal school trust and reciprocity at school. Family support, cooperation, and trust between students positively affect their achievement. Policies and strategies for a healthy environment for children need to be incorporated, especially within the school system for students' better progress.

KEY WORDS social capital, adolescents, academic success, multiple regression analyses

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Introduction

School represents the fundamental basis for success today (Parcel & Dufur, 2001). Those students who were successful in school were more likely to have occupational placement and earnings attainment and achieve career success (Rodriguez, 2009) in later life. In contrast, academic achievements in school could be directly predicted by learning motivation (Legault, Green-Demers, & Pelletier, 2006). However, research shows that only 7% of school-age children in Lithuania have high learning motivation (Barkauskaitė & Sinkevičienė, 2012).Theories (Ryan & Deci, 2000), research (Edwards & Mullis, 2001; Niemiec & Ryan, 2009) and practice show that learning motivation, as a precondition of students' academic performance, could be enhanced if the social environment at school is supportive (Niemiec & Ryan, 2009).

Although students spend most of their time in school, other studies have reported that it is not the only factor responsible for promoting children's and adolescents' academic achievement (Stockard & Mayberry, 1992). Israel et al. (2001) state that the children that perform well academically were from well-educated families. The perception of parental (Sanders, 1998) and other types of social support (Legault et al., 2006) is also significant. The literature emphasizes that both family and neighbourhood social capital plays an important role for children gaining their knowledge and participating in public engagement (Lenzi et al., 2012). As a child develops mainly within the family, elements of family social capital, such as trust and networks, seem to have positive effects on the child's choices, accomplishments, and schooling performance (Putnam, 2000). Findings indicate that school-age children who perceive high support from all three sources (parents, peers and teachers) as opposed to none, one, or two, have better school attendance, have higher school satisfaction,

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engagement, study more, avoid problem behaviour, and show greater self-efficacy as well as higher schooling achievements. Thus, the combined support of parents, teachers and friends promotes positive school outcomes (Huang, 2009; Parcel & Dufur, 2009; Rodgers & Rose, 2002; Rosenfeld, Richman, & Bowen, 2000; Schwartz et al., 2009).

A study in Lithuania that examined family support have found that only 18% of school-age children perceived high support from their families and 25% did not feel supported at all (Buzaitytė-Kašalynienė, 2004). The results of another study in Lithuania showed that the better children perceive the relationship with teachers, the better their academic performance (Jurkėnaitė & Cibulskaitė, 2014).

To the knowledge of the authors of the current paper, there has been lack of studies investigating the associations between family, neighbourhood, and school social capital on youth academic performance. Along with social capital domains, there has also been a lack of studies that include covariates, such as physical activity, psychological distress, body-mass index, gender, and self-perceived socioeconomic status affecting academic achievements. Thus, the present study aimed to determine the associations between family, neighbourhood, and school social capital with academic achievement among Lithuanian secondary school pupils.

Methods

Participants

The study was conducted among Lithuanian secondary school students. They were selected using a random sampling approach. A total of 1863 adolescents (906 males and 957 females) aged 16-18 years were enrolled in the 2015-2016 school year. Characteristics are presented descriptively in Table 1. Before the procedure, all participants and their parents/guardians signed informed consent for testing approval. Every procedure

TABLE 1 Characteristics of the Study Participants

Characteristics	Total (N=1854) N (%)	Male (N=901) N (%)	Female (N=953) N (%)	p*
Body mass index				
Normal (<25 kg/m$^{2)}$	1683 (91.0)	793 (88.0)	890 (93.4)	
Overweight/obesity (≥25 kg/m^{2})	171 (9.0)	108 (12.0)	63 (6.6)	<0.001
Self-rated health				
Poor	808 (43.6)	306 (34.0)	502 (52.7)	
Good	1046 (56.4)	595 (66.0)	451 (47.3)	<0.001
Self-perceived socioeconomic status				
Low	413 (22.3)	205 (22.7)	208 (21.8)	
Middle/high	1441 (77.7)	696 (77.3)	745 (78.2)	0.632
Psychological distress				
Low	1554 (83.8)	821 (91.1)	733 (76.9)	
High	300 (16.2)	80 (8.9)	220 (23.1)	<0.001
Physical activity				
Low	419 (22.6)	159 (17.6)	260 (27.7)	
Moderate/vigorous	1434 (77.4)	742 (82.4)	692 (72.6)	<0.001
Family social capital				
Poor	224 (12.1)	109 (12.1)	115 (12.1)	
Good	1630 (87.9)	792 (87.9)	838 (87.9)	0.984
Neighbourhood trust				
Poor	939 (50.6)	405 (44.9)	534 (56.0)	
Good	915 (49.3)	496 (55.1)	419 (44.0)	<0.001
Informal social control				
Poor	1286 (69.4)	650 (72.1)	636 (66.7)	
Good	568 (30.6)	251 (27.9)	317 (33.3)	0.012
Vertical school trust				
Poor	922 (49.7)	415 (46.0)	507 (53.2)	
Good	932 (50.3)	486 (54.0)	446 (46.8)	0.002
Horizontal school trust				
Poor	856 (46.2)	364 (40.4)	492 (51.6)	
Good	998 (53.8)	537 (59.6)	461 (48.4)	<0.001
Reciprocity at school				
Poor	429 (23.1)	205 (22.7)	224 (23.5)	
Good	1425 (76.9)	696 (77.3)	729 (75.6)	0.701

Note. *Chi-square test

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that was carried out was done so in accordance with the ethical standards of the institutional and/or national research committee and also met the ethical standards of the 1964 Helsinki declaration.

Academic achievement

The Lithuanian school system has 10-item scale categories representing student's average grade points: (1.00-1.99) completely poor, (2.00-2.99) very poor, (3.00-3.99) poor (all three are equivalent to grade F in US grading system), (4.00-4.99) unsatisfactory (is an equivalent of grade D), (5.00-5.99) sufficient, (6.00-6.99) satisfactory – both represent C, (7.00-7.99) highly satisfactory, (8.00-8.99) good – are an equivalent of B, (9.00-9.99) very good and (10.00) excellent; both represent grade A in the US grading system (http:// www.classbase.com/countries/Lithuania/Grading-System). Table 2 presents the average grades for males and females.

TABLE 2 Academic Achievement Points According to Gender

	Total (N=1854)	Male (N=901)	Female (N=953)	Z	p*
Students' achievement	7.95±1.19	7.57±1.25	8.32±1.01	13.21	**<0.001**

Note. *Man-Whitney U test

Social capital domains

Social capital in children and youth consists of family, neighbourhood and school social trust (Morrow, 1999). One item was used to assess family social capital: "Do you feel that your family understands and gives attention to you?". Neighbourhood social capital was assessed using two items: "Do you feel people trust each other in your neighbourhood?", indicating neighbourhood trust and "Do you feel that your neighbours step in to criticize someone's deviant behaviour during high school", indicating informal social control. School social capital was assessed using three items: "Do you feel that teachers and students trust each other in your high-school?", "Do you feel students trust each other in your high-school?" and "Do you think students collaborate with each other in your high school?". The first school social capital item referred to vertical school trust, the second one to horizontal school trust, and the third to reciprocity at school. Possible answers were arranged across a five-item Likert-type scale: (1) strongly agree, (2) agree, (3) neither agree nor disagree, (4) disagree and (5) strongly disagree. We binarized the outcome of each variable as "high" (strongly agree and agree) and "low" (neither agree nor disagree, disagree and strongly disagree).

Covariates

The validated short version of the International Physical Activity Questionnaire (IPAQ) was used to assess covariates of physical activity and was expressed as the metabolic equivalent hours per week) (Craig et al., 2003). As additional potential mediators, self-reported height and weight were used to calculate body mass index. Based on body mass index results, participants were divided into two groups (normal and overweight/obese), according to the International Obesity Task Force. Parental socioeconomic status was entered in our regression models as a potential confounder, that is, theoretically associated with self-rated health and social capital (Subramanian et al., 2002). The participants' socio-economic status was based on their parents' occupation at the time the research was carried out. Three levels were used to categorize self-measured socio-economic (high, middle and low) (Wang et al., 2005); it was defined as high/middle (answers from 2-4) and low (answers from 5-6).

A potential confounder was psychological distress and was assessed using the six-item Kessler scale by the questions: "About how often during the past 30 days did you feel nervous?", "During the past 30 days, about how often did you feel hopeless?", "During the past 30 days, about how often did you feel restless or fidgety?", "How often did you feel so depressed that nothing could cheer you up?", "During the past 30 days, about how often did you feel that everything was an effort?" and "During the past 30 days, about how often did you feel worthless?" (Kessler et al., 2003). Every item is given a score from 0 (never) to 4 (always). When all six questions were totalled together, a lower result suggested lower psychological distress. A score of 13+ was used as a scoring system in the literature (Kessler et al., 2003).

The question "How would you estimate your health?" was used to asses self-rated health. Possible responses were arranged through a five-item Likert-scale: very poor (1), poor (2), fair (3), good (4) and excellent (5). Given responses were binarized, where answers very poor, poor and neither poor nor good were categorized as poor, while good and excellent represented good self-rated health. Perceived health in previous research has been used as a measure of predicting mortality in adults (Idler & Benyamini, 1997), as well as in adolescents (Johnson & Richter, 2002).

Statistical analysis

SPSS 18.0 software was used to analyse all the data (SPSS Inc. Chicago, IL USA). Percentages were used to determine the number of questions answered (%). A Chi-square test was used to determine the categorical variables. Gender differences in average grade points were determined using a non-parametric Man-Whitney U-test. The relationship between social capital and schooling performance were determined using multivariate regression analysis. Gender, body mass index, level of socio-economic status, self-rated health,

level of psychological distress, and level of physical activity were used as potential cofounders. In the present study, we investigated the associations between family social capital and academic achievement (model 1; adjusted for gender, body mass index, self-rated health, self-perceived socioeconomic status, psychological distress and physical activity), between neighbourhood social trust and academic achievement (model 2; adjusted for gender, body mass index, self-rated health, self-perceived socioeconomic status, psychological distress and physical activity), between school social trust and academic achievement (model 3; adjusted for gender, body mass index, self-rated health, self-perceived socioeconomic status, psychological distress and physical activity) and between all social capital determinants, simultaneously entered into the model, with academic achievement (model 4; adjusted for gender, body mass index, self-rated health, self-perceived socioeconomic status, psychological distress and physical activity).

Results

Over 90% of all participants had normal body mass index. Roughly, 40% of all participants reported having poor self-rated health. Males and females almost equally reported middle/high self-perceived socioeconomic status. Females reported having higher psychological distress than males did (23.1% vs. 8.1%, respectively). Furthermore, females had higher distrust towards neighbours, teachers and other colleagues than males did (Table 1).

Average grade points are presented in Table 2. According to the analysis, females had significantly better grade averages than males did ($p<0.001$).

The associations between family, neighbourhood, and school social capital with academic achievement are presented in Table 3. While controlling for gender, body mass index, self-rated health, self-perceived socioeconomic status, psychological distress, and physical activity, better academic achievement was significantly predicted by higher family social capital in Model 1 (β 0.28; 95% CI 0.09 to 0.54) and by higher horizontal school trust (β 0.15; 95% CI 0.03 to 0.27) as well as better perceived reciprocity at school (β 0.22; 95% CI 0.08 to 0.36) in Model 3. Neighbourhood trust and informal social control had no predictive value in Model 2. When all variables were entered simultaneously in Model 4, better academic achievement was predicted by higher family social capital (0.27; 95% CI 0.08 to 0.0.45), lower neighbourhood trust (β -0.11; 95% CI -0.22 to -0.01), higher horizontal school trust (β 0.17; 95% CI 0.05 to 0.29) and better perceived reciprocity at school (β 0.21; 95% CI 0.07 to 0.34). Informal social control and vertical school trust remained insignificant ($p > 0.05$) in the last model. Gender (females reported higher grade point average), higher self-rated health, self-perceived socioeconomic status and physical activity, and lower body mass index and psychological distress were related with higher schooling performance.

TABLE 3 Associations between Predictors with Individual High-school Academic Achievement

Predictors	Model 1 β (95% CI)	Model 2 β (95% CI)	Model 3 β (95% CI)	Model 4 β (95% CI)
Family social capital	0.28 (0.09 to 0.47)***			0.27 (0.08 to 0.45)**
Neighbourhood trust		-0.03 (-0.13 to 0.08)		-0.11 (-0.22 to -0.01)*
Informal social control		-0.05 (-0.16 to 0.05)		-0.06 (-0.17 to 0.04)
Vertical school trust			-0.06 (-0.17 to 0.05)	-0.06 (-0.18 to 0.05)
Horizontal school trust			0.15 (0.03 to 0.27)*	0.17 (0.05 to 0.29)**
Reciprocity at school			0.22 (0.08 to 0.36)**	0.21 (0.07 to 0.34)**
Gender	0.76 (0.65 to 0.86)***	0.76 (0.65 to 0.87)***	0.76 (0.66 to 0.87)***	0.75 (0.65 to 0.86)***
Body mass index	-0.26 (-0.46 to -0.07)**	-0.27 (-0.46 to -0.08)**	-0.26 (-0.46 to -0.06)**	-0.26 (-0.44 to -0.06)**
Self-rated health	0.21 (0.10 to 0.32)***	0.23 (0.12 to 0.34)***	0.22 (0.11 to 0.32)***	0.21 (0.10 to 0.32)***
Self-perceived socioeconomic status	0.55 (0.42 to 0.68)***	0.57 (0.44 to 0.70)***	0.54 (0.41 to 0.66)***	0.53 (0.40 to 0.66)***
Psychological distress	-0.28 (-0.41 to -0.14)***	-0.24 (-0.38 to -0.10)**	-0.29 (-0.42 to -0.14)***	-0.31 (-0.45 to -0.17)***
Physical activity	0.15 (0.02 to 0.29)*	0.17 (0.04 to 0.30)*	0.14 (0.01 to 0.27)*	0.14 (0.00 to 0.27)*

Note. *p<0.05; **p<0.01; ***p<0.001

Discussion

The present study aimed to determine whether family, neighbourhood, and school social capital were associated with academic achievement among Lithuanian high-school students aged 16-18 years.

The development of the current system of education in Lithuania started in the 1990s. General education lasts for 12 years and is acquired in three stages: primary: four years (forms 1-4); lower secondary: six years (forms 5-10); and secondary: two years (forms 11-12). Each stage can be followed in a separate independent institution or in one general institution. Secondary education can also be provided by other types of establishments, such as classic gymnasiums and international baccalaureate (IB) schools. Education at municipal state schools is free of charge. According to the constitution adopted in 1992, education is compulsory until the age of 16 (http://

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www.smm.lt/web/en/education_1). The current research covered 10-12th form students in lower secondary and secondary schools and 2nd–4th form students in gymnasiums. Our results showed the relationship between academic achievement and family social capital, which is similar to the results of other studies (Huang, 2009; Kim & Schneider, 2005, Parcel & Dufur, 2009). Meier (1999) reported positive associations between human and economic capital at home with parent-child discussion of school activities, involvement in school activities and parent-school academic contact. Kim & Schneider (2005) showed that the alignment of parents' and students' goals increases students' odds of attending a college institution in the year after high-school graduation. The relationship of the educational upbringing of the parents is dependent on aligned ambition and action between parents and youth (Kim & Schneider, 2005). A few studies reported that a strong children's home environment was associated with greater verbal facility (Parcel & Menaghan, 1990), mathematics and reading achievements (Parcel & Menaghan, 1994), and lower levels of risky behaviours (Parcel & Menagham, 1993). Children from more cohesive families and living with both parents have advantages in educational achievement and overall well-being (McLanahan & Sandefur, 1994).

The results of the current study showed an inverse, although weak, relationship between academic achievement and neighbourhood trust. Higher neighbourhood trust was related to lower academic achievement. Most likely, relationships in the neighbourhood are not significant enough factors to impact academic achievements. Other studies reported links of neighbourhood trust to children's mental health (Meltzer, Vostanis, Goodman, & Ford, 2007). The negative impact of neighbourhood trust on children's academic achievement maybe explained following Wilson (1987), who reported that many negative outcomes observed in poor neighbourhoods. Moreover, children who live in high-poverty neighbourhoods interact poorly with people who are employed, possibly causing discouragement, and put in less effort, leading to poor performance (Wilson, 1987). Another study also showed that children's neighbourhood social capital is closely related to their parents' neighbourhood social capital. If parents avoid the local environment, then children are less likely to become immersed in local networks (Weller & Bruegel, 2009).

Since independence in 1990, there have been many changes in Lithuania: increased unemployment, emigration, crime, alcoholism, drug abuse, and depression (Juska, Johnstone, & Pozzuto, 2004) have definitely affected social connections within the communities. Furthermore, different reasons forced people to move from one area to another, which might affect neighbourhood trust as new people in the area are less likely to have high neighbourhood social capital (Weller & Bruegel, 2009). Since Independence, society in Lithuania has turned from collectivistic to individualistic. As a result, young people are generally more Westernized than their parents and the people they are surrounded with, which represents a major gap between the generations.

Academic achievement was positively associated with horizontal trust and reciprocity at school in the current study, which is similar to some other studies (Edward & Mullis, 2001; Huang, 2009). Huang (2009) found that higher school social capital was associated with better academic achievement. It also might be suggested that the nature of the relationship is one way (i.e. school social capital impacts better achievement, and not vice versa) as one retrospective study showed that assessment marks did not impact relationships at school (Emeljanovas, Malinauskas, Valantine, & Hardman, 2015). Furthermore, some studies showed that academic performance can be encouraged when schools possess social capital through strong ties and networks with communities, such as family (Coleman, 1988; Haghighat, 2005). Haghighat (2005) reported that, aside from parents' involvement, school social capital played an important role in reaching out to parents, creating a positive learning ambience for teachers and students and supporting parents to be more involved. Moreover, the author stated that school ambience (absence of conflict between teachers and students, absence of violence in the school) had a significant and positive effect on students' mathematics and reading achievements. School outreach (parents involved in students' achievements) also showed positive association with mathematics achievement, but not on reading test scores (Haghighat, 2005). Another study, from Gottfried, (2010) showed a strong positive relationship between school attendance and academic achievement for both primary and secondary school students.

This study has several limitations. First, due to its cross-sectional design, we cannot exclude possible reverse causality, that is, higher academic achievement may result in higher family and school social capital. Secondly, a subjective approach of social capital was used; therefore, common method bias is a possibility. Again, the different findings for each type of social capital suggest that this is not very likely. Third, the social capital variables in our study are analysed at the individual level. Therefore, we are referring to the students' individual perceptions of social capital.

In general, this study showed that both family and school social capital are the key factors for students' academic achievement. Cohesive and supportive family and cooperation with peers within the school contribute to better school attendance, stronger relationships and help, which lead to academic achievement. Connections between families, communities, and schools need to be built to contribute to the school effectiveness and functioning. Similar studies in other countries with different socioeconomic characteristics and different school systems need to be made for future policies and strategies to be incorporated and realized. More in-depth studies examining not only students' perceptions of different domains of social capital, but also their parents, school, family and neighbourhood social capital perceptions, would be appreciated. The interactional effect on students' achievement not only of different domains of social capital, but also of different sources of obtained information would be essential to examine in the future.

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ORIGINAL SCIENTIFIC PAPER

Comparison of Training Volumes in Different Elite Sportspersons According to Sex, Age, and Sport Practised

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ABSTRACT Training is a complex process that depends, among other factors, on the intensity and volume of training. The objective of this study was to analyse the volume of training in several sports as a function of sex and age. The study sample consisted of 302 sportspersons (men, n=132; women, n=170) who participated in the 16th Games of the Small States of Europe (1st to 6th June 2015) in representing nine countries. The subjects practised the following sports: artistic gymnastics, athletics, basketball, beach volleyball, golf, judo, shooting, swimming, table tennis, tennis, and volleyball, and were classified by sex, sport, and age (younger: ≤20 years; intermediate: from 21 to 30 years; older: ≥31 years). They responded to five questions about their training volume and the annual number of competitions in which they participated. A one-way ANOVA with a Bonferroni post hoc test was used to establish differences by sex, sport, and age group. Three-way ANOVAs (sex [men, women] × age [3 levels: younger, intermediate, older] × sport [11 sports]) were performed to determine any relationships between the variables. Neither interactions between the groups nor differences depending on sex were found in the training volumes, but the older the sportsperson, the lower the training volume (days per week, and total time per week). The sports with the greatest training volumes were artistic gymnastics and swimming, while those with the most competitions per year were basketball and volleyball.

KEY WORDS training load, training volume, performance, long-term plan, team sports

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Introduction

To reach the very peak in the world of sport performance, where medals and honours are earned by the smallest of margins, sportspersons seek every opportunity to gain a competitive edge. The successful development of an elite sportsperson requires years of careful planning and the manipulation of training variables to optimize his or her potential. To prepare for elite sport performance, sportspersons must undertake thousands of hours of training. The training process is dependent on many variables which coaches strive to structure and control to allow the sportspersons to achieve their goals (Saavedra, Escalante, García-Hermoso, & Domínguez, 2013). Training is a complex process whose intensity and volume need to be quantified and controlled. These parameters in harmony with proper rest and recovery yield desired performance adaptations (Rietjens et al., 2005). The magnitude of a training load can be determined by the relationship between training intensity and volume (Laursen, 2010). The influence of training volume and intensity on performance has been extensively studied, but the relationship between these two parameters is complex. Intensity, on the one hand, has been described as a key component of team-sport performance and should be emphasized in training (Mujika, 2013), and a system of high-volume training, on the other, is characteristic of an elite sportsperson's preparation. Evidence of a sudden rise in training volume of elite sportspersons was seen in the almost doubling of swimmers' training volumes in preparation for the 1972 Olympic Games, and the improvement of world records in sports is generally

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recognized as reflecting higher training volumes (Ericsson, Frampe, & Tesch-Römr, 1993). Although evidence has been found for decreasing volumes over the past decade, this can at least in part be explained by the increase in the number of competition days, advances in training methods, and enhanced technology (Issurin, 2008).

Adaptation to training volume and intensity can be different in men and women, producing different results. A recent study, for example, showed that women respond more strongly to two phases of an eight-week resistance training program than men do, and the authors conclude that the adaptation is sex-influenced (Ribeiro et al., 2015). Similarly, the values of maximum oxygen consumption in children and adolescents differ between the sexes (Armstrong, Tomkinson & Ekelund, 2011). While in elite endurance sports (e.g., triathlon) there are no differences in training volume between men and women (Knechtle et al., 2015), younger and lower-level sportswomen (intercollegiate distance runners) train fewer miles per week and have fewer weekly sessions than their male counterparts do (Deaner, Lowen, Rogers, & Saksa, 2015).

Age is another factor determining training volume. Sports participation is often encouraged and introduced early in children's lives as a way of maintaining a healthy lifestyle, of engaging in social interaction, and for enjoyment (Post et al., 2017). In elite adult sportspersons, training volume can reach 5 to 8 hours per day. In the last decade, training volumes have increased to 25-30 hours per week at their highest, eventually reaching elite status at around 4000 hours per year (Côté, Baker, & Abernethy, 2007). However, in general terms, the increase in training volume is usually gradual until puberty, after which it increases substantially until adulthood when, in general, it is usually maintained to allow an increase in intensity (Bompa & Haff, 2009). In this sense, different models of long-term sportsperson development have been proposed.

One model, initially developed in Canada (Balyi, 2001), points to different stages over a sportsperson's life: 1) active start (0-6 years old), 2) fundamental (men: 6-9 years old; women: 6-8 years old), 3) learn to train (men: 9-12 years old; women: 8-11 years old), 4) train to train (men: 12-16 years old; women: 11-15 years old), 5) train to compete (men: 16-23 years old; women: 15-21 years old), 6) train to win (men: >19 years old; women: >18 years old), and 7) active for life (physical activity sports). Sometimes, however, these stages are not respected, and there is early specialization in which volume and intensity are increased before puberty, which can lead to injuries (Post et al., 2017). Moreover, the age of peak sports performance usually coincides with training stages in which the volume is constant, although this may change from one sport to another. Thus, sports with high anaerobic demands, such as basketball, athletics, and table tennis, tend to have a peak age of around 22-28 years, whereas the more endurance- and technique-based events are at the older end of that continuum. In general, women peak at a younger age, e.g., in swimming at 18-22 years old, and in gymnastics, the most extreme, usually at around 14-18 years old (Stone, Stone, & Sand, 2007). Furthermore, the age of peak competitive performance decreases linearly with increasing event duration for explosive power or sprint events, and increases linearly with increasing event duration for endurance events (Allen & Hopkins, 2015).

With regard to sporting specialities, an adequate combination of volume and intensity is a prerequisite for efficient training. This combination is dependent on the duration and, therefore, on the metabolic requirements, of discipline-specific competition (Faude et al., 2008). Thus, for example, professional cyclists accumulate between 29,000 and 35,000 kilometres per year, while other specialities such as the 800-metre footrace have fewer hours of training (Laursen, 2010). Nonetheless, even within the same sport, for example, in swimming, the training volume can differ markedly between individuals of the same speciality and level (Saavedra et al., 2013). Moreover, there can be high training volumes in events that last just a little over two minutes, such as the 200-metre butterfly swim, in which the last Olympic women's champion, Mireia Belmonte, for the last Olympics accumulated nearly 200 weeks of >80 km swum per week, 6 to 10 hours weekly of dryland training, and 12 to 14 weeks of altitude training per year (Mujika, 2017). In this context, the objective of the present study was to analyse the volume of training in various sports as a function of sex and age.

Methods

Subjects

A total of 653 sportspersons were invited to participate in this study through the collaboration of National Olympic and Sports Association of Iceland (Itrotta- og Olympiusamband Islands) (ISI). The final sample consisted of 302 sportspersons (men, n=132; women, n=170) who participated in the 16th Games of the Small States of Europe (1st to 6th June 2015) in the representation of nine countries: Andorra (n=25), Cyprus (n=13), Iceland (n=76), Liechtenstein (n=22), Luxembourg (n=51), Malta (n=16), Monaco (n=51), Montenegro (n=18), and San Marino (n=30). The subjects participated in eleven sports: artistic gymnastics (n=18), athletics (n=40), basketball (n=56), beach volleyball (n=13), golf (n=5), judo (n=20), shooting (n=11), swimming (n=52), table tennis (n=11), tennis (n=7), and volleyball (n=63). They were classified by sex, sport, and age (younger: ≤20 years old; intermediate: between 21 and 30 years; older: ≥31 years old), and completed an informed consent form. The study was approved by the Ethics Committee of the National Bioethics Committee of the Government of Iceland and followed the principles of the Declaration of Helsinki.

Instrument

The sportspersons responded to a short questionnaire (Saavedra, Escalante & Rodríguez, 2010) about their volume of training and competition: 1) *How many years have you been training?* 2) *How many days a week do you train?* 3) *How many hours a week do you train?* 4) *How many hours does your training session last?* and 5)

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How many competitions do you have in a year?

Procedure

Initially, the researchers contacted the Olympic Committee of the country that organized the games to explain the project. Subsequently, they contacted the National Olympic Committees to explain the study. Informed consent and questionnaires were filled out by each participant before the competition. Both the consent and the questionnaire was presented in the official language of each country.

Data analysis

The normality and homoskedasticity of the distributions were tested using the Kolmogorov-Smirnov and Levene tests, respectively. Basic descriptive statistics (mean and standard deviation) were used to characterize the sample. A one-way ANOVA with a Bonferroni post hoc test was used to establish differences by sex, sport, and age group. Three-way ANOVAs (sex [men, women] × age [3 levels: younger, intermediate, older] × sport [11 sports]) were performed to determine the relationships between the variables. A p-value <0.05 was considered to be statistically significant. All analyses were performed using the computer software Statistical Package for Social Sciences (SPSS) version 21.0.

Results

Table 1 presents the results of the one-way ANOVA according to the sex. Only the variable "How many years have you been training?" presented differences between men and women.

TABLE 1 Means and standard deviations of responses to training volume questions, and one-way ANOVA as a function of sex.

	Men (*n*=132)	Women (*n*=170)	*F*	*p*
	Mean (SD)	Mean (SD)		
How many years have you been training?	10.88 (2.00)	10.38 (2.42)	3.726	0.045
How many days a week do you train?	5.00 (1.4)	5.19 (1.18)	1.637	0.202
How many hours a week do you train?	15.85 (5.34)	15.29 (4.58)	0.944	0.322
How many hours does your training session last?	2.38 (0.61)	2.52 (0.81)	2.850	0.092
How many competitions do you have in a year?	17.56 (6.14)	18.45 (6.31)	1.481	0.225

Table 2 presents the results of the one-way ANOVA with Bonferroni post hoc test according to age. All variables except "How many competitions do you have in a year?" presented differences between age groups. The younger sportspersons train more days per week and more times per week than the intermediate group, who in turn train more than the older group. The duration of the session is longer for the younger than for the older sportspersons.

TABLE 2 Means and standard deviations of responses to training volume questions, and one-way ANOVA with Bonferroni post hoc test as a function of age.

	(a) Younger (≤20 years) (*n*=108)	(b) Intermediate (21 to 30 years) (*n*=152)	(c) Older (≥31 years) (*n*=42)	*F*	*p*	Differences
	Mean (SD)	Mean (SD)	Mean (SD)			
How many years have you been training?	9.59 (2.53)	10.97 (1.92)	11.65 (1.55)	18.551	<0.001	a,b<c
How many days a week do you train?	5.54 (1.11)	5.04 (1.27)	4.31 (1.34)	16.836	<0.001	a>b>c
How many hours a week do you train?	16.89 (4.80)	15.40 (4.92)	12.87 (4.10)	11.796	<0.001	a>b>c
How many hours does your training session last?	2.59 (0.79)	2.43 (0.72)	2.27 (0.54)	3.450	0.033	a>c
How many competitions do you have in a year?	17.41 (6.05)	18.63 (6.31)	17.80 (6.40)	1.192	0.305	-

Table 3 shows the results of the one-way ANOVA with Bonferroni post hoc test according to the sport. All the variables showed differences. Artistic gymnastics, athletics, and swimming are the sports that involve the most days of training. Artistic gymnastics and swimming have the most training time per week, and artistic gymnastics and shooting have the longest training sessions. Finally, the team sports (basketball and volleyball) have more competitions per year than the other sports do.

There were no significant differences with respect to interactions (sex × age × sport) in any question: "How many years have you been training?" (F=.163, p=.999), "How many days a week have you been training?" (F=.967, p=.478), "How many hours a week do you train?" (F=1.252, p=.255), "How many hours does your training session last?" (F=1.582, p=.106), "How many competitions do you have in a year?" (F=1.903, p=.060).

TABLE 3 Means and standard deviations of responses to training volume questions, and one-way ANOVA with Bonferroni post hoc test as a function of the sport

	(a) Artistic gymnastics (n=18)	(b) Athletics (n=48)	(c) Basketball (n=56)	(d) Beach volleyball (n=13)	(e) Golf (n=5)	(f) Judo (n=20)	(g) Shooting (n=11)	(h) Swimming (n=52)	(i) Table tennis (n=11)	(j) Tennis (n=7)	(k) Volleyball (n=63)	F	p	Differences
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)			
How many years have you been training?	11.19 (1.17)	9.93 (2.89)	11.61 (1.17)	9.09 (2.43)	10.75 (1.89)	11.42 (1.21)	9.91 (4.37)	12.13 (2.06)	10.91 (2.30)	10.71 (2.56)	10.68 (2.00)	3.176	0.001	b,d<c<h
How many days a week do you train?	5.57 (0.75)	5.48 (1.11)	4.89 (1.29)	4.23 (1.17)	3.25 (0.50)	5.05 (1.32)	4.10 (1.20)	6.17 (0.61)	3.60 (0.97)	5.57 (0.96)	4.69 (1.27)	11.732	<0.001	a>c,e,g,i b>d,e,g,i,k h>c,d,e,f,g,i,k f,j>i
How many hours a week do you train?	20.07 (4.07)	15.26 (4.56)	14.45 (4.17)	13.35 (3.92)	12.25 (1.50)	14.53 (4.13)	13.20 (4.87)	20.13 (4.17)	11.95 (3.76)	18.79 (5.82)	13.17 (3.56)	13.838	<0.001	a,h>b,c,d.e.f.g.i.k j>i,k
How many hours does your training session last?	3.24 (0.60)	2.26 (0.44)	2.06 (0.23)	3.31 (0.48)	2.50 (0.58)	2.35 (0.68)	3.00 (1.25)	2.70 (0.82)	2.36 (0.50)	3.14 (0.90)	2.53 (0.82)	6.492	<0.001	a>b,c,f,k b<g,h,j,k
How many competitions do you have in a year?	10.57 (1.21)	14.95 (5.16)	23.29 (4.75)	17.04 (6.24)	18.25 (7.89)	14.20 (5.00)	14.75 (5.33)	17.38 (5.82)	16.27 (7.03)	20.21 (5.52)	21.29 (4.23)	16.668	<0.001	a<c,k c>b,d,f,g,h.i k>b,f,g,h

Discussion

This study has analysed the training volume of more than 300 elite sportspersons based on sex, age, and sport practised. It offers the first comparison of participation in the same sport championship, in this case, the Games of the Small States of Europe. This championship is held every two years, and only countries with fewer than 1,000,000 inhabitants can participate. In general, the study has shown that there are no differences in training volume between men and women, but the older the sportsperson, the fewer the days per week and the less total time per week they train. The sports with the greatest training volumes were artistic gymnastics and swimming, and those with the most competitions annually were basketball and volleyball. These results suggest that training volume does not depend on sex but does depend on age and the sport practised. This seems to indicate the need for the individualization of training volume according to these last two aspects. This concurs with the International Olympic Committee consensus statement on training load in sport and injury risk (Soligard et al., 2016), indicating that training volume should always be monitored individually.

There were no differences by sex in the variables related to training volume except for the variable "How many years have you been training?" (men: 10.88±2.00 years; women:10.38±2.42 years; F=3.726; p=.045). Perhaps this is because the male participants were older on average than the females (26.54 years versus 23.89 years, respectively). These results do not concur, however, with the "long-term athlete development model" (Balyi, 2001), which showed that women should start the training stages before men: train to train, train to compete, and train to win. With respect to age, the younger sportspersons (<20 years old) had more training days and greater total training time per week than those of 21 to 30 years in age, and these in turn more than those of 31 years in age or older. Young sportspersons take on more generalized training than older sportspersons who concentrate more on sport-specific training aimed at maintaining performance levels for competition (Stone et al., 2007). However, this general training does not always entail longer training time. While at young ages training is usually focused on technique and aerobic content, in adulthood, training is usually focused on anaerobic content (Sweetenham, 2006). While the latter requires less time involving effort at high speeds, it also requires more recovery time, so that the total training time could be similar.

Analysing the sports disciplines, we observed that artistic gymnastics and swimming had the most sessions and total training time per week. The values found were lower than those reported in other studies (Saavedra et al., 2013; Silva & Paiva, 2013). A weekly training time of more than 35 hours in artistic gymnastics has, however, been associated with poor sleep quality (Silva & Paiva, 2013). The sports with longest training session durations were artistic gymnastics, tennis, and shooting. This could be because the first two of these sport specialities have high technical complexity, which means that they require a considerable recovery time between exercises, while shooting requires an extra time of concentration before each shot, which could lengthen the duration of its training sessions. Regarding the annual number of competitions, basketball and volleyball had the most (more than 21 competitions per year). That team sports reported more competition days was to be expected since these sports normally compete in a league format with multiple games, whereas individual sports

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usually enter a competition lasting a couple of days or more. Although basketball and volleyball competition management organisations develop more matches per year, it should be taken into consideration that the increase in the number of competitions per year could lead to an increase in the number of injuries (Soligard et al., 2016). In this sense, it would be interesting to identify the cut-off points for the maximum number of annual competitions for young and professional sportspersons (Schwellnus et al., 2016).

This study has various limitations. First, the level of the participants was heterogeneous. They all represented their different countries; some of them were at levels that would allow them to compete in World Championships or Olympic Games, while others were not at that level. Second, the distribution of the number of participants was not the same in all the sports. Third, Olympic and non-Olympic sports were compared with each other – a fact that could have influenced the training volumes that each of them implemented.

In conclusion, the study has shown that, in the sportspersons analysed, while their training volume is unrelated to their sex, it is related to their age. In particular, the older the sportsperson, the less their volume of training (training sessions per week and weekly training time). There are differences in training volume depending on the sport, with artistic gymnastics and swimming being the sports that have the greatest volumes. These results seem to reflect the need to prescribe the volume of training according to the sportsperson's age and the sport. Finally, the sports with the most competitions annually are those that use a league system: basketball and volleyball.

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ORIGINAL SCIENTIFIC PAPER

Burnout and Paths to Turnover Intentions among South African Sport Coaches

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ABSTRACT This study investigated burnout and turnover intentions among 119 South African sport coaches (78 males and 38 females) aged 18 to 64 years (M = 30.28, SD = 9.83 years), who were recruited to participate in the study. Data were collected using the Maslach Burnout Inventory and Turnover Intentions Questionnaire. The results showed that sport coaches reported low levels of emotional exhaustion and personal accomplishment, with the exception of depersonalization, demonstrating that sport coaches were less burned out. Of the three subscales of burnout, the highest significant correlation was observed between emotional exhaustion and turnover ($r = .227$, $p < .01$). The practical implications of the findings are discussed, and recommendations for future research are provided.

KEY WORDS burnout, sport, coaches, turnover intentions

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Introduction

Sport coaching is a very demanding and stressful profession (Koustelios, 2010). This is because the role of a sport coach has evolved, and coaching is steadily moving towards professionalization. Unlike in the past, when sport coaches were required to impart skills and knowledge to their athletes, today they are often also expected to perform a myriad of duties, including being a sport psychologist, planner, role model, organizer, disciplinarian, confidant, and motivator, to mention just a few. Sport coaches are expected to conduct practice sessions in preparation for games, motivate athletes to achieve, interact with the public and press, and often go on the road to scout opponents (Wuest & Fisette, 2012), while also being responsible for improving and expanding their own capabilities on an ongoing basis to fully meet the needs of the athletes they serve (International Council for Coaching Excellence and the Association of Summer Olympic International Federations, 2012). Additionally, sport coaches need to keep abreast of the latest technology in sport in order to improve their athletes' performances.

These and many more demands, coupled with the pressure to win, impose considerable stress on coaches. Sometimes, the pressure to do it all and do it well can be overwhelming for coaches (Wuest & Fisette, 2012), thereby frustrating them to the extent that they feel they have to leave the coaching profession prematurely. Although some researchers (e.g. Everhart & Chelladurai, 1998; Kamphoff, 2010; Kubayi, 2015; Kubayi, Coopoo, & Morris-Eyton, 2015) have found that coaches leave the profession due to factors such as unfavourable working hours, low salary, interference from management, time constraints, job insecurity, inadequate resources, and parental pressure, Wuest and Fisette (2012) and Raedeke (2004) are of the opinion that most coaches stop coaching because of a desire for a career change, disenchantment with the profession, and most importantly, as a consequence of burnout. Burnout can be defined as a psychological syndrome of emotional exhaustion, depersonalization, and reduced personal accomplishment that can occur among individuals who work with people in some capacity (Maslach, Jackson, & Leiter, 1997).

Burnout has drawn increasing interest from researchers in a number of disciplines (Raedeke, Granzyk, &

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Warren, 2000). Consequently, this has resulted in studies investigating the prevalence of burnout among sport coaches (Hjalm, Kentta, Hassmenan, & Gustafsson, 2007). However, according to Kelley, Eklund, and Ritter-Taylor (1999), early studies on the subject of burnout have sought to examine demographic (e.g. gender, marital status, coaching experience, individual or team sports), dispositional (e.g. leadership style) and situational variables (e.g. role ambiguity, work overload) (e.g. Caccese & Mayerberg, 1984; Dale & Weinberg, 1989; Pastore & Judd, 1993). Despite the significant contribution of such studies, turnover has received surprisingly little attention in research on coach burnout (Kilo & Hassmen, 2016).

Consequently, there is a lack of information about the role of burnout in association with turnover intentions (Zhang & Feng, 2011). Such research is important because the repercussions of burnout are numerous and often quite severe, affecting coaches as well as athletes. Furthermore, insomnia, hypertension, ulcers, and other stress-related symptoms may manifest themselves in burned-out sport coaches (Wuest & Fisette, 2012). Burnout is also associated with low productivity, absenteeism, deterioration of health and employee turnover. Workers (i.e., coaches) who are burned out are more likely to remain in their current jobs but will be dysfunctional or ineffective, or seek another profession, or leave the profession entirely (De Croon, Sluiter, Blonk, Broersen, & Frings-Dresen, 2004; Gencay & Gencay, 2011; Wuest & Fisette, 2012). Similarly, coach turnover is of great concern because it forces organizations and clubs to use already limited resources to recruit new coaches, rather than developing existing ones (Sport Coach UK, 2013).

Therefore, this study seeks to fill the gap in the literature by investigating burnout and intentions to leave the coaching profession among South African coaches. The results of this study could provide a better understanding of the early detection of potential coach turnover and possible strategies to prevent it (Leiter & Maslach, 2009). Specifically, the aims of this study were twofold: (1) to examine the prevalence of burnout among sport coaches, and (2) to ascertain the relationship between burnout and turnover intentions among sport coaches.

Methods

Participants

The sample comprised 119 sport coaches (78 males and 38 females) aged between 18 and 64 years (M = 30.28, SD = 9.83 years). The participants represented four sports: rugby (n = 58), netball (n = 24), cricket (n = 24), and hockey (n = 12). The participants were purposively recruited to participate in this study through their sport federations.

Measures

Maslach Burnout Inventory

Coach burnout was measured using the Maslach Burnout Inventory (MBI) (Maslach & Jackson, 1986). The MBI measures three subscales of burnout: emotional exhaustion, depersonalization, and personal accomplishment. The emotional exhaustion subscale contains nine items (e.g. "I feel frustrated by my job"), the personal accomplishment subscale consists of eight items (e.g. "I feel very energetic"), and the depersonalization subscale comprises five items (e.g. "I worry that this job is hardening me emotionally"). All items were anchored on a 7-point Likert scale, ranging from 0 (*never*) to 6 (*every day*).

Turnover Intentions Questionnaire

Three items developed by Meyer, Allen, and Smith (1993) and adapted by Kilo and Hassmen (2016) were used to assess sport coaches' intentions to leave the coaching profession. Examples of these items included "I plan to leave the coaching profession in the next year due to job stress", "I think a lot about quitting coaching because of job stress", and "I am actively searching for a position outside of coaching because of job stress". All items were scored on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Data collection and analysis

Prior to data collection, this study received full ethical clearance from the Faculty of Science Research Ethics Committee of the Tshwane University of Technology, South Africa. Informed consent was sought from the participants after the purpose of the study was explained. The questionnaires were administered to the participants in hand and collected once completed. Data analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 23. Descriptive statistics such as means, standard deviations and frequencies were used to analyse the data. Correlation coefficients were also computed to assess the relationships between the three dimensions of burnout and turnover intentions among sport coaches.

Results

Table 1 shows the descriptive statistics of the burnout subscales according to demographic variables. Female coaches reported higher levels of emotional exhaustion (M = 20.24, SD = 11.15), while male coaches reported a high score of personal accomplishment (M = 35.06, SD = 8.34) and depersonalization (M = 7.73, SD = 6.38). Findings further showed that the coaches' emotional exhaustion seemed to increase with age and coaching experience. Additionally, experienced coaches (6–10 years) scored high on emotional exhaustion (M = 21.28, SD = 14.71) and depersonalization (M = 12.67, SD = 7.39) than less experienced (1–5 years) and more experienced coaches (11+ years).

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TABLE 1 Means and Standard Deviations of Burnout Subscales for Demographic Variables

Variable	n	Emotional exhaustion M (SD)	Personal accomplishment M (SD)	Depersonalization M (SD)
Sex				
Male	78	14.27 (10.89)	35.06 (8.34)	7.73 (6.38)
Female	38	20.24 (11.15)	33.55 (10.28)	7.55 (6.57)
Age categories				
18–29 years	65	14.31 (10.51)	35.42 (9.45)	6.20 (5.76)
30–39 years	26	18.35 (13.30)	33.77 (7.24)	9.62 (7.58)
40+	25	19.00 (10.37)	33.20 (9.56)	9.48 (5.95)
Coaching experience				
1–5 years	81	14.75 (10.10)	34.80 (8.92)	6.57 (5.94)
6–10 years	18	21.28 (14.71)	34.11 (9.90)	12.67 (7.39)
11+	17	17.88 (11.44)	33.94 (8.92)	7.65 (5.18)

Table 2 displays the MBI subscales' norms set by Maslach, Jackson, and Leiter (1996) and the means of coaches' three dimensions of burnout. In comparison to the norms, the results of the present study indicated that coaches scored relatively low on emotional exhaustion and personal accomplishment, with the exception of depersonalization, thus suggesting that coaches were less burned out.

TABLE 2 Comparisons of Present Sample to Gender Norms on the Maslach Burnout Inventory

Variable	Emotional exhaustion M (SD)	Personal accomplishment M (SD)	Depersonalization M (SD)
MBI norms			
Male	19.86 (10.47)	36.29 (6.76)	7.43 (5.99)
Female	20.99 (10.66)	36.50 (6.56)	7.02 (6.34)
Present study			
Male	14.27 (10.89)	35.06 (8.34)	7.73 (6.38)
Female	20.24 (11.15)	33.55 (10.28)	7.55 (6.57)

Correlation coefficients for demographic variables, the three burnout subscales, and turnover intentions are shown in Table 3. Among the three subscales of burnout, the highest correlation was found between turnover intention and emotional exhaustion ($r = .227$, $p < .01$), and the least negative relationship with depersonalization ($r = -.195$, $p < .05$). However, there was a strong positive correlation between emotional exhaustion and depersonalization ($r = .615$, $p < .01$).

TABLE 3 Correlations Between Demographic Variables, Burnout Subscales and Turnover Intention

Variable	1	2	3	4	5	6
Age	–					
Coaching experience	.627**					
Emotional exhaustion	.157	.172				
Personal accomplishment	–.050	.070	–.250**			
Depersonalization	.197*	.149	.615**	–.175		
Turnover intentions	.224*	.033	.227**	.212*	–.195*	–

Note: *p<.05; **p<.01

Discussion

The primary aim of this study was to examine the prevalence of burnout among coaches. Female coaches reported higher scores of perceived burnout on the emotional exhaustion subscale than male coaches did. This finding is consistent with that of Pastore and Judd (1993). Although the reasons for high levels of emotional exhaustion among female coaches in the current study are not clear, Caccese and Meyerberg (1984) and Pastore and Judd (1993) speculated that female coaches tend to stress themselves excessively in order to prove their worth. Another possible explanation could be that female coaches are expected to perform coaching responsibilities while also fulfilling duties outside work, such as being a good wife, mother, and so forth. Thus, future studies should focus on investigating strategies that could reduce high burnout levels encountered by female coaches. This is very important for women because the proportion of female coaches is declining, and

they are leaving the coaching profession sooner than their male counterparts do. Such studies may provide strategies to encourage female coaches to remain in the profession for longer periods (Pastore & Judd, 1993).

The results of this study further showed that coaches' emotional exhaustion increased with age and years of coaching experience. This finding contradicts those of Pastore and Judd (1993) and Weinberg and Gould (2007), who reported that emotional exhaustion decreased with age and coaching experience. This result could indicate that burnout occurs over the course of time; therefore, older and experienced coaches could have accumulated it (Dale & Weinberg, 1989). In comparison to MBI norms (see Table 2) established by Maslach et al. (1996), both male and female coaches reported lower levels of emotional exhaustion and personal accomplishment and higher levels of depersonalization. This is a positive finding, given the most publicity concerning the higher levels of stress associated with the coaching profession (Dale & Weinberg, 1989; Frey, 2007; Kubayi, Toriola, & Didymus, 2018). However, this does not mean that burnout is not a problem in coaching. Rather, researchers have to be sensitive to the situational and personal variables that may be related to or predictive of burnout (Dale & Weinberg, 1989). Overall, both male and female coaches displayed lower scores of perceived burnout. A plausible reason for this finding is that coaches who feel extremely high levels of burnout have already left coaching (Weinberg & Gould, 2007). Consequently, this leaves only the "survivors" who have developed adequate coping skills to handle the extra pressure in coaching (Hjalm et al., 2007).

The secondary aim of the study was to ascertain the relationship between burnout and turnover intentions among sport coaches. Emotional exhaustion was the most strongly related subscale of burnout that significantly correlated with turnover intentions. This finding is in sync with the assertion that sport coaches who are emotionally exhausted feel that they are no longer able to give of themselves at a psychological level (Maslach et al., 1997) and are thereby more likely to withdraw from coaching. In conclusion, the results of this study showed that sport coaches experienced low levels of burnout. However, the small sample size limits the generalizations of the findings of this study to the wider South African population. Therefore, future studies should examine burnout among a larger sample of coaches in various sports (e.g. athletics, cricket, and soccer). Future research should also adopt longitudinal designs that could provide helpful information on the actual causes of burnout.

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ORIGINAL SCIENTIFIC PAPER

Post-Match Changes in Muscle Damage Markers among U-21 Soccer Players

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ABSTRACT This study aimed to investigate the effect of official soccer matches on selected markers of muscle damage in U-21 soccer players. A group of 19 trained, healthy male soccer players from the junior category took part in this study. Blood samples were assessed pre-match and immediately after a match in response to a competitive (2×45 min) soccer match. Analysis was performed for muscle damage and inflammatory markers. Significant differences between two measures (before and after soccer match) exist in Aspartate-aminotransferase (AST), Lactate dehydrogenase (LDH), and Myoglobin. Plasma K^+ significantly decreased after the match ($p<0.05$), whereas plasma Na^+ decreased slightly. This study showed that most selected markers of muscle damage were influenced by a soccer match. However, results remain inconsistent because of the influence of the type, duration, and intensity of exercise. Moreover, some markers show great variability among individuals.

KEY WORDS football, fatigue, junior players, competitive match

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Introduction

Regular physical activity can have significant health benefits. However, some activities might not be healthy, due to dehydration, substrate depletion, muscle damage, inflammation, and the increased production of free radicals. Free radicals, which are particularly produced as a result of physical exercise (Cooper, Vollaard, Choueiri, & Wilson, 2002), are involved in the process of muscle fatigue, many diseases, and aging (Finaud, Lac, & Filaire, 2006). Although there is no definitive conclusion on fatigue, it is assumed that two main origins are involved in this process. The first is the central fatigue hypothesis, in which the central nervous system blocks continued extraordinary effort, perhaps as protection from injury (Taylor, Allen, Butler, & Gandevia, 2000). The second is the peripheral fatigue, in which the muscle's homeostasis has been perturbed, either through tissue damage, or some other way, to the point that the muscle is incapable of responding as effectively as it does when rested (MacIntosh & Rassier, 2002).

Nybo et al. (2013) suggested that muscle pain, reduced power, increased creatine kinase, Myoglobin, aspartate aminotransferase and lactate dehydogenase levels are the most significant indicators of muscle damage. Two studies have used very high intensity or volume of exercise to provoke muscle damage (Byrne & Eston, 2002; Davies, Rowlands, & Eston, 2009). However, match activity in soccer is influenced by several factors. The style of play can influence the physiological demands on players. The national teams of Ireland and Norway use the "direct method of play", maintaining the game at a high pace (Reilly, 1997). Thus, the findings of a recent study (Gregson, Drust, Atkinson, & Salvo, 2010) indicate that match-to-match variability in performance characteristics of elite soccer players is high. Moreover, many factors within the body can influence muscle damage, such as inflammation (Stoner et al., 2013), nutrition (Muñoz & Costa, 2013), intake of supplements (Goldfarb, 1999; Goldfarb, Garten, Cho, Chee, & Chambers, 2011). A significant increase in muscle damage markers (Andersson, Ekblom, & Krustrup, 2008; Ascensão et al., 2008; Ispirlidis et al., 2008; Magalhães et al., 2010) has been described immediately after "friendly" soccer matches and throughout the post-match recovery. Ascensão et al. (2008) and more recently Fatouros et al. (2010) found noticeable muscle damage up to 72 hours post-exercise, following a soccer match.

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Conflict of interest: None declared.

There have been numerous studies on muscle damage after competitive matches in multiple sprint sports involving body contact, such as soccer, rugby, and field hockey. However, only a few studies have evaluated muscle damage markers immediately after the official soccer match. Therefore, this paper aimed to estimate the markers of muscle damage in U-21 players, before and immediately after an official soccer match.

Methods

Participants

A group of 19 trained, healthy male soccer players from the junior category of a Croatian soccer association took part in this study. The players were informed about the experimental procedures and possible discomforts associated with the study, and written informed consent was obtained. The study was approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb and according to the Helsinki Declaration. The participants were aware that they could withdraw from the study at any time. The participant's characteristics were in average: age 20.26 ± 0.65 years, mean ± SD: body mass: 71.3 ± 5.9; body height: 1.77 ± 0.07 and maximal oxygen uptake (VO2max) 64.95±3.99 ml·kg–1·min–1. Selection criteria included: (1) participation at professional (top three division leagues) level of soccer competition for at least 5 years, (2) all players participated in at least 75% of the training sessions per week and played at least 16 matches during season, (3) no consumption of exogenous anabolic-androgenic steroids or other drugs that might have affected their physical performance or hormonal balance during the study (for at least 6 months) (4) no recent history of febrile illness, muscle lesions, lower limb trauma, or metabolic diseases. Soccer players were instructed not to change their normal eating habits during the entire period of data collection. Nutritional supplements were not included in their diets. In addition, players were instructed to refrain from drinking beverages containing caffeine or alcohol and from consuming food in the 3 h before testing.

Blood collection and analysis

Blood samples were assessed pre-match and immediately after the match in response to a competitive (2×45 min) soccer match. On the day of the game, players arrived at the laboratory after an overnight fast of between 10 and 12 h. A resting blood sample was taken after participants had been standing for at least 15 min, after which participants consumed a light standardized meal and drink and rested for 2 h. The meal consisted of 1.7 g white bread and 0.3 g of low-fat spread (both values are per kilogram of body mass) (Thompson et al., 2003). Participants abstained from alcohol and caffeine consumption for at least 24 h and did not perform any exercise for the 72 h before testing.

Fasting venous blood samples were withdrawn into heparinized tubes from a cubital vein just before and immediately after the soccer match, then centrifuged at 3000 rpm for 10 min to separate the plasma. The plasma samples were stored at -20°C until the analysis of muscle damage and inflammatory markers.

Concerning the muscle damage and inflammatory markers, analysis of Myoglobin, Creatine kinase (CK), Lactate dehydrogenase (LDH), Aspartate-aminotransferase (AST), C-reactive protein (CRP) were automatically performed using a Dimension Xpand Plus Analyzer (Siemens, Munich, Germany). Plasma concentrations of K+ and Na+ were determined using commercially available assays on a Dimension Xpand Plus Analyzer (Siemens, Munich, Germany).

Statistical analysis

All statistical analyses were performed using the STATISTICA v.8.0 software (StatSoft Inc., Tulsa, OK, USA). Descriptive statistics and Kolmogorov–Smirnov (normality of the distribution) tests were calculated for all experimental data before inferential testing. Data were expressed as mean values ± standard deviation. A sample t-test was used to analyse where the significant variations occurred. Effect size (ES) was classified as follows: <0.2 was defined as trivial, 0.2–0.6 was defined as small, 0.6–1.2 was defined as moderate, 1.2–2.0 was defined as large, >2.0 was defined as very large and >4.0 was defined as extremely large (Hopkins, Marshall, Batterham, & Hanin, 2009). Statistical significance was set at $p < 0.05$.

Results

As can be seen in Table 1, statistically significant differences between two measures (before and after soccer match) exist in AST ($p<0.05$). Furthermore, LDH values were significantly higher immediately after the

TABLE 1 Muscle damage and inflammatory responses following an official soccer match. Data are presented as Mean ± SD

	Prematch	Postmatch	%diff	ES
Mioglobin (ng/mL)	33.29±14.91	277.77±131.19*	734.4	2.61
CRP (mg/dL)	0.52±0.34	0.50±0.39	-3.8	-0.05
AST (U/L)	25.58±11.16	34.21±14.81*	33.7	0.65
CK (IU/L)	483.53±910.78	530.89±442.52	9.8	0.06
LDH (U/L)	195.68±26.71	273.74±35.08*	39.9	2.50

Note: (CRP) C-reactive protein, (AST) Aspartate-aminotransferase, (CK) Creatine kinase, (LDH) Lactate dehydrogenase, *$p < 0.05$ from the corresponding pre-match value.

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match ($p<0.05$). No significant changes were observed in plasma CK activity after the match ($p >0.05$). This was also the case with CRP levels, for which similar results were obtained following the match ($p=0.87$). Plasma Myoglobin concentrations were significantly higher after the match in comparison to pre-match values ($p < 0.05$).

Table 2 shows plasma concentrations of K^+ and Na^+ measured before and after the matches. Plasma K^+ was significantly decreased after the match ($p<0.05$), whereas plasma Na^+ gradually decreased.

TABLE 2 Electrolyte values of the players before and after the played match. Data are presented as Mean ± SD

	Prematch	Postmatch	%diff	ES
K (mmol/L)	4.56±0.27	4.29±0.33*	-5.9%	-0.89
Na (mmol/L)	140.47±1.43	137.48±19.49	-2.1%	-0.22

Note: K- potassium; Na- sodium: *$p < 0.05$ from the corresponding pre-match value.

Discussion

The purpose of the present study was to investigate the accuracy of selected markers to reflect changes in fatigue in male U-21 players after an official soccer match. The results of this study showed that significant changes occurred immediately after an official soccer match. We found that plasma LDH, AST and Myoglobin levels increased. In addition, K^+ levels were significantly different before and after the match.

Previous investigations have reported that a single soccer match educes significant changes in muscle damage markers for as long as 48 h to 72 h post-exercise (Ascensão et al., 2008; Ispirlidis et al., 2008; Silva et al., 2013). Published data are inconsistent for many markers of muscle damage depending on the type, duration, and intensity of exercise. For instance, Takahashi et al. (2007) reported that only LDH increased after a rugby match lasting 10 min, while CK, AST, and ALT remained essentially unchanged. In contrast to this, Burger-Mendonca, Bielavsky, and Barbosa (2008) showed that maximal physical exercise leads to significant elevation of muscle damage markers and enzymes.

Lazarim et al. (2009) analysed the changes in CK levels in 128 professional soccer players at different times during the Brazilian national championship. The aforementioned authors identified the upper limit reference value of 950IU/L as the decision limit to detect muscle overload. Recently, Hammouda, Chaouachi, Ferchichi, Kallel, and Souissi (2012) showed increased CK and LDH levels after the level-1 Yo-Yo intermittent recovery test in young soccer players. Accordingly, Brancaccio, Lippi, and Maffulli (2010) consider these markers as essentially indicative of muscle damage. In this study, no significant change was observed in CK levels following an official soccer match in junior players. It is possible that due to the high frequency of matches and inadequate recovery soccer players can have consistently elevated CK, which was confirmed in one study (Heisterberg et al., 2013). Our data show much higher values compared to the upper reference value (270 UI/L), for the general population (Mougios, 2007). Furthermore, the high variability of the measure of CK activity must also be taken into account (Halson, 2014), which was the case in this study. Research conducted on elite soccer players has also reported large variability in CK levels (Meister, Faude, Ammann, Schnittker, & Meyer, 2013). Moreover, some athletes show only small increases in CK activity due to a lower permeability of muscle cell membranes (Urhausen & Kindermann, 2002). Bearing in mind that activities of CK and Myoglobin correlate with a neutrophil response induced by stress (Suzuki et al., 1999), Myoglobin represents a useful marker to monitor the effectiveness of workload on muscle tissue in training (Speranza et al., 2007). After a soccer match, Myoglobin may increase within 30 min (Ascensão et al., 2008), and remain increased for 72 hours, which is probably the result of low-grade inflammation (Neubauer, König, & Wagner, 2008). The present findings indicate that Myoglobin levels increased significantly after an official soccer match in junior professional players, which is in line with other studies.

CRP is a well-characterized biomarker of chronic inflammation. However, it is significantly influenced by BMI, gender, age, and smoking status (Shanely et al., 2013). Accordingly, a very small decrease in C-reactive protein levels was observed after the match among junior soccer players. Similarly, no relevant changes in CRP were determined following the HIIT programme (Wiewelhove et al., 2015). It appears that CRP may not be a useful muscle damage marker for monitoring fatigue and recovery immediately following a soccer match in U-21 players. However, in their study, Kostrzewa-Nowak et al. (2015) stated that CRP levels could be a valuable tool to assess the metabolic response to aerobic exercise. Because the post-match inflammatory response of CRP levels has a 24-hour peak (Ispirlidis et al., 2008), this time-course could be considered as a valuable tool for assessing fatigue in soccer players. However, other explanations of the fatigue that occurs after the intense exercise periods in soccer should be sought.

During matches, some players will lose considerable quantities of electrolytes and may need to replace these during the match (Shirreffs, Sawka, & Stone, 2006). Moreover, it has been suggested that the development of fatigue during high-intensity exercise is related to an accumulation of potassium in the muscle interstitium (Bangsbo, Madsen, Kiens, & Richter; Sejersted & Sjøgaard, 2000). This statement was supported by the observation of muscle interstitial potassium concentrations higher than 11 mmol/l during exhaustive exercise

(Nielsen et al., 2004). The aforementioned values are high enough to depolarize the muscle membrane potential and reduce force development markedly (Cairns & Dulhunty, 1995). Takarada (2003) found that plasma K^+ concentrations had significantly increased after the match, whereas plasma Na^+ concentration gradually decreased. Interestingly, we demonstrated reduced levels of plasma [K^+] after a soccer match. However, the plasma [Na^+] concentration was unchanged after an official soccer match in U-21 players, which is in line with Takarada (2003). Fraser et al. (2002) observed reduced maximal activity of the Na^+ /K^+ pump following different types of exercise. While these plasma values do not provide a clear picture of the concentrations around the contracting muscle fibres in soccer (Bangsbo, Mohr, & Krustrup, 2006), further research is needed to reveal what may cause fatigue during a soccer game.

This study approached the analysis of muscle damage markers before and immediately after the match. The strength of our study lies in the fact that the results come from an official soccer match played by U-21 professional players. We can say that most selected markers of muscle damage were influenced by a soccer match. However, the results of this study, along with those of other numerous studies are inconsistent because of the influence of type, duration and intensity of exercise. Moreover, some markers show great variability among individuals. Therefore, more studies like this are needed to reveal which markers are essential for designing the proper training programme and how to prevent injuries and overtraining in professional soccer players.

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ORIGINAL SCIENTIFIC PAPER

Jumping Exercise Restores Stretching-Induced Power Loss in Healthy Adults

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ABSTRACT The purpose of this study was to examine the acute effects of jumping exercise (JE) immediately after different stretching protocols on flexibility and power in healthy adults. This study was conducted with a balanced crossover design. Thirteen healthy males (25.4±3.46 years old) voluntarily participated in this study. All participants randomly completed four trials, including three different stretching protocols; 1) static stretching (SS), 2) dynamic stretching (DS), 3) proprioceptive neuromuscular facilitation stretching (PNFS), and 4) a non-stretching control (NS) followed by the JE with seven-day intervals between tests. JE was composed of three sets of five tuck jumps. Flexibility was determined by the ability to perform a straight leg raise (SLR) and power by vertical jump performance (VJP). Both SLR and VJP were measured at four time points; 1) baseline, 2) post-jogging, 3) post-stretching, and 4) post-JE; 4 × 4 repeated measures analysis of variances were applied. There were significant interaction effects on SLR (F=8.935, p<.001) and VJP (F=3.965, p=.009). The SLR score increased in all stretching protocols except the NS protocol post-stretching and post-JE. After stretching, the VJP score decreased in the NS (-2.6%), SS (-3.6%), and PNFS (-4.4%) protocols but maintained a positive score for the DS (1.8%) protocol. However, the VJP score recovered to the previous value in the SS (3.2%) and PNFS (6.5%) protocols after the jumping exercise. The present study suggests that jumping exercise immediately after SS and PNFS protocols could be an efficient program for restoring stretching-induced power loss in healthy adults.

KEY WORDS flexibility, jumping exercise, power, stretching

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Introduction

The importance of warm-up prior to main exercise and sports events has been widely recognized for preventing injuries and optimizing exercise performance (Woods, Bishop, & Jones, 2007). The warm-up programme generally consists of light aerobic activity, stretching, and sport-specific movements for 15-20 minutes (Woods et al., 2007). Light aerobic activities, such as jogging and cycling, have been known to increase body temperature and blood circulation, which leads to improved exercise performance, such as flexibility, strength, and power (Bishop, 2003; Young & Behm, 2002).

Stretching exercises are commonly applied following light intensity aerobic activities to increase flexibility and decrease injuries (Hartig & Henderson, 1999). Various stretching protocols, such as static stretching (SS), dynamic stretching (DS), and proprioceptive neuromuscular facilitation stretching (PNFS), have been introduced as pre-exercise stretching protocols. SS is a common stretching technique that serves as a warm-up programme, and this technique has been known to improve range of motion and decrease muscle soreness (Andersen, 2005). The DS has become a preferred choice in the athletic community in recent years, because this technique has been shown to improve performances in power (Franco, Signorelli, Trajano, Costa, & de Oliveira, 2012), sprints (Fletcher & Jones, 2004), and strength (Sekir, Arabaci, Akova, & Kadagan, 2010) despite musculotendinous unit (MTU) stiffness being decreased (Herda et al., 2013). The PNFS is widely

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applied in a clinical environment to enhance both active and passive ranges of motion with the ultimate goal being to optimize muscular performance (Bradley, Olsen, & Portas, 2007). The PNFS protocol is not commonly recommended immediately prior to explosive athletic movement because it could diminish jump performance and muscle strength (Bradley et al., 2007; Marek, Cramer, Fincher, & Massey, 2005). However, this protocol provides great benefits for those who participate in exercises that require great flexibility, such as gymnastics. Many studies on stretching and exercise performance have been conducted, but the outcomes are still controversial depending on the duration and type of stretching protocols (Bradley et al., 2007; Fletcher & Jones, 2004; Franco et al., 2012; Marek et al., 2005; Sekir et al., 2010), the performer's baseline status (Behm & Chaouachi, 2011; Donti, Tsolakis, & Bogdanis, 2014), and gender differences (Donti et al., 2014).

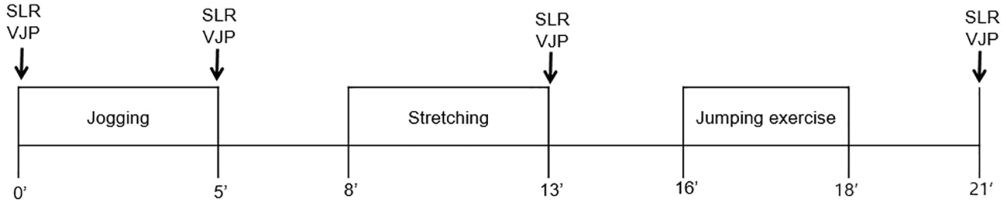
As a final component of warm-up programmes, potentiating exercise is applied with specific forms related to upcoming sports events or activities. The potentiating exercise focuses on the intensity of activities that include various explosive movements such as sprinting, jumping, and throwing (Till & Cooke, 2009; Tillin & Bishop, 2009). It has been known to facilitate a high degree of central nervous stimulation; thus, the recruitments of fast twitch motor units are enhanced (Hamada, Sale, MacDougall, & Tarnopolsky, 2000; Hodgson, Docherty, & Robbins, 2005). In particular, plyometric type jumping exercise (JE) is often used as a form of potentiating exercise. However, it is not well understood how plyometric jumping exercise influences flexibility and power performance when combined with different stretching protocols. A previous study reported that three sets of five jumping exercises after static stretching restored counter-movement jump (CMJ) in international fencing athletes (Tsolakis, Bogdanis, 2012). However, Donti et al. (2014) reported that one set of five tuck jumps did not improve power performance in elite gymnasts. Another study also reported that jumping exercise immediately after DS did not improve vertical jump performance (Turki et al., 2011).

As mentioned previously, the performance outcomes, including strength and power, following different stretching are well understood in the previous studies (Behm & Chaouachi, 2011; Bishop, 2003), but it is unclear the how the jumping exercise affects performance when combined with different types of stretching (i.e., SS, DS, and PNFS) even though warm-up programmes commonly include stretching and explosive movements. In this study, we have specifically selected a jumping exercise (tuck jump) as a potentiating exercise because strength and power in lower limbs play an important role in most sports events. In addition, the tuck jump does not require specific techniques, which enable it to be applied for general populations, such as healthy adults. Thus far, most studies regarding stretching and performance predominantly have used athletes as subjects (Donti et al., 2014; Tsolakis & Bogdanis, 2012; Turki et al., 2011). However, it is important to know that athletes are a unique group in comparison to the general population, because their body (i.e., physiological, functional) and mind (psychological) respond differently to exercise or warm-up (Dehkordi, 2001; Koch et al., 2003). We believe the importance of warm-up programmes should be emphasised in healthy adults as well as athletes as the number of participants who exercise has increased among healthy adults. This study would provide practical information to healthy adults, which enable the application of a warm-up programme before exercise or a sport event. Therefore, the purpose of this study was to examine the acute effects of jumping exercise immediately after different stretching protocols on flexibility and power in healthy adults. We hypothesize that jumping exercise immediately after different stretching protocols will enhance flexibility and power performance in healthy adults.

Methods

Participants

Participants were recruited through advertisements at the university. Seventeen healthy collegiate males voluntarily participated in this study. No subjects engaged in any stretching-related exercise (i.e. yoga, Pilates), and had no skeletomuscular injuries in the previous two to three years. During the study period, four subjects dropped out due to personal reasons. Therefore, thirteen healthy males (25.4±3.46 years, 171.7±6.97 cm, 77.0±12.28 kg) completed the study. The study procedures, including the potential risk factors, were explained to the participants. Written informed consent was obtained from the participants prior to testing. This study was approved by the Institutional Review Board of Texas A&M University-San Antonio.



* SLR; straight leg raise, VJP; vertical jump performance

* Stretching protocols: three different stretching protocols (SS, DS, PNFS) and NS control were applied in a 7-day interval

* Jumping exercise: three sets of five times tuck jump

FIGURE 1 Study procedure

Note. * SLR; straight leg raise, VJP; vertical jump performance; * Stretching protocols: three different stretching protocols (SS, DS, PNFS) and NS control were applied in 7-day intervals; * Potentiating exercise: three sets of five tuck jumps.

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Study design

This study was conducted in a balanced crossover design (Figure 1). Height and weight were measured via the use of a wall-mounted stadiometer (Stadi-O-Meter®, Rockton, USA) and a digital scale (SECA, Hamburg, Germany), respectively. Prior to stretching, participants performed five minutes of jogging on a treadmill (6.4 km/hour). Three different stretching protocols (SS, DS, and PNFS) combined with JE were randomly applied with a seven-day interval between tests. Non-stretching combined with JE served as the control group. Straight leg raise (SLR) and VJP were measured at four time points; baseline, post-jogging, post-stretching, and post-JE with three minutes of recovery time between the measurements.

Stretching protocols

Three stretching (SS, DS, and PNFS) protocols were specially targeted towards lower limb muscles (calf, hamstrings, quadriceps, and gluteus maximus). Each stretching protocol was applied to a single muscle group of 30 seconds with mild discomfort for a total of five minutes. For NS control, participants sat in a chair for five minutes. The stretching protocols were modified based on previous studies (Donti et al., 2014; Franco et al., 2012). The components of stretching techniques are described in Table 1.

TABLE 1 Stretching techniques

Stretching	Target	Description
Static	Calf	Subjects stood facing a wall further than arms-length away. Next, subjects leaned into the wall and placed their hands on the wall for stability. Subjects placed their right foot forward while leaving their left foot back. While leaning into the wall, subjects' calf muscles are stretched until the point of slight discomfort. Position was repeated for the opposite side.
	Hamstring	Subjects sat on a mat with left leg fully extended. Next, the right leg flexed at the knee and the foot was placed alongside the medial aspect of the knee of the left leg. The subjects then bent forward, keeping the back straight, while grabbing the dorsiflexed left foot until the hamstring stretched to the point of slight discomfort. Position was repeated for the opposite side.
	Quadriceps	Subjects stood facing a wall, placing their left hand on the wall for stability. The right knee was flexed so that the right hand could hold the right ankle and pull toward to hip until slight discomfort in the quadriceps. Position is repeated for the opposite side.
	Gluteus maximus	Subjects stood facing a wall and flexed the right hip. Next, the knee was flexed so that the subject could hold the right ankle. While holding the right ankle, the knee was pulled towards the chest until slight discomfort in the glutes. Position is repeated for the opposite side.
Dynamic	Calf	Walking with dorsiflexion to plantar flexion: Subjects stood and raised one foot with the knee fully extended. Then, subjects dorsiflex the ankle joint intentionally so that the toe was pointing upward. Then, subjects plantar flex the ankle joint intentionally so that the toe was pointing downward. Both positions of flexion should cause slight discomfort.
	Hamstring	Frankenstein walks: Subjects flexed at the hip while intentionally keeping the knee fully extended. Leg was then flexed at the hip as high as possible until slight discomfort was felt in the hamstring. Inch worms: Subjects started in the push-up position. Keeping the knees extended, subjects walked feet forward towards their hands. Once slight discomfort is felt, subjects walked hands forward, keeping knees extended, back to start position.
	Quadriceps	Heel-ups: subject kicked heels towards buttocks while moving forward High knee up to chest: subject running forward with high knee up
	Gluteus maximus	Walking lunges: Subjects took one large step forward with either the right or left foot. Next, with both arms out in front, the subject rotated their upper bodies, keeping arms horizontal to the ground.
PNF	Calf	Subjects laid in the supine position with knees fully extended. Next, both legs were flexed at the hip until perpendicular to the floor. This dorsiflexed both feet at the ankle joints so that the instructor could place both hands on the subject's feet. First, the subject pushed against the instructor's force for 10 sec. (contraction phase) and then relaxed for 20 sec. (relaxation phase). Instructor then pushed the subject's feet (extreme dorsiflexion) during relax phase.
	Hamstring	Subjects laid in the supine position with both knees fully extended. Next, one foot was placed on the instructor's shoulder and flexed the hip joint. First, the subject pushed against the instructor's force for 10 sec. (contraction phase), and then relaxed for 20 sec. (relaxation phase). Instructor then pushed the leg forward (extreme hip flexion) pushing the subject's knee toward the chest during relaxation phase.
	Quadriceps	Subjects laid in the prone position on the mat with knees fully extended. Next, one knee was flexed until perpendicular to the floor. Instructor then placed their hand on the subject's ankle. First, subjects pushed against the instructor's force for 10 sec. (contraction phase), and then relaxed for 20 sec. (relaxation phase). Instructor then pushed the foot towards the hip (extreme flexion of the knee) during the relaxation phase.
	Gluteus maximus	Subjects sat on the floor and brought the soles of the feet together. Subjects then brought their heels in towards their body. Instructor sat with knees behind subject and placed their hands on the subject's knees. First, subjects pushed against the instructor's force for 10 sec. (contraction phase), then relaxed for 20 sec. (relaxation phase). Instructor then pushed the subject's knees toward to floor (extreme hip abduction) during the relaxation phase.

Jumping exercise programme

After each stretching protocol was completed, participants performed three sets of five tuck jumps with 30-second intervals between sets (Donti et al., 2014).

Exercise performance testing

SLR and VJP tests were selected for the measurements of flexibility and power performance. The SLR was measured with a goniometer (Baseline stainless steel goniometers, USA). Participants lay in a supine position on a medical bed with their backs flat to prevent possible pelvic rotation. Then participants raised their dominant leg as far as possible while maintaining the knee fully extended with ankle joint in a dorsiflexion position. One lever of the goniometer was marked on the lateral midline of the pelvis, while the pivot was placed on the lateral aspect of the hip joint, at the greater trochanter. The opposite leg was firmly held down to prevent flexion at the hip joint. Participants performed two-trials, and the highest score was recorded. The intra-class correlation coefficient (ICC) for SLR was 0.98. The VJP test was measured as a marker of power performance. Participants first raised their right arm on the measuring bar with a fully extended elbow, which marked an initial point. Then, they were instructed to jump with their maximal effort as high as possible. The jump height was calculated from maximal jump height minus initial point. Each participant performed two trials, and the highest score was recorded. The ICC for VJP was 0.93.

Statistical analysis

SPSS (version 24.00, SPSS Inc., Chicago, Illinois) was used for statistical analysis. All data were presented as mean and standard deviations. The percentage change of scores was also calculated for all measures. 4 × 4 repeated measures analysis of variances (ANOVA) were applied to analyse the changes of SLR and VJP between (a) different stretching protocols and (b) time sequences. If any significant interactions or main effects were detected, repeated measure ANOVAs with a Bonferroni post hoc test was applied. One-way ANOVAs were applied to analyse the percentage changes of SLR and VJP between the different protocols at the post-jogging, the-post-stretching, and the post-JE. Partial eta squared (η_p^2) was used to classify the effect size. The reliability estimated for the best score in SLR and VJP was determined by calculating the intra-class correlation coefficient (ICC) (Wood, & Zhu, 2006). The level of statistical significance was set at $p<.05$.

Results

Flexibility

There was a significant interaction effect (protocol × time) on the straight leg raise ($F=8.935$, $p<.001$, $\eta_p^2=.427$). There were also significant effects for time ($F=61.789$, $p<.001$, $\eta_p^2=.837$) and trial ($F=17.739$, $p<.001$, $\eta_p^2=.596$). The Bonferroni post hoc test showed that the SLR score significantly increased in all trials after jogging. Although the SLR score increased after SS, DS, and PNFS, this score did not change after NS. Jumping exercise immediately after all stretching protocols did not provide additional benefit in flexibility. Overall, jumping exercise immediately after three stretching protocols increased SLR from baseline. Figure 2 describes the changes in flexibility.

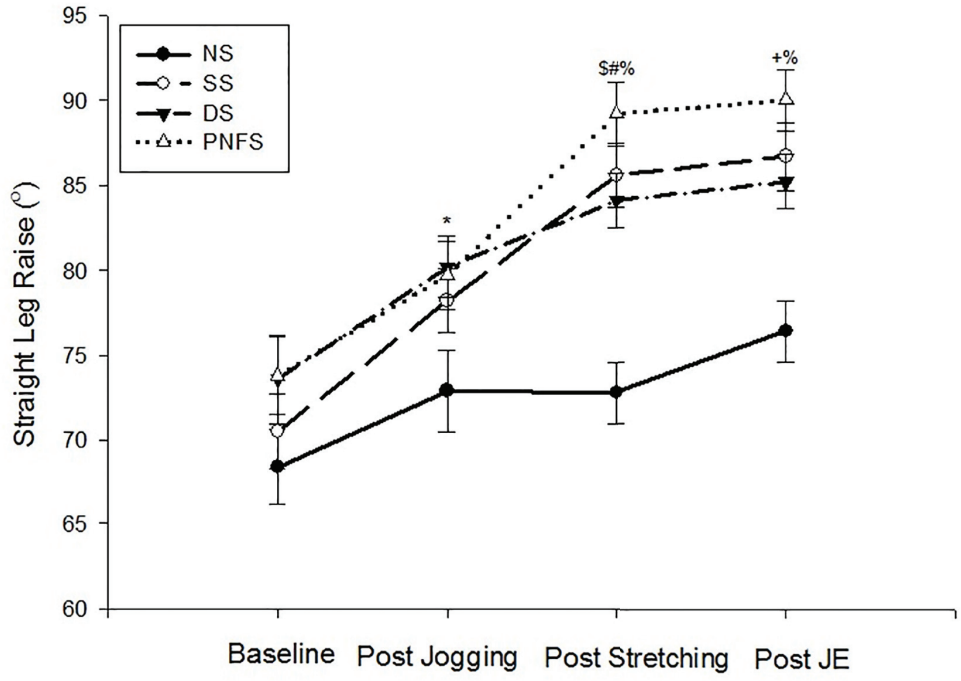

FIGURE 2 The changes of flexibility

Note. Values are mean and standard deviation; NS: non-stretching; SS: static stretching; DS: dynamic stretching; PNFS: proprioceptive neuromuscular facilitation stretching; JE: jumping exercise; *p<.05, significantly improved from baseline in all protocols; $^{\$}$p<.05, significantly improved from baseline in all protocols; $^{+}$p<.05, significantly improved from baseline in all protocols; $^{\#}$p<.05, significantly improved from post-jogging in SS, DS, PNFS; $^{\%}$p<.05, significantly differed between SS, DS, PNFS and NS post-stretching and post-JE.

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Power

A significant interaction effect (protocol × time) on VJP was observed (F=3.965, p=.009, η_p^2=.248). There was also a significant time effect (F=20.403, p<.001, η_p^2=.630). The Bonferroni post hoc test revealed that the VJP score significantly increased in all trials after jogging. However, the VJP score decreased after the NS, SS, and PNFS protocols, although it did not change after DS. After the jumping exercise, the VJP score was only restored post-jogging in the SS and PNFS protocols, whereas it did not change in the NS and DS protocols. Overall, the jumping exercise immediately after DS and PNFS significantly improved the VJP from baseline. Figure 3 represents the changes of VJP.

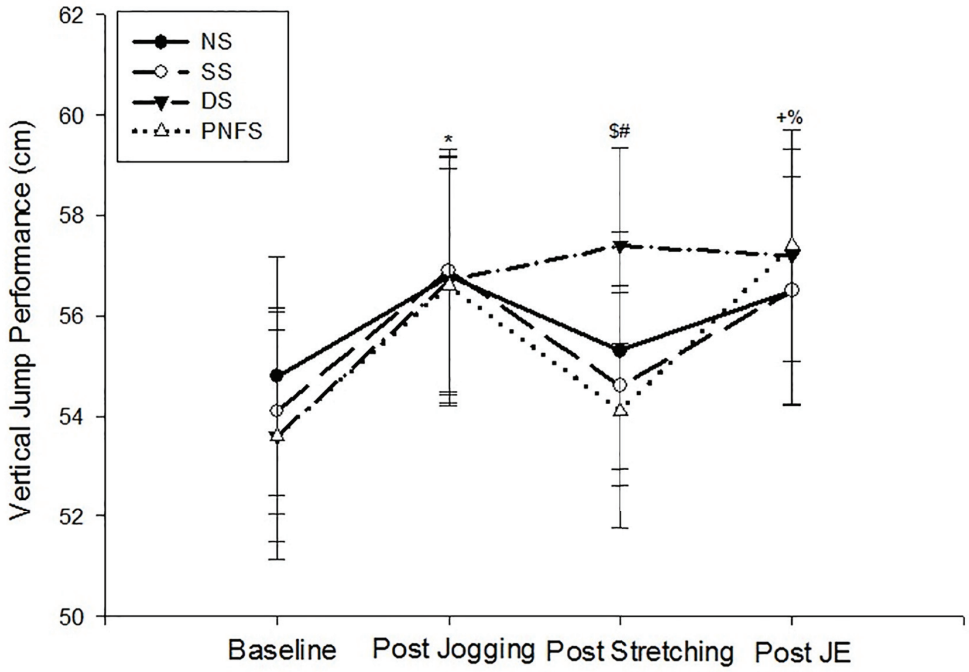

FIGURE 3 The changes of vertical jump performance

Note. Values are mean and standard deviation; NS: non-stretching; SS: static stretching; DS: dynamic stretching; PNFS: proprioceptive neuromuscular facilitation stretching; JE: jumping exercise; *p<.05, significantly improved from baseline in all protocols; $^{\$}$p<.05, significantly improved from baseline only in DS; $^{+}$p<.05, significantly improved from baseline in DS and PNFS; $^{\#}$p<.05, significantly decreased from post-jogging in NS, SS, PNFS; $^{\%}$p<.05, significantly improved from post-stretching in SS and PNFS.

Discussion

This study was aimed at investigating the acute effects of jumping exercise immediately after different stretching protocols on flexibility and power in healthy adults. The main findings are as follows: 1) jumping exercise immediately after the DS and PNFS protocols improves flexibility and power from the baseline; 2) jumping exercise restores the static and PNF stretching-induced power loss in healthy adults.

The flexibility and power increased in all groups after jogging in the present study. It is known that increasing body temperature through light intensity activities provides physiological benefits (Bishop, 2003; Young & Behm, 2002). With an increase in body temperature, blood flow increases through vasodilation; thus, more oxygen might be supplied to working muscle as well as increase nerve transmission (Bishop, 2003). Although this study did not directly measure body temperature, we assume that increased body temperature through jogging may improve flexibility and power performance.

In the current study, the percentage increase in SLR from jogging was greater in SS (9.4%), DS (4.9%) and PNFS (11.9%) trials than NS (-0.1%) trial at post-stretching. Even though there were no statistical differences in SLR among the three stretching protocols, the PNFS protocol showed the greatest improvement in SLR. PNFS is known as the most effective method for increasing range of motion in joints and flexibility (Konrad, Gad, & Tilp, 2015). This contract-relax stretching method may have an impact on autogenic inhibition, especially the Golgi tendon organ. Increasing tension during the contraction phase may increase antagonist muscle activity while the function of the Golgi tendon organ decreases during the relaxation phase; therefore, the joint range of motion increased (Konrad et al., 2015). The DS protocol showed the lowest improvement in SLR among three stretching protocols. A previous study reported that DS is not as effective in increasing flexibility compared to SS and PNFS (Behm & Chaouachi, 2011).

In the present study, VJP significantly decreased in the NS (-2.6%), SS (-3.6%), PNFS (-4.4%) trials but did not change in the DS (1.8%) trial post-stretching. Non-dynamic stretching, such as static and PNF stretching, has been known to reduce power performance (Behm & Chaouachi, 2011). Wallmann, Mercer, & McWhorter

(2005) demonstrated that three sets of 30 seconds static stretching decreased jump performance (-5.6%). Another study also reported that four reps of 30 seconds SS and PNFS (5 sec contract and 25 sec relaxation phase) for five minutes, decreased vertical jump performance (SS; 4%, PNFS; 5.1%). The mechanism underlying these results demonstrated that prolonged static stretching might inhibit the neural drive and asynchronies of muscle activity (Power, Behm, Cahill, Carroll, & Young, 2004). The stretch-induced impairment of the length-tension relationship may be another factor that limits further motor unit recruitments (Costa et al., 2012). However, the VJP score was maintained after the DS trial in the present study. We assume that DS may have a different role in power performance compared with other stretching protocols. DS involves many active movements, which induce physiological changes such as increased heart rate, body temperature, and altering other metabolic factors (Fletcher, 2010). Even though a previous study speculated that MTU stiffness is decreased after DS (Herda et al., 2013), which is similarly shown in other stretching protocols (Ryan et al., 2014), the physiological benefits may outweigh the stretching-induced power loss. This study confirmed that five minutes of static and PNF stretching alone reduce VJP while DS did not affect the improved VJP induced by jogging.

A plyometric-type jumping exercise after stretching is commonly applied as a potentiating exercise to promote muscle activity. In the present study, jumping exercise restored the VJP in the SS (3.2%) and PNFS (6.5%) protocols whereas this score did not significantly change in the NS and DS protocols. A previous study reported that the combination warm-up (run+stretch+jumps) programme showed the highest score in jumping performance compared to running alone or a run+stretch warm-up programme (Young & Behm, 2003). Another study reported that 45 seconds of static stretching decreased CMJ (5.5%), but 3 sets × 5 tuck jumps immediately after stretching restored the power performance in international fencing athletes (Tsolakis & Bogdanis, 2012). Donti et al. (2014) conducted different volumes of jumping exercise. The study reported that 3 sets × 5 tuck jumps after 30 sec static stretching enhanced CMJ, but one set of five times tuck jump did not improve CMJ in elite gymnasts.

There are various possible reasons that additional jumping exercise after stretching provides benefit to power performance. The first theory is that various explosive-movements may increase central nerve stimulation, which involves the Hoffmann Reflex (H-reflex), resulting in greater fast twitch motor unit recruitments (Hodgson et al., 2005). The second theory involves phosphorylation, which produces more ATP, resulting in greater muscle activation at the structure level of skeletal muscle (Rixon, Lamont, & Bemben, 2007). It has also been proposed that explosive movements recruit more fast twitch muscle fibres that lead to improved power performance after JE (Hamada et al., 2000). However, the additional jumping exercises after DS do not provide positive benefits over VJP. Behm, Button, Barbour, Butt, & Young (2004) pointed out the importance of balance between post-activation potentiation exercise and fatigue. A previous study supported our result that dynamic stretching alone improved muscular performance, but an additional 3 × 3 times of tuck jumps did not provide the benefits on VJP (Turki et al., 2011). The current study suggests that jumping exercise (5 times × 3 set) after DS may not provide additional benefit over VJP, while undertaking this programme immediately after SS and PNFS may restore the stretching-induced power loss.

The present study suggests that jumping exercise immediately after SS and PNFS protocols could be an efficient programme for restoring stretching-induced power loss in healthy adults. However, jumping exercise after DS did not provide additional benefit to power performance.

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The Brain and Movement: How Physical Activity Affects the Brain

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ABSTRACT In recent years, many studies have demonstrated the importance of movement for the human body, from the improvement of cardiovascular efficacy to the enhancement of muscular functions, metabolic balance, and organ systems. The brain is no exception and benefits greatly from movement, both structurally and functionally. Memory, creativity, and intelligence, are only a few of the many things that are regulated by the brain. The literature demonstrates the benefits of physical activity on numerous factors that influence brain functions. The present short review aims to clarify how physical activity affects the human brain. We have identified the influence of movement on the brain, through investigation of this influence according to the close relation of physical activity with cognitive processes and brain development. These findings offer an insight into several conclusions regarding the influence of movement on the brain, which is soundly based on relevant literature.

KEY WORDS motor activity, neurotrophic factors, language, human movement

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Introduction

The influence of movement on the brain, an introduction

Research papers that support the importance of movement for our body are almost countless. These works start from the improvement of heart and lung efficacy to the enhancement of joint function (Padulo, Di Capua & Viggiano, 2012; Padulo et al., 2013; Oliva, Osti, Padulo & Maffulli, 2014; Gheller et al., 2015); from regulating blood sugar and fat to that of the sleep-wake cycle (Matinez-Gomez et al., 2010; Umpierre et al., 2011; Lang et al., 2013). Obviously, among all the organs of our body, the brain is richly benefitted by movement, both structurally and functionally. The literature demonstrates the movement benefit on mood in depression (see, e.g. Schuch et al., 2016; Chen et al., 2016), anxiety (see, e.g. De Souza Moura et al., 2015; Herring et al., 2015), and in bipolar disorder (see, e.g., review by Melo et al., 2016).

It has been widely demonstrated (see the review by Heijnen, Hommel, Kibele & Colzato, 2016) that the motor activity stimulates the so-called brain-derived neurotrophic factor (BDNF), a neurotrophin responsible for neural conservation and differentiation, synaptic plasticity (also for the formation of new synapses), long-term potentiation, and brain neurogenesis (also in adulthood). To this family of proteins also belong NGF (nerve growth factor), NT3 and NT4 (neurotrophin 3 and 4). BDNF exerts its effects on the cognitive (Alesi et al., 2014) sphere through the abilities described above, and it is thought to influence learning (Leckie et al., 2014). Interestingly, an increase in BDNF after exercise is positively correlated with cognitive performance; this was also confirmed recently by Van Dongen, Kersten, Wagner, Morris & Fernández (2016), who demonstrated that physical activity performed four hours after learning improves memory efficiency, showing how the hippocampus improves its efficacy in memory retention.

However, the increase of neurotrophins differs depending both on the type of exercise and gender. Huang, Larsen, Ried-Larsen, Møller & Andersen (2014) published a review in which it was highlighted that only one aerobic exercise session is needed to increase BDNF levels and that frequent aerobic exercise further increases

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this effect. A meta-analysis of the studies that take into account the effects of aerobic exercise on BDNF has confirmed this neurotrophic influence on the brain but it has also shown that effects may be lower in females relative to males (Szuhany et al., 2015). The hypothesis is that this discrepancy is caused by hormonal changes occurring during the menstrual cycle by the hypothalamic-pituitary-adrenal (HPA) axis and subsequent levels of anandamide (AEA; Maccarrone et al., 2001).

Therefore, considering the link between sex hormones and cognitive functions (Colzato et al., 2010; Colzato & Hommel, 2014), it is hypothesized that aerobic exercise can affect mood and cognitive functions in women in a different way, depending on whether they are in the follicular phase (low levels of progesterone) or the mid-luteal phase (high progesterone levels). In particular, during the luteal phase, the increase of AEA induced by exercise is particularly low. In turn, this mechanism leads to a reduction in the amount of BDNF released. Starting from this assumption, we can say that engagement in aerobic exercise during the luteal phase weakens the cognitive benefits of the follicular phase.

Furthermore, physical activity can be closely related to a person's environment (Vando et al., 2013) and emotions. The environment, and in particular environmental enrichment, is able to stimulate physical activity (De Giorgio, 2017), and physical activity is also able to regulate both emotions and health outcomes (De Giorgio, 2016; Hoying & Melnyk, 2016). Chakrabarti, Scafidi, Gallo, and Haydar (2011) highlighted how physical exercise and environmental enrichment increase neurogenesis, cellular proliferation, and gliogenesis both in a particular part of the hippocampus, the dentate gyrus, and in the forebrain sub-ventricular zone. These two structures are known as places where neurogenesis in the adult mammalian brain occurs (Ming & Song, 2011).

Physical activity and cognitive processes: what changes in "the moving brain"

In the last twenty years, research regarding the effects of movement on the brain in children and adolescents has increased (Alesi et al., 2015). According to these studies, motor activities should gain a significant role in preventing metabolic, respiratory, and cardiovascular diseases as well as in the ability to support, increase and re-activate the cognitive processes useful for each type of learning. Significantly, these human studies have confirmed the results of research on experimental models (Gheller et al., 2015), demonstrating once again their importance in scientific research (Padulo, Maffulli & Ardigò, 2014). Physical activity positively contributes to human growth and development, thus preparing children for the mental and physical challenges of adolescence and emerging adulthood, which require stamina. (Felfe, Lechner, & Steinmayr, 2016; Prakash, Voss, Erickson, & Kramer, 2015). There is a huge body of research indicating that physical activity has, indeed, both physiological and psychological benefits, being associated with better mental health and enhancement of brain function and cognition (Donnelly et al., 2016).

Chaddock et al. (2010a) conducted a study on children aged 9 and 10 demonstrating that physical activity is able to increase the volume of the striatum, one of the structures belonging to base ganglia which are related to both the motor and cognitive tasks, in particular regarding attentive functions. The same research group (Chaddock et al., 2010b) demonstrated through functional magnetic resonance a positive correlation between increased hippocampal volume and mnestic performance in pre-adolescent children who performed regular exercise (Alesi et al., 2015). Whiteman, Young, Budson, Stern and Schon (2016) further demonstrated how aerobic activity affects a particular area in the hippocampus called the entorhinal cortex. Researchers have shown that aerobic activity is related to an increase in grey matter in the entorhinal cortex, through which information travels.

Physical activity also influences the process of myelination. Myelin is a substance that envelops the axons of the neurons and allows, among other things, an efficient conductor of electrical signals throughout the central nervous system. In general, when the grey matter increases in the brain, it is also possible that myelination process begins due to the creation of new axons (Bechler, Swire & Ffrench-Costant, 2017). However, myelination is a complex mechanism that is also related to how much neurons fire. In other words, when a gesture is performed, impulses are sent along axons, and when impulses increase on the same pathway, due to repetitions of the same gesture, more myelin is created. In this way, the signal among brain areas is faster, and the brain can use reduced energy to perform that gesture. However, this mechanism is present in all motor and cognitive functions, which can be linked during the decision-making process, which is a vital skill in many sports. Increased efficiency in making decisions is also due to a myelination mechanism: if neural signals among brain areas are more effective and faster, athletes can make decisions faster than their opponents can. Also noteworthy is a review by Tomlinson, Leiton, and Colognato (2016) in which the authors document how physical activity, environmental enrichment, and motor experiences promote more efficient neuronal myelinization and, conversely, that social retreat, inadequate physical activity, and poor environmental experiences reduce it.

Wens et al. (2016) report an increase in BDNF in subjects with multiple sclerosis as a result of aerobic activity over the course of six months. Have et al. (2016) wanted to test the effects of motor activity on creative performance, as well as executive and math functions in primary school children, and correlate it with their body mass index. Again, in this case, the correlation was positive (i.e. the children who carried out physical activity improved their school performance), and the authors conclude by stating (2016, p. 8):

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> [...] The results of this study will expand the current evidence on the relationship between physical activity and academic achievement in schoolchildren. We expect the results to stimulate the debate about whether the integration of physical activity into the classroom can enhance children's cognitive skills and creativity, and will help educational practitioners to design learning environments that are optimal for cognitive development and academic achievement.

Physical activity and brain development are closely related

Language is maybe the most significant skill in humans, and the study of motor activity linked to the development of language yields much information regarding the link between these two characteristics that influence each other. There are two language areas of the brain in humans: Broca's area and Wernicke's area. In the vast majority of the population (9 out of 10), these areas are present solely in the left hemisphere. It is rarely possible to find these areas in the right hemisphere alone, while bilingual or multilingual have dedicated areas in both hemispheres. Broca's area is defined as the area to "say what you understand"; it is where a motor language program can be established. Wernicke's area is for "understanding what is said"; this area enables the understanding of language.

The ability of the humans to connect the information in a word by moving the lips that produces the sound of the work is a very early ability, evident at two months of age. In an interesting article, Patterson and Werker (2003) show that an infant can detect a discrepancy between the movement of the lips and the sound heard when an adult pronounces a word that does not match the expected sound. In addition, this discordance elicits more attention in the child rather than when he can observe an adult moving his lips in accordance with the word spoken.

Further evidence of the link between the development of motor skills and the development of language skills emerge from a rich series of studies. For example, research performed by Mervis and Velleman (2011) took into account canonical babbling, which characterizes the early developing stages of the articulation of sounds in the child. In particular, the authors describe how in Williams syndrome vocalization by the baby, usually accompanied by rhythmic movements of hands characterized by the same temporal profile, is delayed perhaps because of a motor delay of hand-clapping. In other words, in children with normal development, hand-clapping seems to promote babbling, and vice-versa. The use of hands for development and improving language is also demonstrated by Iverson and Goldin-Meadow (1998; 2005). In particular, the researchers published in Nature (1998) an experiment in which they asked people to speak with their hands free to move or to talk with their hands motionless, held under their thighs. The cognitive performance of the latter group of people was significantly worse than the former group. Bernardis and Gentilucci (2006) conducted an interesting experiment in which people had to move their arms through three motor conditions: *hello*, *no*, or *stop.* The researchers studied the gesture, lips movement, and sound quality when the subject pronounced and simultaneously moved the arm with *hello, no,* or *stop.* When *hello*, *no*, or *stop* were pronounced, the corresponding gesture slowed down. These studies, among others, show us that present a similar or even overlapped neural circuit for both spoken and non-verbal language probably exists.

In addition to the cerebral cortex, the basal ganglia and cerebellum are structures also involved in both motor and cognitive aspects, including language. For example, the basal ganglia circuits are essential in some motor aspects of language such as planning, learning, and control of speech production (Macoir et al., 2013; Hanakawa & Hosoda, 2014). Moreover, these structures are very connected to each other. The basal ganglia receive a large amount of input both from the cerebral cortex (Haber, 2016), and cerebellum (Bostan & Strick, 2010; De Bartolo et al., 2011), and their role in cognition is well established (Middleton & Strick, 2000).

It has also been demonstrated that all these structured are impaired in intellectual disabilities. The cerebral cortex (Tavian, De Giorgio & Granato, 2011; Granato, Palmer, De Giorgio, Tavian & Larkum, 2012; Granato & De Giorgio, 2014; De Giorgio & Granato, 2015; Granato & De Giorgio, 2015), basal ganglia (De Giorgio, Comparini, Intra & Granato, 2012) and cerebellum are very sensitive to environmental factors during the development of the brain. However, physical activity is able to repair, at least in part, damage that has occurred during brain development (see for review, De Giorgio, 2017).

Conclusion

In this short review, we have brought together some of the findings relevant to the influence of the movement on the brain or, more precisely, we offered presented articles which discuss how physical activity affects the human brain. These articles indicate that the use of movement and environment enrichment contribute to the development of the central nervous system and can repair several cerebral structures that have encountered damage during the development period. Furthermore, it can be concluded that physical activity is closely related to cognitive processes and brain development. These findings are especially significant in the cognitive and motor development of infants and children. Effects of physical activity on some cognitive processes in children and the connections between the development of motor and language skills are evidenced in many studies conducted in recent years.

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☑Open Submissions ☑Indexed ☑Peer Reviewed

Short reports should be:

- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Peer review - fair review provides authors who feel their paper has been unfairly rejected (at any journal) the opportunity to share reviewer comments, explain their concerns, and have their paper reviewed for possible publication in MJSSM.

☑Open Submissions ☑Indexed ☐Peer Reviewed

Peer review - fair review should be:

- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Invited papers and award papers include invited papers from authors with outstanding scientific credentials. Nomination of invited authors is at the discretion of the MJSSM editorial board. MJSSM also publishes award papers selected by the scientific committee of the International Scientific Conference on Transformation Processes in Sport.

☐Open Submissions ☑Indexed ☐Peer Reviewed

Invited papers and award papers should be:

- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

1.3. Submission

MJSSM only accepts electronic submission to the e-mail of the Journal Office: **office@mjssm.me**.

Submitted material includes:

- A manuscript prepared according to the Guidelines for the Authors;
- A signed form that states the study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere, that states that all of the authors are in agreement with submission of the manuscript to MJSSM, and that, for studies that use animal or human individuals, authors must include information regarding their institution's ethics committee, and which identifies the official approval number;
- A signed form that there is no conflict of interest.

Name the files according to the family name of the first author. Authors submitting revised versions of the manuscript can use the identification number of their manuscript as provided by the Journal Office. *See* example:

- ✓ FAMILY NAME-manuscript.doc – (main manuscript file)
- ✓ FAMILY NAME-statement.PDF – (authorship statement)
- ✓ FAMILY NAME-declaration.PDF – (declaration of potential conflict of interest)
- ✓ FAMILY NAME-fig1.tiff – (Figure 1)

1.4. Peer Review Process

An original manuscript submitted for publication will be submitted to the review process as long as it fits the following criteria:

- The study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere;
- All persons listed as authors approved its submission to MJSSM;
- Any person cited as a source of personal communication has approved the quote;
- The opinions expressed by the authors are their exclusive responsibility;
- The author signs a formal statement that the submitted manuscript complies with the directions and guidelines of MJSSM.

The editors-in-chief, executive editor and associate editors will make a preliminary analysis regarding the appropriateness, quality, originality and written style/grammar of the submitted manuscript. The editors reserve the right to request additional information, corrections, and guideline compliance before they submit the manuscript to the ad-hoc review process.

MJSSM uses ad-hoc reviewers, who volunteer to analyze the merit of the study. Typically, one or two expert reviewers are consulted in a double-blind process. Authors are notified by e-mail when their submission has been accepted (or rejected). Minor changes in the text may be made at the discretion of the editors-in-chief, executive editor and/or associate editors. Changes can include spelling and grammar in the chosen language, written style, journal citations, and reference guidelines. The author is notified of changes via email. The final version is available to the author for his or her approval before it is published.

1.5. Open Access License and Publisher Copyright Policies

MJSSM applies the Creative Commons Attribution (CC BY) license to articles and other works it publishes. If author(s) submit its paper for publication by MJSSM, they agree to have the CC BY license applied to their work. Under this Open Access license, the author(s) agree that anyone can reuse their article in whole or part for any purpose, for free, even for commercial purposes. Anyone may copy, distribute, or reuse the content as long as the author(s) and original source are properly cited. This facilitates freedom in re-use and also ensures that MJSSM content can be mined without barriers for the needs of research. On the other hand, the author(s) may use content owned by someone else in their article if they have written permission to do so. If the manuscript contains content such as photos, images, figures, tables, audio files, videos, et cetera, that the author(s) do not own, MJSSM will require them to provide it with proof that the owner of that content has given them written permission to use it, and has approved of the CC BY license being applied to their content. Otherwise, MJSSM will ask the author(s) to remove that content and/or replace it with other content that you own or have such permission to use. MJSSM provides a form the author(s) can use to ask for and obtain permission from the owner.

In addition, the author(s) may freely use the content they previously published in a paper through another publisher and they own the rights to that content; however, that's not necessarily the case and it depends on the license that covers the other paper. Some publishers allow free and unrestricted reuse of article content they own, such as under the CC BY license. Other publishers use licenses that allow reuse only if the same license is applied by the person or publisher reusing the content. If the article was published under a CC BY license or another license that allows free and unrestricted use, the author(s) may use the content in the submitted manuscript provided that the author(s) give proper attribution, as explained above. If the content was published under a more restrictive license, the author(s) must ascertain what rights they have under that license. MJSSM advices the author(s) not to include any content in the submitted manuscript which they do not have rights to use, and always give proper attribution.

The editors of MJSSM consider plagiarism to be a serious breach of academic ethics. Any author who practices plagiarism (in part or totality) will be suspended for six years from submitting new submissions to MJSSM. If such a manuscript is approved and published, public exposure of the article with a printed mark ("plagiarized" or "retracted") on each page of the published file, as well as suspension for future publication for at least six years, or a period determined by the editorial board. Third party plagiarized authors or institutions will be notified, informing them about the faulty authors. Plagiarism will result in immediate rejection of the manuscript.

MJSSM only publishes studies that have been approved by an institutional ethics committee (when a study involves humans or animals). Fail to provide such information prevent its publication. To ensure these requirements, it is essential that submission documentation is complete. If you have not completed this step yet, go to MJSSM website and fill out the two required documents: Declaration of Potential Conflict of Interest and Authorship Statement. Whether or not your study uses humans or animals, these documents must be completed and signed by all authors and attached as supplementary files in the originally submitted manuscript.

1.6. After Acceptance

After the manuscript has been accepted, authors will receive a PDF version of the manuscripts for authorization, as it should look in printed version of MJSSM. Authors should carefully check for omissions. Reporting errors after this point will not be possible and the Editorial Board will not be eligible for them.

Should there be any errors, authors should report them to the Office e-mail address **office@mjssm.me**. If there are not any errors authors should also write a short e-mail stating that they agree with the received version.

1.7. Code of Conduct Ethics Committee of Publications

MJSSM is hosting the Code of Conduct Ethics Committee of Publications of the **COPE** (the Committee on Publication Ethics), which provides a forum for publishers and Editors of scientific journals to discuss issues relating to the integrity of the work submitted to or published in their journals.

2. MANUSCRIPT STRUCTURE

2.1. Title Page

The first page of the manuscripts should be the title page, containing: title, type of publication, running head, authors, affiliations, corresponding author, and manuscript information. *See* example:

Transfer of Learning on a Spatial Memory Task between the Blind and Sighted People Spatial Memory among Blind and Sighted

Original Scientific Paper

Transfer of learning on a spatial memory task

Selcuk Akpinar[1], Stevo Popović[1,2], Sadettin Kirazci[1]

[1]Middle East Technical University, Physical Education and Sports Department, Ankara, Turkey
[2]University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro

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E-mail: stevop@ac.me

Word count: 2,980

Abstract word count: 236

Number of Tables: 3

Number of Figures: 3

2.1.1. Title

Title should be short and informative and the recommended length is no more than 20 words. The title should be in Title Case, written in uppercase and lowercase letters (initial uppercase for all words except articles, conjunctions, short prepositions no longer than four letters etc.) so that first letters of the words in the title are capitalized. Exceptions are words like: "and", "or", "between" etc. The word following a colon (:) or a hyphen (-) in the title is always capitalized.

2.1.2. Type of publication

Authors should suggest the type of their submission.

2.1.3. Running head

Short running title should not exceed 50 characters including spaces.

2.1.4. Authors

The form of an author's name is first name, middle initial(s), and last name. In one line list all authors with full names separated by a comma (and space). Avoid any abbreviations of academic or professional titles. If authors belong to different institutions, following a family name of the author there should be a number in superscript designating affiliation.

2.1.5. Affiliations

Affiliation consists of the name of an institution, department, city, country/territory(in this order) to which the author(s) belong and to which the presented / submitted work should be attributed. List all affiliations (each in a separate line) in the order corresponding

to the list of authors. Affiliations must be written in English, so carefully check the official English translation of the names of institutions and departments.

Only if there is more than one affiliation, should a number be given to each affiliation in order of appearance. This number should be written in superscript at the beginning of the line, separated from corresponding affiliation with a space. This number should also be put after corresponding name of the author, in superscript with no space in between.

If an author belongs to more than one institution, all corresponding superscript digits, separated with a comma with no space in between, should be present behind the family name of this author.

In case all authors belong to the same institution affiliation numbering is not needed.

Whenever possible expand your authors' affiliations with departments, or some other, specific and lower levels of organization.

2.1.6. Corresponding author

Corresponding author's name with full postal address in English and e-mail address should appear, after the affiliations. It is preferred that submitted address is institutional and not private. Corresponding author's name should include only initials of the first and middle names separated by a full stop (and a space) and the last name. Postal address should be written in the following line in sentence case. Parts of the address should be separated by a comma instead of a line break. E-mail (if possible) should be placed in the line following the postal address. Author should clearly state whether or not the e-mail should be published.

2.1.7. Manuscript information

All authors are required to provide word count (excluding title page, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References), the Abstract word count, the number of Tables, and the number of Figures.

2.2. Abstract

The second page of the manuscripts should be the abstract and key words. It should be placed on second page of the manuscripts after the standard title written in upper and lower case letters, bold.

Since abstract is independent part of your paper, all abbreviations used in the abstract should also be explained in it. If an abbreviation is used, the term should always be first written in full with the abbreviation in parentheses immediately after it. Abstract should not have any special headings (e.g., Aim, Results…).

Authors should provide up to six key words that capture the main topics of the article. Terms from the Medical Subject Headings (MeSH) list of Index Medicus are recommended to be used.

Key words should be placed on the second page of the manuscript right below the abstract, written in italic. Separate each key word by a comma (and a space). Do not put a full stop after the last key word. *See* example:

Abstract

Results of the analysis of…

Key words: spatial memory, blind, transfer of learning, feedback

2.3. Main Chapters

Starting from the third page of the manuscripts, it should be the main chapters. Depending on the type of publication main manuscript chapters may vary. The general outline is: Introduction, Methods, Results, Discussion, Acknowledgements (optional), Conflict of Interest (optional), and Title and Abstract in Montenegrin (only for the authors from former Yugoslavia, excluding Macedonians and Slovenes). However, this scheme may not be suitable for reviews or publications from some areas and authors should then adjust their chapters accordingly but use the general outline as much as possible.

2.3.1. Headings

Main chapter headings: written in bold and in Title Case. *See* example:

- ✓ **Methods**

Sub-headings: written in italic and in normal sentence case. Do not put a full stop or any other sign at the end of the title. Do not create more than one level of sub-heading. *See* example:

- ✓ *Table position of the research football team*

2.3.2 Ethics

When reporting experiments on human subjects, there must be a declaration of Ethics compliance. Inclusion of a statement such as follow in Methods section will be understood by the Editor as authors' affirmation of compliance: "This study was approved in advance by [name of committee and/or its institutional sponsor]. Each participant voluntarily provided written informed consent before participating." Authors that fail to submit an Ethics statement will be asked to resubmit the manuscripts, which may delay publication.

2.3.3 Statistics reporting

MJSSM encourages authors to report precise p-values. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Use normal text (i.e., non-capitalized, non-italic) for statistical term "p".

2.3.4. 'Acknowledgements' and 'Conflict of Interest' (optional)

All contributors who do not meet the criteria for authorship should be listed in the 'Acknowledgements' section. If applicable, in 'Conflict of Interest' section, authors must clearly disclose any grants, financial or material supports, or any sort of technical assistances from an institution, organization, group or an individual that might be perceived as leading to a conflict of interest.

2.4. References

References should be placed on a new page after the standard title written in upper and lower case letters, bold.

All information needed for each type of must be present as specified in guidelines. Authors are solely responsible for accuracy of each reference. Use authoritative source for information such as Web of Science, Medline, or PubMed to check the validity of citations.

2.4.1. References style

MJSSM adheres to the American Psychological Association 6th Edition reference style. Check "American Psychological Association. (2009). Concise rules of APA style. American Psychological Association." to ensure the manuscripts conform to this reference style. Authors using EndNote® to organize the references must convert the citations and bibliography to plain text before submission.

2.4.2. Examples for Reference citations

One work by one author

- ✓ In one study (Reilly, 1997), soccer players…
- ✓ In the study by Reilly (1997), soccer players…
- ✓ In 1997, Reilly's study of soccer players…

Works by two authors

- ✓ Duffield and Marino (2007) studied…
- ✓ In one study (Duffield & Marino, 2007), soccer players…
- ✓ In 2007, Duffield and Marino's study of soccer players…

Works by three to five authors: cite all the author names the first time the reference occurs and then subsequently include only the first author followed by et al.

- ✓ First citation: Bangsbo, Iaia, and Krustrup (2008) stated that…
- ✓ Subséquent citation: Bangsbo et al. (2008) stated that…

Works by six or more authors: cite only the name of the first author followed by et al. and the year

- ✓ Krustrup et al. (2003) studied…
- ✓ In one study (Krustrup et al., 2003), soccer players…

Two or more works in the same parenthetical citation: Citation of two or more works in the same parentheses should be listed in the order they appear in the reference list (i.e., alphabetically, then chronologically)

- ✓ Several studies (Bangsbo et al., 2008; Duffield & Marino, 2007; Reilly, 1997) suggest that…

2.4.3. Examples for Reference list

Journal article (print):

Nepocatych, S., Balilionis, G., & O'Neal, E. K. (2017). Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 57-65. doi: 10.26773/mjssm.2017.09.008

Duffield, R., & Marino, F. E. (2007). Effects of pre-cooling procedures on intermittent-sprint exercise performance in warm conditions. *European Journal of Applied Physiology, 100*(6), 727-735. doi: 10.1007/s00421-007-0468-x

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., . . . Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. doi: 10.1249/01.MSS.0000058441.94520.32

Journal article (online; electronic version of print source):

Williams, R. (2016). Krishna's Neglected Responsibilities: Religious devotion and social critique in eighteenth-century North India [Electronic version]. *Modern Asian Studies, 50*(5), 1403-1440. doi:10.1017/S0026749X14000444

Journal article (online; electronic only):

Chantavanich, S. (2003, October). Recent research on human trafficking. *Kyoto Review of Southeast Asia, 4*. Retrieved November 15, 2005, from http://kyotoreview.cseas.kyoto-u.ac.jp/issue/issue3/index.html

Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

Encyclopedia entry (print, with author):

Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.

Encyclopedia entry (online, no author):

Ethnology. (2005, July). In *The Columbia encyclopedia* (6th ed.). New York: Columbia University Press. Retrieved November 21, 2005, from http://www.bartleby.com/65/et/ethnolog.html

Thesis and dissertation:

Pyun, D. Y. (2006). *The proposed model of attitude toward advertising through sport.* Unpublished Doctoral Dissertation. Tallahassee, FL: The Florida State University.

Book:

Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human kinetics.

Chapter of a book:

Kellmann, M. (2012). Chapter 31-Overtraining and recovery: Chapter taken from Routledge Handbook of Applied Sport Psychology ISBN: 978-0-203-85104-3 *Routledge Online Studies on the Olympic and Paralympic Games* (Vol. 1, pp. 292-302).

Reference to an internet source:

Agency. (2007). Water for Health: Hydration Best Practice Toolkit for Hospitals and Healthcare. Retrieved 10/29, 2013, from www.rcn.org.uk/newsevents/hydration

2.5. Tables

All tables should be included in the main manuscript file, each on a separate page right after the Reference section.

Tables should be presented as standard MS Word tables.

Number (Arabic) tables consecutively in the order of their first citation in the text.

Tables and table headings should be completely intelligible without reference to the text. Give each column a short or abbreviated heading. Authors should place explanatory matter in footnotes, not in the heading. All abbreviations appearing in a table and not considered standard must be explained in a footnote of that table. Avoid any shading or coloring in your tables and be sure that each table is cited in the text.

If you use data from another published or unpublished source, it is the authors' responsibility to obtain permission and acknowledge them fully.

2.5.1. Table heading

Table heading should be written above the table, in Title Case, and without a full stop at the end of the heading. Do not use suffix letters (e.g., Table 1a, 1b, 1c); instead, combine the related tables. *See* example:

- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

2.5.2. Table sub-heading

All text appearing in tables should be written beginning only with first letter of the first word in all capitals, i.e., all words for variable names, column headings etc. in tables should start with the first letter in all capitals. Avoid any formatting (e.g., bold, italic, underline) in tables.

2.5.3. Table footnotes

Table footnotes should be written below the table.

General notes explain, qualify or provide information about the table as a whole. Put explanations of abbreviations, symbols, etc. here. General notes are designated by the word *Note* (italicized) followed by a period.

- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

Specific notes explain, qualify or provide information about a particular column, row, or individual entry. To indicate specific notes, use superscript lowercase letters (e.g. $^{a, b, c}$), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript ^{a}.

- ✓ ^{a}One participant was diagnosed with heat illness and n = 19.^{b}n =20.

Probability notes provide the reader with the results of the texts for statistical significance. Probability notes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || etc.

- ✓ *P<0.05,†p<0.01.

2.5.4. Table citation

In the text, tables should be cited as full words. *See* example:

- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

2.6. Figures

On the last separate page of the main manuscript file, authors should place the legends of all the figures submitted separately.

All graphic materials should be of sufficient quality for print with a minimum resolution of 600 dpi. MJSSM prefers TIFF, EPS and PNG formats.

If a figure has been published previously, acknowledge the original source and submit a written permission from the copyright holder to reproduce the material. Permission is required irrespective of authorship or publisher except for documents in the public domain. If photographs of people are used, either the subjects must not be identifiable or their pictures must be accompanied by written permission to use the photograph whenever possible permission for publication should be obtained.

Figures and figure legends should be completely intelligible without reference to the text.

The price of printing in color is 50 EUR per page as printed in an issue of MJSSM.

2.6.1. Figure legends

Figures should not contain footnotes. All information, including explanations of abbreviations must be present in figure legends. Figure legends should be written bellow the figure, in sentence case. *See* example:

- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

2.6.2. Figure citation

All graphic materials should be referred to as Figures in the text. Figures are cited in the text as full words. *See* example:

- ✓ Figure 1
- × figure 1
- × Figure 1.
- ✓ ….exhibit greater variance than the year before (Figure 2). Therefore…
- ✓ ….as shown in Figures 1 and 3. (citing more figures at once)
- ✓ ….result has shown (Figures 1-3) that... (citing more figures at once)
- ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

2.6.3. Sub-figures

If there is a figure divided in several sub-figures, each sub-figure should be marked with a small letter, starting with a, b, c etc. The letter should be marked for each subfigure in a logical and consistent way. *See* example:

- ✓ Figure 1a
- ✓ …in Figures 1a and b we can…
- ✓ …data represent (Figures 1a-d)…

2.7. Scientific Terminology

All units of measures should conform to the International System of Units (SI).

Measurements of length, height, weight, and volume should be reported in metric units (meter, kilogram, or liter) or their decimal multiples.

Decimal places in English language are separated with a full stop and not with a comma. Thousands are separated with a comma.

Percentage	Degrees	All other units of measure	Ratios	Decimal numbers
✓ 10%	✓ 10°	✓ 10 kg	✓ 12:2	✓ 0.056
× 10 %	× 10 °	× 10kg	× 12 : 2	× .056

Signs should be placed immediately preceding the relevant number.		
✓ 45±3.4	✓ p<0.01	✓ males >30 years of age
× 45 ± 3.4	× p < 0.01	× males > 30 years of age

2.8. Latin Names

Latin names of species, families etc. should be written in italics (even in titles). If you mention Latin names in your abstract they should be written in non-italic since the rest of the text in abstract is in italic. The first time the name of a species appears in the text both genus and species must be present; later on in the text it is possible to use genus abbreviations. *See* example:

- ✓ First time appearing: *musculus biceps brachii*

Abbreviated: *m. biceps brachii*

UCG
Univerzitet Crne Gore

UNIVERZITET CRNE GORE
ARHITEKTONSKI FAKULTET

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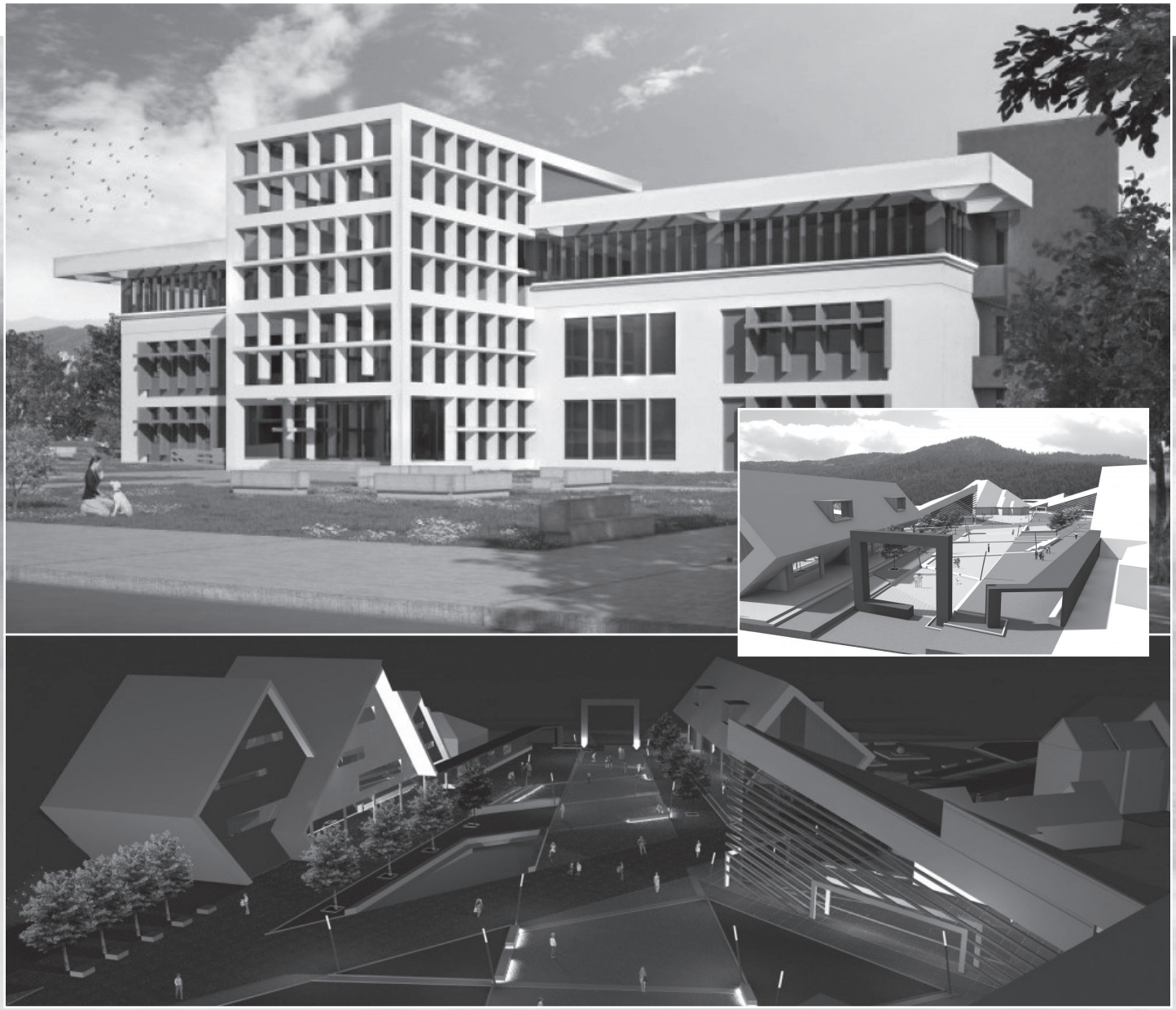
FACULTY OF ARCHITECTURE



The goal of establishment of our institution is the education highly qualified professional cadre based on the best knowledge of the theory and practice in the world, and its application to the development and implementation of plans and projects in the space - as a basic condition for the quality valorization, programming, management and protection of natural and inherited built environment. In this way conceptualized school forms internationally experts in all areas of creativity - in the field of urban planning, architecture, construction and design - which includes the ability to create useful objects, architectural forms of all categories, urban and vacant space at different levels. Such qualified cadre are the spiritus movens of development of culture and technology in the modern world.

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The University of Montenegro is the leading higher education and research institution in Montenegro. It is a public institution, established by the state, operating as a unique legal entity represented by the Rector. It is an integrated university organized on the model of the most European universities. Organizational units are competent for provision of study programmes, scientific-research and artistic work, use of allocated funds and membership in professional associations.

Since its foundation, the University of Montenegro has continuously been conducting reforms in the area of education and research, while since 2003 in line with the trends in EHEA. After adoption of the Bologna Declaration, University of Montenegro organized systematic preparation of documents aligned with it. Already in 2003, the experimental teaching programme started and today, all studies are organised in line with the Bologna principles. During the last two years systematic reforms of the University`s study programes have been conducted in order to harmonize domestic higher education system with European standards and market needs to highest extent.

The University of Montenegro has unique academic, business and development objectives. It comprises 19 faculties and two research institutes. The seat of the UoM is in Podgorica, the capital city, while university units are located in eight Montenegrin towns. The University support services and centers (advisory services, accounting department, international cooperation, career orientation) are located in the Rectorate.

Academic community of University of Montenegro is aware of the importance of its functioning for further development of the state and wider region. It has been so far, and will be in the future, the leader in processes of social and cultural changes, along with the economic development.

In the aspect of attaining its mission, University of Montenegro is oriented towards the priority social needs of the time in which it accomplishes its mission; open for all the students and staff exclusively based on their knowledge and abilities; dedicated to preservation of multicultural and multi-ethnic society in Montenegro; entrepreneurial in stimulating social and economic application of supreme achievements within the scope of its activities.

In 2015/16 there were a total of 1.192 employees at UoM, 845 of which were engaged in teaching. In the same year there were 20.236 students registered at all three cycles of studies.

Internationalization is high on the agenda of UoM priorities, thus it has participated in a number of international projects – over 50 projects funded under the Tempus programme, over 15 Erasmus Mundus Action 2 projects for student mobility, a number of projects under FP7 funding scheme or IPA supported projects, Erasmus + capacity building and International credit mobility projects and other.

For more information about University of Montenegro, please visit our website www.ucg.ac.me or send e-mail to pr.centar@ac.me.

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UNIVERSITY OF MONTENEGRO
MARITIME FACULTY - KOTOR

In addition to maritime education in navigation and marine engineering, University of Montenegro - Maritime Faculty in Kotor also provides additional training for professional seafarers in:

- Different IMO model courses
- DP - Dynamic positioning courses
- Offshore courses

From 2015 runs the newly established joint training center with partners from NTNU - Aallesund in Norway, being one of the most experienced and most successful in providing offshore and DP training courses worldwide. The up-to-date bridge simulator, accompanied by AB simulations and instructor station, enables the organization of all the courses held as in the Norwegian training centers, with the same team of instructors and certificates. So far, a series of courses have been organized related to the operation of complex offshore equipment and team work in these demanding operations, both for students and international crews. In addition, the Kotor/Aalesund training center has recently been awarded with the Nautical Institute accreditation for holding DP (Induction and Simulator) trainings and so far has successfully launched several groups of DP operators.

OSC offshore simulator at Maritime Faculty Kotor, Montenegro

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Centrala ++382(0)32 - 303 - 188
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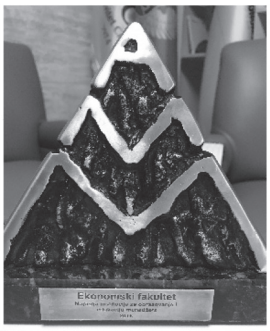
FACULTY of ECONOMICS PODGORICA

UCG
University of Montenegro

Faculty of Economics
University of Montenegro

The Faculty of Economics celebrated its 57th anniversary this year, and it is the oldest higher education institution in the country. Since its establishment, 8,630 students graduated at our Faculty.

Today, Faculty of Economics is a largely interdisciplinary institution, characterized by expressed dynamism in its work. Employees at the Faculty are dedicated to constant improvements and enhancements, all in accordance with the needs brought by the changes.



We provide our students with the best theoretical and practical knowledge, enabling them to develop critical spirit in approaching economic phenomena and solving concrete problems in daily work. From September 2017, at the Faculty, the new generation will start a 3 + 2 + 3 study, which will improve the quality of studying.

Development of Faculty of Economics in the coming period will follow the vision of development of the University of Montenegro, pursuing full achievement of its mission

Comprehensive literature, contemporary authors and works have always been imperative in creation of new academic directions at Faculty of Economics, which will form the basis of our future.

Faculty and its employees are dedicated to developing interest in strengthening the entrepreneurial initiative, creative and interdisciplinary approach among young people, using modern teaching and research methods. In this regard, the Faculty has modern textbooks and adequate IT technology, which supports the objectives set.

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Sports Science and Medicine Journals
from Montenegrin Sports Academy

We have expanded the quality of our journals considerably over the past years and can now claim to be the market leader in terms of breadth of coverage.

As we continue to increase the quality of our publications across the field, we hope that you will continue to regard MSA journals as authoritative and stimulating sources for your research. We would be delighted to receive your comments and suggestions, mostly due to the reason your proposals are always welcome.

Look Inside!

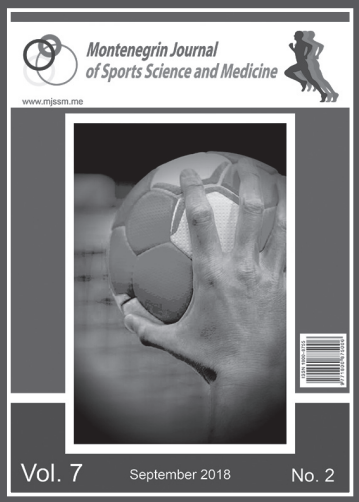
Sport Mont Journal

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Zoran Milosevic**, Serbia
Managing Editor: **Jovan Gardasevic**, Montenegro

Volume 16, 2018, 3 issues per year; Print ISSN: 1451-7485, Online ISSN: 2337-0351

Sport Mont Journal is a scientific journal that provides: Open-access and freely accessible online; Fast publication time; Peer review by expert, practicing researchers; Post-publication tools to indicate quality and impact; Community-based dialogue on articles; Worldwide media coverage. SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

www.sportmont.ucg.ac.me



Montenegrin Journal of Sports Science and Medicine

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Stevo Popovic**, Montenegro
Executive Editor: **Selçuk Akpınar**, Turkey
Associate Editors: **Mehmet Uygur**, USA; **Catalina Casaru**, USA; and **Predrag Bozic**, Serbia

Volume 7, 2018, 2 issues per year; Print ISSN: 1800-8755, Online ISSN: 1800-8763

Montenegrin Journal of Sports Science and Medicine (MJSSM) is published biannually, in September and March of each year. MJSSM publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest. MJSSM covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

www.mjssm.me

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UNIVERZITET CRNE GORE
PRAVNI FAKULTET – PODGORICA

UNIVERZITET CRNE GORE
PRAVNI FAKULTET PODGORICA

Faculty of Law was founded on October 27th, 1972 in Podgorica as a scientific and artistic educational institution, in which educational and research work was organized in the area of law and similar social studies. While making into law the establishment of this institution, Assembly of Socialistic Republic of Montenegro highlighted that "The establishment of this institution of high education is necessary for meeting overall demands of the society of the Republic". Faculty of Law is one of the founding fathers of the University of Montenegro.

During the forty-five years of its existence Faculty of Law grew to a modern, contemporary, scientific and artistic educational institution. Forty-five generations studied at the faculty. About 17.000 students enrolled at the faculty and 4285 students graduated from the faculty. About 15 percent of the students studied abroad. Part of the best students continued postgraduate and doctoral studies at prominent university centers. Most of the former students stayed in Montenegro due to family ties. 88 professors and associates worked at the faculty, out of whom there were 26 guest professors. Today most of the professors and cadre at the faculty are former students.

Faculty organizes graduate and postgraduate studies. There are teaching and cadre resources for organizing specialist and doctoral studies in all the areas of law.

As a university branch Faculty of Law realizes a big number of its planned aims and tasks and finds soulutions for many important questions of cadre organization, technical and material problems. With the help of the University of Montenegro, faculty largely develops the international coorporation net.

Faculty follows world trends and achievements in the area of high education with the aim to coordinate its work with European and world demands. This year faculty made the first steps in realization of Bologna declaration. There is enough cadre for all the necessary teaching at the faculty.

The faculty was founnded because of expression of need to reach the neccessary standard for socio-economic, political, cultural and social development of Montenegro. During its overall existence faculty shared the fate with Montenegrin society. It will continue to do so by making steps towards implementing new practises and creating new relations, with the help of implementatation of modern European trends .

The faculty is a complex organization and managing institution nowadays.

UNIVERSITY OF MONTENEGRO
FACULTY OF MECHANICAL ENGINEERING
Podgorica

www. ucg.ac.me/mf

Mechanical engineering studies in Montenegro started during the school year 1970/71. On April 15th, within the Technical Faculty, the Department of Mechanical Engineering was formed. The Department of Mechanical Engineering of the Technical Faculty was transformed in 1978 into the Faculty of Mechanical Engineering, within the University "Veljko Vlahović". Since 1992 the Faculty of Mechanical Engineering is an autonomous University unit of the University of Montenegro. It is situated in Podgorica.

The University of Montenegro is the only state university in the country, and the Faculty of Mechanical Engineering is the only faculty in Montenegro from the field of mechanical engineering.

Activities of the Faculty of Mechanical Engineering can be divided into three fields: teaching, scientific-research work and profes- sional work.

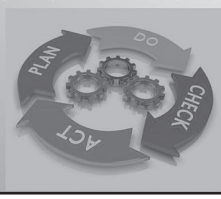
Two study programmes were accredited within the Faculty of Mechanical Engineering:

- Academic study programme MECHANICAL ENGINEERING
- Academic study programme ROAD TRAFFIC

The study programmes are realised according to the Bologna system of studies in accordance to the formula 3+2+3.

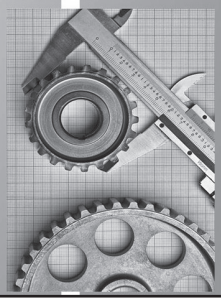
On the study program Mechanical Engineering it is possible to study next modules:

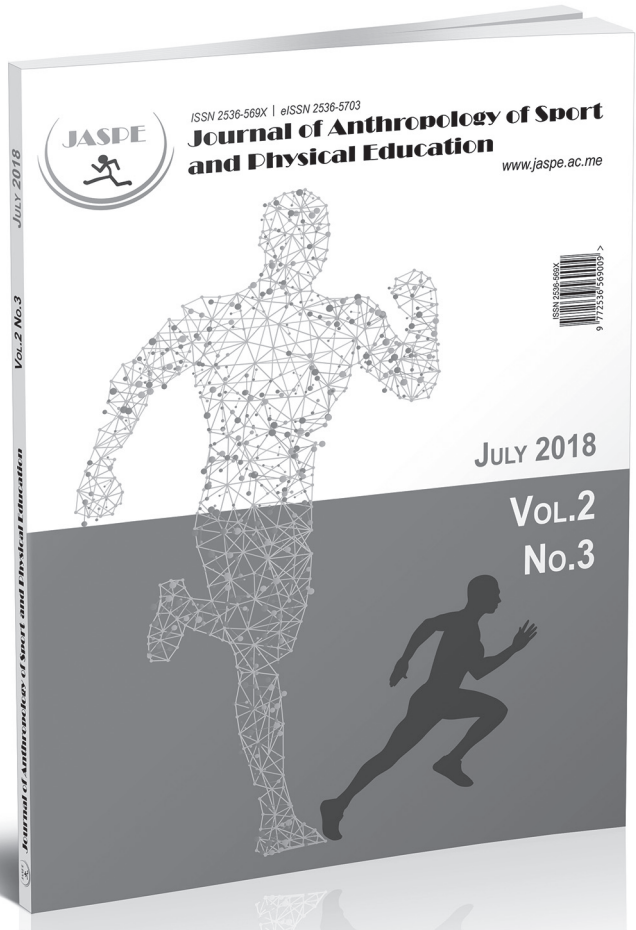
- Mechanical Engineering – Production
- Applied Mechanics and Construction
- Energetics
- Energy Efficiency
- Mechatronics
- Quality



At the Faculty of Mechanical Engineering, as organisational units, there are centres and laboratories through which scientific-re- search and professional work is done:

- Centre for Energetics
- Centre for Vehicles
- Centre for Quality
- Centre for Construction Mechanics
- Centre for Traffic and Mechanical Engi- neering Expertise
- Centre for transport machines and metal constructions
- 3D Centre
- Didactic Centre – Centre for Automation and Mechanomics training
- European Information and Innovation Centre
- Cooperation Training Centre
- Laboratory for Metal Testing
- Laboratory for Turbulent Flow Studies
- Laboratory for Vehicle Testing
- Laboratory for Attesting of Devices on the Technical Examination Line





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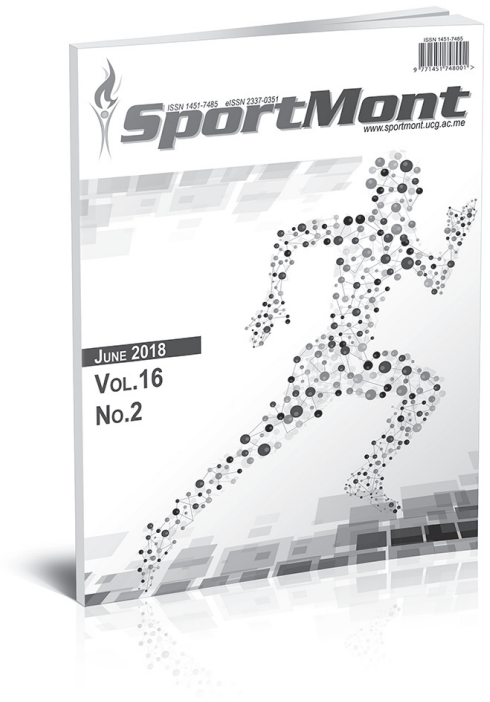

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Sport Mont Journal (SMJ) is a print (ISSN 1451-7485) and electronic scientific journal (eISSN 2337-0351) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:

- Open-access and freely accessible online;
- Fast publication time;
- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

SMJ covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the SMJ website: http://www.sportmont.ucg.ac.me/?sekcija=page&p=51. Contributors are urged to read SMJ's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to sportmont@ac.me or contact following Editors:

Dusko BJELICA, *Editor-in Chief – dbjelica@ac.me*
Zoran MILOSEVIC, *Editor-in Chief – zoranais@eunet.rs*
Jovan GARDASEVIC, *Managing Editor – jovan@ac.me*

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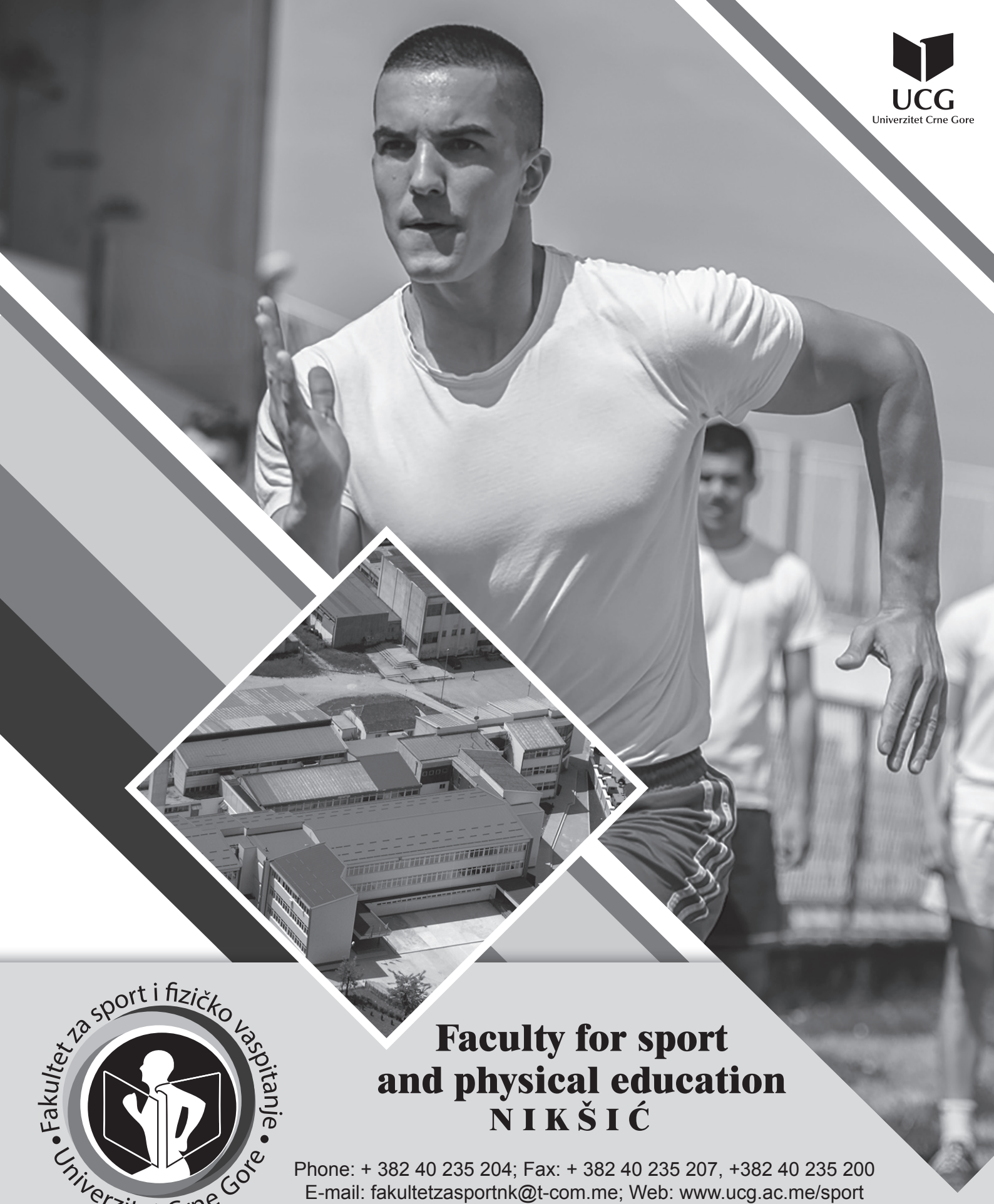

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16th Annual Scientific Conference of Montenegrin Sports Academy "Sport, Physical Activity and Health: Contemporary Perspectives"

http://www.csakademija.me/conference/

CRNOGORSKA SPORTSKA AKADEMIJA
MONTENEGRIN SPORTS ACADEMY

UCG
Univerzitet Crne Gore

4th - 7th April 2019,
Dubrovnik - Croatia