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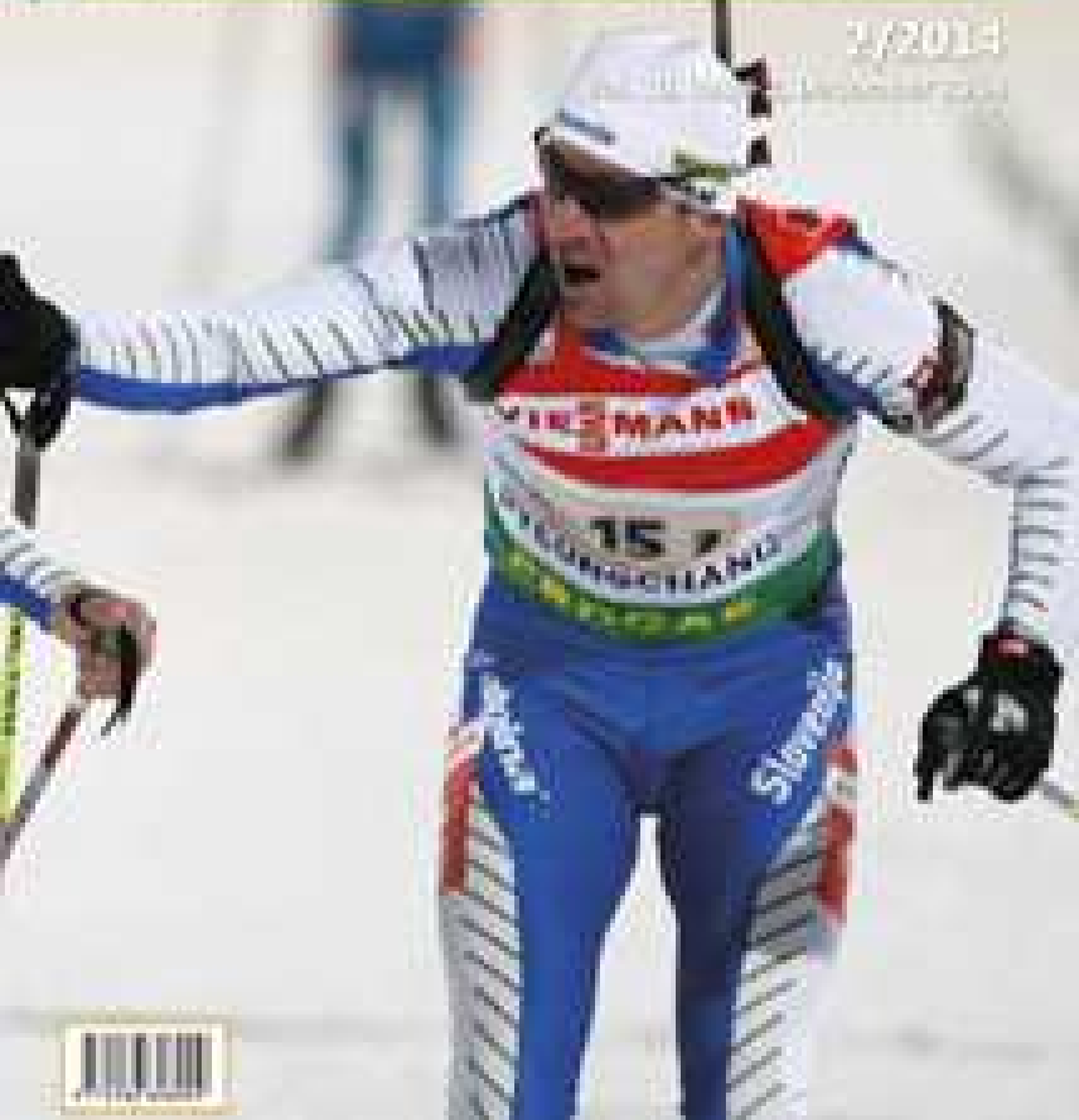

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ANTHROPOLOGICAL AND METHODOLOGICAL (DIDACTIC) ASPECTS OF WORK IN CONTEMPORARY SPORTS

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SUMMARY

Theoretical and methodological issues, solving of which may give a new impulse to the development of sport and sports achievements, are recently generated by newly established centers for scientific and professional work in sports, like sport science institutes, or institutes for applicative theory and methodology of training. Anthropological and methodological scientific investigation within the framework of the centers should solve issues put forward by sport practice, and vice versa, findings and inferences of scientific research into sport should be as quickly as possible built into actual sport practice. It is the only way in which the gap between science and practice can really be bridged over, or in which these two areas can be associated to benefit top-level sports achievements.

Key Words: anthropological research, didactic research, professional work in sports..

INTRODUCTION

Consistent development and preservation of sports achievements of individuals and teams alike is achievable only through the synergy of anthropological and methodological premises of professional work in sports regardless of sport branch, quality level, or age of trainees. Scientific research facilitates and improves solving of various theoretical and methodological issues that occure in sports training. It further contributes to the establishment of objective criteria for the selection of athletes and to the definition of preconditions needed for optimal level of fitness and sports form accomplishment, all in the function of the highest possible competition achievements.

Consequently, the main orientation in the professional sports training work regards the issue of how to design successfully the process of both the long- and short-term sports preparation to suit selected athletes on the basis of scientifically obtained information about the current level of athletes' shape and by implementing the admissible training technologies and recovery methods while simultaneously observing the given, sport-specific competition systems. Recently, sport science has been enriched with new concepts and insights into the previously mentioned factors of sport achievements that should be transferred to and substantiated with everyday sport practice.

Scientific research into sport depends on the participation of scholars and researchers not only from kinesiology of sport, or sport sciences, but also from other social-humanistic, biomedical and natural sciences as well and of experts of research methodology (Mraković, 1992; Reilly, 2007). Out of various social-humanistic sciences certain should be singled out like, primarily, kinesiology, understood as the science of movement and programmed processes of exercise and learning the target of which is optimal development and protection of human abilities, features and motor skills (knowledge), as well as several other social-humanistic scientific disciplines, like philosophy and sociology of sports, sport psychology, ethics, pedagogy, sports legislation, economics and marketing. From the area of biomedical sciences, contributions of kinesiological physiology and anthropology, sports medicine, pharmacology and nutrition science to sports should also be highlighted here. Additionally, fair proficiency in mathematics, information science, statistics and kinesiometry is indispensable to advance research methodology in the area of sports.

Quite a number of experimental scientific studies has been published from the area of *anthropological research* providing opportunities for the verification of hypotheses regarding the structure of various anthropological characteristics and motor skills and associations among them, as well as hypotheses on quantitative and qualitative transformations of features, abilities, motor skills, behaviour and health status that have been induced by the influence of various training programmes. These explorations primarily focus on the determination of quantitative indicators and on the establishment of latent structure of various anthropological variables, then on the analysis of relations between particular anthropological characteristics of athletes and their performance in sports activities, and the last but not the least, on the analysis of the effects of the involvement with particular sporting activities on changes in diverse anthropological characteristics. The other important research area regards the analysis of differences in anthropological characteristics among athletes pertaining to diverse sports branches, or among group of athletes of various age and gender within the same sport discipline.

Methodological research is focused on the analysis of effects diverse methods of physical conditioning and technical-tactical training as well as programmed training programmes have on athletes' performance and on their states in particular stages of fitness and sports form development across typical cycles of both the annual and perennial periodization.

The purpose of the so defined scientific research orientations in the area of sports and sports training can be expressed in short as the determination of *kinesiological, anthropological, and methodological* (covering the research and didactical methodology alike) principles or laws of planning, programming and control of the processes of sports training, competition participation and recovery in different cycles of sports preparation (Milanović, 2013).

ANTHROPOLOGICAL RESEARCH AS A FACTOR OF PROFESSIONAL WORK IN SPORTS

Each and every sport, that is, each sport branch has its own specific structure of performance factors, which are translated into sport-specific anthropological requirements imposed on the involved athletes. If an athlete possesses the required influencing features, then he/she meets the premises that define the status of an elite, high-performance athlete. The athlete who does not meet the sport-specific requirements remains at the threshold of elite-level sport and probably will never accomplish any outstanding sport achievement. *Anthropological research in sport* can be classified into several categories:

- Construction and validation of measuring instruments aimed at assessing anthropological features of athletes,
- Diagnostics of athletes' basic anthropological characteristics,
- Training fitness status assessment – model characteristics,
- Effects of anthropological characteristics on performance in sporting activities,
- Establishment of the differences in anthropological characteristics among athletes of various age, gender and sport orientation,
- Developmental characteristics of anthropological features of athletes across typical stages of one's sports career.

High performances and outstanding sport achievements are results of quality training plans and programmes as well as their realization. To design and realize such a programme one must get an insight into sport-specific requirements as well as into actual status of relevant abilities, features and skills (knowledge) of either individual athletes or of a group of athletes (Cardinale, Newton, & Nosaka, 2011). Such insights are provided by quality scientific research processes. Therefore the following performance-relevant indicators must be determined and monitored: morphological, functional (cardio-respiratory and metabolic), biochemical, biomechanical, motor (basic and sport-specific alike) and psycho-social ones. The information based on the listed indicators allows a successful diagnostics of the initial, transitive and final (post-programme application status) states of fitness in the function of top-level performances and sports achievements. Validation of current fitness and sports form is a basic precondition for optimal planning, programming and control of the process of sports preparation, containing clearly defined targets and tasks, cycles and working conditions (planning) as well as prescribed loads, training contents (means) and training methods (programming).

Preparedness evaluation of one group of top-level basketball players, members of the national team

An example of research into preparedness level will be analysed. The investigation in question was conducted with elite basketball players at the beginning of a training cycle within the scope of preparation for the main competition. In Table 1 average scores are presented of the members of one national senior basketball team and model values of scores on the tests assessing basic and specific physical conditioning abilities, presumed to be target values for the basketball players aspiring to be elite athletes in terms of top-level performances and sports achievements.

The presented results make the following inference viable: the status of physical condition of the observed basketball players is satisfying just in certain indicators; therefore it should be improved considerably during the preparation period. Most of attention the coaching team should direct at developing predominant motor and functional abilities, like explosive and speed strength, agility and speed endurance in order to bring, that is to elevate, the status of physical condition of the observed group of basketball players closer to the model values (scores of basketball players with the highest level of physical condition). The results of the comparison of individual characteristics with the model values are a basis for the design of group and individual physical conditioning programmes

The axes of preparedness profiles of elite athletes have being defined for a long time now. Also, there are many investigations into the relationships among anthropometric, functional (cardio-respiratory and metabolic), motor, social, cognitive dimensions as well as personality traits and certain other dimensions, on the one hand, and variously defined performance variables of a particular sport, on the other.

TABLE 1
Average scores of the national team players (x) vs. model scores of elite basketball players (Source: Milanović & Fattorini, 1990).

Tests	Scores	Model (required) scores
SAR_1 (cm)	68.50	70.00
SAR_2 (cm)	77.70*	80.00
SAR_3 (cm)	84.40*	90.00
BLG (cm)	17.20*	18.00
TROS (cm)	7.83*	8.00
TROJ (cm)	8.07*	8.50
SPR (s)	11.37*	11.25
20VS (s)	2.97	3.00
OSMB (s)	8.57*	8.50
OSMS (s)	8.94	9.00
4x5B (s)	4.87*	5.00
4x5S (s)	5.02	4.80
TRB (No)	35.90	36.00
SMB (s)	27.72*	26.00
SUT (%)	79.60	80.00
VUK (s)	56.17*	55.00
VO_2 (m/kg/min)	64.85	66.00

Legend: **SAR_1** - Explosive strength of jumping type; **SAR_2** - Explosive strength of jumping type;. **SAR_3** - Explosive strength of jumping type; **BLG** - Specific strength of throwing type; **TROS** - Explosive strength of repetitive jumping type; **TROJ** - Explosive strength of repetitive jumping type; **SPR** - Speed strength; **20VS** - Explosive strength of sprinting type; **OSMB** - Agility; **OSMS** - Specific agility; **4x5B** - Speed coordination; **4x5S** - Specific speed coordination; **TRB** - Trunk strength - endurance; **SMB** - Specific speed endurance; **SUT** - Accuracy; **VUK** - Lactic speed endurance; **VO_2** - Aerobic endurance; ***** - Tests in which members of the team scored lower than required model values.

Determination of differences between members of the Croatian national handball cadet and senior teams in the physical condition indicators

Vuleta, Milanović, and Jukić (1999) analysed the differences in nine physical condition indicators of handball players between the members of the cadet (n = 16) and senior (n = 16) national team. Statistically significant differences were obtained in six variables of flexibility (MFLPRR), absolute strength of arms (MFABPT), trunk repetitive strength (MRCPRE), specific speed of dribbling (MFESVM2), specific speed while dribble the ball (SRBV30), and specific explosive strength of throwing type (SRSBLT) (Table 2). The differences were attributed to the players' age and quality of the long-lasting sports training, especially to the well programmed training loads. specific speed of dribbling

TABLE 2

Differences in nine physical condition indicators of handball players between the members of the cadet and senior national team (Source: Vuleta et al., 1999).

Variable	M_C	M_S	SD_C	SD_S	Max D	t	df	p
MFLPRP	55.69	74.31	10.33	14.69	.09	-4.11	29	**.00**
MFABPT	60.63	74.69	11.24	14.43	.13	-3.08	30	**.00**
MRCPRE	30.50	32.81	2.56	3.64	.20	-2.08	30	**.05**
MFE30V	4.49	4.34	.18	.15	.08	2.67	30	.12
MFESVM1	63.69	61.33	6.17	5.48	.14	1.27	30	.21
MFESVM2	80.81	73.04	7.03	4.45	.09	3.74	30	**.00**
MFEBM1	248.35	269.60	35.41	28.01	.10	-1.88	30	.07
SRBV30	4.75	4.38	.22	.19	.10	5.05	30	**.00**
SRSBLT	226.15	257.00	41.00	33.11	.09	-2.34	30	**.03**

Legend: **MFLPRP** - Flexibility; **MFABPT** - Absolute strength of arms; **MRCPRE** - Trunk repetitive strength; **MFE30V** - Explosive strength of sprinting type; **MFESVM1** - Specific speed; **MFESVM2** - Specific speed of dribbling; **MFEBM1** - Explosive strength of jumping type; **SRBV30** - Specific speed while dribble the ball; **SRSBLT** - Specific explosive strength of throwing type; $\mathbf{M_C}$ - Mean cadets; $\mathbf{M_S}$ - Mean seniors; $\mathbf{SD_C}$ - Standard deviation cadets; $\mathbf{SD_S}$ - Standard deviation seniors; **Max D** - Empirical relative cumulative frequency deviation from the theoretical cumulative frequency; **t** - T-test; **df** - Degrees of freedom; **p** - Probability.

Physiological and biochemical requirements of sportaerobics (citated at Rodriguez, Iglesias, Marina, & Fado, 1998)

Portable telemetric systems make it possible nowadays to continuously and simultaneously measure oxygen consumption and heart rate. These indicators, together with blood lactate concentration determination, allow us to get an insight into the physiological requirements of a particular sport, in this instance the one of sportaerobics. The aim of research was to analyse heart rate (HR), oxygen consumption, and blood lactate concentration in the group of elite athletes of both genders as obtained during their competition performances. Further, the aim was also to describe their anthropological and physiological profiles. A group of 13 Spanish elite athletes (6 women and 7 men) of sportaerobics, out of which three were world champions, participated in the experiment that was conucted simultaneously with their competition season (competitions in the following categories: singles, mixed pairs, trios). During two weeks of the execution of experimental training programme, oxygen consumption and heart rate (HR) were measured by means of suitable equipment. Training programme drills lasted two minutes on average. Blood lactate concentration was analysed on the capillary blood samples taken at rest (min 1, 3, 4, 5, 7, 10, 12).

Moderate values of maximal aerobic power were obtained (moderate especially when compared to body weight), as well as considerable individual differences among subjects of both genders. Competition routines, lasting two minutes on average, are characterised with very intensive cardio-respiratory and metabolic requirements, and equalized at the maximum values about 88% of maximal oxygen consumption (quick oxygen kinetics), and average values of blood lactate concentration above 13 mmol/l (intensive glycolytic activation) with values ranging from 9.4 to 20 mmol/L. Higher metabolic values were obtained in singles and mixed pairs performances. Aerobics pertains to a group of sports with high cardio-respiratory and metabolic requirements, which intensively activate all metabolic sources. Competition-specific drills primarily aimed at the physiological activation of both the aerobic and anaerobic energy supply processes, with a high contribution of strength/power, flexibility, coordination and balance.

TABLE 3
Anthropometric characteristics and spirometry values of elite aerobics athletes obtained from all-out test on ergometer and during competition (Source: Rodriguez et al., 1998).

Varibales	*M±SD* Men	*M±SD* Women
Age (Years)	24.6±4.3	24.6±3.4
Body Height (cm)	173.8±1.1	157.9±4.9
Body Weight (kg)	72.4±5.8	51.8±3.1
Fatty Tissue (Yuhasz-Carater, %)	7.51±.9	12.77±2.7
Somatotype (Carter)	1.89-5.48-2.00	2.26-4.37-2.45
All-out ergometer test		
fHRmax (beat/min)	191±7	185±3
VO2max (mL/min)	4521±530	3015±162
rel VO2max (mL/kg/min)	65.4±6.8	58.6±4.0
VEmax (L/min)	146±7.2	106±8.2
During cometition		
fHRmax (beat/min)	185±4	184±7
VO2max (mL/min)	3828±412	2750±190
rel VO2max (mL/kg/min)	54.2±4.9	53.5±4.8
%VO2max	85.3±9.3	89.2±7.2
Blood Lactate (mmol/L)	13.4±3.6	13.0±2.0

Legend: **M** - Mean; **SD** - Standard deviation; **fHRmax** - Maximum heart rate; **VO2max** - Maximum oxygen uptake; **rel VO2max** - Relative oxygen uptake; **VEmax** - Pulmonary ventilation; **%VO2max** - Percentage of maximal oxygen uptake.

METHODOLOGICAL (DIDACTICS) RESEARCH AS A FACTOR OF WORK IN SPORTS

Unfortunately, the fewest scientific evidences have so far been provided of the efficiency of certain exercise and teaching methods. Investigations are needed to obtain information on the most quality methods for the development of particular abilities in conjunction with age, gender and quality level of athletes. On the other hand, investigations are also needed to determine efficacy of diverse methods in particular cycles of both the annual and perennial periodization. Special scientific interest has recently been arosed by explorations into the effects of integral preparation on the comprehensive development of all components relevant to optimal preparedness of athletes.

In the last thirty years numerous research studies have been published in the world that determined quantitative and qualitative changes in physical condition characteristics of subjects after the implementation of transformational procedures. Various quantitative changes have been investigated that have been generated under the influence of differently designed transformational procedures aimed at developing cardio-respiratory and metabolic capabilities (functional abilities) (Baquet., van Praagh, & Berthoin, 2003; Gettman, Ayres, Pollock, & Jackson, 1978; Hickson, Rosenkoetter, & Brown, 1988; Jones & Carter, 2000), motor abilities (Heitkamp, Horstmann, Mayer, Weller, & Dickhuth, 2001; Hunter & Marshall, 2002; Sale, MacDaugall, Jacobs, & Garner, 1990;

Zafeiridis et al., 2005) and morphological characteristics (Blazevich, Gill, Bronks, & Newton, 2003; Fry, 2004; Gettman et al., 1978; Tremblay, Despres, & Bouchard, 1985). Within the body of scientific research studies the greatest interest has been payed to training programmes intended for the development of various types of strength and their influence on adaptative transformations in human organism. This is espe-

TABLE 4

Review of the selected studies on the effects of various physical conditioning training methods (Source: Milanović, Barić, Jukić, Šimek, & Vuleta, 2007).

Study	Aim	Groups	Treatment	Results	Conclusion
Handel, Horstmann, Dickhuth, and Gulch (1997)	Efects of 8-wk unilateral isometric flexibility training (post-isometric contraction passive stretching) on muscular activity.	16 athletes.	Unilateral stretching drills; contraction – relaxation – stretching.	↑ active and passive flexibility. ↑ maximum force (up to 21.6%) and work (up to 12.9%) under the conditions of excentric loads.	Muscular activity under the conditions of ex-centric loads has probably been infringed by mental processes..
Lephart, Abt, Ferris, Sell, Nagai, Myers, and Irrgang (2005)	To determine efects of 8-wk plyometric and resistance training programmes on the neuromuscular and biomechanical characteristics of female athletes.	27 female secondary-school athletes in each group.	Plyometric training and basic resistance training programme.	↑ isokinetic power of knee extensors. EMG values for m.gluteus medius prior to the ground contact and EMG for m.gluteus medius at and post the ground contact were significantly higher in both groups.	Basic resistance training programme causes positive neuromuscular and biomechanical transformations. Plyometric training programme is beneficial to mastering muscular abilities.
Helgerud, Engen, Wisloff, and Hoff (2001)	To determine aerobic training effects on performance in fotball matchesand specific tests.	10 subjects – elite football players (C). 9 subjects – football players (E).	Interval aerobic training, 4x4 min at the 90-95% MaxHR with 3 min jogging between the intervals. 2x8-week.	Experimental group: augmentation of VO2max, lactic threshold, running economy, specific abilities in perfomances with ball. Control group: no changes.	Advanced aerobic training enhances distances covered by running, activity intensity and nzmber of sprints during the game.
Olsen and Hopkins (2003)	To analyse effects of: a) attempted ballistic training (explosive movement performance with elastic ribbon) and b) conventional resistance training.	13 subjects (E) 9 subjects (C) – regular martial arts training.	Ballistic training and conventional resistance training.	Resistance training generated increase of 12% in the frontal kick power. Both training modalities reduced the side kick power by 15%±14%, but they also increased its speed by 11-21%±13-17%.	Balistic training may be efficient for the athletes with quality kicking technique in the sports requiring speed and not strength.
Tricoli, Lamas, Carnevale, and Ugrinowitsch (2005).	To determine short-term effects of large resistance training combined with vertical jumping training or with weightlifting	Weightlifting group (WL) (E1) = 12 subjects. Vertical jumps group (E2) = 12 subjects. 8 subjects (C)	8 weeks WL training programme Jumping training. In addition, each group performed 4x6RM semi squats	WL programme significantly increased running speed. Both experimental groups increased vertical jumping ability, with a greater rate of increments in group E1 than in group E2. In rement in 1RM semi squat than group E1 (47.8 vs. 43.7%). Only group E1 improves scores of squat jumps (9.5%). Control group – no significant changes.	It seems WL drills have a more significant effect on the improvement of performances of physically active athletes than jumping drills.

Marković (2004)	To determine the influence of sprinting and plyometric training.	Plyometric and sprinting experimental group, n = 50 in each group; control group, n = 51.	10 weeks, 3 times a week jumping and sprinting training.	Both experimental procedures = changes in the space of strength/power. Plyometric training had a significant effect on all strength/power dimensions, except on maximum muscular force and elastic strength especially. Sprinting training did not improve scores of isometric squat and weighted jump.	Sprinting training has a more versatile influence the measured strength manifestations than plyometric training.
Šimek (2006)	Determination of the proprioceptive training effects.	38 (E), 37 (K).	10 weeks (3x60 min a week).	Proprioceptive training improved performance of a two-legged vertical jumps, sprinting, frontal agility and balance.	Proprioceptive training is recommendable as a supplement to physical conditioning.

cially valid for the determination of changes in the indicators of subjects' physical condition provoked by the explosive and maximal strength developmental training programmes (Colliander & Tesch, 1990; Crewther, Cronin, & Keogh, 2005; Delacluse, 1997; Little, Wilson, & Ostrowski, 1996; Peterson, Rhea, & Alvar, 2005; van den Tillaar, 2004; Wilson, Murphy, & Giorgi, 1996).

Research on the effects of various physical conditioning methods

Table 4 represents a selection of methodological research studies conducted in Croatia and abroad. Although forming a firm foundation, these investigations have not managed to elicit which transformation procedures, and to which extent, generate adaptations of functional and motor abilies and morphological characteristics of subjects. Thus the explorations into transfromations of physical condition features under the influence of various modalities of training work and various sizes of loads become even more important, as well as the investigations into integral effects of particular transformational procedures

The findings of research into the effects of various physical conditioning methods, like the concrete examples presented in Table 4, make it viable to advance methodology of training work aimed at developing conditioning abilities. Findings of single research studies on the effects of particular physical conditioning methods are frequently grouped according to target orientations (development of abilities, particular training system applications, specific training programmes…) and analysed through meta-analyses that, eventually, offer syntheses of a particular method or training system efficiency for the development and sustainment of physical condition abilities.

Peterson, MD., Rhea, MR; Alvar (2004) published their meta-analysis on strength development. Efficiency and safety of strength training programmes are extremely important to sport performance. If variables of training methods are optimal, then they are maximally efficient in strength development over a time unit and in overtraining or overloading risk reduction. The aim of the analysis was to determine optimal ratio of training variables in athletes. A meta-analysis of 37 research studies indicates the maximum effects of strength training are realized when 85% 1RM training is implemented 2 times a week, with the average volume of 8 series per muscular group. Previous research demonstrated differences between athletes and non-athletes in training methodology and in defining the optimal relationship between training variables. The findings of this meta-analysis are directly applicable to sports practice for strength training optimal effects. The meta-analysis of plyometric training influence on jump height suggests positive effects of the training on jumping ability development (Marković, 2007). The analysis of 26 research studies indicates statistically significant and relevant improvement of vertical jumping ability ranging from 4.7% for the squat jump and depth jump, and up to 8.7% for the counter-movement jump after the application of plyometric training. Also, there are many meta-analyses of studies dealing with investigation into methodical parameters of preventive training and incidence of certain injuries incurred in sports. The meta-analysis by Hewett, Ford, and Myer (2006) established positive preventive effects of neuromuscular interventions on the anterior cruciate ligament (ACL) injuries in female athletes. A huge disproportion in the number of ACL injuries between female and male athletes (4-6 times higher incidence in female athletes) led to a great number of explorations into this health-threatening issue and the effects of neuromuscular interventions, designed to facilitate avoidance of injuries. Meta-analysis of published studies (Ibid) indicates a significant effect of most neuromuscular programmes on the reduced incidence of the anterior cruciate ligament injuries in female athletes involved in the strength, jumping, stability and agility training programmes (total effect, $z = 4.31$; $p < .0001$). This review summarizes evidence-based conclusions through compiling common parts of diverse interventions, thus enabling understanding of potential of certain programmes and their combinations as well as of their efficient application in practice.

A meta-analysis embraced 27 explorations into the effects of taper on sports form (Basquet et al., 2003). Performance was the dependent variable, whereas the reduced exercise intensity, exercise extensity and frequency as well as a type and duration of taper were the independent variables. This meta-analysis indicates the optimal strategy of timely enhanced sports form for a competition would be an intervention in the form of a two-week taper prior to competition. In it training volume is exponentially lowered by 41-60% with or without modifications of intensity and work-out frequency.

Sports practitioners use findings of individual investigations, reviews and meta-analysis as to continually adjust training methods and procedures in accordance with characteristics of sport groups they are working with, then with working conditions and specific features of a particular cycle of sports preparation.

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SUPPORT OF SCIENCE FOR POLITICAL DECISIONS ABOUT PHYSICAL EDUCATION IN SLOVENIA

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SUMMARY

The changes in Physical Education (PE) curriculum, amount of PE lessons, number of students in class, improvement in class environment, amount and competency of PE teachers and increase of extra-curricular and out-of school sport programmes have effects on physical fitness of young people. It is very important to have special concern about this factors/systematic measures in public schools to ensure more equal opportunities for each child.

Key Words: physical fitness, Slovenia, young people.

INTRODUCTION

The lives of young people in developed countries today are mostly characterised by the modern information era. Many young people live in a half-virtual world of web social networks; they also choose to participate in physical activities less often than they used to (Froberg & Andersen, 2010; Strel, Kovač, & Jurak, 2007; Strong et al., 2005). In connection with the sheltering praxis of parents (restriction of children from access to public spaces, e.g. playing on city playgrounds, from walking alone in their own neighbourhood, from crossing the street by themselves), individualisation (children's incorrect impressions of their role in society) and permissive education, sedentary lifestyles are common among young people (Armstrong, 2007; De la Cruz-Sanchez & Pino-Ortega, 2010; Ferreira et al., 2007; Jurak, 2006; Strel et al., 2007). According to the findings of secular trend studies, it can be concluded that changes in the lifestyles of young people in developed countries are manifesting themselves in an increased subcutaneous fatness (Olds, Ridley, & Tomkinson, 2007; Strel et al., 2007), a higher proportion of the overweight population (Currie et al., 2004; Lobstein & Frelut, 2003; Malina, 2007; Strel et al., 2007; Wedderkopp, Froberg, Hansen, & Andersen, 2004), and deterioration of their cardiorespiratory and motor fitness (Froberg & Andersen, 2010; Strel et al., 2007; Tomkinson & Olds, 2007; Tomkinson, Olds, & Borms, 2007).

The main part of children's physical activity is presently allocated to regular PE classes in schools (Bailey, 2006). Sufficient quantity of a quality PE programs can contribute significantly to the overall amount of moderate-to-intense physical activity of the school-age child (Trudeau & Shephard, 2005). PE should also serve as a venue to prepare students to be physically educated person: to teach them the importance of regular physical activity for health and to build skills that support active lifestyles (Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Fairclough & Stratton, 2005; Froberg & Andersen, 2010; Sallis, Prochaska, & Taylor, 2000). In addition, the fact that motor development and physical fitness are closely related to cognitive and emotional-social areas of a child's development (Kovač & Strel, 2000; Sibley & Etnier, 2003; Tomporowski, 2003) should not be disregarded. PE is therefore very important systematic tool for physical development of young people.

The decision-making process concerned with key issues of the education profession is not always kept within the domain of the critical professional and/or scientific public. It is usually controlled by the governing political party, which legitimately has been granted the right to make decisions, albeit that these decisions can seriously hinder the development of an educational system if exercised solely on the ruling party's authority without due regard to any carefully considered research-based arguments. Populist decisions on, and in, an educational system are especially questionable professionally.

From this point of view, it is not just important that scientist and experts notice and understand the changes and needs of young people. They should also listen to the problems facing teachers, coaches and parents and should be involved in the process of looking for solutions which derive from actual situations and can be realistically carried out. Especially important are systemic measures in the area of PE which have long-term positive or negative consequences. Within this paradigm some cases of application of research findings to PE practice in Slovenia will be presented.

METHODS

This paper particularly draws from several databases, carried out by University of Ljubljana. The representative data of physical fitness and lifestyle's patterns of young people and environmental impacts on their physical activities have been collected on sample around 3.500 students aged 7 to 19 in Slovenia since 1970 within BPS SLO study (Bio-psycho-social characteristics of Slovenian children and youth) pro (Strel et al., 2007). Some morphological characteristics and motor fitness of the whole population of children and youth aged 7 to 18 have been systematically monitored since 1987 as part of the SLOFIT (see Table 1; Strel, 1997). To get broader picture about factors influencing on physical fitness of young people data from some other research studies will be presented:

- Sports and physical activities levels of Slovenian children and youth (Jurak, Kovač, & Strel, 2002a, 2002b; Jurak et al., 2003; Strel et al., 2007; Jurak et al., 2014; Sorić et al., 2014),
- Excusing from PE lessons (Jurak & Kovač, 2011a, 2011b),
- Sports talented youth in Slovenian educational system (Jurak et al., 2005),
- Lifestyles of Slovenian high school students (Jurak, 2006),
- Environmental factors of physical activity of primary school students (Starc et al., 2011),
- Competency of PE teachers (Kovač, Sloan, & Starc, 2008),
- Comparison of physical fitness of Slovenian and Serbian young people (Jurak et al., 2011a),
- The analysis of school sports area with guidelines for further investments (Jurak et al., 2011b).

Motor fitness of children in SLOFIT is assessed by *t* and M_t values. *T* values are normalized values of tests results in certain variable by ranking quantile normalization using whole population of the same gender and age as a reference group. M_t values is computed by averaging the normalized (*t*-values) scores of all eight motor tests and linearly transformed, so that the M_t score in entire population (at particular gender and age) has normal distribution with mean of 50 and standard deviation of 10.

Following, three major problems in physical fitness of Slovenian young people are presented. For each research finding measures and key actions for PE practice on policy (PE curriculum, national programme of sport, guidelines for PA in Slovenia, standards for PE) and teacher's level will be introduced. This paper will therefore elucidate that there is a large potential

TABLE 1
Tests in SLOFIT system.

Abbreviation	Variable	Measured capacity	Measuring unit
ATT	Body height	Longitudinal dimension of the body	mm
ATV	Body weight	Voluminosity of the body	kg
AKG	Triceps skinfold	Subcutaneous fatness	mm
DPR	Arm plate tapping	Speed of alternate motion	no. of repetitions
SDM	Standing long jump	Explosive power	cm
PON	Polygon backwards	Co-ordination of whole body movements	s
DT	Sit-ups	Strength of abdominal muscles	no. of repetitions
PRE	Bend forward on a bench	Flexibility	cm
VZG	Bent arm hang	Muscular endurance of the shoulder girdle and arms	s
T60	60-metre run	Sprint speed	s
T600	600-metre run	General endurance	s

for changes of physical fitness of young people in scientists' engagement on application of research findings to PE practice, especially on political level.

DECREASING OF PHYSICAL FITNESS OF YOUNG PEOPLE IN SLOVENIA

Increased body weight and fatness are markedly presence at Slovenian children and youth. In 19-years-old youth 2.2% of boys and 1.8% of girls could be class among obese, on the other side number of underweight girls is increasing because of feeding disturbance – there share is between 5 and 10% (Starc, Strel, & Kovač, 2010). Tracking overweight and obesity from childhood to young adulthood (Starc & Strel, 2011) shows that height, weight and BMI at 18 years were well predicted from childhood and become more predictable with age, while TSF was not. Obese and overweight children had the greatest risk of becoming obese or overweight young adults. The history of their weight shows that 40.0% of males and 48.6% of females who were obese at 18 years had already been obese at 7 years.

FIGURE 1

Negative changes in motor potential of Slovenian youth in period 1990-2008.

Similar negative changes are also noticed in motor fitness of Slovenian young people: deterioration of their motor potential, mainly endurance and strength (Starc & Strel, 2011; Strel et al., 2007). The findings also demonstrate a decline of results in activities which require young people's body movement (Strel et al., 2007). On the other side, sporting activity of Slovenian primary school children is increasing (Jurak et al., 2003; Strel et al., 2007); primary school children are physically active 1 hour per day (Strel et al., 2007). On this basis it can be concluded, that recommended and actual physical activity (60 minutes of moderate to vigorous physical activity per day) is not enough to neutralise all negative effects of nowadays lifestyles of Slovenian youth!

Applications

90 min of moderate to vigorous physical activity per day should be recommended for children aged 6 to 19. 50% of this physical activity should be allocated in school in regular PE lessons and other curriculum activities. In such manner few changes of Slovenian PE curriculum were done:

- *Emphasis on endurance sports activities.* The effects of modern routines, the informational way of life and democratic education are reflected in the ever decreasing endurance of children and youth. It is suggested that PE teachers concentrate on organised exercise and encourage children to become involved in endurance activities. Various contents of curriculum are available to achieve this aim (not just running) and they should be practised outside more often than currently, even in slightly adverse weather conditions. Heart rate monitors could be successfully used during exercise.
- *"Play is fun, but it's hard work too!"* Pleasure effects should be outcome of systematic, goal oriented

planned and professionally lead PE lessons. Some modern trends of society, like individualisation, permissive education principles, taking care about pleasure, are in contradiction with a lot of principles of PE. PE in not only pleasure if we are planning to meet goals, it is also pain. It is not only relaxation, first it is effort…

- *Education for understanding sport*. Only young people who understand the importance of PE can in their free time and subsequent adult life be expected to undertake physical activity suited to their abilities, wishes and needs. The teaching of PE should include theoretical contents, which teachers should present alongside practical work. Teachers should use various didactic materials (posters, study notes, computer programmes, computer games etc.) in order to pass on the theoretical contents of sport.

Despite some attempts to shortening the standards of PE teaching we were manage to keep them. This was done on the basis of research findings arguments. Basic standards of PE teaching in Slovenia are:

- *an average no. of students per teacher* is 16.6 students at age of 6 to 11 and 8.2 students at the age of 12 to 14 (Statistični urad Republike Slovenije, 2011),
- *competencies of PE teachers* are relatively high (Kovač et al., 2008),
- *material conditions for PE* are good, since every primary school have at least one sports hall, most of them also have outdoor sports terrains (Jurak et al., 2011b).

In Slovenia we have national programme of sport (Jurak et al., 2010) which define public interest and consequently public finances in sport out of school system. One of strengths of this programme is intertwining with school programme in some project:

- *Interventional kinesiological programmes* (classes with additional PE, project Healthy lifestyle)[2].
- *Hurrah*, free time (spending summer holidays in school sports halls; cooperation with NGO). Project started on the basis of our findings (Jurak et al., 2003) that students would like to take part in sports activities in the school sports halls during the summer holidays. Only about 10% of programmes organized during the summer holidays took place in school sports halls in that time; in such way sports activities could be organized with minimal financial costs.
- *National media campaign* about the significance of youth sport.
- *Improved quality of diet* at home and at school (planned diet at school).
- "*A minute for health*" and "*Recreational break*".
- "*Safe paths*" to allow safe walking or cycling to and from school.
- Public (fee-free) *sports facilities*.
- National and local communities *sports schools* (co-financing of university educated professionals for working with young sports people).

PHYSICAL AND MOTOR DEVELOPMENT OF YOUNGER SCHOOL CHILDREN

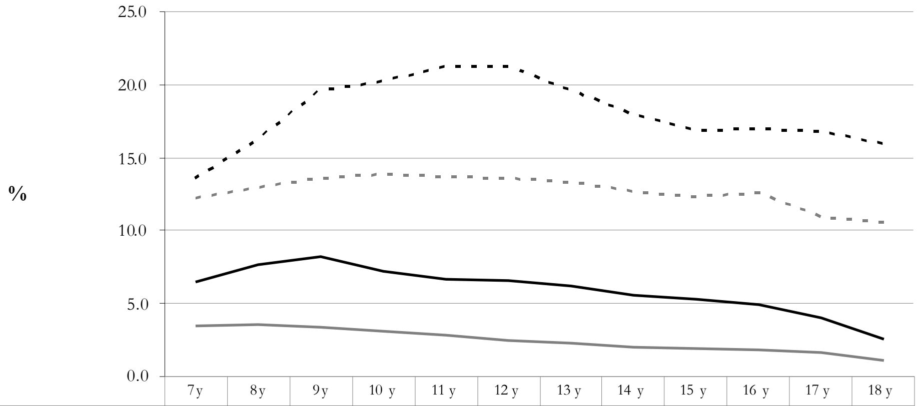
The most favourable period for the development of a child's various motor abilities is between the ages of 6 and 12 (Gallahue & Ozmun, 1998); developmental aspects ignored during this period are difficult or impossible to compensate for later. Practitioners and researchers have been warning for a long time that children in this age period require at least an hour of quality physical exercise every day, provided by professionally competent teachers. Studies (Starc et al., 2010; Strel et al., 2007) of the physical development of children aged 6-10 have revealed that the proportion of overweight and obese children in Slovenia has been increasing particularly in this age group (see Figure 2) and that the physical fitness of these children is decreasing, more so than amongst adolescent youth.

In the first six years of schooling, Slovenian children have three PE lessons (45 minutes each) per week and that legislation prescribes that all the subjects in the first three-year period are taught by elementary class teachers. In the fourth and fifth years, two or three subjects can be taught by a subject specialist (including PE). Notably, current legislation does not allow PE teachers to teach PE independently in the first three years of primary school but rather they have to be accompanied by elementary school class teachers. Such joint teaching comes at a cost because schools are responsible for the necessary financial resources either through local municipalities, or parents or their own sources (Jurak et al., 2005).

Some primary schools understand the importance of everyday physical activity on children's physical fitness and have been offering an enhanced PE curriculum, containing daily PE lessons and joint teaching of elementary class and PE teachers in the first four years of schooling since 1984 (Jurak et al., 2005). In longitudinal study Jurak et al. (2011c, 2013) examined the effects of the implementation of such school-based kinesiological intervention. The kine-

FIGURE 2

Comparison of overweight and obese pupils in Slovenia by age (1991-2009).



	7 y	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	16 y	17 y	18 y
overweight 1991	12.3	13.0	13.6	13.9	13.7	13.6	13.3	12.7	12.3	12.6	11.0	10.6
overweight 2009	13.6	16.3	19.6	20.3	21.3	21.3	19.6	18.0	16.9	17.0	16.8	16.0
obese 1991	3.5	3.6	3.4	3.1	2.8	2.5	2.3	2.1	1.9	1.9	1.6	1.1
obese 2009	6.5	7.7	8.2	7.3	6.7	6.6	6.3	5.6	5.3	4.9	4.0	2.6

siological intervention group achieved better results than the control group in all motor variables, especially in the motor tasks of polygon backwards, sit-ups for 30 seconds, and 600-metre run. This is particularly important because the muscular endurance and running speed of children of that age have been falling in recent decades. The results point to a better quality of sessions in kinesiological intervention consisting of a wide range of motor skills, a suitable organisation of work and greater amounts of exercise.

Applications

Further development of interventional sports programme depends on the initiative of parents for organising them in individual schools as well as on financial support of local community and the government, on prospective financial contribution of parents for above-standard services and on the reasonable flexibility of a model, which would permit various organisational solutions according to the characteristics of school environment. The systemic co-financing of such joint teaching through action plan of national programme of sport has been providing.

On the research findings and good experience with interventional sports programme two years ago national project Healthy lifestyle also started, funded from European funds. In this project students in primary school have 2 extra hours of optional physical activities per week. These activities are free of charge, led by PE teachers. PE teachers are extra employed teachers for half time employment. This project represents starting point for many young PE teachers, who proved themselves and get permanent full time job.

PHYSICAL ACTIVITY OF SECONDARY SCHOOL STUDENTS

During the period of adolescence, when young people are at a crossroads of searching for their future path and the formation of their own identity, their motivation for participation in various activities changes. Public opinion research shows, particularly for younger age groups, that major values, once based on strong ideologies, are being replaced by values closer to the individual and personal experience. Their different interests, the supply of comfort via the click of the mouse and a virtual world without realistic problems lead young people into more passive spending of their free time (Brettschneider & Naul, 2004; Jurak, 2006; Jurak et al., 2003; Riddoch et al., 2004), most often in front of TV screens and play stations and on mobile telephones etc. "Screenagers" feel comfortable only in virtual world in which they communicate only with the computer screen (Rushkoff, 2006), which prevents them from acquiring important social competencies – expressed by the term *cocooning*. Specific ways of spending free time at weekends for some young people usually include risky types of behaviour, such as smoking, drug use and drinking alcohol (Jurak, 2006).

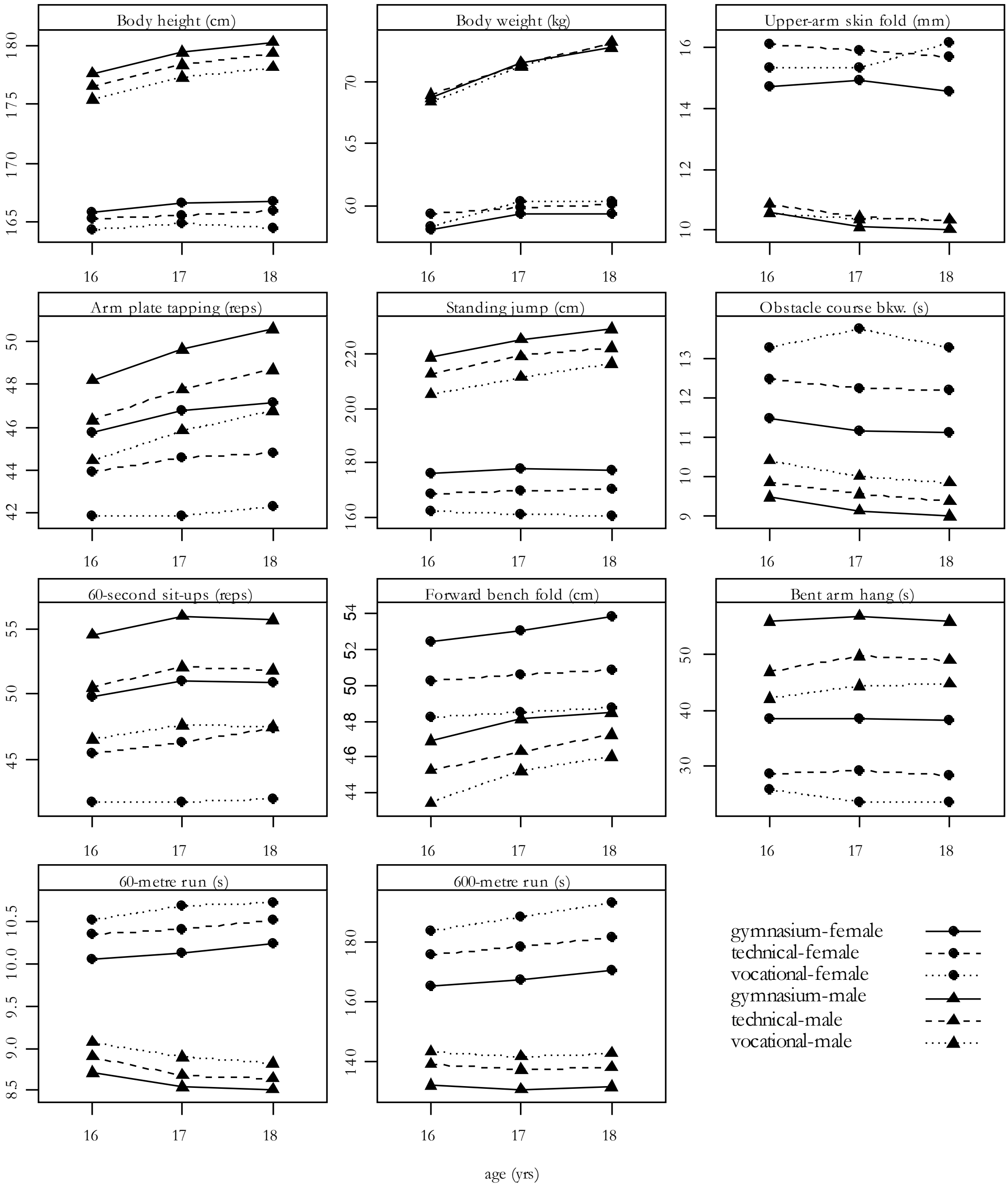
For modern youth, physical activity has lost its primary value – enjoyment in movement. Activity, particularly sport, does not represent any challenge for adolescent young people today, because results require time and effort, as the effects of motor learning and achieving adequate fitness are possible only with a sufficient number of repetitions of specific motor patterns. Jurak et al. (2003) found that teenagers feel cramped by being included in the organised types of sport activity offered by schools and sport clubs. This represents "traditionalism" and "ideology", whereas they wish to practise in their own time. Certain sports that young people participate in mostly in an informal way have become a part of the culture of teenage behaviour and dressing (skateboarding, snowboarding, mountain biking etc.).

It is acknowledged that physical fitness of youth has a correlation with the amount of free time they devote to sporting activities (Jurak et al., 2003). In recent years, some major changes in the way Slovenian young people spend their free time have been observed. Boys are more physically active in their free time than girls; nevertheless, the amount of free-time physical activity gradually decreases with age in both genders (Jurak et al., 2003; Kovač, Jurak, Starc, & Strel, 2007). The proportion of secondary-school boys who do not participate in any sport activity during summer holidays rose from 10.6% in 1993 to 15.2% in 2004 (Strel et al., 2007).

As a result, studying the lifestyles of young people has also become the subject of numerous research projects in Slovenia, indeed in many other countries

FIGURE 3

Differences (interaction plots) among secondary school students in different educational programmes.



across the globe. Jurak (2006) found that in Slovenia young people can be divided in two extreme typical groups according to their lifestyle, which have, in relation to the (un)healthy habits, been named the "coffee and cigarettes" and the "sport" lifestyles. The groups show statistically significant differences not only in free time sporting activity, regular smoking and alcohol drinking, academic results, educational level of their parents, but also in eating meals and self-evaluation of well-being. Two extremes of lifestyles is also visible in their motor performance, since proportion of students with worse physical performance index (M_t < 40) increase in secondary schools.

Next problem is amount of PE in secondary schools. It is a paradox that students in secondary school education who follow different academic programmes have different amounts of PE lessons, as the need for physical activity is the same for all groups. Consequently, it would be legitimate reasonable to expect that in the subject intended to foster a healthy lifestyle, everyone be offered optimal developmental opportunities. Furthermore, in view of differences between young people, those in need of more motor encouragement should also have more PE lessons.

We analysed differences in various characteristics between groups of students from different secondary school programs according to their gender, age and the type of programmes they attend (Leskošek, Kovač, & Strel, 2007). Amongst others, the findings featured in Figure 3 revealed:

- the type of programme differentiates boys and girls the most with the best results in all tests achieved by boys and girls in gymnasia school programmes, followed by technical schools programmes and the worst results achieved by boys and girls from vocational schools programmes;
- the differences are smaller amongst boys than girls;
- the greatest difference between the types of programme – whilst controlling for age and gender – was observed in the results of sit-ups and arm-plate tapping tests; and
- statistically significant differences were also observed in morphological differences, particularly in body height and the amount of body fat.

The researchers concluded that these differences may occur as a result of the students' different socio-economic environments. The less favourable morphological structure of students from vocational programmes is probably a result of their lower amount of physical activity and unsuitable eating habits. The results confirm the findings of other researchers suggesting that vocational schools' students have the worst nutritional habits (Gabrijelčič Blenkuš, 2001). The poorer physical fitness of vocational schools' students is probably a result of the more infrequent free-time sport participation, the lower amount of school PE lessons as well as attitudes to sport activity, which serve as an indicator of a quality way of spending one's free time (Jurak et al., 2003). There is also a problem of excusing from PE practise, where girls from secondary school dominate (Jurak & Kovač, 2011a, 2011b).

Applications

A systematic, structured PE process has important effects on the physical fitness of young people and their knowledge about healthy lifestyles. At the same time, it can serve as an important compensational tool. The appropriate physical activity can effectively prevent the negative effects of work stress, which are in the case of vocational load usually one-sided (most often also asymmetrical), often static and can in the long-term cause physical defects. Hence, modernisation of contents in secondary school PE curriculums has been made. There are more health related contents, education for understanding sport and emphasis on endurance sports activities and neutralisation of occupational health problems.

To decrease the excusing from PE practise guidelines adopted by national association of PE teachers has been set in two directions (Jurak & Kovač, 2011a, 2011b):

- Limitation of reasons for excusing (more individualization during lessons, appropriate examination and evaluation, improvement of class environment, establishing school fond of sport outfit, improve equipment, preserve the numeric normative of pupils, appropriate schedule of PE lessons).
- Implementation of universal school rules for excusing and activities of the excused students according to curriculum: including the excused students as assistants, learning theoretical materials of PE, preparation of didactic materials.

As schools cannot provide the recommended amount of daily physical activity for all youth within the compulsory curriculum, suitable programmes must be set and the amount of public finance for extra-curricular and out-of school sport programmes needs to be increased. These programmes should be well organized with ensured free access to them and so help in increasing the amount of young people's daily physical activity regardless of social status. Jurak et al. (2002b) found that young people do not have any constrains to join sports activities during summer holidays if organised by schools, only that it is organised in a manner acceptable for them. On such basis the project of installing lights for open sport areas (part of project Hurrah, free time) has been founded. Within project youth could, with the assistance of mentors, organise their own sport activities by themselves at evenings: a) activities at evenings when they want to hang up together, b) participation in sport activities, which belong to their life style, c) free of charge activities (Jurak et al., 2002b).

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ROLE OF CENTRAL FATIGUE IN RESISTANCE AND ENDURANCE EXERCISES: AN EMPHASIS ON MECHANISMS AND POTENTIAL SITES

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SUMMARY

An exercise-induced reduction in maximal force production, or the inability to continue an activity with enough force, is defined as fatigue. Although the etiology of fatigue is complex, it can be divided into two distinct components: central and peripheral. Central fatigue is the progressive exercise-induced loss of the voluntary activation, or decrease in the neural stimulation, of the muscle, thereby reducing maximal force production. Considering the different mechanisms of strength and endurance activities as well as previous research, the authors suggest that there is peripheral fatigue in both kinds of activities. However, the mechanisms of fatigue and the rate of perceived exertion are distinct (mentally, endurance exercise is more difficult). An analysis of fatigue kinetics shows that peripheral fatigue occurs initially, and the central nervous system tries to prevent the disorder via output force through the perceptions of the metabolic condition of the muscle and the activation of additional motor units. Once peripheral fatigue surpasses a certain amount, the central nervous system reduces the number of activated motor units to prevent serious disorders in homeostasis and muscle damage, and protects the central governor. Still, in important and critical situations such as the final stages of running a marathon (when the last flight of runners is observed) and fight-or-flight situations in which someone faces a worse outcome if a task is abandoned, humans can choose one of worse or the worst alternatives to write their final destiny.

Key Words: central fatigue, maximum voluntary contraction, neurotransmitters, temperature, perceived exertion.

INTRODUCTION

Since long time ago, the fatigue has been considered by human ancestors, battle warriors and athletic champions to prevent or at least delay it by using some substances. Even now, preventing fatigue and performance degradation is the concern of professional athletes who seek colorful medals and championship platforms. This issue needs knowledge of the fatigue's underlying causes and mechanisms. Exercise-induced drop in maximal force production or inability to continue the activity with sufficient force is defined as fatigue. When a series of persistent or frequent contractions is done, the processes that cause muscle fatigue can occur at any part of the muscle to the brain pathways (Taylor, Todd, & Gandevia, 2006). Although the causes of fatigue are complex, but it can be divided into two distinct components: central and peripheral (Gandevia, 2001). Peripheral fatigue is a reduction in the force generating capacity of the skeletal muscle that may occur within muscle, or at the neuromuscular junction. Peripheral fatigue is determined as a failure or disruption in the conduction of potential action, impairment in excitability of the sarcolemma, excitation-contraction coupling or disturbance in the cross bridge cycle, in the presence of increased or unchanged nerve excitation (Gibson, Lambert, & Noakes, 2001). Central fatigue is a progressive loss of voluntary activation or reduced nervous excitation into muscles and thus decreased maximal force production during exercise (Ross, Middleton, Shave, George, & Nowicky, 2007). In this review, after a preliminary study of central fatigue, its different aspects will be studied to get a thorough perception of this point of view during different exercises and some ideas to prevent or slow it down.

WHAT IS THE CENTRAL FATIGUE?

Neuromuscular fatigue can be described as a decline in performance that is usually determined by power generation capacity. During a static maximal contraction, force will decrease steadily and fatigue would be observed from the beginning of the exercise. Contrarily, in submaximal contractions, the target force is preserved for a long time. In this situation, the fatigue is defined as the inability in maintaining the force, even if the capacity of maximal force generation is impaired earlier during contraction. Neuromuscular fatigue is usually defined as a reduction of the capacity of maximal force generation (Gandevia, 2001). Velstad (1997) defined neuromuscular fatigue as any exercise-induced reduction in the maximal capacity of force generation or output force. This definition allows us to define fatigue in different sports and various intensities. In addition, there must be a distinction between the muscle weakness as a chronic disorder in force generation or output force and the acute effect of neuromuscular fatigue. So, it seems that neuromuscular fatigue develops differently depending on the muscle activity (Taylor & Gandevia, 2008). Fatigue was traditionally related to the metabolic occurrence of ending point during the exercise in which glycogen concentration within the muscle was depleted completely (Bergström, Hermansen, Hultman, & Saltin, 1967). Furthermore, cardiovascular (González-Alonso & Calbet, 2003; Rowell, Marx, Bruce, Conn, & Kusumi, 1966) and metabolic load, and temperature adjustment are likely peripheral candidates for the fatigue outbreak during long exercises (Hargreaves & Febbraio, 1998).

Sites of neuromuscular fatigue can be divided into two categories: central and peripheral. Central fatigue is considered as any exercise-induced decrease in maximal voluntary contraction force that is associated with a fall in the maximal force generation (Taylor & Gandevia, 2008) may be caused by the cerebral cortex (reduced descending stimulation or motivation). It can also be derived from spinal cord (a disorder in shooting of alpha motor nerves or submaximal recalling for force generation) (Kent-Braun, 1999; Taylor & Gandevia, 2008; Taylor et al., 2006). Thus, excitation factors, integrating sensory informa-

TABLE 1
Fatigue mechanisms associated with CNS disorders.

1. Weakness due to the failure of the motor cortex for recalling the muscle.
2. Poor coordination of motor units shooting.
3. Delayed transmission and disorder in dynamic recruitment.
4. Changes in synergistic muscles cooperation with special forces.
5. The lack of coherence between different central motor nerves or between motor nerves in motor cortex and spinal motor neurons.
6. Changes in connective tissue and joint mobility from spasticity.
7. Muscle atrophy because of denervation.
8. Muscle atrophy, resulting from inactivity.
9. Decreased aerobic phosphorylation of muscle because of physical unfitness.

TABLE 2
The central fatigue mechanisms (Source: Dobkin, 2008).

1. The lack of high-threshold motor units recalling.
2. Decreased central excitation because of the increased intra neurons inhibitory input to the motor cortex.
3. Obstruction of central guidance as a result of motor nerve demyelination or its dysfunction.
4. Increased negative feedback from type III and IV afferents.
5. The lack of positive feedback from afferent type I of muscle spindle.

tion and motor signal transmission affect the central fatigue. However, in healthy human, broadcasting motor signals for physiological excitations in normal levels seems to be enough. In Tables 1 and 2, we review the mechanisms proposed for occurring central fatigue.

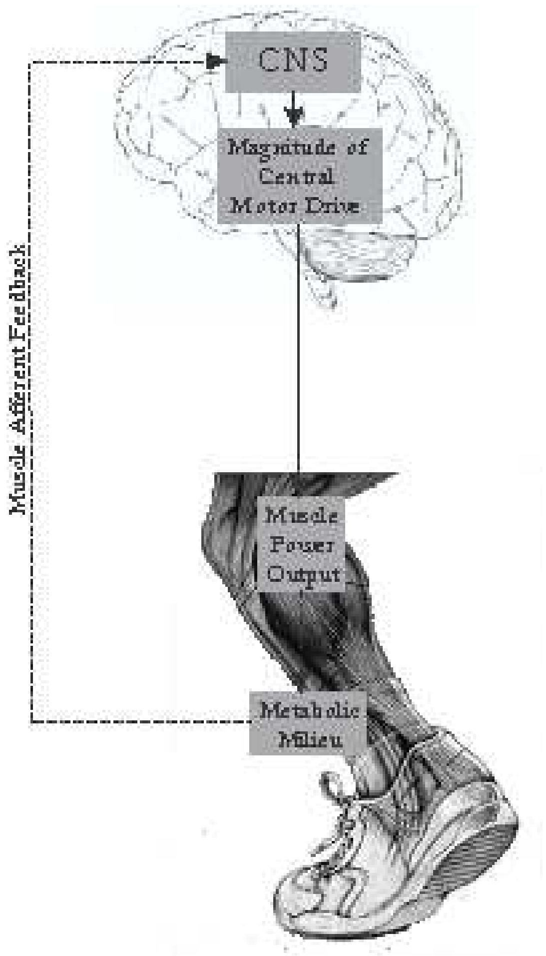
UNDERLYING MECHANISMS OF CENTRAL FATIGUE

Protecting the organism and central fatigue

Why is the brain unable to recruit additional motor units to keep up the activity during long-term exercise?

Prediction of the central governor model during endurance exercises is that the brain does not use extra motor units because such a use could threaten the capacity of preserving the homeostasis which potentially causes to an early ending of exercise in the best case, and organism damage or even death in the worst cases (Noakes, Gibson, & Lambert, 2005). Findings of isolated muscles suggest that CNS monitors the peripheral state of active muscles through the sensory feedback and uses this information to adjust muscle activation to protect muscle storage capacity. Alternatively, muscle afferents probably disturb slowly the desire or ability of maintaining the high Central motor output (CMO) and therefore, the high-intensity exercises and performance to prevent more development of peripheral fatigue over than the tolerable level which causes exercise to be painful (Figure 1). This model, known as the fatigue nonlinear system is an optimized model which by that fatigue will be felt as unconscious perception of afferent feedback through the different linear model. Brain integrates these afferent signals (which are received because of a severe disruption in homeostasis), in order to protect the organism against damage or death (Abbiss & Laursen, 2005). Studies have also shown that by increasing the running time, reduction in force may eventually reach a plateau. This could be due to the influence of the central protective mechanism that tries to limit the muscular work during prolonged running to prevent large homeostasis disorders, muscle damage, and biological damages (Noakes, 2000). Gandevia (2001) stated that, CMO reduction as a result of the inhibitory afferent feedback costs to the maximal performance. This regulatory mechanism is suggested as a limiting factor in endurance performance (Ibid). However, this model predicts that the rising feeling of pain increasingly decreases the individual's conscious tendency to stop this mechanism that may cause more motor unit utilization. Thus, the existence of this canceling system is undesirable because it can preserve or increase the intensity of activities that may threaten homeostasis (Noakes et al., 2005).

FIGURE 1
Visual view of the supraspinal inhibition reflex model in endurance exercise (Source: Dempsey, 2008).



Legend: The red line represents the efferent nerve activity (central stimulation). The white dash line represents the afferent activity. This regulatory mechanism indicates that projection of muscle efferent (inhibitory feedback) affects central motor stimulation which in turn determines the power output of muscles. The size of power output determines the metabolic milieu of the active muscle, which in contrast, controls the amount of inhibitory afferent feedback.

Brain areas involved in central fatigue

Central fatigue may be stemmed from the cortex (impaired impulse in descending stimulation or decreased motivation) (Taylor & Gandevia, 2008; Taylor et al., 2006; Kent-Braun, 1999). Findings show that muscular fatigue, changes the activity of complementary and premotor regions. On the other hand, some studies found that the charge per unit of perceived exertion includes supplementary and premotor areas, primary motor cortex and the pre-visual cortex. Preoptic cortex is where recent activities are compared to the prior activities as a component of the decision-making process to create the sufficient intensity of contraction. Other involved areas are such as the amygdala and hippocampus (which plays a key role in emotional status), and the hypothalamus, brain stem and spinal cord, which are part of the metabolic regulatory system between afferent input and efferent commands. Cognitive activities linked to the activation of anterior cingulate cortex (ACC) may trigger central fatigue. This prefrontal cortex area plays an important role in controlling the autonomic nervous system during hard cognitive and motor activities (Marcora, Staiano, & Manning, 2009). It also is affected by mental fatigue and provides neurobiological logic to better understand impaired motor performance after mental fatigue (Ibid). In fact, ACC activity has a relationship with exercise RPE. According to bio-psychological model of exercise performance (Ibid), and motivational intensity theory, these effects of mental fatigue can limit exercise independent of cardio-respiratory and musculo-energetic changes. consider that the prefrontal cortex is not solely involved in the planning, attention and executive and inhibitory functions, but also in working memory processes. Studies have shown that isometric contraction of the big muscle groups such as the quadriceps need frequent adaptation of force output, which is done through the information processing between the brain and peripheral system, fine motor control, executive and inhibitory processes during the contraction planning, motor visual integration and high levels of attention. High cognition effort, necessary to plan these performances, can influence the prefrontal cortex and cause to central fatigue and increased rate of perceived exertion (RPE).

Synaptic and central fatigue

Synaptic fatigue is a form of short-term activity dependent plasticity that affects the neural efficiency and cause a temporary inability to shoot and disturbed transmission of the input signal. It is thought that synaptic fatigue is a kind of negative feedback to control physiologically certain types of nervous system activities (Kilpatrick, 2010). Synaptic fatigue includes temporary inhibition of neurons because of constant and lasting stimulation in which fatigue effects are dependent on the type and frequency of the input stimuli. In fact, the reason of fatigue in the synapses is a temporary reduction of synaptic vesicles that is the position of presynaptic neurotransmitter. For signal distribution, neurotransmitters are released into post-synaptic cells. Further, it is assumed that synaptic fatigue could occur because of the reduced sensitivity of post-synaptic receptors or changes in post-synaptic conductivity. However, recent evidence has suggested that synaptic fatigue is mainly a pre-synaptic phenomenon (Simons-Weidenmaier, Weber, Plappert, Pilz, & Schmid, 2006).

Acetylcholine (Ach) is a main neurotransmitter involved in the autonomic nervous system, particularly in a motor end plate (Deschenes, Maresh, & Kraemer, 1994). In motor end plates, acetylcholine causes to the muscle contraction in small amounts, and in large amount cause inhibition of muscle contractions derived from nervous stimulation. At the neuromuscular junction (NMJ), there are about 50 to 70 vesicles containing Ach in per micrometer square of nerve terminals with 30 to 50 nm diameter. These vesicles are strategically located at neuromuscular junction in a way that Ach clusters can directly exist in all over the post-synaptic receptors (Ibid).

It is believed that Ach increases at the NMJ and cause to the inhibition of nerve stimulations during fatigue. Distinct training conditions cause different responses of Ach at NMJ. Wilson and Deschenes (2005) showed that high-intensity exercises lead more dissipation of vesicle receptors and Ach vesicle in the nerve terminal and motor end plates and thereby reduce stimulation and eventually increase fatigability. In addition, endurance exercises increase nerve terminals, pre and post-synaptic areas, while resistance trainings increase the post-synaptic area. Moreover, it has been shown that resistance exercise induced hypertrophy increases Ach at NMJ. Increased muscle size as a result of hypertrophy cause enhanced NMJ size, which in turn cause to commensurate increase in Ach for enough stimulation of more muscle fibers, so fatigue will be delayed.

Neurotransmitters and central fatigue

Clearly, training affects the neural mission of the brain (Meeusen & De Meirleir, 1995) and increases the concentration of the various neurotransmitters (Meeusen & Roelands, 2010). Romanowski and Grabiec (1974) associated central fatigue to the changes in transmitting brain neurotransmitters (specifically serotonin or 5-HT), while others concerned the role of dopamine (DA) and noradrenalin (NA) about the changes in the performance (Meeusen & Roelands, 2010). Newsholme, Acworth, and Blomstrand (1987) suggested that fatigue was created by the increased 5-HT concentration within the brain (which decreases arousal and leads to lethargy and sleepiness). Bailey, Davis, and Ahlborn (1993) developed this hypothesis by showing the importance of the increases in DA synthesis and metabolism in the brain during the exercise. They found that fatigue is accompanied by higher levels of 5-HT and reduced dopamine in the brain stem and midbrain. Furthermore, when DA synthesis and metabolism throughout the brain are preserved, fatigue is delayed (Ibid). Manipulation of the human 5-HT could not clearly confirm these results. Some studies (Davis et al., 1993; Wilson & Maughan, 1992) diagnosed reduced performance after administration of paroxetine and fluoxetine (reuptake inhibitors of 5-HT). However, most studies (Pannier, Bouckaert, & Lefebvre, 1995; Parise, Bosman, Boecker, Barry, & Tarnopolssky, 2001; Roelands et al., 2009) couldn't confirm these findings. Strüder and Weicker (2001) suggested the reduced performance capacity occurred after acute administration of 5-HT reuptake inhibitors may be as a result of the reduced functional capacity of 5-HT as a multipurpose generator that provides adaptability of neural network to address the needs of the central critical demands, not because of the increased activity of 5-HT. In addition, the researchers stated that trained athletes may be able to compensate for the excessive formation within the brain 5-HT.

About dopamine, it should be noted that early studies by amphetamines, DA releasers, have shown a significant increase in performance in both animal (Heyes, Garnett, & Coatrs, 1985) and human (Wyndham, Rogers, Benade, & Strydom, 1971) studies. DA neurotransmitter levels increases in order to improve the performance in the case of amphetamine administration (Borg, Edström, Linderholm, & Marklund, 1972). However, there is evidence that brain dopamine level is similar to the resting condition during fatigue (Foley & Fleshner, 2008) and this creates the possibility that dopamine concentration in various groups differently increases during exercise. For instance, it has been reported that inhibition of DA reuptake, increases the core temperature at the end of exercise, but has no effect on the performance in normothermia (Watson et al., 2005). Although, increased brain dopamine leads to better exercise performance (ergogenic effect) this response is associated with the increase of heat storage and body temperature (Hasegawa et al., 2008). Once dopamine effects mesolimbic reward system, it seems that by putting the inhibitory signals away from central nervous system, thermal safety domains are increased that can change perceived effort and improve exercise performance (Foley & Fleshner, 2008; Hasegawa et al., 2008).

Furthermore, recent studies have shown that the increased noradrenalin concentration may be unfavorable for exercise performance (Roelands et al., 2008). Administration of Reboxetine, NA reuptake inhibitor, decreased performance in normothermia (Piacentini et al., 2002). The extra concentration of NA can increase sympathetic activity (Meeusen & Roelands, 2010), but it may also result in an increased central NA reuptake inhibition within the parasympathetic nucleus that causes to reduced parasympathetic cardiac tune and enhanced heart beat (Schüle et al., 2004). The negative effect of reuptake inhibitors on performance has been detected unpredictably because it was thought that NA mechanisms were involved in arousal, awareness, and reward mechanism control of the brain (Meeusen, Watson., Hasegawa, Roelands, & Piacentini, 2007). Through this mechanism, it can be suggested that NA has an important role in performance regulation. In other hands, it has been proved that NA neurons regulate the 5-HT system by excitatory α1 adrenergic receptors. In the brain stem, dorsal raphe 5-HT neurons receive ascending NA neuron afferents, which are originated from locus coeruleus (Szabo & Blier, 2001). The role of 5-HT in central fatigue has been proved and there is both pharmacological evidence of human and animal studies (Meeusen & Roelands, 2010) which are in line with the results have been observed after NA reuptake inhibition.

Because of the complexity of the brain function and contradictory results of the studies trying to manipulate simply serotonergic, dopaminergic or noradrenergic activity, it doesn't seem only one neurotransmitter system be responsible for central fatigue. In fact, changes of all serotonin, catecholamines, amino acid neurotransmitters (glutamate, GABA), and acetylcholine are mentioned as a possible mediator in central fatigue during exercise (Meeusen & De Meirleir, 1995). These neurotransmitters can influence arousal, temper, motivation, awareness, stress, and reward mechanisms. In the case of being severely influenced, they disturb performance.

Temperature and central fatigue

Fatigue is a defense mechanism which prevents homeostasis disruption that puts physical integration in danger, particularly brain that is strongly capable of increased temperature (Kay & Marino, 2000). During exercise in irrecoverable thermal pressure, temperature generation surpasses the body heat releasing capacity and as a result central and skin temperature increase (Cheung & McLellan, 1998). Several studies have shown that exercise capacity in lower peripheral temperature is better (cycling to exhaustion at 70% VO_2max) (Galloway & Maughan, 1997, Parkin, Carey, Zhao, & Febbraio, 1999). This unfavorable effect of elevated environmental temperature on performance can't be related to only peripheral and muscular factors since these factors don't change up to the amount that can explain the decrease of endurance capacity during prolonged exercise in heat (Nybo & Secher, 2004). In some cases, muscle glycogen storage has more distances up to the depletion, muscle and blood lactate concentration isn't high comparing with exhausting exercise in normothermia and potassium release doesn't explain its induced fatigue (González-Alonso et al., 1999). In contrast, researchers suggested that during prolonged maximal voluntary contractions (MVCs), performance is decreased by central nervous system in first step under heat (Brück & Olschewski, 1987; Nielsen et al., 1993).

In recent literature, two possible mechanisms have been mentioned, which show how hyper-thermal fatigue can limit performance (Cheung, 2007). This mechanism presupposes that approaching or achieving the higher brain and core temperature is a symptom of exhaustion development to keep the individual being knocked down. Morrison, Sleivert, and Cheung (2004) has shown a progressive central disruption associated with increased temperature. Therefore, it seems that during exercise under increased thermal pressure, high body temperature may directly or indirectly affect endurance performance. Literature review shows the existence of critical core temperature (Nielsen et al., 1993). This model is developed based on the muscular observations and equal core temperatures at the voluntary end point of exercises, with different core temperatures at the beginning and different activity time (Nielsen et al., 1993, Walters, Ryan, Tate, & Mason, 2000). So, the body protects itself in front of potential damage. However, the concept of critical core temperature has been challenging issue recently. During competitions, some well-trained athletes may reach to the core temperature of over 40 °C (Byrne, Lee, Chew, Lim, & Tan, 2006; Ng, Lee, Byrne, Ho, & Lim, 2008). Researchers have shown that in optimal environment conditions for thermal exchange in which temperature of skin remains fairly low during the 8 km running, achieving to the critical core temperature (40° C) doesn't reduce running speed (Meeusen & Roelands, 2010). Finally, pharmacological manipulation to increase DA has indicated along with performance improvement, core temperature of the individuals surpasses 40° C (Roelands et al., 2008; Watson et al., 2005). From this point of view, the critical core temperature should not be considered an all-or-none phenomenon, but it's better to be considered as a continuum with the complex interaction of various physiological systems (Meeusen & Roelands, 2010).

The second mechanism mentions that complex feedback and feed-forward mechanisms regulate fatigue. It has been recently suggested that exercise performance in heat is controlled by the predicted response which decreases the use of involving muscles to limit temperature generation (Marino, 2004; Tucker, Rauch, Harley, & Noakes, 2004). Feed-forward regulations of the output force may guarantee the thermal storage limit of the body to prevent developing the heat-induced illness. However, a recent article published by Shephard (2009) discusses in contrast to the existence of the central governor. Until now, lack of satisfying scientific evidence on this hypothesis and some findings such as the constant oxygen plateau in young adults has been discussed strongly in contrast to the limited role of the central governor.

Both mechanisms are probably related to each other and can be affected by the manipulation of the several neurotransmitters (Cheung, 2007). Brain monoamines 5-HT, DA, and NA innervate different areas of the hypothalamus in which there are also pre-optic and anterior hypothalamus (PO/AH). It is thought that PO/AH is the main place of body temperature regulation (Boulant, 1974) since PO/Ah contain both kinds of cold and heat sensitive neurons. These neurons respond to the small changes of temperature (Boulant, 1974; Nakayama, Eisenman, & Hardy, 1961). This brain region integrates the thermal data from peripheral and central thermo-receptors and begins proper heat loss and production responses. It has been well indicated that NA, and DA play important roles in regulation of the temperature in hypothalamus areas. For example, local injection of NA into PO/AH in rats cause to the increase of the body temperature (Clark & Lipton, 1986) and NA inhibits the activity of heat sensitive neurons in PO/Ah (Watanabe, Morimoto, & Murakami, 1986). These findings show that NA is involved in the heat production mechanism. In other hand, Quan, Xin, and Blatteis (1991, 1992) has shown that NA micro-dialyzed into the aware Guinea pig has stimulated the reduction of core temperature, which mediated by a decreased metabolic rate (Ibid). In addition, it has been reported that DA stimulates heat responsive neuron shooting rate and inhibits the cold sensitive neurons in PO/AH tissue slices (Scott & Boulant, 1984). Furthermore, microinjection of apomorphine (an agonist of DA) into the hypothalamus of rat creates a DA mediated fall of temperature (Brown, Gisolf, & Mora, 1982). Besides, DA release in PO/AH during the treadmill exercise was risen (Hasegawa et al., 2008), and DA caused to the increased temperature of the rats body (Myers & Yaksh, 1968), It can be expected that changes in the concentration of these neurotransmitters, helps to the changes in temperature regulation because of fatigue, especially when the exercise is being done in the hot environment (Roelands et al., 2009).

Several studies have explored the relationship of 5-HT and temperature regulation. Local treatment of preoptic cortex and anterior hypothalamus (PO/AH) by 5-HT caused changes in the activity of heat sensitive neurons (Watanabe et al., 1986). Feldberg and Myers (1963) have reported that injection of 5-HT into PO/AH causes to an increase in body core temperature. Again, findings of human and animal studies indicated that how projections of pharmacological effects are difficult even when they perform in those neurotransmitters. The results don't show any role for DA releasers and 5-HT in controlling motor and central fatigue. However, any possible role of 5-HT and DA and other transmitters in motor performance should be considered as a continuum (Davis, Bailey, Jackson, Strasner, & Morehouse, 1993). This continuum is not only important in brain level, but also in the interaction between neurotransmitters and peripheral processes in exercise such as the neurohormonal system, especially hypothalamic-pituitary-adrenal axis.

Perceived exertion and central fatigue

During the fatigue state, there needs more effort to continue a task (Taylor et al., 2006). Perceived exertion is a tool for central stimulating through corollary feedbacks into the sensory cortex. This sense reflects internal performances of increased motor order or central stimulation to continue the task (Davis & Walsh, 2010). Brain senses the intensity of activity and environmental condition by measuring the RPE changes and coordinates duration of activity with them. Effort perception may generally be considered as a central governor, which prevents extensive damage to the muscle (Crewe, Tucker, & Noakes, 2008). In fact, Perceived exertion is defined as a sense of neural stimulation, which is centrally produced through the prior sending of concurrent discharge or copies of efferent from motor areas into sensory areas of the brain by the corticofugal feedback system (Berchicci, Menotti, Macaluso, & Dirusso, 2013). Therefore, locating perceived exertion and fatigue in a single area of the brain is very difficult. More probably, development of fatigue sensation is dependent on the short-term reorganization of the prefrontal motor network during the changes in the progressive model and motor awareness (Ibid). Furthermore, being aware about perceived exertion can be created prior to the movement and regardless of muscle fatigue in some areas of the brain, which are responsible for planning and motor control (frontal and prefrontal areas). Particularly, preliminary motor cortex controls the voluntary contraction and increases the movement stimulation congruent with fatigue. While, prefrontal region has an important role in creating awareness about fatigue and perceived exertion during exercise (Ibid). In other hands, reduced 5-HT production causes to the decreased circulation of 5-HT in the brain, which would be followed by the reduced sense of mental fatigue. Generally, the ratio of tryptophan to branched amine acids can be balancing in this case. So, increased dopamine production leads to a mental state that decreases perceived fatigue and increases motivation, attention and performance (Georgiades et al., 2003). Although increased brain dopamine causes to improvement of sport performance (ergogenic effect), this response is associated with increased temperature and thermal storage of the body (Hasegawa et al., 2008). Once dopamine affects the mesolimbic reward system, obviously through putting inhibitory signals away central nervous system increases safe temperature domains that can change perceived exertion and improve exercise performance (Foley & Fleshner, 2008; Hasegawa et al., 2008). Excessive sense of exertion occurs before the tribulation in force. If an organ is weakened by neuromuscular disorder or peripheral sense be disturbed (using the use of local anesthetic or tendon vibration), perceived exertion remains unchanged in spite of the reduction of afferent signals from muscle, skin and tendons (Davis & Walsh, 2010). During isometric contractions, perceived effort is increased as a capability of power (1.7 times of the target force) (Ibid). Furthermore, exertion sense is delayed by the psychological state of the individual. In the participants who have anxiety, depression or psychosis, RPE in the same tasks is higher and in the participants who have extrovert personality, RPE is lower (Ibid). These findings can be a bridge between fatigue and depression. Naloxone (a semi narcotic medicine, which interferes with dopamine) also increases RPE rate and decreases the time to the fatigue (Marcora et al., 2009).

CENTRAL FATIGUE IN ENDURANCE EXERCISES

Scientists have found that in prolonged activities (such as endurance cycling and running) fatigue may occur in submaximal levels because of neural changes, which cause to the decreased central stimulations in order to protect the organism in front of extensive damage or death (Abbiss & Laursen, 2005). Seemingly, many factors are joined in order to trigger central fatigue as a result of endurance exercise and finally to stop these activities. According to the different studies and literatures of fatigue these factors are: increased ratio of serotonin/dopamine, increased core temperature, hypoxemia, which causes to the blockage of the axon, decreased motor neuron stimulation from spinal cord parts and eventually stimulation of type III/IV muscle afferent, which will be discussed one by one with research evidence.

Ohta et al (2005) has surveyed biochemical changes during a 24-hour running, and by indirect measurement such as serum serotonin and free tryptophan have suggested that this sort of exercise causes producing supraspinal fatigue. Note that serotonin synthesis and change in CNS depends on the changes in preparation of the brain tryptophan (a responsible enzyme in catalyzing the first reaction in serotonin synthesis) (Fernstrom & Fernstrom, 2006). Clearly, endurance exercise induced increase in plasma FFA indirectly facilitates the tryptophan influx into the brain because both compete for the same carrier (albumin) (Ibid). In other words, increased plasma free fatty acids following endurance exercise, increases the free tryptophan level. Evidence shows that more mobilization of free fatty acids in adipose tissues causes to an increase in serotonin concentration in preoptic and hypothalamus areas (Leite, Rodrigues, Soares, Marubayashi, & Coimbra, 2010). The precursor of dopamine (tyrosine) also competes with other amino acids (including tryptophan) for entering into the brain (Foley & Fleshner, 2008). This shows that interaction between serotonin and dopamine may be an effective issue among central fatigue factors (Foley & Fleshner, 2008, Meeusen et al., 2007). In fact, the central fatigue hypothesis suggests that high ratio of serotonin to dopamine is associated with poor exercise performance (Ibid). This issue is important because increased serotonin activity during exercise is involved in fatigue development through inhibition of the dopaminergic system (Ibid). To support such an approach it has been shown that usage of serotonin agonists inhibited the exercise-induced increase in dopamine and treatment by the serotonin antagonists prevented the dopamine decline in the exhausted state (Foley & Fleshner, 2008). Therefore, it seems that performance downfall is generally dependent on the increased serotonin levels which overcome dopamine ergogenic effects. A combination of such effects on the development of fatigue causes to the high ratio of hypothalamic serotonin to dopamine through central angiotensinergic inhibitors in preoptic and hypothalamus areas (Leite et al., 2010).

On the other hand, decreased serotonin level in the hippocampus is related to decreased time to the fatigue in rats with losartan treatment that suggests serotonin plays an important role in this area of the brain in controlling motor activity during exercise (Ibid).Therefore, it should be mentioned that the roles of serotonin and tryptophan differ in various areas of the brain, and it can't be said only increased brain serotonin causes the appearance of untimely fatigue. However, note that changes in serotonin and dopamine ratio have high correlation with the onset of central fatigue.

Then again, endurance activities cause an increase in metabolism and as a result generate temperature. Review of literature gives the idea of critical core temperature existence triggering central fatigue (Nielsen et al., 1993). This phenomenon has obtained from evidence in which individuals stopped the activity at the same central temperature in spite of starting at a different core temperature and getting various time trial records. Of course, it should be considered that although fatigue is often accompanied by core temperature of 40° C, but in laboratory examinations on well trained individuals, it has been reported that the core temperature of athletes had reached to even 41 °C without any symptoms of heat exhaustion during sport events (Périard, Caillaud, & Thompson, 2011). Researchers have shown that passive heating (PaH) and hyperthermia induced during prolonged exercise (ExH) are associated with a significant decrease in voluntary activation and force generation during MVCs (Ibid). Brain is strongly susceptible to temperature increase (Kay & Marino, 2000) and approaching or achieving to the higher brain and core temperature is a symptom of developing exhaustion to let the body to protect itself from potential damage. Furthermore, individual's performance in endurance activities in heat is controlled by the predicted response which decreases the use of skeletal muscles to limit the temperature generation (Marino, 2004; Tucker et al., 2004). Feed-forward regulating of output force may guarantee the limitation of the body temperature storage rate to prevent developing heat induced illness. Both mechanisms cooperatively help the organism to protect itself from heat damage, and so it causes that athletes' performance to be limited in endurance activities.

Additionally, metabolic/pain receptor afferents (III/IV group) derived from active muscle are stimulated during sustained exercise by intramuscular metabolic byproducts (Adreani, Hill, & Kaufman, 1997; Amann & Secher, 2010; Light et al., 2008), and parallel to metabolite accumulation their inputs to the CNS increases. This central projection, reflectively causes an increase in blood flow (blood pressure increasing reflex due to blood vessel contraction during exercise) and ventilation (Kaufman & Forster, 1996) and gradually decreases CMO/voluntary activation of muscle and so central fatigue is increased (Gandevia, 2001). Once lower limb muscles' central projection is blocked by the medicine (L3/L4), the performance of the experimental group was significantly increased compared with the placebo group during a time trial 5 km-cycling and subjects went over their critical threshold of peripheral fatigue (Amann & Dempsey, 2008). Blocking the muscle afferent, released the break of central CMO and CNS tolerated muscular fatigue in a way that it reached about 44 % over than what observed in the placebo group. Also, higher peripheral fatigue by this method was associated with motor problems (Ibid).

Evidence points out that the onset of peripheral fatigue of muscle during sustained exercise is exclusive to the individual's critical threshold and sensory tolerance range, which increases by the individual's will (Amann, Romer, Subudhi, Pegelow, & Dempsey, 2007; Duhamel, Green, Sandiford, Perco, & Ouyang, 2004; Gagnon et al., 2009). This means that during efforts with a constant load, when peripheral fatigue reaches to the crucial threshold (probably dependent on the task), the exercise reaches to the end either voluntarily or CMO doesn't have efficiency for continuing the task. For example, following the electrical stimulation of the quadriceps of healthy individuals to create peripheral fatigue, the time of cycling with fixed load up to the failure, was lower than the control group (who only cycled without electric stimulation of their muscles). However, at the failure point of both groups, tiredness of quadriceps and individual's perception of thigh fatigue was equal (Gagnon et al., 2009). These studies confirmed the research previously done using a time trial (instead of fixed load). During time trials after quadriceps fatigue, CMO was significantly lower and the time for crossing the finish line was more. Even so, quadriceps fatigue and individual's perception of this fatigue were equal at the end of the trial, which shows that CMO is adapted according to the peripheral condition of active muscle (Amann & Dempsey, 2008). About the trials with fixed load, once an individual reaches the critical threshold; the endurance exercise is voluntarily reached to the end or about the exercise with a time trial, when the critical fatigue (or critical change rate in an intracellular metabolic environment) was created; the intensity of the activity gets decreased by a drop in CMD. The scientists have hypothesized that CNS processes the nervous feedback derived from the active muscle afferents and regulates the exercise, according to CMD to prevent developing peripheral fatigue more than the critical threshold since the otherwise sensory input would be intolerable (Amann & Dempsey, 2008, Amann et al., 2006).

The effects of peripheral and central disruptions in CMD (and consequently, exercise) are changed by oxygenation of the brain (Amann et al., 2007). In a recent work, participants were asked to exercise with the fixed load (333± 9 w) and high-intensity up to the exhaustion in normoxia (activity up to the exhaustion ≈10 min, hemoglobin saturation in exhaustion ≈93 %) and acute hypoxia (≈2 min, ≈ 67 %). When the participants stopped the exercise in normoxia condition, peripheral fatigue reached to the participants' critical threshold (Ibid). In contrast, when participants stopped the task in hypoxia condition, peripheral fatigue of the active muscles was significant, but it was only two third of the amount that was recorded for normoxia group, and thus it was very lower than the individual's critical threshold (Ibid). In other words, participants could store more fatigue, but they stopped the exercise before a critical threshold. In this condition, when researchers secretly changed the breathing gases into the combination of supplemental oxygen (30% oxygen, hyperoxia) during exhaustion of the normoxia subjects, they couldn't continue the task. In contrast, when researchers stealthily used the complementary oxygen for hypoxia-exhausted participants, all of them continued the task up to reach the critical threshold (Ibid).

About developing the central fatigue, fewer studies have explored the kinetics of maximal voluntary activation during the multijoint movements. Lepers, Millet, and Maffiuletti (2001), and Place, Lepers, Deley, and Millet (2004) have measured VA in every hour of 5 hours running and cycling with normal intensity. Both groups of researchers have reported a reduction of VA simply close to the end of the activity. Ross, Goodall, Stevens, and Harris (2010) has recently measured maximal voluntary activation in knee extensors in every 5 km during a 20 km running on treadmill and reported just a significant reduction after 20th km. Since in most of the studies, VA reduction was accompanied with exhaustion, probably we can conclude that VA reduction is the main factor of the individual's inability to maintain the required intensity of the activity.

In addition, the existence of the plateau or reduction in motor stimulation, which have been reported at the end of the task (Ibid) are very likely independent of the changes in the various muscular junction or sarcolemma stimulation because M wave properties didn't change during the protocol. Therefore, it seems that when inability in contraction reaches to a critical point or when the increase rates of motor stimulation get to the certain level, no increase would occur in central orders seemingly to prevent more contraction disruption or because of the fact, that inability to increase motor stimulation during intensive activities is due to the brain disruption (central fatigue).

Study of peripheral and central fatigue kinetics during high-intensity cycling showed that peripheral fatigue occurs in the preliminary steps of cycling, and individual compensates this fatigue by more motor stimulation, while central fatigue is accompanied by failure in a task and happens at the last stages of the activity (Decorte, Lafaix, Millet, Wuyam, & Verges, 2012). Therefore, it can be mentioned that it's not only central fatigue that determines the athletes' performance in endurance activities, but also different factors such as temperature, oxygen and substrate availability, metabolites…, cause to peripheral fatigue, and it facilitates the central fatigue development and at the end to stop the exercise. In addition, Millet (2011) investigated neuromuscular fatigue in super marathon running in a review study and concluded that both peripheral and central fatigue have an important role in determining the exercise performance, and both have interaction with each other (Millet, 2011).

CENTRAL FATIGUE IN RESISTANCE EXERCISES

Clearly, several causes are involved in triggering central fatigue as a result of resistance exercises and finally to stop these activities. According to different studies and literature, these factors are such as reduction of EMG activity because of the decrease in frequency of the recruited motor unit shooting, the role of post-synaptic membrane, depletion of neurotransmitters and stimulation of type III/IV afferents, which will be explored by giving research evidence.

According to different studies, it can be inferred the origin of fatigue depends on the muscular activity form and angular speed of the movement (Babault, Desbrosses, Fabre, Michaut, & Pousson, 2006). Most of the studies have examined the effect of isometric contraction on central fatigue development. For example, Berchicci et al. (2013) asked the participants to perform 242 isometric contractions with their quadriceps muscle of the right foot by 40% of their MVC using optical feedback on force output provided by an oscilloscope. These movements finally led to the fatigue. It seems that the isometric contraction of the big muscle groups such as the quadriceps requires frequent coordination of output force done through the process of the information between brain and peripheral system, frail kinetic control, motor-visual integration and high levels of attention. Frequent isometric contractions affect the monotonic state of the intramuscular environment that cause developing fatigue sense. Therefore, developed peripheral fatigue during this task incorporates with the central fatigue created by higher cognitive processes, which requires performing the proper task and needs emotional factors such as attention and arousal levels. Observed activity in the prefrontal area of the fatigued group who reported higher RPE was probably the result of high cognitive effort, which is necessary for planning these actions (Ibid). Prefrontal area is not involved only in planning, attention and inhibitory and executive tasks, but also in working memory processes. Studies have shown that conscious perception of fatigue is derived from the prefrontal area where the recent activities are compared with the prior activities as a part of the decision-making process to create adequate intensity of the contraction. Other involved regions such as the amygdala and hippocampus (that have key roles in an emotional condition), hypothalamus, brain stem, and spinal cord, are parts of the metabolic regulatory system between afferent inputs and efferent orders (Ibid). So, it seems that one of the factors involved in fatigue development during isometric contraction is over activity of the prefrontal cortex, which has an important role in the RPE. According to the literature of the central fatigue, higher RPE reduces the activation of the motor units and so the output force to relieve the organism from severe threatening changes that put its health at risk.

In other hands, strong isometric contraction causes the blockage of active muscle's blood vessels that leads to ischemia, hypoxemia, and accumulation of metabolic byproducts such as lactate and therefore, increases the rate of the shooting type III and IV afferent (Adreani et al., 1997; Amann & Secher, 2010; Light et al., 2008). As previously mentioned, stimulation of metabolic/pain receptor afferents gradually decreases CMO/voluntary activation of the muscles and increases the central fatigue (Gandevia, 2001). Remember that experienced strength athletes can highly recruit their muscles, which leads to more central fatigue in forced repetitions (Ahtiainen & Hakkinen, 2009). In addition, the RPE in strength exercises and isometric contractions can be generated without involving muscle afferent feedback system, but in a feed-forward way through simultaneous sending of a copy of afferent from the motor to the sensory area of the brain (Berchicci et al., 2013). When this perceived exertion goes over the critical rate, CNS or central governor would reduce the stimulation of motor units, and central fatigue would be observed.

Performing prolonged isometric contractions or frequent electric stimulation can reduce end plate potentials (EPPs) and decreases the output force because of either reduction in the numbers of vesicles or each vesicle's acetylcholine content or both. In addition, researchers have concluded the major reason of EPPs decrease during the continuous stimulation is decreased sensitivity of end motor plates and not because of the transmitters' evacuation. It seems that because of frequent concentric or isometric contractions the receptors exposing acetylcholine for a long time, first become susceptible to nonsensitiveness and then face with a nonsensitive state which its characteristic is a slow and a shorter period of each attachment.

About the other types of contracts, Robbins, Goodale, Docherty, Behm, and Tran (2010) studied fatigue indices in descending pattern (DP), in which repetitions were decreased the next sets, and ascending pattern (AP), in which repetitions were increased in the following sets. Both patterns were done under the loads of 5 and 10 maximal repetitions. Fatigue was studied by monitoring the output force changes, motor unit activation, and muscle twitch properties, peak twitch (PT), time to peak twitch (TPT) and half-life of the relaxation time (RT). The findings showed that all four protocols created a significant decline in force output, TPT and RT. The findings of the study showed that central fatigue is independent of load and training pattern while the onset of peripheral fatigue is more dependent on training load not training pattern. In contrast, Babault et al. (2006) suggested that as a result of concentric training, peripheral fatigue develops first and then central fatigue occurs following that, while in isometric training, fatigue pattern is vice versa (first central and then peripheral fatigue occurs).

CONCLUSION

Based on the different mechanisms during resistant and endurance exercises and findings of various studies, researchers suggest central fatigue happens in both kinds of activities. However, the mechanisms of fatigue development and the RPE are distinct in each of them (mentally, endurance exercises are more difficult). Study of the fatigue kinetics shows that first peripheral fatigue occurs and CNS tries to prevent disturbing output force by activating more motor units. Once peripheral fatigue goes over the certain rate, nervous system reduces activation of motor units to prevent extensive disruption in homeostasis and muscle damage and protect the central governor, which is strongly sensitive to temperature, and thereby central fatigue happens. Still, in important and critical situations such as the final stages of running a marathon (when the last flight of runners is observed) and fight-or-flight situations in which someone faces a worse outcome if a task is abandoned, humans can choose one of worse and the worst alternatives to write their final destiny.

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EXPLORING THE PERCEPTION OF SELF ESTEEM AMONG HIGH SCHOOL ATHLETES

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SUMMARY

The main purpose of this study was to explore the self esteem among high school athletes with regard to their participation in recreational and leisure activities and also to see the differences of self esteem level between both sexes (male and female). To achieve the study purpose, 250 (124 male and 126 female) adolescent athletes at the high school level were invited to participate in this survey. Their ages were ranged from 12 to 17 years. They were invited on the basis of their active participation in games and sports and also those who used to participate in various tournaments conducted by the District Sports Office, under the authority of Directorate of Sports, Assam. They were asked to indicate their perception of self esteem on their games and sports participation. The Principal Component analysis extraction and Varimax Rotation methods were adopted for analysis the 10 items in this survey. Three items showed low factor loading (< .50) after EFA. Description of the three items is "I feel that I have a number of good qualities"; "I feel that I'm a person of worth, at least on an equal plane with others", and "On the whole, I am satisfied with myself". Level of self esteem between male and female was found significantly different as it was hypothesized earlier. The results were further enhanced with Confirmatory factor analysis where the result of the Confirmatory factor analysis Model Fit Summary indicated: $\chi^2 = 36.928$ with $df = 32$ to be significant as CFI = .978, RMSEA = .025, GFI = .972, AGFI = .952, PGFI = .566, PCLOSE = .905.

Key Words: adolescent, exploratory and confirmatory factor analysis, recreational and leisure activities, self esteem.

INTRODUCTION

Self esteem is sometimes indicated as an intricate model (Marsh, 1986, 1995; Marsh, Hey, Roche, & Perry, 1997) for researchers to study as its complex, hierarchical and multidimensional nature attracts our attention (Steinberg, 1996). Self esteem associated with the self worth of an individual through by which someone assesses the overall performance and positive self worth. Self esteem is an important aspect of an individual's own identity. Self esteem is defined by the degree of worth and competence that we attribute to ourselves. It has an important role in achieving good results, if you deeply believe in your own skills and abilities, you will perform well. If there is no such faith but doubts which prevails, the sportsman will have the feeling that the task is far too hard for him, beyond his potentials (Hardy & Crace, 2009, Velikić, Knežević, & Rodić, 2014). Through sport, we may enhance our self esteem by having a positive image of our bodies and the physical skills and abilities that we develop. A number of research proved that participation in games and sports and exercise (Vealey, 1992) is usually positively enhances the level of self esteem exercise, but at the same time it is also found that this level is the most stable and difficult to change

(Marsh, 1986, 1995; Marsh, Hey, Roche, & Perry, 1997). Adolescent age is the crucial period to develop self worth and self assessment and overall assessment of how one feels about oneself. Understanding how individuals feel about themselves has been a quest of researchers for many years (Blumer, 1969; Mead, 1934). It has been seen that the development of self esteem is an important need to develop among the adolescent because it is the period when they discover the things around them and assume different perception out of it. So it is found from research findings that we feel a kind of positive self worth through the recognition received from family and friends and the social relationships (Holland & Andre, 1994). The self esteem development as a result of our involvement in sport and physical activity is being enhanced. Yet, we may be vulnerable to low self esteem in sport and physical activity if we perceive our body to be inadequate, unfit or inappropriate for our selected activity. We may feel that our self-worth is judged on our losses and wins versus our abilities and intentions. The intensive participation in sport may lead to social isolation and lack of family support. All of these negative emotions need to be refocused in order to build positive self-esteem. Coaches, physical education teachers and active living leaders can positively influence self-esteem and provide girls and women with ongoing incentive to participate and personally succeed in physical activity endeavours. Thus, the self esteem is an aspect that needs to be enhanced and the participation in games and sports across both sexes should be an agenda in the study. As, it is evident from the number of research that participation in games and sports and exercise (Vealey, 1992) positively enhances the level of self esteem. This association holds for many kinds of athletic activity, such as playing a sport, taking a Taekwondo class (Bosscher, 1993), weight training (Finkenberg, 1990; Ford, Puckett, Reeve, & Lafavi, 1991; Melnick & Mookerjee, 1991; Pascarella & Smart, 1991), or running, and for various populations, particularly male and female children, adolescents (Delaney & Lee, 1995; Kalliopuska, 1987), and adults (Vealey, 1992; Wilkins, Boland, & Albinson, 1988; Yeung & Hemsley, 1996). Again in another study it was found that there is relationship conducted by between exercise activity and self-esteem was positive for men, but no concordance for women and even negative for young women under 21 (Tiggemann & Williamson, 2000). In view of these somewhat conflicting findings, the main purpose of the study was decided to explore the self esteem among the athletes with regard to their participation in recreational and leisure activities and also to see the level of self esteem differences between both sexes (male and female). It was hypothesized that all the items on Self Esteem would be retained after exploratory factor analysis. It was also hypothesized that male athletes would have a higher level of self esteem in comparison to the female high school level athletes because of various socialization reasons as well as parents unequal eye on female physical activity participation. It was further hypothesized that the CFA adjustment indices of the retained factor would be acceptable.

METHODS

To achieve the purpose of the study, 250 high school athletes was selected. Out of which 124 were male and 126 were female athletes. Their ages ranged between 12 to 17 years. These athletes were selected on the basis of their active participation in games and sports and also have participated in various tournaments conducted by the different agencies and federation as well as the directorate of sports in the Assam region. To measure the self esteem level of the male and female athletes, the Self Esteem Questionnaire as devised by Rosenberg (1965) was used. It assessed the level of self esteem of an individual. The questionnaire consists of 10 items based on the four point rating scale.

RESULTS

To explore the study and lucid interpretation, Descriptive statistics such as mean and standard deviation were used. To establish the correlation matrix Pearson correlation was used. Further, to explore the perception of the high school athletes on their level of self esteem across all the ten items, factor analysis using principal component analysis extraction method and varimax rotation method were used. To see the gender based analysis *t*-test was used. Cronbach alpha was used to see the reliability of the retained items of the self esteem questionnaire.

It can be noticed after rotation the first (26.769%), second (10.738%), and third (10.247%) explain a total variance of (47.755%). The decision about the number of factors to be retained in the factor analysis is taken on the basis of eigenvalues. The only factor with eigenvalue more than 1 and items with a factor loading more than .50 were considered. If the factor has a low eigenvalues, then it is contributing little to the explanation of variances in the variable and may be dropped.

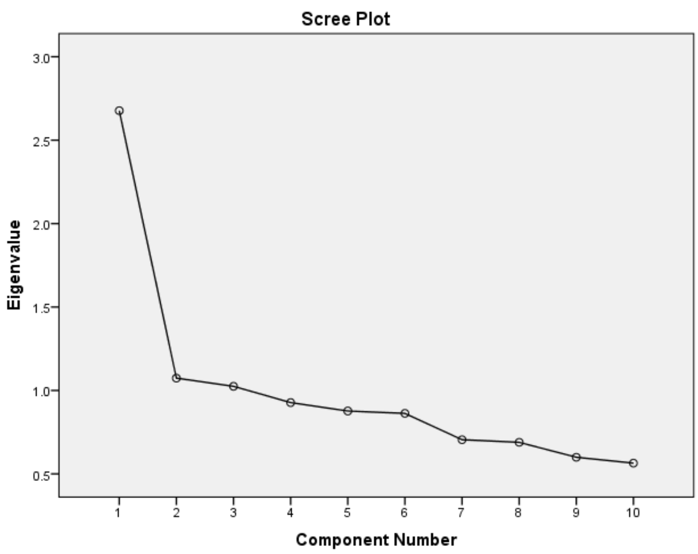
The scree plot proposed by Cattell (1966) is another popular technique. The scree plot is a plot against the

TABLE 1
Total Variance Explained.

Components	Initial eigenvalues			Extraction sums of squared loading			Rotation sums of squared loadings		
	Total	% variance	Cumula. %	Total	% variance	Cumula. %	Total	% variance	Cumula. %
Item 1	2.677	26.769	26.769	2.677	26.769	26.769	2.137	21.374	21.374
Item 2	1.074	10.738	37.507	1.074	10.738	37.507	1.454	14.544	35.918
Item 3	1.025	10.247	47.755	1.025	10.247	47.755	1.184	11.837	47.755
Item 4	.927	9.272	57.026						
Item 5	.877	8.768	65.795						
Item 6	.863	8.626	74.421						
Item 7	.705	7.048	81.469						
Item 8	.689	6.891	88.360						
Item 9	.600	5.998	94.358						
Item 10	.564	5.642	100.000						

Legend: **Item 1** - On the whole, I am satisfied with myself; **Item 2** - At times, I think I am no good at all; **Item 3** - I feel that I have a number of good qualities; **Item 4** - I am able to do things as well as most other people; **Item 5** - I feel I do not have much to be proud of; **Item 6** - I certainly feel useless at times; **Item 7** - I feel that I'm a person of worth, at least on an equal plane with others; **Item 8** - I wish I could have more respect for myself; **Item 9** - All in all, I am inclined to feel that I am a failure; **Item 10** - I take a positive attitude toward myself.

FIGURE 1
A scree plot technique based on eigenvalues signifying a sharp drop in variance accounted for the factors merely represent error or unique components.



number of factors, and one looks for an "elbow" signifying a sharp drop in variance accounted for the factors merely represent error or unique components (Netemeyer, Bearden, & Sharma, 2003) or we can say it is also based on a plot of the eigenvalues associated with successive factors (DeVelliss, 2003). Because each factor after the first is extracted from a matrix that is a residual of the previous factor's extraction, the amount of information in each successive factor is less than in its predecessors. Cattell suggested the right number of factors that can be determined by looking at the drop in the amount of information across successive factors. Inlay term, scree describes the rubble that collects on the ground following a landslide. This term, then implies that the vertical portion of the plot is where substantial factors are located while the horizontal portion is the scree, or rubble, that should be discarded. Ideally, the progression of factors will have a point at which the information drops off suddenly, with an abrupt transition from vertical to horizontal and a clear "elbow" (Ibid). The factors plotted along X-axis against eigenvalues, on the Y-axis. As one moves toward the X-axis (factors), the eigenvalues dropped. When the drop ceases and the curve made an elbow towards less steep decline. The purpose of factor extraction is merely to determine the appropriate number of factors to examine. Table 2 represent the results of factor analysis done on all the 10 items. We used the Statistical Package for Social Sciences (SPSS: version 20.00) to conduct an exploratory factor analysis Principal Component analysis and Varimax Rotation with Kaiser Normalization was done on the result obtained to the items of the factor on self esteem to assess the self esteem level of the athletes. It has been seen that none of the item was excluded from the analysis. When reporting the items for each of the factors, we only included items with factor coefficient loadings at or above .40. Although McDonald (1999) suggests that it is commonly accepted to consider an item as salient if its factor loading is at least .30, we adopted a more rigorous standard based upon Hair, Anderson, Tatham, and Black's (1995) suggestion that in a sample size of 200 using loadings of at least .40 will provide more statistical power (power = .80) than a loading of at least .30 (power < .80). Also, in an attempt to identify simple structures (Thurstone, 1947), we excluded items that met the .40 cutoff on more than one factor. Rotation converged in 5 iterations. It is noticed that 7 items were above the loading of .50.

TABLE 2
Rotated Component Matrix.

Items	*M*	*SD*	Component				ἀ	*N*
			1	2	3	h^2		
2	2.28	.623	.712			.552		250
3	2.29	.700	.451			.356		250
5	2.24	.693	.696			.495	.633	250
6	2.22	.676	.578			.431		250
8	1.38	.630	.569			.371		250
4	2.16	.651		.558		.470		250
7	2.28	.637		.422		.361	.391	250
9	2.32	.589		.762		.594		250
1	2.40	.581			.434	.396	.265	250
10	2-30	.555			.864	.750		250

Legend: **M** - Mean; **SD** - Standard deviation; **N** - Number of respondents; **Item 1** - On the whole, I am satisfied with myself; **Item 2** - At times, I think I am no good at all; **Item 3** - I feel that I have a number of good qualities; **Item 4** - I am able to do things as well as most other people; **Item 5** - I feel I do not have much to be proud of; **Item 6** - I certainly feel useless at times; **Item 7** - I feel that I'm a person of worth, at least on an equal plane with others; **Item 8** - I wish I could have more respect for myself; **Item 9** - All in all, I am inclined to feel that I am a failure; **Item 10** - I take a positive attitude toward myself.

It is also noticed that after EFA three items showed low in factor loading (< .50). Description of the items were, "I feel that I have a number of good qualities", "I feel that I'm a person of worth, at least on an equal plane with others", and "On the whole, I am satisfied with myself". The result of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) test which tells whether the sample size taken for the factor analysis was adequate or not. It tests whether the partial correlation among the variables are small. KMO values range from 0 to 1. The closer the value to 1 the more adequate is the sample to run the factor analysis. Usually KMO more than .5 is considered is sufficient for doing factor analysis reliably. For this present study, Kaiser-Meyer-Olkin Measure of Sampling Adequacy yielded a measure of .781 which is > .5; hence the sample size is adequate to run the analysis and to make it more lucid. Further the Bartlett's Test of Sphericity was used to test the null hypothesis the correlation matrix is the identity matrix. Since the significance value ($p < .01$) of Bartlett's Test is .00, which is < .01 hence it is significant and the correlation matrix is not an identity matrix. Thus, it may conclude the factor model is appropriate. The Communalities of all the variables shows its appropriateness because the values of all the items after varimax rotation are more than < .4 except the item 3 (Sharma, 2007).

The study was further having gone through a gender based analysis on the perception of self esteem among all the high school athletes with all the 10 items of self esteem. To see the gender based analysis ^{t}-test (11.93) was administered at the .05 level of significance. The result of t-test found a significant difference between the two groups. It is also noticeable for the table that the level of self esteem of male high school athletes is higher than the female high school athletes.

Further a Confirmatory factor analysis was administered with all the retained items irrespective of any factor loading to see the validity of the original version and which provided the graphical representation of the pattern of correlations between a set of variables. Accordingly, the result of the model fit summary supported the indices (Measurement Models Fit Indices Examined) extended by Leach et al. (2008). Confirmatory Factor analysis was tested where the Model Fit Summary are: χ^2 = 36.928 with df = 32 to be significant as CFI = .978, RMSEA = .025, GFI = .972, AGFI = .952, PGFI = .566, PCLOSE = .905.

TABLE 3

Gender based difference of self esteem.

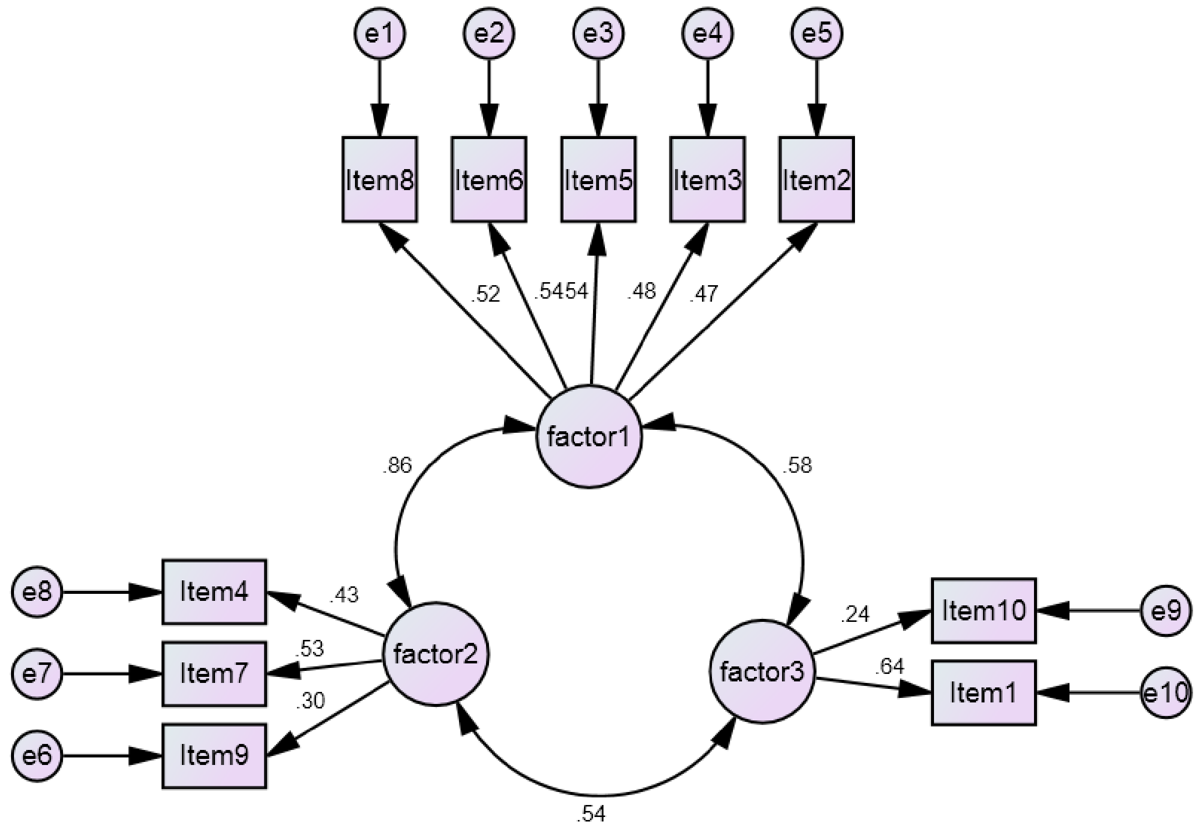
Gender	*N*	*df*	*M*	*MD*	SD_M	SE_D	*t*
Male	124	1.85	24.87	3.91	.166	.32845	11.93
Female	126	3.15	20.96		.281	.32717	

Legend: **N** - Number of respondents; **df** - Degrees of freedom; **M** - Mean; **SD** - Standard deviation; **MD -** Mean difference; $\mathbf{SD_M}$ - Stadrad error mean; $\mathbf{SE_D}$ - Stadrad error difference; **t** - T-test.

DISCUSSION

The overarching aim of the study was to find the perception of self esteem among the high school students and also to see the difference of self-esteem between both sexes. Out of ten items; 7 items showed higher level of factor loadings, but the remaining three items didn't show higher item loading, but still these three items were included in the further analysis because factor coefficient loadings at or above .40 is considerably relevant (McDonald, 1999). The description of the items are, "I feel that I have a number of good qualities", "I feel that I'm a person of worth, at least on an equal plane with others", and "On the whole, I am satisfied with myself". Level of self esteem between male and female was found significantly different as it was hypothesized. This same result is also corroborated by the finding of Tiggemann and Williamson (2000). So from this finding we could assume that male student's physical activities would be more emphasized than the female students and the same result is also corroborated by the finding of that participation in extracurricular activities has been linked to: higher self-esteem (Duda, 1989; Holland & Andre, 1994; Jaffee & Ricker, 1993), lower dropout rates (Finn, 1993), better attendance (O'Brien & Rollefson 1995), success in school and on tests (Snyder & Spreitzer, 1990; Soltz, 1986), reduction of at-risk behaviors (Eccles & Barber, 1999; Ebie 1998); physical fitness (Rainey, MeKeown, Sargent, & Valois, 1998); and as a predictor of success in college and later in life (O'Brien & Rollefson, 1995). Spence and Poon (1997) reported that 79% of males in their survey chose sports because they believed they were capable of being good athletes and good at sports, while 68% of female athletes reportedly playing for socialization reasons, and physical fitness. Freyer (1997) investigated the reasons for participation in team sports of adolescent females. She found that her sample of 130 adolescent female athletes identified 11 variables of sports participation. These included increasing athletic skills, achievements in compe-

FIGURE 2
Represents three factors Measurement model extracted from the total items of Self esteem.



tition, staying physically fit and attractive, improving feelings of self-worth, and making new friends. These results are supported by Dworkin, Larson, and Hansen, (2003) who emphasized that extracurricular activities are different from many other school activities because of the opportunities provided to develop socially and leadership skills, increase peer--awareness, and improve emotional fitness. The results were further enhanced with CFA where the result of the Confirmatory factor analysis Model Fit Summary indicated: χ^2 = 36.928 with df = 32 to be significant as CFI = .978, RMSEA = .025, GFI = .972, AGFI = .952, PGFI = .566, PCLOSE = .905. which supports the indices as per the Measurement Models Fit Indices supported (Leach et al., 2008). Hence it is assumed that the items were perfect to measure the level of self esteem on the aforesaid samples as it also corroborates with the global results conducted by various researchers.

CONCLUSION

Within the limitations of the study and on the basis of statistical finding, so the following conclusions are drawn. It was found that all the items were retained after applying an exploratory factor analysis of self--esteem as it was hypothesized earlier. Confirmatory analysis was also found a significant model fit summary indicated which supports the indices as per the Measurement Models Fit Indices supported by Leach et al. (2008). Further, it was found that there was a significant difference in the mean score of the male and female self-esteem level; where male students showed a higher mean level. From this finding we can assume that, female students are not taking active participation in games and sports and leisure activities (Vealey, 1992; Wilkins et al., 1988; Yeng & Hemsley, 1996). As much as the same initiative been taken up by the male high school students (Tiggemann and Williamson, 2000).

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INFLUENCE OF LUMBOPELVIC STABILITY ON DEADLIFT PERFORMANCE IN COMPETITIVE POWERLIFTERS

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SUMMARY

The deadlift exposes the spine to extreme loads and requires adequate lumbopelvic (core) stability. Deadlift performance may be influenced by the neuromuscular control of the trunk. In this study, we aimed to compare the transversus abdominis contractile rates in an elite powerlifter with those of a control group during deadlift and estimate the relationships between core stability and deadlift performance. In the present controlled laboratory study, 16 powerlifters [8 male national-level powerlifters and 8 male regional-level powerlifters (control group)] were tested for changes in transversus abdominis thickness to evaluate transversus abdominis contractility at each deadlift phase using ultrasound imaging. Compared with the control group, the elite powerlifters showed a higher transversus abdominis contractile rate when the weight was at knee level (2.16 vs. 1.74; p = .04). There were no significant differences between the transversus abdominis contractile rates in both groups when the weight was at the floor and top level. This study reveals that deadlift performance may be influenced by transversus abdominis contractility (lumbopelvic stability).

Key Words: athletic performance, core stability, lumbopelvic stability, transversus abdominis.

INTRODUCTION

Competitive powerlifting requires explosive muscular power and exposes the spinal column to extreme forces. In this sport, the following three lifts are included: squats, bench press, and deadlift. Each lift has its own primary movers, with the deep trunk muscles acting primarily as stabilizers. The deadlift was chosen for this study because this lift exposes the spine to extreme loads and requires adequate lumbopelvic stability. In the deadlift, a powerlifter lifts the barbell off the floor and stands in an upright position. The lift concludes with the powerlifter standings with the knees and hips extended and the scapula retracted. Previous studies indicate that the deadlift includes the following three phases of movement (Hales, Johnson, & Johnson, 2009; McGuigan & Wilson, 1996): first when the powerlifter applies force to the bar to lift it off the floor; second when the bar passes the knee; and third when the powerlifter lifts the bar into a full upright position.

The core muscles do not generate power but the thigh, gluteal, and back muscles are considered the primary power generators that maintain core stability (McGill, 2010). Core stability is related to the body's ability to control the lumbopelvic region in response to internal or external disturbances; it is a foundation by means of which the trunk produces, transfers, and controls force, enabling motion of terminal segments in the kinetic chain (Cook, 2001; Kibler, Press, & Sciascia, 2006; Liemohn, Baumgartner, & Gagnon, 2005; Panjabi, 1992). The core has been defined as a double-walled cylinder with the diaphragm as the roof, abdominals as the anterior wall, paraspinals and gluteals as the posterior wall, and pelvic floor and hip musculature as the bottom. Coordinated activation of these muscles is vital for core stabilization (Bergmark, 1989; Panjabi, 1992). The core has received particular attention because it serves as the center of the functional kinetic chain. The ideal core stability includes the ability to control the lumbopelvic region and transfer the greatest torque levels to the distal segments (McGill, 2002). Therefore, core instability is believed to cause alterations in energy transfer, resulting in a reduction in athletic performance. Consequently, the ability to stabilize the lumbopelvic region can significantly affect the deadlift performance by maintaining the kinetic chain. Thus, deficits in core stability may lead to an abnormal kinetic chain, which in turn may influence the deadlift performance.

Transversus abdominis (TrA) is considered as a primary stabilizing muscle in the lumbopelvic area (Cresswell, Oddsson, & Thorstensson, 1994; Hodges, 1994; Maughan, Watson, & Weir, 1984; Miller & Medeiros, 1987). TrA originates from the iliac crest, the lower six ribs, lateral raphe of the thoracolumbar fascia, and then passes medially to the linea alba. Because of its transverse fiber orientation, the TrA controls the lumbar spinal posture by increasing the tension in the thoracolumbar fascia and intra-abdominal pressure (Cresswell, Grundstrom, & Thorstensson, 1992; Cresswell et al., 1994; Oddsson, 1990). Springer and Gill (2007) also suggested that TrA is more responsible for motor control than for strength.

A number of studies regarding TrA have focused on motor control and sequencing of muscle contractions (Hodges, 1994; Hodges & Richardson, 1996; Hodges, Richardson, & Hasan, 1997; Misuri, Colagrande, & Gorini, 1997). In this respect, TrA has a distinct function during movements that involve the trunk (Hodges, 1994; Hodges & Richardson, 1997, 1998; Hodges et al., 1997). In particular, it has been demonstrated that core stability has a positive influence on athletic performance (Parkhouse & Ball, 2011). However, no study has evaluated the lumbopelvic stability and its influence on the deadlift performance in competitive powerlifters. To the best of our knowledge, this study is the first to evaluate changes in TrA thickness in competitive powerlifters by ultrasound (US) imaging.

Because core stability is considered as one of the factors influencing strength or power output, we hypothesized that a relationship exists between core stability and deadlift performance in competitive powerlifters. Therefore, to investigate the influence of lumbopelvic stability on deadlift performance, we compared TrA muscle contractile rates between national and regional level powerlifters while they performed the deadlift.

METHODS

Participants

Sixteen male Japanese powerlifters recruited from a local powerlifting gym participated in this study (8 national level and 8 regional level male powerlifters). All participants completed a questionnaire to assess their suitability for the study. The following were the exclusion criteria: low back pain in the past three months, significant spinal deformity, current urinary tract infection, history of surgery in the lumbopelvic area, or history of neuromuscular disease. The participant's physical characteristics were measured by standard procedures (Table 1). The study was explained to the participants before they provided written informed consent.

Several methods have been developed to counterbalance a competitor's bodyweight during powerlifting in order to allow for comparisons among different classes of weight. The Wilks equation, by the International Powerlifting Federation, was used to evaluate the powerlifters' yield, regardless of the body mass. Using this method, the amount of weight lifted by the powerlifter was multiplied by an index based on the body mass. In this study, participants who have participated in previous world championships (2010, 2011, 2012) were categorized as national level (elite) powerlifters and who have never been qualified were categorized as regional level (control) powerlifters.

Procedure

A number of studies used needle electromyography to measure TrA contractility (Hodges & Richardson, 1997; Hodges & Richardson, 1998). However, this method is invasive and uncomfortable for the participants. Thus, researchers have used US imaging to evaluate the muscle contractility by demonstrating that changes in TrA thickness correlate with changes in the muscle activity (Hales et al.. 2009). Therefore, the muscle thickness can be used to estimate the muscle activity because muscle force correlates with the muscle's cross-sectional area (Kanehisa, Ikegawa, & Fukunaga, 1994; Maughan et al., 1984; Misuri et al., 1997). US imaging has been used reliably and successfully to measure the lateral abdominal muscles (Bunce, Moore, & Hough, 2002). In the present study, we conducted US imaging to measure TrA thickness using a US scanner (UF-4500; Fukuda Denshi, Tokyo, Japan) in brightness mode with a 12-MHz linear array transducer. An electroconductive water-based transducer gel was applied to the skin prior to US imaging. The transducer was positioned perpendicular to the abdominal wall, superior to the left iliac crest, and along the mid-axillary line. This placement enables accurate readings and provides optimal image clarity (Misuri et al., 1997). Care was taken to place the transducer in the same spot during data collection. The transducer was placed such that the hyperechoic interface between the TrA and thoracolumbar fascia appeared at the far right of the image, and the transducer's angle was adjusted to optimize image visualization. The TrA muscle thickness was determined by the distance between the superior border of the internal oblique muscle and inferior border of the TrA. This method for measuring TrA is both reliable and noninvasive and has been used to successfully estimate TrA activity (Bunce et al., 2002). Participants were instructed to inhale and hold their breath during US imaging because the TrA thickness varies with the respiratory cycle (Ainscough-Potts, Morrissey, & Critchley, 2006; Misuri et al., 1997). Measurements were performed under the following four conditions (Figure 1, 2, and 3):

- While the subject lay quiet in the prone position (a);
- While the subject bent over and touched the barbell on the floor with no intention of moving (b);
- While the subject stood, holding the barbell at knee level (c);
- While the subject stood, holding the barbell in the upright position (d).

Each position was held long enough for the examiner to obtain a clear US image of the TrA thickness. The participants held a barbell during the US measurements (conditions c and d). The loard was prescribed individually for each subject as 20% of 1RM (repetition maximum).

Reliability of measurements

Data from five participants were chosen to examine both the intra-rater and inter-rater reliability of US imaging. A single TrA thickness measurement was obtained from each subject with a 2-min interval between each measurements (total, five measurements). After each measurement, the participant stood up, walked around, and was then repositioned in the testing posture. The reliability across repeated measurements of the same image position was determined by intraclass correlation coefficients (ICC) (Rankin & Stokes, 1998). The ICC for both inter- and intra-rater reliability was greater than .95 for the TrA muscle thickness measurements.

Statistical analysis

Statistical analyses were performed using Stastistica 5.1 (StatSoft, Tulsa, OK, USA). Analysis of variance (ANOVA) was used to examine similarities between the groups for age, height, weight, BMI, and maximum deadlift performance. Two-way ANOVA was performed for each condition (a–d), and was used to examine the significance between the groups and conditions. Tukey's honestly significant difference was used to account for multiple comparisons. Statistical significance was set at $p < .05$. The data are presented as means (standard deviation) unless otherwise stated.

RESULTS

We found no significant intergroup differences with respect to the participants' characteristics ($p >$ .05), including age, weight, height, and BMI (Table 1). Changes in TrA muscle thickness was calculated between measurements obtained during each condition (b–d) with TrA contracted and in the resting

TABLE 1
Participants' characteristics.

	Elite (n = 8)		Control (n = 8)		t	p
	M	SD	M	SD		
Age (year)	39.9	8.8	34.6	7.0	1.31	.21
Body height (cm)	169.1	8.8	168.9	6.5	.05	.96
Body weight (kg)	83.4	27.3	74.4	10.3	.87	.40
BMI (kg/m^2)	28.9	8.9	26.1	3.4	.85	.41
Raw Dedalift (kg)*	245.3	47.8	185.9	35.9	2.81	.01
Wilks equation	177.9	26.0	133.7	17.2	4.01	**.00**

*Raw deadlift was performed in the classic style with the use of a lifting belt

Legend: **n** - Number of participants; **M** - Mean; **SD** - Standard deviation; **t** - t-test; **p** - Probablity; **BMI** (kg/m^2) - Bodi mass index; **Raw Dedalift (kg)** - Was performed in the classic style with the use of a lifting belt; **Wilks equnition** - Weight lifted by the powerlifter was multiplied by an index based on the body mass.

(prone) position (a). The TrA thickness measured during each contracted condition (b, c, and d) was divided by the TrA thickness measured during the resting condition (a) to determine the relative change in TrA muscle thickness. For example, a thickness ratio of 2.0 indicates that the muscle thickness doubled from that during its resting position.

The interaction between groups and conditions was significant. TrA contractility was significant between conditions c (bar at the knee level) and d (bar at the top position) for both the elites and controls. In the elite group, there was a significant difference between conditions c (bar at knee level) and b (bar on the floor) (Table 2).

Elite powerlifters demonstrated a TrA contractile rate that was significantly greater than that for controls when the weight was at the knee level (c/a) (Table 2). However, there was no significant difference in the contractile rates when the bar was on the floor (b/a) or in the top position (d/a).

FIGURE 1
Condition (b); The subject bent over and touched the barbell on the floor with no intention of moving.

FIGURE 2
Condition (c); The subject stood, holding the barbell at knee level.

FIGURE 3
Condition (d);The subject stood, holding the barbell in the upright position.

TABLE 2
Mean transversus abdominis (TrA) contractile rates during each condition.

	Floor		Knee		Top		Two-way ANOVA			Post hoc. Turkey's HSD
	M	*SD*	*M*	*SD*	*M*	*SD*		*F*	*p*	
Elite	1.47	.07	2.16	.15	1.27	.10	F1	2.35	.15	Elite, Control: Knee > Top
Control	1.40	.07	1.73	.13	1.27	.08	F2	33.31	**.00**	Elite: Knee > Floor
							F3	3.59	.04	Knee: Elite > Control

Thickness ratio ($M \pm SD$) is the ratio of TrA thickness between the contracted and resting positions. A thickness ratio of 1.0 indicates no change in the TrA muscle thickness from the resting position.

Legend: **M** - Mean; **SD** - Standard deviation; **F** - *F*-test; **p** - Probablity; **F1** - Gropus; **F2** - Conditions; **F3** - Interaktions; Thickness ratio ($M \pm SD$) is the ratio of TrA thickness between the contracted and resting positions. A thickness ratio of 1.0 indicates no change in the TrA muscle thickness from the resting position

DISCUSSION

Core stability is important for both strength and athletic performance. However, there is no direct evidence that establishes a relationship between core stability and athletic performance. Our study investigated whether core stability is related to deadlift performance in competitive powerlifters.

The relative TrA contractility in the starting position did not differ between the groups. This may be because TrA increases segmental stabilization and intra-abdominal pressure, and it activates in anticipation of loads to the spine. During the deadlift, the lumbopelvic area was exposed to maximum stress when the weight is at the knee level. Two previous studies reported that a sticking point, which is the weakest point in the range of motion, tends to occur around the knee, resulting from biomechanical disadvantages (Hales et al., 2009). Therefore, powerlifters should be able to generate high forces and have a stronger lumbopelvic region to overcome these biomechanical disadvantages. Based on our analysis, both groups showed higher TrA activity levels when the barbell was at the knee level. This result indicates that stronger lumbopelvic stability is indeed necessary at this point during movement. However, relative TrA contractility was greater in elite powerlifters than in controls while the weight was held at knee level (p = .04). Given that elite powerlifters showed higher TrA contractile rates than controls when the barbell was at the knee level, the elite powerlifters showed greater lumbopelvic stability to clear the sticking point.

This result indicates that deadlift performance can be influenced by TrA function.

Relative TrA contractility was not significant in elite powerlifters while holding the weight at the top position. This may be because holding the weight in the upright position not only depends on muscular contractility but also on the joint locking mechanisms.

It should be noted that a relatively small number of elite powerlifters were available for this study, which is a common situation in any study with elite athletes. Furthermore, only TrA was examined in this study. The contribution of other lumbopelvic stabilizers, such as lumbar multifidus, should be investigated in future studies.

Core strength training is often used with the aim to enhance athletic performance (McGill, 2001). However, few scientific studies have demonstrated a direct relationship between TrA muscle contractile ability and athletic performance. The present findings suggest that deadlift performance can be influenced by TrA function. Therefore, it is likely that core stability exercises along with weight training have the potential to increase the deadlift performance.
However further research should focus on the efficacy of neuromuscular training interventions that are aimed at improving core stability, and whether they can improve the deadlift performance.

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SOCIOMETRIC STRUCTURE OF PREMIER LEAGUE VOLLEYBALL CLUB

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SUMMARY

For the investigation of interpersonal relations in small groups such as sports, sociometric procedure are used. In this study, sociometric procedure is conducted and sociometric structure has been made for the female University Volleyball Club BL volley from Banja Luka, who competes in the Premier League BiH. The task was to discover the emotional-social and functional status of the players, and the status of congruency and to evaluate the atmosphere at the club. Further analysis has been done of the aspirations of the players in terms of taking a position at the score table, as well as their assessment of management's expectations regarding the position on the score table. After sociogram and sociometric matrices has been made, it can be said that the team has three distinctive groups that are separated by mutual election of its members when it comes to emotional and sociological status. The assessment of functional status identifies two players who received 16 and 14 votes out of 17 possible. Two players who have received the most votes by socio-emotional criteria, were not selected in the first team by the coplayers, which again speaks of a team that very well makes a distinction between "friendship and business". Based on these results, it can be concluded that the atmosphere in the team is good and that it is not affected by functional status, or age of the players (almost half of the team is younger than 18). And finally, using Man-Vitni and Kruskal-Volis test it was found that neither age nor functional status does not affect significantly the assessment of the position on the score table. Functional status and age is also not a source of significant differences in the assessment of the players on what they think the club management is expected from them.

Key Words: sociometry, sociometric structure, volleyball.

INTRODUCTION

The behavior of individuals in the group, the group as a whole and relations between groups in the last few decades have become the subject of intensive study. Small groups in which interactions among members are multiple and in which members are extremely emotionally close to each other are called primary group. According to the criteria of psychological closeness and mutual influence, members of the Sports Group are one of the primary groups - interactions are very numerous and varied, behavior and activity of each individual takes place under the influence of other members, and members are focused on common goals (Dunđerović, 1999). About groups and the classification of social groups also extensively wrote Milosavljević (2005) in his book "The social psychology of human groups." The study of interpersonal relationships deal with sociometric research first introduced in psychology by Jakob Moreno. In his research he studied the emotional relationships within the group, mutual attraction and repulsion of the group members and based on the obtained results he defined the structure of relationships in the form of sociogram. Moreno (1962), by sociometric method and its instrument (sociometric surveys, questionnaires) conducted a survey on the development and organization of the group, and the position of individuals in groups. The results of these methods are used to improve relationships in these groups, where possible, by regular and professional approach to improve the cohesion and unity of the group, as well as the adaptation and integration of "isolated" individuals. Sociometric methods are also used in the children's ages when it is possible to better influence on the socialization of children, and in one such study, about the creation of mutual friendships among the young children, results showed that children who have friends are better in meeting the developmental task of forming a friendship dyads and indicate a higher degree of social adaptation (Trbojević, 2014).

Klein and Christiansen (1966) have tried, with the help of sociometric methods, to choose the best five players in basketball with the help of some psychological and sociological variables. Their assumption was that it was not of primary importance to assemble a team of quality individuals, but to set up the circumstances in which individual characteristics may maximaly contribute to the final goal. Ruder and Gil (1982) have studied what are the immediate effects of lost - obtained match to the cohesion within the volleyball team. The results showed that perceptions of cohesion are under the influence of the direct effect of defeat or victory. "Group cohesion indicates the strength of connections between group members. Cohesion is much easier to achieve in smaller groups than larger. In any case, quality of interactions contributes to the cohesion of a small group, and vice versa" (Suzić, 2005, p. 245). In the paper, related to communication and sports groups (Petković, Veličković, & Petkiović, 2013) is discusses about the factors which determine success in this groups and who depends on three types of processes that are: structuring, group processes and leadership. Structuring of the group is a process in which is determined position or place of an individual in the group. Cohesiveness is a complex feature which includes a number of group processes which have multiplier effect on the operation, and thus the efficiency of the group. Leadership represents the most distinctive feature of the group that determines the interpersonal communication (cohesiveness, communication).

In sports and sports teams cohesion or homogeneity is crucial for the success and results. There are countless examples where a set of top and "expensive players" does not give good results because of poor interpersonal relations, and vice versa, where the average quality of the team achieve great results. There are also examples where individuals, top players and key players in their clubs, changed the club, and because of the inability of integration and adaptation, due to isolation from their new teammates, they simply vanished from the sporting scene or had to change the club again. Banister says that sport is very strong verbal and nonverbal communication in its original meaning and comprehension (Banister, citated in Koković, 2001). Martinović and Barić (2012) in their work on the cohesiveness in a team sport, as an important factor for preparation, says that the degree of cohesion is best measured in the middle of the season when the team has gone through the stages of formation and excitement in the development of cohesion, but also is desirable that the measurement is done at the beginning of the preparatory period for determining the initial state of cohesion and compare with measures obtained in mid-season, in order to monitor the pace and progress of the group. As a rule, the coach has a leading influence on the behavior of his team, it is expected from him some more understanding of psychosocial interactions and behavior in a group. In order to know what kind of team it is, whether the team has split, or whether the team present opposition groups (cliques), who is respected and who is not, whether the leader (captain) is formal or informal, whether and who are isolated individuals, and so on, it is appropriate to use sociometric method (Mijanović & Vojvodić, 2008). On some sociological relationships between coaches and players Vejnović (2006), among other things says that it is necessary to cope with problems, and solving these problems should be to the satisfaction of all, on the individual meeting in the coach office. The coach needs to know the socio-psychological reactions and interactions of his players after victory and defeat, as writen by the Puni (1966), and these findings can be obtained by sociometric research. About principles that should be followed in sociometric research Gutović (2006) has writen and emphasized the principle of information, the consent principle, the principle of confidentiality and the principle of accountability. It is clear that the practice commonly present subjective assessment of trainers on the situation within the team. Šnajder (1984) has made a sociometric analysis of volleyball team "Mladost", which at that time was one of the best teams in the former Yugoslavia, before and after important international tournaments where they achieved an excellent result. The microsocial structure of the team has very much changed after the completion of the tournament, a good result in this competition had a positive impact on interpersonal relationships within the team in the next competitive season. Marelić, Đurković, and Rešetar (2007), in the work of "Interpersonal relationships in cadet volleyball team before and after the event," says that the coach must be much more than "practitioners" and that sociometric studies can certainly confirm the coach's thoughts or initiate significant changes in the operation and management of the group. Sindik and Mihaljević (2011) examined the socio-economic status and the microsocial structure in the women's handball club and among others, came to the result that the players of the same socioeconomic status better emotionally accept each other. Barbaros-Tudor, Martinčević, and Novak (2010) in sociometric research at the tennis club, got results that indicate the hierarchical structure by the functional and emotional criteria.

The problem and the subject of this work are interpersonal relationships in the sports group, ie. its sociometric structure. The aim and objectives of this study was to define interpersonal relations within the team, and in order to do this it is necessary:

- To discover the mutual relations in the matter relating to socializing outside of the training and selection of a roommate at the preparations (affective expansiveness and sociodinamic effect, ie the emotional and sociological status)
- To detect functional or playing status of individuals in a team
- To detect the satisfaction of players with their status in the team (status congruency)
- To detect the views of the players about the atmosphere in their team
- To analyze the aspirations and expectations of the players and management of the club about the place in the standings at the end of the season

For this purpose to create a sociograme and index about group cohesion. One of the assumptions is that the cohesion of the team could be affect by the age of the players (10 out of 18 players has 20 years or less), as well as their functional status in the team and for this purpose the relationships should also be analyzed. It is interesting to analyze the relationships between functional status and age on the one hand, and estimated place by the player on the standings table (to their assessment, as well as on the assessment of what they think is a place that management expects from them) on the other.

METHODS

Sample of respondents

The sample consisted of 18 registered players of the University women's volleyball club BL Volley from Banja Luka that compete in the Premier League Bosnia and Herzegovina [BH]. They are aged 17 to 23 years and all are students at the University of Banja Luka, except the two youngest who are at the high school. It should be noted that a large number of them are from different parts of the Republic of Srpska and BH and that they simultaneously play and study. After the sociometric questionnairewas given to them, the methodology for completing was explained, as well as guarantees of anonymity.

Procedure

Sample of variables of the questions are in sociometric questionnaire, which relate to the assessment of the atmosphere at the club. Questions in sociometric instrument which are designed to measure the so-called emotional expansiveness and sociodinamičkog effect, and on which players had to answer were:

- Which teammates do you prefer to hang out after training?
- Which teammates would you select as the "roommates" in the hotel, during the preparation or stay in other cities?

The number of choices was limited to 3, and, based on the choices following variables were constructed: number of points from sociometric matrix choice for socializing outside of training, number of points from sociometric matrix choice for "roommate" in the hotel.

In order to determine the functional (gaming) status of individual players in the team, the following choice was formulated: respondents to indicate five players with whom they would prefer to play in the lineup, in order, from best to worst. On that occasion it was determined number of points from sociometric matrix, the number of mutual choice, and the number of times someone was chosen.

To test the atmosphere within the team it was designed a five-point Likert scale where respondents were offered with five possible testimony-attitudes (strongly disagree, disagree, undecided, mostly agree, strongly agree) to assess how many players respected each other as a person, how they and the coach respect each other, how frequent are the conflicts, how much time is needed to eliminate the conflict, and in the end they generally rated the atmosphere in the team.

To determine the degree of satisfaction of their position in the team, it was designed a five-point numerical rating scale in which each of the respondents assessed their position in the team. With grade 1 respondents expressed a feeling of complete subordination to the group, grade 2 expressed partial subordination, grade 3 when respondents is and is not satisfied, or when the undecided regarding their status in the team. With grade 4 the respondents expressed satisfaction with the situation, a grade 5 full satisfaction of the position in the team.

Aspirations of the players, compared to the final place in the standings and their assessment, or management's expectations, are represent by two numbers with which the respondents assessed that place she expected at the end of the competition, and a place which, according to her assessment, it is expected the by the club management.

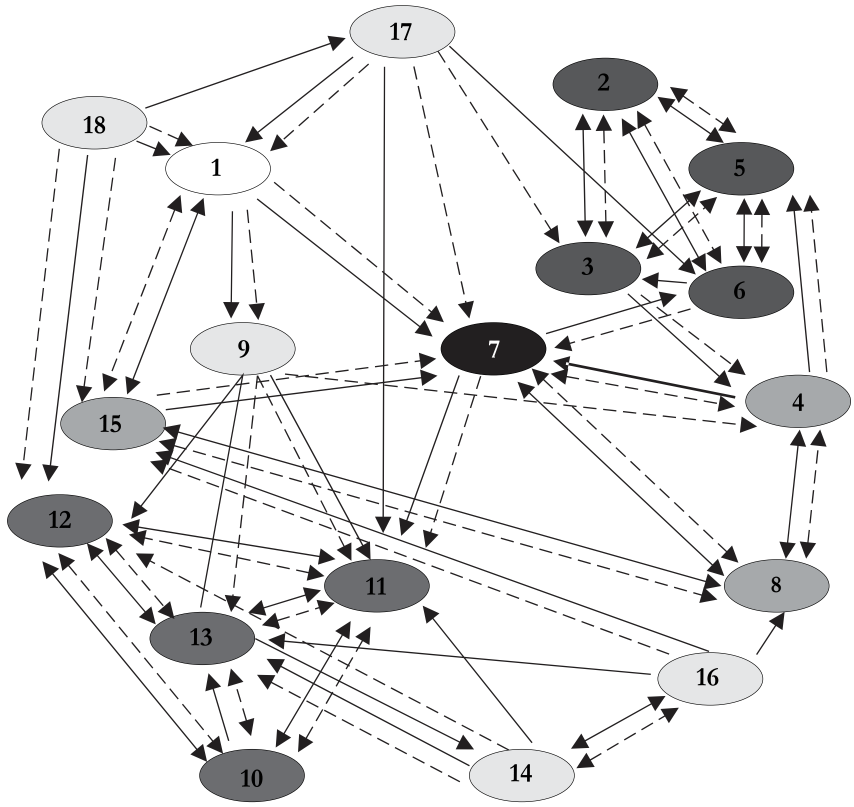
Statistical analysis

For better transparency of players interactions in the team two sociogram have been done, one social and other functional, but before that sociometric matrix is done and based on it is determined the position of each volleyball players at first and the second sociogramu. For analysis of the atmosphere within the team and determining the degree of satisfaction of players with position in the team five-point scale, was constructed, and the absolute and cumulative frequencies and percentages were determined. Whether players age (younger, older) affects on different estimates about the standings end of the season, will be determined by Man-Whitney U test.

By determining the functional status, mutual choice of players who are the best we will get three settings: the first (those players who were selected most times), the second (players with less choice) and third (players who were least chosen). Man-Whitney U test will also determine whether functional status affects volleyball player on difference choice in the assessment of the club standings at the end of the season. Does the age structure of the players and their functional status affect the atmosphere and interpersonal relationships in the team will be determined by another non-parametric methods, Kruskal-Volisov H test,

FIGURE 1

Sociogram of social and emotional relationships in a team.



Legend:

→ The solid arrow in one direction is a selected teammates with whom you preferre to hang out after training

↔ The solid arrowin both directions is a mutual choice

⇢ The dotted arrow in one directionrepresents a choice of a teammates who you would prefer as a roommates at the time of preparations

⇠⇢ The dotted arrow in both directions is a mutual choice which is a nonparametric alternative analysis of variance for different groups.

RESULTS AND DISCUSSION

The first step in the analysis and consideration of interpersonal relationships in the team is analysis sociogram.

In the analysis of sociogram (Figure 1) it is immediately seen some characteristic grouping (different intensity of gray), as well as players who do not belong to any of these groups. One group consists of players 2, 3, 5, and second 6, 4, 7, 8, 15, and third players 10, 11, 12, and 13 other members that are not in differentiated groups. As can be seen within the formed groups, it was largely mutual chioce for hanging off the court and being roommate in training. The players from the first group (2, 3, 5, 6) are associated with a four and a seven out of the other group over 3 and 6. These is quite introvert group, but over players 3 and 6 still open to other teammates. The players 4, 7, and 8 out of the secong group were chosing each other on first and the second criterion, while the remaining have chosen four different players (4 → 5) from the first group, 7 selected 11 out of the third and 6 from first group, and No. 8 elected number 15 from "their" group, who again chosed number 1, which does not belong to any of these groups. Here you can confidently say that it is a ekstravertly organized group or structure where its members want to hang out in training and off with the other members of the club. Third group (10, 11, 12, and 13) is the most closed and it seems self-sufficient. There is no doubt that it has introvert structure whose members want to socialize and train only with members of their group. It is obvious that when we are talking about the third group, it is a clique, so it is very interesting and that the players who do not belong to any group and having from 0 to three choices, were giving the majority of their votes to them. These are the players with numbers (9, 14, 16, 17, 18). They are mostly isolated, except No. 14 who was selected from number 13 on the criteria of socializing outside the court and mutually chose with the number 16. No. 17 has only one choice and that from the number 18 who does not have one. Player number 9 has two votes from players No. 1, which also do not belong to any group and has six choices, and who, through mutual chosing with the number 15 and the double election of No. 7, is associated with the blue group. It is obvious that it is a "free shooter", but ready to cooperate.

In the end, it can be concluded on the basis of the votes counted (the election) that the players from the third group were most chosen, and the greatest number of choices (12) has received a player with the number 11, then No. 13 with 11 votes and No. 12, which has ten of the votes. However, if we take a closer look at the structure and sociogram and intercorrelation matrix (due to the size it is not placed in this paper), although they are almost completely closed, players from the third group, for some reason, have a great impact on the players who are the least selected. So number 11, which has the highest number of votes, received 4 votes from "do not belong to any group", No. 13 got 5, and No. 12 has received 3 votes. This indicates that it is popular, but less influential groups because those who gave them the most votes are less popular (not elected).

The player with a large number of votes, is number 7 out of the second group, who has 10 votes, but received by all, except the third group, although she gave two voices to No. 11 from the third group. One voice she gave to the first group which speaks of her openness to all, and popularity among all groups except in the red.

Group cohesion index was calculated by the formula:

$$IK = \frac{\Sigma\Sigma \text{mutual choices} / 2}{\Sigma_{max} \text{mutual choices}}$$

$$\Sigma_{max} \text{ mutual choices} = \frac{\text{max choices x} N}{2} \quad \frac{3 \text{ x } 18}{2} = 27$$

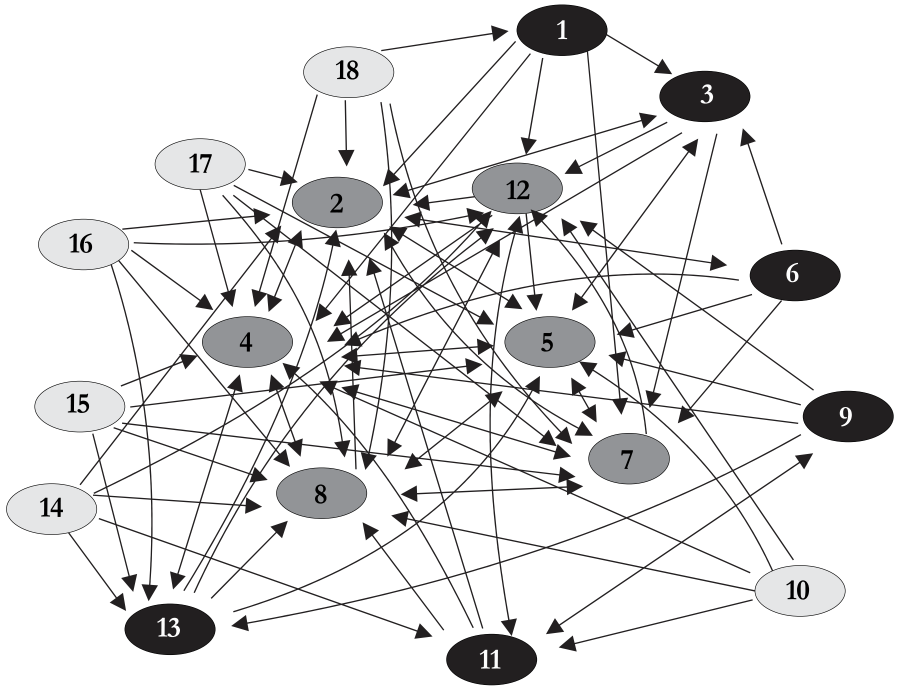
$$IK = \frac{33 / 2}{27} = .61$$

Because the number of mutual choices was 33, and the maximum number of possible choices 54, calculated coefficient of group cohesion is .61 so we could say that it was a good group cohesion, or cohesion which is on the border between medium and high correlation (IK < 00:40 - low correlation, .40 < IK < .60 - Medium, .60 < IK - high correlation). Therefore, hypothesis about the possibility that a large number of young players negatively affect the cohesion of the team is waste.

Second sociogram and intercorrelative matrix (Figure 2), obtained the answer to the question with which five players would you most want to play. In this way we got first team chosed by all 18 players. They are No. 4 (which has the most choices - 16), followed by the number 2 who has 14 choices, No. 5, who has 12 choices, and players 7, 8, and 12, who each have 10 votes. The second setup would consist of number 13 (5 votes), 11 and 3, each with four votes and players 1, 6 and 9 who were selected by one. Other players were not selected at all in the first six.

From all the above it can be concluded that mutual choices in terms of socializing outside of training and roommates in hotels (sociological status) does not affect much on the functional status of the player, or the choice in the lineup. Two players from the sociogram No.1, who had the most votes (11 and 13) now are nowhere near the first team, while the players 4 and 2 in the sociological sense a bit isolated, in functional terms are leaders in the field (4 selected 16, and 2 selected 14 times). It should be to mention

FIGURE 2
Sociogram of Functional status of players.



the other players who have achieved a good result in terms of the social and functional status, and these are the players with numbers 5, 7, 8 and 12, but it is necessary to emphasize that No. 7 in addition to being selected into the first line is also most open for cooperation in the sociological criteria, and she is perhaps the best solution for the team captain. On the basis of this sociogram which refers to the functional status of the players on the team, three settings can be formed: the first (2, 4, 5, 7, 8, 12), the other (1, 3, 6, 9, 11, 13) and the third (10, 14, 15, 16, 17, 18).

The research results related to questions about satisfaction with the status in the team showed that 12 players or slightly more than 66% of the team are happy and completely satisfied, 5 players stated that both is and is not satisfied or somewhat less than 28%, while only one volleyball player feels completely subordinate, as shown in Table 1.

To the question if players respect each other, the 84% or 15 of them responded generally agree and completely agree, and three players or less than 17% were undecided in the evaluation of mutual respect.

About mutual respect between players and coaches, volleyball players have declared themselves so as of 3 or 16.7% said that they generally do not agree that the coach and the players respect each other, while 15 or 83.3% as in the previous table declared that they agree or completely agree about the comments on mutual respect. Results are in third part of Table 1.

Fourth part of Table 1 shows the results of the testimony of the players on the frequency of conflict in the team. At the conclusion that the conflicts in the team are rarity, undecided was one player, two declared to mostly disagree, 10 said they mostly agree with, a 5 to completely agree with that statement.

On the issue of conflict resolution in a team, in fifth part of Table 1 we can see that only one player was undecided, while 17 of them agreed generally and completely about the fact that if there was a conflict, they are quickly resolved.

That the atmosphere in the team is good, generaly and fully agreed 17 players, or nearly 95%, and only one player has not agreed with it, as can be seen in sisxth part of Table 1.

TABLE 1
The survey results related to the atmosphere in the team .

	Frequency	Percent	Valid Percent	Cumulative Percent
Satisfaction with status in the team				
Full subordinated	1	5.6	5.6	5.6
Yes and no satisfied	5	27.8	27.8	33.3
Satisfied	11	61.1	61.1	94.4
Fully satisfied	1	5.6	5.6	100.0
Total	18	100.0	100.0	
Mutual respect among players				
Udecided	3	16.7	16.7	16.7
Mostly agree	12	66.7	66.7	83.3
Fully agree	3	16.7	16.7	100.0
Total	18	100.0	100.0	
Mutual respect among players and the coach				
Generaly not agree	3	16.7	16.7	16.7
Generaly agree	12	66.7	66.7	83.3
Fully agree	3	16.7	16.7	100.0
Total	18	100.0	100.0	
Conflicts are rare				
General not agree	2	11.1	11.1	11.1
Undecided	1	5.6	5.6	16.7
Generaly agree	10	55.6	55.6	72.2
Fully agree	5	27.8	27.8	100.0
Total	18	100.0	100.0	
Conflicts are solved quickly				
Undecided	1	5.6	5.6	5.6
Mostly agree	10	55.6	55.6	61.2
Fully agree	7	38.9	38.9	100.0
Total	18	100.0	100.0	
Atmosphere in the team is good				
Fully disagree	1	5.6	5.6	5.6
Generaly agree	10	55.6	55.6	61.2
Fully agree	7	38.9	38.9	100.0
Total	18	100.0	100.0	

As it can be seen, Man Whitney U test was "proved" that there are no statistically significant differences between younger and older players on any proposed statements about the atmosphere in the team. Most differ in their assessment is that conflicts are a rarity in the team (.203), but that is far from statistical significance. Based on these results we can rejects the assumption which speaks of the existence of differences between younger and older players in terms on the assessment of the atmosphere in the team. (Table 2).

Testing differences in the assessment of the atmosphere in the team, considering the functional status of the player, on the basis of results obtained with Kruskal Volis H test, one can conclude that the difference in functional status of the players is not the source of differences, as they were not in the previous test. The smallest difference in the assessment that the atmosphere in the team is good is .686, and the largest in the evaluation of rare conflicts and its value is .113, which is also far from statistically significant differences, and therefore we can reject the second assumption which assumed that the different functional status can cause different estimates about the atmosphere at the club. (Table 3).

In the assumption was that age will not significantly affect the assessment of the players what place they will take at the end of the season, and the club management assessment of what is expected of them. Analysis of the results obtained by Man-Vitni U test showed that the players do not differ in the assessment of the position at the table for those who have aspirations, as well as in the evaluation of what place management expects from them. Results in Table 4 show that the obtained coefficients (.897 and .762) is very far from any significant differences and talk more about similarities in their assessment and thus we confirmed the assumption.

One of the tasks in this study was also to determine possible differences in the assessment of players that have different functional status in the team on position at the table at the end of the season (their assessments and what management expects of them) and satisfaction with their position in the team.

Analyze of the results obtained by Kruskal-Volisovog H test undoubtedly establishes that the differences in their estimates are not statistically significant (.610 and .366), and there is no statistically significant difference in the statements on their satisfaction with the status in the team. The difference is greater than in the estimate of the position of the table, but it is not statistically significant (.182), what also confirmes that part of the assumption which refers to the functional status

TABLE 2

The differences in the assessment of the atmosphere in the team between younger and older players.

	Age	*N*	*M*	Σ
IMU	O	8	10.44	83.50
	Y	10	8.75	87.50
ITMU	O	8	8.56	68.50
	Y	10	10.25	102.50
KPR	O	8	11.31	90.50
	Y	10	8.05	80.50
KBR	O	8	9.69	77.50
	Y	10	9.35	93.50
ATD	O	8	10.57	86.00
	Y	10	8.50	85.00

	IMU	ITMU	KPR	KBR	ATD
U	32.500	32.500	25.500	38.500	30.000
W	87.500	68.500	80.500	93.500	85.500
z	-.798	-.798	-1.433	-.152	-1.011
Asymp. *p*	.425	.425	.152	.879	.312
Exact *p*	.515	.515	.203	.897	.408

Legend: **N** - Number of participants; **M** - Menan; **Σ** - Sum of Rnak; **IMU** - Mutual respect among players; **ITMU** - Mutual respect among players and the coach; **KPR** - Conflicts are rare; **KBR** - Conflicts are solved quickly; **ATD** - Atmosphere in the team is good; **Y** - Younger; **O** - Older; **U** - Mann-Whitney U; **W** - Wilcoxon W; **z** - Z score; **p** - Probability.

TABLE 3

The differences in the assessment of the atmosphere in the team with regard to functional status in team.

	Team	*N*	*M*
IMU	1st	6	8.25
	2nd	6	10.75
	3rd	6	9.50
ITMU	1st	6	7.00
	2nd	6	10.75
	3rd	6	10.75
KPR	1st	6	6.17
	2nd	6	11.33
	3rd	6	11.00
KBR	1st	6	7.92
	2nd	6	11.25
	3rd	6	9.33
ATD	1st	6	8.42
	2nd	6	10.57
	3rd	6	9.33

	IMU	ITMU	KPR	KBR	ATD
χ^2	.944	2.833	4.357	1.572	.754
df	2	2	2	2	2
Asymp. *p*	.624	.243	.113	.466	.686

Legend: **N** - Number of participants; **M** - Mean; **IMU** - Mutual respect among players; **ITMU** - Mutual respect among players and the coach; **KPR** - Conflicts are rare; **KBR** - Conflicts are solved quickly; **ATD** - Atmosphere in the team is good; χ^2 - Kruskal Wallis test; **df** - Degrees of freedom; **p** - Probability.

TABLE 4

Differences in the evaluation of players due to the age, about the place in the standings at the end of the season (their assessments and what management expects from them).

	Age	*N*	*M*	Σ
MTABJA	O	8	9.69	77.50
	Y	10	9.35	93.50
MTABUPR	O	8	9.06	72.50
	Y	10	9.85	98.50

	MTABJA	MTABUPR
U	38.500	36.500
W	93.500	72.500
z	-.148	-.331
Asymp. *p*	.882	.741
Exact *p*	.897	.762

Legend: **N** - Number of participants; **M** - Menan; **Σ** - Sum of Rnak; **MTABJA** - Assessment of the position at the table for those who have aspirations; **MTABUPR** - the evaluation of what place management expects from them; **Y** - Younger; **O** - Older; **U** - Mann-Whitney U; **W** - Wilcoxon W; z - ; **p** - Probability.

TABLE 5

The differences in the assessment of the players with respect to the functional status in the team, position at the table at the end of the season (their assessments and what management expects of them) and their satisfaction with the status in the team.

	Team	*N*	*M*
MTABJA	1st	6	10.92
	2nd	6	8.17
	3rd	6	9.42
MATABUPR	1st	6	11.42
	2nd	6	7.33
	3rd	6	9.75
ZADSTATIM	1st	6	11.17
	2nd	6	10.67
	3rd	6	6.67

	MTABJA	MTABUPR	ZADSTTIM
χ^2	.988	2.009	3.405
df	2	2	2
Asymp. *p*	.610	.366	.182

Legend: **N** - Number of participants; **M** - Mean; **MTABJA** - Assessment of the position at the table for those who have aspirations; **MTABUPR** - the evaluation of what place management expects from them; **ZADSTATIM** - Satisfaction with status in the team; χ^2 - Kruskal Wallis test; **df** - Degrees of freedom; **p** - Probability.

CONCLUSION

Sports teams are small groups, where members are their relatively long period together and where functional and social cohesion is crucial to the performance and success of the club. In amateur clubs social component is more emphasized, there is more orientation towards socializing and friendship, and in such areas quality relationships are higher, while the top competitive teams more accentuated functional component, where the main focus is on the victory. In this study clearly it's a team that has a good deal in the emotionally-sociological and in the functional components. Very different results in the selection of players per emotionally-sociological and functional component did not affect the cohesion and the atmosphere in the team, which speaks of the maturity of the team, or the knowledge and recognition of hierarchical structure, especially functional components. As seen from the results of research, not a very large number of young players, not functional status, are not ruining the atmosphere and cohesion of the team, nor were the source of the difference in the estimates of the position on the table. At the end of the results of this sociometric research, as well as other similar studies of this type, should be taken with some caution because of the honesty and openness of the respondents in answering. There is always a fear among them that others will find out the results, and the fear of knowing their own positions in the team.

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RELATIONSHIPS BETWEEN OVERWEIGHT, OBESITY AND PHYSICAL FITNESS OF THIRTEEN AND FOURTEEN-YEAR-OLD MACEDONIAN ADOLESCENT

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SUMMARY

The aim of this research is to determine the fitness level of the Macedonian adolescents, including adolescents from both sexes with different variables of their body mass indexes (BMI). The research has been carried out on 1835 adolescents and students from 19 elementary schools throughout Central and Eastern Macedonia. The sample (average age being 13.43 ± .5) was split into two sub-samples in relation to their gender, 933 being male and 902 being female respondents. Five anthropometric measurements (IBP methodology) were used in the research, in which the body fitness was analyzed using the following parameters: estimating motor skills applying seven tests of the Eurofit fitness testing battery; body composition by applying the BIA; aerobic capacity by applying a 3-minute step test. The results have been statistically analyzed using the SPSS, v. 20.0 for Windows (variance analysis, Spearman's correlation analysis and the test). The percentage of the overweight children, classified according to the BMI is equal to 31% of the Macedonian adolescents of the same age. Both male and female respondents with a high or an increased BMI have lower muscle mass percentage and show poor test results in the evaluation of the body strength, explosive power, speed, agility and coordination, as well as a low aerobic capacity.

Key Words: aerobic capacity, body composition, Body Mass Index, EUROFIT, Macedonian adolescents.

INTRODUCTION

Obesity is a global epidemic, a situation declared by the World Health Organization [WHO] almost fifteen years ago (WHO, 2000). If childhood obesity has developed, and especially so in the adolescent age, it remains into adulthood (Biro & Wien, 2010; Janssen, Katzmarzyk, & Ross, 2002; WHO, 2003). Also, it is considered a risk factor for cardiovascular disease, diabetes, asthma and some socio-psychological disorders in older age (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Reillly et al., 2003). The fact that in the last three decades the number of overweight children in the world has repeatedly increased, so that today there are over 150 million obese children (International Obesity Task Force [IOTF], 2004). Although obesity is mostly prevalent in highly developed countries it is expanding rapidly in developing countries and transitional countries (IOTF, 2004; Lobstein & Frelut, 2003).

Obesity is a multifactorial problem that is influenced by a variety of areas including heredity, social conditions, lifestyle, dietary habits, level of physical activity and differences in upbringing that exist in different environments (National Institutes of Health of USA, 2000). Its actual level of prevalence differs depending on the geographical region (Jackson-Leach & Lobstein, 2006).

Physical fitness has been shown to be another important issue from a Public Health perspective, both in adults (Metter, Talbot, Schrager, & Conwit, 2002; Myers et al., 2002) and in children and adolescents (Ortega et al., 2008, Ortega, Ruiz, Castillo, & Sjostrom, 2008). Studies examining the relationship between weight status and health-related physical fitness in youth have often reported a decrease in fitness with increasing BMI (Brunet, Chaput, & Tremblay, 2007; Casajus, Leiva, Villarroya, Legaz, & Moreno, 2007; Deforche et al., 2003; Fogelholm Jackson-Leach & Lobstein, 2008; Graf et al., 2004; Haerens, Deforche, Maes, Cardon, & De Bourdeaudhuij, 2007; Huang & Malina, 2007; Kim et al., 2005a, 2005b; Prista, Maia, Damasceno, & Beunen, 2003).

Monitoring the nutritional status and physical fitness of children and adolescent of the population represents a particularly important and useful activity that indicates the adequacy of the process of growth and development of children and youth, helping in understanding the present, and can serve as a prognostic factor in their future health. Up until now, there was a limited amount of quantitative data regarding Macedonia especially regarding organized and systematic monitoring of nutritional status of certain population groups, primarily children and youth. Often, previous research focused on a specific group or region, using various and oftentimes non-standard criteria, reference values or standards.

According to the presented researches as well as to the fact that the period of early adolescence age is particularly exposed to intensive changes in hormonal status, the main aim of this research is to determine the connection of the fitness with the different status of weight, categorized by the BMI size and the percent of body fat in Macedonian adolescents.

METHODS

Sample of respondents

The research was realized on a sample of 1835 adolescents of Macedonian nationality, from 19 primary schools from the central and east part of the Republic, out of which 8 are in rural and 11 are in urban environment. The sample has been divided into two sub-samples by gender – 933 of the respondents are boys and 902 respondents are girls. The average age of the respondents of both genders was 13.43 ± .5 years.

The study included students for whom their parents had given consent to take part in the research, who were psychically and physically healthy and who regularly attended the classes of physical and health education. The respondents were treated in accordance with the Helsinki Declaration. Measurements were realized in March, April and May 2012, in standard school conditions at regular classes of physical and health education. The measurement was realized by experts from the area of kinesiology and medicine, previously trained to perform functional tests and to take anthropometric measures.

Anthropometric measures and body composition

Measuring of the anthropometric measurements was realized at the recommendations given by IBP-International Biology Program (Lohman et al., 1988). For estimation of the morphologic characteristics the following anthropometric measures have been applied:

- BH - body height in standing position (cm),
- BW - body weight (kg),
- CUA - circumference of the upper arm (cm)
- CT - circumference of the thight (cm),
- BMI - body mass index.

Components of the body composition have been determined by the method of bioelectrical impedance (measuring of the electric conductivity – Bioelectrical Impedance Analysis [BIA]). The measuring was realized by a Body Composition Monitor, model "OMRON - BF511", by means of which we have measured the body weight, fat tissue percent and muscular mass percent. Prior to commencing the measurement we had entered the parameters of gender, years and body height of the respondent in the Body Composition Monitor. In order to provide better precision of the results obtained from the estimation of the body composition, prior to each measuring, we ensured that the preconditions recommended by American College of Sports Medicine [ACSM] (2005) and Heyward (2006) had been fulfilled.

Evaluation of Physical Fitness

Prior to starting the study, the researchers involved in the project undertook training sessions in order to guarantee the standardization, validation, and reliability of the measurements (Moreno et al., 2003). Seven tests, forming part of the EUROFIT battery, validated and standardized by the European Council, were applied in the following order:

- SR - Sit and Reach test. With the subject seated on the floor and using a standardized support, the maximum distance reached with the tip of the fingers by forward flexion of the trunk is measured. Test indicative of amplitude of movement or flexibility.
- HG - Hand Grip test. With the use of a digital Takei TKK 5101 dynamometer (range, 1-100

kg), the maximum grip strength was measured for both hands.

- SBJ - Standing broad jump test. The maximum horizontal distance attained, with feet together, was measured. This test evaluates lower limb explosive-strength.
- BAH - Bent Arm Hang test. A standardized test was used to measure the maximum time hanging from a fixed bar. This test estimates the upper limb endurance- strength.
- SU30 - Sit-ups 30 s. Maximum number of sit ups achieved in 30 seconds. This test measures the endurance of the abdominal muscles.
- SR4x10 - Shuttle run 4×10 m. This test provides an integral evaluation of the speed of movement, agility and coordination. The subject does four shuttle runs as fast as possible between 2 lines 10 meters apart. At each end the subject places or picks up an object (a sponge) beside the line on the floor.
- ST3 - 3 minute step test. The aerobic capacity has been estimated by means of a 3-minute step test. The respondent had a task, for 3 minutes, to get up and get down of a bench 30.5 cm high, in four cycles (up, up, down, down), with standardized rhythm of 96 beats in a minute (bmp), which was dictated by the metronome. Before beginning of the test we have measured the heart frequency, whereas the children, even in the stand-by state had sub maximal value in terms of the age, were not exposed to burdening. The heart rate was measured by means of the monitor Polar RS800 for registration of the heart frequency.

TABLE 1

Characteristics of the study sample by gender.

	Boys (*n* = 933)		Girls (*n* = 902)		Total (*n* = 1835)		*p*
	M	*SD*	*M*	*SD*	*M*	*SD*	
Age (year)	13.43	.50	13.44	.50	13.43	.50	ns
CUA (cm)	24.98	3.67	24.74	3.28	24.86	3.49	ns
CT (cm)	50.90	6.84	50.90	7.18	52.37	6.37	.000
BH (cm)	165.00	8.82	160.11	6.44	162.63	8.13	.000
BW (kg)	58.95	14.19	55.35	11.20	57.20	12.95	.000
BF (%)	18.67	8.01	26.70	7.12	22.61	8.58	.000
FM (kg)	11.68	7.18	15.40	6.96	13.50	7.31	.000
FFM (kg)	47.59	9.62	40.02	5.63	43.92	8.79	.000
BMI (kg/m^2)	38.17	3.14	32.92	2.44	35.59	3.85	.000
MM (%)	21.57	3.99	21.52	3.95	21.54	3.97	ns
SBJ (cm)	174.06	28.94	135.95	24.43	155.61	32.92	.000
SU30 (No)	19.16	4.73	15.56	4.39	17.41	4.91	.000
BAH (s)	13.26	13.11	4.03	5.54	8.79	11.17	.000
HG (kg)	43.56	17.80	32.22	11.40	38.05	16.06	.000
SR (cm)	14.44	7.45	19.08	7.66	16.70	7.90	.000
SR4x10 (s)	12.50	1.43	14.04	1.59	13.24	1.69	.000
ST3 (bmp)	134.99	17.81	154.19	16.05	144.28	19.50	.000
	n	%	*n*	%	*n*	%	*p*
Normal weight	599	65.50	646	71.60	1245	69.30	.049
Overweight	252	27.00	197	21.80	446	23.70	ns
Obese	141	7.50	59	6.50	141	6.90	ns

Legend: **M** - Mean; **SD** - Standard deviation; **p** - Probablity; **ns** - Non-significant; **CUA** - Circumference of the upper arm; **CT** - Circumference of the thight; **BH** - Body hight; **BW** - Body weight; **BF** - Body fat; **FM** - Fat mass; **FFM** - Fat-free mass; **BMI** - Body mass index; **MM** - Muscular mass; **SBJ** - Standing broad jump test; **SU30** - Sit-ups 30 s; **BAH** - Bent Arm Hang test; **HG** - Hand Grip test; **SR** - Sit and Reach test; **SR4x10** - Shuttle run 4×10 m; **ST3** - 3 minute step test..

TABLE 2

Correlation quotients of BMI and body fat percentage with anthropometric and physical parameters (boys).

	BMI				BF			
	N	O	OB	T	N	O	OB	T
Anthropometrical parameters								
CUA (cm)	.896**	.907**	.913**	.907**	.600**	.644**	-.695**	.616**
CT (cm)	.868**	.886**	.890**	.883**	.650**	.674**	.725**	.655**
BH (cm)	.150**	.271**	252**	.244**	-.248**	-.108**	-.078*	-.173**
BW (kg)	.859**	.897**	.898**	.882**	.450**	.531**	.589**	.483**
MM (%)	-.489**	-.447**	-.523**	-.465**	-.917**	-.888**	-.903**	-.905**
FM (kg)	.858**	.891**	.900**	.876**	.955**	.935**	.948**	.944**
FFM (kg)	.513**	.636**	.631**	.587**	-.088**	.083**	.140**	-.004
Physical parameters								
SBJ (cm)	-.264**	-.188**	-.251**	-.216**	-.633**	-.551**	-.570	-.598**
SU30 (No)	-.120**	-.083**	-.125**	-.112**	-.386**	-.337**	-.353	-.369**
BAH (s)	-.501**	-.499**	-.568**	-.505**	-.723**	-.695**	-.718	-.722**
HG (kg)	.155**	.236**	.236**	.202**	-.194**	-.091**	-.066	-.147**
SR (cm)	.073**	.006	.030	.024	.085**	.067*	.062	.061*
SR4x10 (s)	.184**	.129**	.168**	.165**	.476**	.402**	.421	.448**
ST3 (bmp)	.275**	.229**	.274**	.233**	.512**	.488**	.496	.489**

Legend: **BMI** - Body mass index; **BF** - Body fat; **CUA** - Circumference of the upper arm; **CT** - Circumference of the thighť; **BH** - Body hight; **BW** - Body weight; **MM** - Muscular mass; **FM** - Fat mass; **FFM** - Fat-free mass; **SBJ** - Standing broad jump test; **SU30** - Sit-ups 30 s; **BAH** - Bent Arm Hang test; **HG** - Hand Grip test; **SR** - Sit and Reach test; **SR4x10** - Shuttle run 4×10 m; **ST3** - 3 minute step test; **N** - Normal weight; **O** - Overweight; **OB** - Obese; ** = $p < 0.01$; * = $p < 0.05$.

Definition of weight status

Four weight status groups were established in this study: underweight, normal weight, overweight and obesity. Participants were categorized according to the international gender and age-specific BMI (kg/m^2) cut-off points (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole, Flegal, Nicholls, & Jackson, 2007). These points have been particularly established for children and adolescents aged from 2 too18 years, separately for males and females and for .5 year age groups. These cutoff values are based on percentiles passing at age 18 years through BMI: 18.5 kg/m^2 for underweight, 25 kg/m^2 for overweight, and 30 kg/m^2 for obesity (Ibid).

Statistical analysis

The data are presented as frequencies (percentage) for categorical variables and mean (*SD*) for continuous variables. Gender differences in fitness and anthropometric characteristics were analyzed by one-way analysis of variance (ANOVA). Categorical data (weight status) were analyzed using the χ^2 - test. Relationships between the variables were determined by Spearman correlation matrices. Adjustment for age was performed using analysis of covariance (ANCOVA) to examine differences in fitness level among weight status groups. Because a significant interaction was found for weight status and gender in relation to all fitness tests ($p < .05$), all the analyses were performed separately for boys and girls. Bonferroni's adjustments were used for pair wise comparisons. All the analyses were performed using the Statistical Package for Social Sciences software (SPSS, v. 20.0 for Windows; SPSS Inc., Chicago, IL, USA), and values of $p < .05$ were considered statistically significant.

RESULTS

Table 1 displays the characteristics of the sample being used in this research. The results from the analysis of the variance (Table 1) show that in variables the average age, arm circumference and BMI there are no statistically significant differences existing between boys and girls, while in all other variables there are statistically significant differences in terms of gender (p > .00). Distribution of the statement of normal, overweight and obesity in adolescents, estimated through BMI, by age and by gender are also displayed in Table 1. Values of Chi-square test (χ^2 = 6.024; p = .049) indicate that there are statistically significant differences in the level of nutrition between boys and girls. Percentage values show that higher percentage of boys is with moderate high and high BMI (fat).

Table 2 and 3 shows the correlation quotients of BMI and body fat percentage with anthropometrical and physical parameters, parameters for estimation of body composition and test for estimation of fitness in respondents of both genders. We can see from the tables that all anthropometrical parameters and parameters for estimation of the body composition (except for the muscle mass percentage) show statistically significant positive correlation in both genders (range from .12 to .91) with the body mass index and the body fat percentage. Statistically significant negative correlation (range from -.11 to -.72) is determined of BMI with body fat percentage by the "Standing long jump", "Sit-ups 30 sec.", "Bent arm hang", "Shuttle run 4 x 10 meters" and "3 minute step test". Only the "Handgrip" test showed positive correlation with BMI, while there was no statistically significant correlation determined of BMI with the body fat percentage in the test "Seat and reach". The correlation quotients are a bit higher of the body fat percentage with variables for estimation of the anthropometrical parameters, body composition and fitness test in terms of BMI and them. In both genders the highest negative correlations of BMI and the body fat percentage are shown by fitness tests "Bent arm hang", "Standing long jump", and "3 minute step test".

Table 4 and Table 5 display the medium values of parameters for estimation of the anthropometrical parameters, body composition and fitness, upon partialization by weight status groups . In both genders there are statistically significant differences determined in all parameters for estimation of the anthropome-

TABLE 3

Correlation quotients of BMI and body fat percentage with anthropometric and physical parameters (girls).

	BMI				BF			
	N	O	OB	T	N	O	OB	T
Anthropometrical parameters								
CUA (cm)	.888**	.908**	.911**	.897**	.657**	.707**	.700**	.698**
CT (cm)	.854**	.890**	.888**	.871**	.690**	.744**	.732**	.730**
BH (cm)	.164**	.177**	.190**	.145**	-.118**	-.119**	-.119**	-.110**
BW (kg)	.872**	.896**	.894**	.887**	.552**	.610**	.595**	.611**
MM (%)	-.511**	-.596**	-.561**	-.593**	-.907**	-.922**	-.913**	-.924**
FM (kg)	.878**	.908**	.899**	.899**	.946**	.956**	.955**	.953**
FFM (kg)	.574**	.580**	.605**	-584**	.076**	.108**	.123**	.130**
Physical parameters								
SBJ (cm)	-.224**	-.329**	-.312**	-.305**	-.541**	-.603**	-.604**	-.574**
SU30 (No)	-.085**	-.160**	-.155**	-.147**	-.307**	-.372**	-.377**	-.339**
BAH (s)	-.498**	-.589**	-.570**	-.533**	-.667**	-.728**	-.722**	-.695**
HG (kg)	.209**	.174**	.192**	.184**	-.074**	-.096**	-.094**	-.065*
SR (cm)	.050	.083**	.067*	.080**	.098**	.113**	.095**	.123**
SR4x10 (s)	.128**	.224**	.205**	.195**	.382**	.449**	.448**	.412**
ST3 (bmp)	.233**	.323**	.312**	.274**	.474**	.520**	.518**	.486**

Legend: **BMI** - Body mass index; **BF** - Body fat; **CUA** - Circumference of the upper arm; **CT** - Circumference of the thight; **BH** - Body hight; **BW** - Body weight; **MM** - Muscular mass; **FM** - Fat mass; **FFM** - Fat-free mass; **SBJ** - Standing broad jump test; **SU30** - Sit-ups 30 s; **BAH** - Bent Arm Hang test; **HG** - Hand Grip test; **SR** - Sit and Reach test; **SR4x10** - Shuttle run 4×10 m; **ST3** - 3 minute step test; **N** - Normal weight; **O** - Overweight; **OB** - Obese; ** = p < 0.01; * = p < 0.05.

TABLE 4

Significance of differences in physical fitness components in the various BMI categories in the boys.

	1		2		3		*F*	*p*	Post hoc pairwise comparisons
	M	*SD*	*M*	*SD*	*M*	*SD*			
CUA (cm)	23.07	2.28	27.71	1.93	30.92	3.05	941.54	.00	1 & 2; 1 & 3; 2 & 3
CT (cm)	47.89	4.56	56.78	4.49	62.25	5.07	775.50	.00	1 & 2; 1 & 3; 2 & 3
BH (cm)	162.15	8.12	164.88	8.59	165.74	9.89	16.80	.00	1 & 2; 1 & 3
BW (kg)	50.75	7.96	67.27	8.39	82.15	11.71	1055.89	.00	1 & 2; 1 & 3; 2 & 3
MM (%)	37.54	3.44	34.68	3.17	32.60	3.36	227.16	.00	1 & 2; 1 & 3; 2 & 3
SBJ (cm)	165.74	31.89	153.87	31.82	141.91	26.95	57.92	.00	1 & 2; 1 & 3; 2 & 3
SU30 (No)	18.40	4.72	17.56	4.69	15.68	4.57	22.13	.00	1 & 2; 1 & 3; 2 & 3
BAH (s)	13.13	12.50	4.67	8.10	1.12	3.51	135.75	.00	1 & 2; 1 & 3; 2 & 3
HG (kg)	38.23	16.16	41.97	17.73	44.35	17.81	8.70	.00	1 & 2; 1 & 3
SR (cm)	16.17	7.55	15.69	7.40	15.46	7.99	.59	.56	
SR4x10 (s)	12.80	1.56	13.29	1.64	13.86	1.57	37.64	.00	1 & 2; 1 & 3; 2 & 3
ST3 (bmp)	139.10	19.30	145.06	18.23	152.09	19.11	37.09	.00	1 & 2; 1 & 3; 2 & 3

Legend: **M** - Mean; **SD** - Standard deviation; **F** - F-test; **p** - Probablity;**CUA** - Circumference of the upper arm; **CT** - Circumference of the thight; **BH** - Body hight; **BW** - Body weight; **MM** - Muscular mass; **FM** - Fat mass; **FFM** - Fat-free mass; **SBJ** - Standing broad jump test; **SU30** - Sit-ups 30 s; **BAH** - Bent Arm Hang test; **HG** - Hand Grip test; **SR** - Sit and Reach test; **SR4x10** - Shuttle run 4×10 m; **ST3** - 3 minute step test; **1** - Normal weight; **2** - Overweight; **3** - Obese.

trical parameters, body composition and tests for estimation of fitness of groups of respondents formed under classification of BMI, except in the "Seat and reach" fitness test.

From the values of the arithmetic means and the level of statistical significance in Tables 4 and 5, one can see that the adolescents of both genders with overweight and obesity achieve better result in the "Handgrip test" compared to the respondents with normal weight ($p < .00$), but they achieve worse results in other fitness tests. There are no statistically significant differences determined in the "Seat and reach" test between adolescents classified with normal, overweight and increased BMI. No statistically significant differences are determined between male respondents with overweight and obesity in the "Handgrip" fitness test. No statistically significant differences are determined between female respondents with overweight and obesity in the "Bent arm hang" and "Handgrip" fitness tests.

DISCUSSION

Overweight and obesity in children and adolescents becomes a global epidemic and threatens its spread in Macedonia. 31% of the 13 and 14-year-old respondents, who were classified according to the BMI criterion, are overeating and obese. Various international studies have also shown similar results (Al-Nakeeb, Duncan, Lyons, & Woodfield, 2007; Jehn, Gittelsohn, Treuth, & Caballero, 2006; Ortega et al., 2007; Ostojić, Stojanović, Stojanović, Marić, & Njaradi, 2011).

Our study results, also, suggest that the male respondents have the tendency to have higher overweight and obesity prevalence in comparison to girls (34.50% among the males to 28.30% among the girls). These results are most probably the way they are due to the fact that girls usually take more care of their looks and eating habits. Furthermore, boys spend less time engaging themselves in organized and spontaneous physical activities and more time on sedentary activities (working on the computer, watching television, etc.). However, this has to be verified with further researching.

Over 22% of the respondents have a body composition that consists of 30% body fat. The high rate of body fat is related to an increased risk of acute and chronic conditions, especially osteoarthritis, higher blood pressure, diabetes mellitus and cardiovascular diseases. Increased body fat may, also, result in low quality lifestyle, personal and financial hardships for the person having it, his/her family and the society, as well as it can reduce his/her longevity (Aristi-

TABLE 5

Significance of differences in physical fitness components in the various BMI categories in the girls.

	1		2		3		*F*	*p*	Post hoc pairwise comparisons
	M	*SD*	*M*	*SD*	*M*	*SD*			
CUA (cm)	23.04	2.26	27.63	1.94	30.77	3.18	846.32	.00	1 & 2; 1 & 3; 2 & 3
CT (cm)	48.49	4.76	56.92	4.11	62.60	5.21	728.51	.00	1 & 2; 1 & 3; 2 & 3
BH (cm)	160.58	7.14	161.99	7.91	161.59	8.12	4.75	.01	1 & 2; 1 & 3
BW (kg)	49.92	7.30	65.42	7.48	79.07	10.15	975.16	.00	1 & 2; 1 & 3; 2 & 3
MM (%)	35.80	3.24	33.04	3.13	30.69	3.55	206.93	.00	1 & 2; 1 & 3; 2 & 3
SBJ (cm)	153.27	29.27	140.24	29.82	128.00	25.68	53.58	.00	1 & 2; 1 & 3; 2 & 3
SU30 (No)	17.38	4.43	16.54	4.60	14.29	5.44	21.51	.00	1 & 2; 1 & 3; 2 & 3
BAH (s)	9.05	10.12	2.44	4.83	.81	3.11	98.24	.00	1 & 2; 1 & 3
HG (kg)	34.59	13.49	38.24	15.46	39.55	15.54	10.97	.00	1 & 2; 1 & 3
SR (cm)	17.42	7.61	17.23	7.66	17.36	7.84	.01	.99	
SR4x10 (s)	13.26	1.58	13.82	1.80	14.54	1.78	36.52	.00	1 & 2; 1 & 3; 2 & 3
ST3 (bmp)	144.94	19.38	150.63	17.53	158.27	17.51	30.68	.00	1 & 2; 1 & 3; 2 & 3

Legend: **M** - Mean; **SD** - Standard deviation; **F** - F-test; **p** - Probablity;**CUA** - Circumference of the upper arm; **CT** - Circumference of the thight; **BH** - Body hight; **BW** - Body weight; **MM** - Muscular mass; **FM** - Fat mass; **FFM** - Fat-free mass; **SBJ** - Standing broad jump test; **SU30** - Sit-ups 30 s; **BAH** - Bent Arm Hang test; **HG** - Hand Grip test; **SR** - Sit and Reach test; **SR4x10** - Shuttle run 4×10 m; **ST3** - 3 minute step test; **1** - Normal weight; **2** - Overweight; **3** - Obese.

muno, Foster, Voors, Srinivasan, & Berenson, 1984; Berenson, McMahon, & Voors, 1980; Berenson et al., 1982; Dugan, 2008; Williams et al., 1992).

The results of this study clearly show that the extra kilograms and obesity have an influence on the health related fitness among 8th and 9h grade students, at an age of 13 to 14-years. The negative influence has its highest effect during the cardiorespiratory endurance, body strength, explosive strength, speed, agility and coordination measurement tests. The successful results of most of these tests, in which the fat mass stands in for ballast weight, depend on how the body, itself, moves or on overcoming the body resistance or some parts of the body's resistance. These are motor manifestations which are influenced by the regulation mechanisms of the excitation's intensity and duration (Kurelić, Momirović, Šturm, Radojević, & Viskić-Štalec, 1975). These mechanisms are obviously more efficient among the youth with balanced weight and height, i.e. lower BMI and body fat values. This concurs with other international researches with a target audience of children aged 5 to 17 years (Baine et al., 2009; Brunet et al., 2007; Casajus et al., 2007; Deforche et al., 2003; FogelholmJackson-Leach & Lobstein, 2006; Graf et al., 2004; Haerens et al., 2007; Huang & Malina, 2007; Kim et al., 2005a, b; Malina et al., 1995; Minck, Ruiter, Van Mechelen, Kemper, & Twisk, 2000; Prista et al., 2003).

Correlation quotients of the body fat percentage and fitness are a bit higher in boys in terms of girls. On the other side, the correlation quotients of the BMI and fitness are a bit higher in girls in terms of boys.

Macedonian adolescents who are mildly overweight or overweight achieve poorer results in the following tests: tests "Standing long jump", "Sit-ups 30 seconds", "Shuttle run 4x10 meters", " Bent arm hang (s)", and "3 minute step test (bmp)" ($p < .001$). Other researches with similar results support the results evaluated in this research (Deforche et al., 2003; Graf et al., 2004; Kim et al., 2005a, b). Regarding flexibility, this research has shown that the respondents who are mildly overweight or overweight achieve similar results as the respondents who have a normal weight do. Two Taiwanese researches can also verify this statement. However, the results of some researches carried out in the Western countries indicate that overweight girls had achieved better results when it comes to flexibility than normally weighing girls, whereas the same can not confirmed for the results of the male respondents (Prista et al., 2003).

Regular physical activity and a high intake of low--carbohydrate and poly-saccharides reduces the risk of obesity, and sedentary lifestyle and intake of high--calorific food which is low in nutritional content, increases the risk of obesity in children. Studies indicate that the choice of healthy food for children in the family and school reduces the risk of obesity, while sweetened beverages also increases the risk of obesity. The diet should be based on foods with a low energy value (fruits and vegetables) and whole grains (which are a good source of fiber).

The obtained data point to scientific planning and development of curriculum for the subject of physical and health education in order to optimize the ratio of the quantity of subcutaneous fat and muscle mass, which will create an opportunity for the maximization of engine operation in a wide range of capabilities, especially in the areas of strength and endurance (Katić, 2003). The purpose of physical education at this age, among other things, should be to reduce fat and increase muscle mass, primarily the large muscle groups.

Teaching should be filled with content that will achieve the stated objectives, properly directing motor development and most importantly – to assist in the proper functioning of the health status of the student.

CONCLUSIONS

This work is an actual research of prevalence of overweight and obesity of children and adolescents in the central and eastern part of Republic of Macedonia based on population approach, putting accent on the prevention. The results indicate that more than 2 children, out of 10, are overweighed and more than one children out of 10 is obese. It affects the prevalence of obesity in the period of adulthood. The prevalence of overweight and obesity based on BMI in Macedonian adolescents is 31%. In terms of gender differences of Macedonian adolescents, boys show higher percentage of overweight and obesity.

Macedonian adolescents with a mildly high or a high BMI have: reduced aerobic capacity, decreased muscle mass percentage, higher percentage of body fat and show poor results in the tests which determine their physical fitness. The adolescents who are mildly overweight or overweight achieve poorer results in the “Standing long jump”, “Sit-ups 30 seconds”, “Shuttle run 4x10 meters”, ”Bent arm hang (s)” tests, however, they achieve similar results regarding their flexibility. “Handgrip (kg)” is the only test with positive results.

Correlation quotients of the body fat percentage and fitness are a bit higher in boys in terms of girls. On the other side, the correlation quotients of the BMI and fitness are a bit higher in girls in terms of boys.

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HOW THROUGH UNDERSTANDING OF ALPINE SKI NOVICES' ATTITUDES TOWARDS ALPINE SKIING MAKE THE ALPINE SKI SCHOOL MORE EFFICACEOUS

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SUMMARY

The assumption of this study was that attitude towards alpine skiing and expectations of ski novices affect the level of achieved alpine ski knowledge. So, the aim was to determine correlation between alpine ski novices' attitude towards alpine skiing before the learning process and level of acquired knowledge after completion of structured alpine ski school program. 112 alpine ski novices (33 females and 79 males) participated in the study. All were tested on 26-item scale questionnaire for attitude evaluation and were included in 10-days alpine ski school program. After completion of ski school, all participants demonstrated eight elements of alpine ski technique which was used as a measure of acquired ski knowledge. Results showed statistically significant correlation between acquired alpine ski knowledge and attitude of ski novices towards alpine skiing (r = .36). The most statistically significant correlation was determined between the level of learned parallel turn and attitude towards skiing (r = .42). Our results point to importance of attitude towards alpine skiing and alpine ski learning.

Key Words: alpine skiing, learning process, attitude towards alpine.

INTRODUCTION

From the perspective of alpine ski novices, going to winter holidays and participation in alpine ski school program depends on the attitudes, which potentially influence their decision on further inclusion in this sport as well as success of alpine ski learning. Psychology defines attitude as a continuous positive and negative evaluation of people, objects and ideas (Petz, 1992). Attitudes are not inborn; they are formed during process of socialization and are connected to previous experience and often under influence of emotional experience (Aranson, Wilson, & Akart, 2005). The alpine ski novices' attitude towards alpine skiing primarily depends on information the person is being exposed. In general, attitudes contain the information about the object of attitude, emotions and reactions toward the object of attitude, but when they are defined, usually one component dominates (Giddens, 2007). As the alpine ski novices' attitude towards alpine skiing can not be formed on personal experience, it is primarily bound to emotions and information from the environment. Attitude towards alpine skiing can also be changed, and this primarily happens after skiers have either positive or negative experience with skiing. Attitude of alpine ski novices towards alpine skiing can also be biased by the fear of injuries on ski terrains. This fear is mainly present due to potential loss of control over skies caused by weather conditions or crash with other skiers (Bouter, Knipschild, & Volovics, 1989). Factors that can additionally either positively or negatively affect the attitude towards skiing are related to specific alpine environment. Namely, weather conditions in the mountains are variable; varying from ideal to extremely difficult for implementation of basic alpine ski school program. Mentioned conditions, especially during first hours or days of learning alpine skiing can have a great impact (again both positive and negative) on motivation for further alpine ski learning. Although the attitude of alpine ski novices is not much taken into account during alpine ski school programs, it can have a major effect on the level of achieved knowledge of alpine skiing. Learning effects will be that much greater if the student is motivated for learning and has a positive attitude. The aim of present research was to determine the correlation between the alpine ski novices' attitudes towards alpine skiing before participation in alpine ski school program and success of alpine ski learning after completion of structured basic alpine ski school.

METHODS

Participants

This investigation included 112 participants, of which 33 females and 79 males, average age 21.98±1.41 years. All participant were alpine ski novices, without prior own experience in alpine skiing.

Variables

The attitude towards alpine skiing was tested with 26-item questionnaire. This particular questionnaire was constructed to determine the alpine ski novices' attitude towards alpine skiing. Measured metric characteristics of the questionnaire enable its use in testing attitude towards alpine skiing (Cigrovski, Božić, Prlenda, Matković, & Vlašić, 2012). The claims in the questionnaire were grouped into several categories and related to attitude towards skiing as a recreational sport, mountains during winter months, cold, physical activity in the open space, fear of injury, fear of speed, and finally fear of heights and slope. Participants were asked to grade each claim on a scale one to five, where one related to extremely negative, and five to extremely positive attitude. The questionnaire was not anonymous in order to be able to correlate results of the questionnaire with the level of achieved knowledge of alpine skiing after completion of structured program of alpine ski school. All participants gave informed consent prior to participation. Participants were graded by three independent judges upon completion of basic alpine ski school for the demonstration of learned elements of alpine ski technique, representing the new knowledge of alpine skiing. Elected were 8 elements of alpine ski technique; traversing left (KSL), traversing right (KSD), uphill turn to the left (ZKBL), uphill turn to the right (ZKBD), snowplough turn (PZ) basic turn (OZ), parallel turn (PZ), and short turn (V). Grades were used as an estimate for the level of new knowledge of alpine skiing. Grade one relates to the low level of alpine ski knowledge while five relates to high level of knowledge.

Investigational protocol: Firstly, all participants were asked to fulfil the questionnaire. Afterwards they were included in the 10-days basic alpine ski school learning program. All participants were then learning alpine skiing according to the same protocol, and similar conditions with respect to size of the group (10 participants per group), hours of learning during the day (4), hours of practicing/training during the day (2), quality of ski equipment, alpine ski instructors and ski terrains. Alpine ski technique consisted of more elements, but eight were chosen for the demonstration of alpine ski knowledge after completion of ski school.

Statistical analysis

Data obtained in this research were analyzed by correlation analysis with aim to determine relationship between alpine ski novices' attitude towards skiing and level of new ski knowledge. The mean grade of each participant on each element of alpine ski technique obtained by three independent judges was used as a final grade. The grade presenting overall ski knowledge was calculated as a mean grade from eight grades obtained for demonstration of elements of alpine ski technique. Statistical analysis included Pearson's coefficients to determine correlation between the alpine ski novices' attitudes towards alpine skiing and success of alpine ski learning. Data were analyzed with statistical package „SPSS for Windows 14.0". Results were considered statistically significant if $p < .05$.

RESULTS

Results of descriptive parameters of questionnaire are presented in Table 1.

Basic descriptive parameters were calculated from grades obtained for evaluation of knowledge of alpine skiing. Level of new knowledge was calculated on basis of mean grade of all evaluated elements of alpine ski technique. Overall result of questionnaire for evaluation of attitude towards skiing was obtained by adding up results of all twenty-six items.

Afterwards we analyzed correlation coefficients between new ski knowledge and results obtained in questionnaire on attitude towards skiing.

Analysis of data presented in Table 3 shows the weak but statistically significant correlation between the attitude towards alpine skiing and level of acquired ski knowledge ($r = 0.36$). Correlation coefficient points to correlation between ski novices' attitude towards

TABLE 1
Twenty-six-item scale for the evaluation of attitude towards alpine skiing.

Claims	*M*	*Min*	*.00*	*M*	*SD*
I don't like skiing because I fear of heights.	112	2.00	5.00	4.59	.84
I don't like skiing because during winter time I prefer being in a confined space.	112	1.00	5.00	4.54	.84
I like thrill, so I like skiing.	112	1.00	5.00	4.21	.89
Just by watching skiing competitions I wished to be engaged in alpine skiing.	112	1.00	5.00	3.78	1.13
I would like to go regularly to alpine skiing/winter vacation with my family.	112	1.00	5.00	4.19	.96
I don't want to learn alpine skiing out of fear of being worse than my colleagues.	112	2.00	5.00	4.68	.75
I would like to become a ski instructor.	112	1.00	5.00	3.41	1.17
I would like my kids to be good alpine skiers.	112	1.00	5.00	4.29	.82
I don't like skiing because I fear of avalanches.	112	2.00	5.00	4.83	.52
I don't like skiing because I fear of injuries that would unable participation in my sport. .....sport.	112	1.00	5.00	3.89	1.16
I love the joys of winter so I like skiing	112	1.00	5.00	3.95	1.11
I like skiing because it makes the adrenalin rise.	112	1.00	5.00	4.22	.94
I don't like skiing because it takes place in unstable winter conditions.	112	2.00	5.00	4.29	.90
I don’t like skiing because of the discomfort caused by the cold.	112	1.00	5.00	4.29	1.01
I don't like skiing, because I can’t stand staying at high altitude.	112	2.00	5.00	4.70	.64
I don’t like skiing because of the feeling of uncertainty when using the ski lifts.	112	1.00	5.00	4.57	.79
I don't like skiing because of fear of fall on ski slopes.	112	1.00	5.00	4.21	1.09
I don't like skiing because I fear of solar radiation.	112	3.00	5.00	4.71	.54
Skiing is a fun activity.	112	2.00	5.00	4.56	.68
Fear of the ice surface distances me from skiing.	112	2.00	5.00	4.40	.91
I don’t like skiing because I fear of a collision with other skiers.	112	1.00	5.00	4.01	1.17
If I didn't have to go to skiing during my university education I would never go skiing.	112	1.00	5.00	3.91	1.20
Exposure to wind on the ski slopes makes me not like skiing.	112	2.00	5.00	4.60	.75
Improvement of ski techniques is more important to me than »partying« at skiing.	112	1.00	5.00	3.90	.98
I don't like skiing because of fear of injuries.	112	1.00	5.00	3.88	1.29
It scares me that I will be hurt in a fall with skis or poles.	112	1.00	5.00	3.96	1.20

Legend: **N** - Number of participants; **Min** - Minimum value; **Max** - Maximum value; **M** - Mean; **SD** - Standard deviation.

skiing and acquired ski knowledge. Namely, if alpine ski novice has a positive attitude towards skiing, one can expect his/hers better achievement during beginning of alpine ski learning program (Table 3). The strongest statistical significance was obtained for the correlation between parallel turn and attitude towards skiing (r = .42).

DISCUSION AND CONCLUSION

Alpine ski schools usually pay a lot of attention on choosing adequate program of learning basics of ski technique, methods of learning/teaching, on adequate ski equipment for each participant of ski school and conditions of learning. A lot less attention

TABLE 2

Basic descriptive parameters for grades given on eight elements of ski technique, grades given for overall ski knowledge and results of attitude questionnaire

	M	*Min*	*.00*	*M*	*SD*
Traversing right	112	2.00	5.00	3.80	.74
Traversing left	112	2.00	5.00	3.87	.81
Uphill turn to the right	112	2.00	5.00	4.05	.75
Uphill turn to the left	112	2.00	5.00	4.09	.74
Snowplough turn	112	2.00	5.00	3.45	.84
Basic turn	112	2.00	5.00	3.18	.82
Parallel turn	112	2.00	5.00	3.53	.83
Short turn	112	2.00	5.00	2.95	.87
Knowledge of skiing	112	2.25	4.81	3.61	.53
Questionnaire results	112	66.00	130.00	110.73	14.47

Legend: **N** - Number of participants; **Min** - Minimum value; **Max** - Maximum value; **M** - Mean; **SD** - Standard deviation.

TABLE 3

Correlation coefficients between ski knowledge at the end of investigation and the attitude towards alpine skiing.

	1	2	3	4	5	6	7	8	KOS	QR
1	1.00	.82**	.53**	.51**	.18	.27**	.14	.32**	.70**	.18
2		1.00	.50**	.51**	.22*	.31**	.21*	.29**	.72**	.24*
3			1.00	.74**	.30**	.34**	.37**	.36**	.77**	.23*
4				1.00	.29**	.39**	.32**	.33**	.76**	.20**
5					1.00	.19*	.32**	.01	.48**	.00
6						1.00	.65**	.32**	.66**	.33**
7							1.00	.42**	.66**	.42**
8								1.00	.59**	.31**
KOS									1.00	.36**
QR										1.00

Legend: **1** - Traversing right; **2** - Traversing left; **3** - Uphill turn to the right; **4** - Uphill turn to the left; **5** - Snowplough turn; **6** - Basic turn; **7** - Parallel turn; **8** - Short turn; **KOS** - Knowledge of skiing; **QR** - Questionnaire results.

is given to characteristics and identity of pupils. This exactly could have a major impact on the better or worse alpine ski knowledge acquired through programs of ski school. Alpine ski novices' expectations, their attitudes and thoughts they have before starting alpine skiing most definitely influence effectiveness of alpine ski learning process in either positive or negative way. Some investigations determined significant correlation between attitude towards sport and physical activity and efficiency of learning new motor activity (Nieminen & Varstala, 1999; Vlašić, 2010). One's attitude towards particular sport or physical activity can have a crucial role on decision to participate or learn basics of sport. From the alpine ski instructors' perspective it is important to be informed about ski novices' attitude towards skiing before his/hers inclusion in the structured alpine ski learning program. This information can be important for realization of ski school program and finally for more efficient learning of alpine skiing. If an individual was satisfied with alpine ski learning in the alpine ski school, he/she will have a positive experience which will be shared with friends/

acquaintances. Particular alpine ski school is classified into a category of quality school which takes into consideration pupils' individuality, namely with respect to attitude, abilities and characteristics. During initial phases of alpine ski learning, just as like learning other motor activities, pupils' motivation contributes the level of new knowledge (Molanorouzi, Khoo, & Riiser et al., 2014). Teacher by his/her attitude and proper teaching methods can definitely influence the pupil's motivation (Cigrovski, Radman, Matković, Gurmmet, & Podnar, 2014). When alpine ski novice experiences pleasant moments in alpine ski school, then his/her attitude towards alpine skiing becomes positive. Alike, if a ski novice has an unpleasant experience during alpine ski school, for example crash or injury, his or hers attitude will become negative. Negative attitude change can be seen through enhanced caution or use of extra security equipment, such as helmet (Hasler et al., 2011). Moreover, sometimes negative experience in the beginning phases of alpine ski learning results in aborting skiing as a physical activity. It is well known that fear of injury has negative effects on process of learning or mastering sport/physical activity (Cartoni, Minganti, & Zelli, 2005). Our results show positive correlation between attitude towards skiing and learning alpine skiing during structured program of alpine ski school (r = .36). During analysis of results one has to take into account the fact that learned alpine ski knowledge is the product of pupil's characteristics and abilities on one hand, and competence and expertise of ski instructors, conditions during ski learning (ski terrains, number of pupils pro group, hours of learning and exercising, weather conditions etc.), learning program and equipment on the other hand. All mentioned factors in larger or smaller extent influence the level of alpine ski knowledge. Factors of interest related to ski novice are his/her abilities and characteristics, and other important factors relate to program of learning and instructors' motivation, while combined they influence efficient alpine ski teaching (Cigrovski, Matković, & Matković, 2010). As previously mentioned, alpine ski novice will form the attitude towards skiing even before the activity start. In order for the instructors to be informed about this attitude, it would be good to ask ski novices to fulfill the attitude questionnaire. The information in return could be helpful in better knowing and understanding pupils. Ski instructors could be in advance better prepared and according to pupils' attitude could adjust ways of ski teaching. For example, if ski novices accentuate the fear of hights, instructors could in their work dominantly use ski lifts, and avoid terrains with cable cars. Moreover, if ski novices express concern or fear of injury or crash, ski instructors can choose less frequent ski terrains and maximally insist on gradual progression of terrain slope. In that manner, instructor will improve safety of pupils, and people who expressed fear in the questionnaire will feel more relaxed. Also, if information from questionnaire shows pupils' interest in fast advances during alpine ski school or wish for learning specific techniques of alpine skiing, a ski instructor would be prepared accordingly. All mentioned will result in better motivation of pupils, and finally better learning of alpine skiing. By mentioned approach, instructors can adapt ski teaching according to attitudes of pupils. The down side of this investigation is primarily the sample of participants, while ski novices in this investigation consisted of merely motorically competent young people. It would be of interest to repeat the protocol of the investigation but on different participants' sample. If results would be comparable, one would with greater certainty claim the correlation between alpine ski novices' attitude towards skiing and success of alpine ski learning.

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INFLUENCE OF THE TIME OF THE DAY AND CHRONOTYPE ON SPEED ABILITIES IN JUNIOR TEAM ICE HOCKEY PLAYERS

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SUMMARY

The aim of the study was to compare the effect of time of day and chronotype on the speed abilities on the sample of junior ice hockey players (n = 20; defenders = 8, forwards = 12; age = 17.05 ± 1.34 years) playing in a competitive year 2013/2014 of Slovak extraligue of juniors. The influence of time of day and chronotype was detected on indicators of speed abilities (speed acceleration of lower legs). The test of acceleration speed was test time measured during the day on the basis of circadian rhythms of players, at 9 o'clock in the morning and 17 o'clock in the afternoon after the warm-up of the players (spaces of ice stadium Banská Bystrica). The criterion of performance evaluation was the average test time. We used Wilcoxon Signed Ranks Test (α = .01) to determine the significance of differences between morning and afternoon performance. Study has result in a different level of morning and afternoon levels of speed abilities that has shown that afternoon performance was higher than the morning. At up to 17 players we observed a higher level of speed abilities in the afternoon, thereof in 7 players the difference was in the level of statistical significance. Only in 3 of players we observed a higher level of speed abilities in the morning. Post hoc analysis have showed better average afternoon time (8.58 ± .17 s) than average morning time (8.65 ± .19 s). We found statistically significant differences p < .01. Based on analysis of chronotype in the file, we found that 15 (75%) players of research group consisted mostly balanced types, 3 (15%) players were evening type and 2 (10%) players morning type. The time of players has not showed a main effect of test time-of-day or chronotype (F = .56, p = .46; F = .08, p = .92). The interactions between the factors were not statistically significant (test time of the day x chronotype: F = .03, p = .97). Evaluating the level of speed abilities of players in terms of chronotype and time of the day, we concluded that chronotype and time of the day has not main influence at the achieved level of speed abilities.i learning.

Key Words: acceleration speed, afternoon performance, morning performance.

INTRODUCTION

Ice hockey is a team sport, which is significantly affected by the performance of individual players. Physiological demands on the individual are different in terms of players' positions. For example, requirements for performance of forward and defender are larger than the goalkeeper. A number of factors affect performance of player, and one of them are time-conditioned biological changes. Players' performance changes throughout the day in response to the change of the physiological systems of the organism. Zeman (2001) argues that circadian rhythms are the universal phenomenon of adaptation to all levels of the organization of living matter. These endogenous biological rhythms have evolved as an adaptation to cyclical changes in the environment indicated by the rotation of the Earth around its own axis.

There are various studies showing the modulation of circadian rhythmicity in sport performance. Among the possibilities for evaluating the influence of biological rhythms most often the studies are focused on the time of the day effect on the sport performance. Štulajter (2007) argues that biorhythmically favorable to the training process and for the given of performance in individual performance, especially in terms of speed and acceleration, are early mid-morning, meaning the beginnings inserted before 9.00 AM, when the curve of energy release has ascending character with the culmination point around 9.00 AM. The influence of circadian rhythms on the performance changes in speed-strength abilities during the day at the ski jumper aroused the attention of Schlank and Pupiš (2007). Based on the research results they concluded that the player has reached the highest performance during the day at noon. This is confirmed by Paugschová, Jančoková, and Šulej (2009), who have dealt with biorhythmical changes in the development of power and speed abilities of soldiers. They concluded that the best performance of subjects was recorded in the afternoon at 16 o'clock and some of the best performances recorded at 18 o'clock. Pivovarniček, Bunc, Malý, Kollár, and Jančoková(2013) and Pivovarniček, Sližik, Kollár, Mojžiš, and Jančoková (2012) did not detect or find any significant differences ($p > .05$) between morning and evening performance of speed indicators of the young football players. Rošková and Demjan (2011) examined psychological and physical performance of female university students ($n = 24$) at 8.00 and at 11.00 AM and at 2.00 and at 5.00 PM. The maximal performance was detected at 5.00 PM. Paugschová and Ondráček (2011) made research about diurnal rhythm of speed and strength preconditions of high school female students ($n = 10$) at 9.00 and 12.00 AM and at 3.00 and 6.00 PM. The strength preconditions showed maximal levels at 9.00 AM and at 6.00 PM. The highest level of speed preconditions was achieved at 12.00 AM.

In the implementation of our experiment must be considered in addition to circadian rhythms also effect of an individual chronotype. Ronneberg (2012) describes chronotype as a genetic component or everyday human behavior, in which it comes to phasic changes in human life, which vary in the length of sleep, melatonin levels, body temperature and other circadian oscillating of physiological parameters. We know the different methods which classify individuals according to their chronotype, among them, one developed by Horne and Ostberg (1976). Based on the results of the questionnaire, subjects are divided into five different categories: extreme morning type, moderate morning type, intermediate type, moderate afternoon type, and extreme afternoon type. Barbosa and Albuquerque (2008), Kim, Dueker, Hasher, and Goldstein (2002), and May and Hasher (1998) have suggested that the chronotype of a subject may change over the course of life and studies indicate that in childhood (between 8 and 12 years) there is a tendency towards being a morning type, whereas in adolescence and in the early adult phase, there is a tendency towards being an afternoon type, returning to the morning type tendency in old age. Researches made by Vančová, Jančoková, Palovičová, and Pivovarniček (2013), and by Vančová and Palovičová (2013) showed that more than 77.4% of female university students tend to be neither chronotype. It is because female university students have no strict and fixed daily regime and have no time stereotype because of timetable - variability of lectures and seminars, what confirms synchronization of chronotype by external requests and impulses.

Brown, Neft, and LaJambe (2008) has researched sportsmen divided into three groups - morning types, evening types and balanced (neutral) types and then examined performance of sportsmen in the early morning hours at 5.00 to 7.00 AM and late afternoon from 4.30 to 6.00 PM. The authors did not detected significantly different performance based on typology (chronotype) of sportsmen in terms of time of day and stated that these results may be affected by training time stereotypes of sportsmen.

METHODS

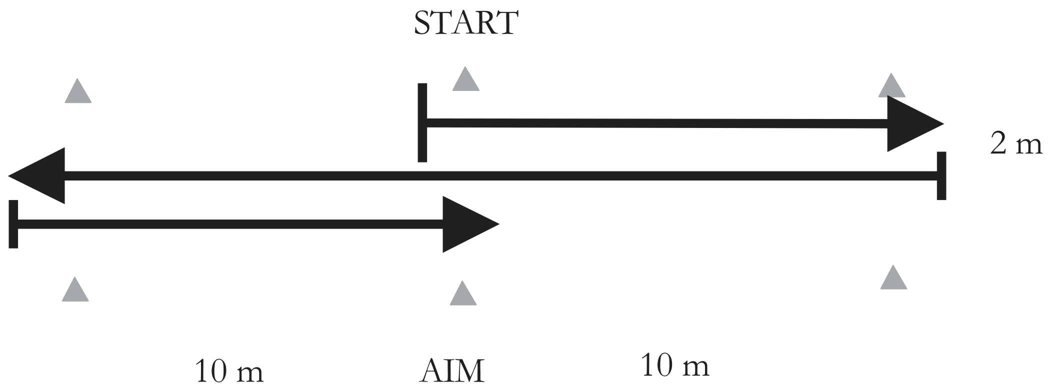
The research sample included 20 junior team players HC'05 Banská Bystrica aged 16-19 years (average age decimal of players is 17.05 ± 1.34 years).

The research was conducted during the preparation period on ice under year training cycle 2013/2014. Diagnostics of level speed abilities took place from 07/25/2013 to 07/31/2013 at the premises of ice stadium in Banská Bystrica. Distribution, completion and collection of questionnaires took place in Thursday, 07/25/2013 7.30 to 8.00 PM at the premises of ice rink before the workout. The players were divided into three groups based on the score achieved in Horne and Ostberg (1976), (Slovak version of the questionnaire). Moderate morning types were classified as morning types and moderate evening types as evening types. Three players were identified as evening type (score 38.67 ± 3.54), two as morning type (score 64.50 ± 6.36) and fifteen as balanced type (score 49.53 ± 4.67).

We investigated the level of speed abilities, namely the acceleration speed of skating during the preparatory period on ice in skating forward at 40 m with changes of direction (Figure 1).

The test time of players was measured during the day on the basis of circadian rhythms of players, at

FIGURE 1
Scheme of the test of skating forward 40 meters, with changes of direction (Source: www.hockeyslovakia.sk).



9 o'clock in the morning and 17 o'clock in the afternoon after the warm-up of players.

The time of players in the test of skating forward 40 meters with changes of direction was used as dependent variable. Time of player was measured by using a hand-held stopwatch and we compiled the exact track, which tested player had to complete. As performance criteria, we used the time in seconds. We realized the test three times in order to eliminate the effect of improving the performance by impact of experience gained during the implementation of the tests (Zemková, 2008) and in the evaluation we better result. For the statistical evaluation of the sample results, we used the nonparametric Wilcoxon test to determine the significance of differences between the morning and afternoon performance of the sample. We used Two-way ANOVA: chronotype and time of the day to prove effect of the factors on speed abilities. In the study we have determined importance on standardly used α - level (alpha) = .01. Statistical analysis was realized with software Statistica 12.

RESULTS

Post hoc analysis have showed better average afternoon time (8.58 ± .17 s) than average morning time (8.65 ± .19 s) (Figure 2). We found statistically significant differences $p < .01$ (Table 1).

Our results are similar to those of several authors, for example Atkinson, Todd, Reilly, and Waterhouse (2005), Reilly et al. (2007), who concluded that the afternoon performance was higher than the morning.

The time of players has not showed a main effect of test time-of-day or chronotype ($F = .56$, $p = .46$; $F = .08$, $p = .92$). The interactions between the factors

FIGURE 2
Average morning and afternoon time of the players.

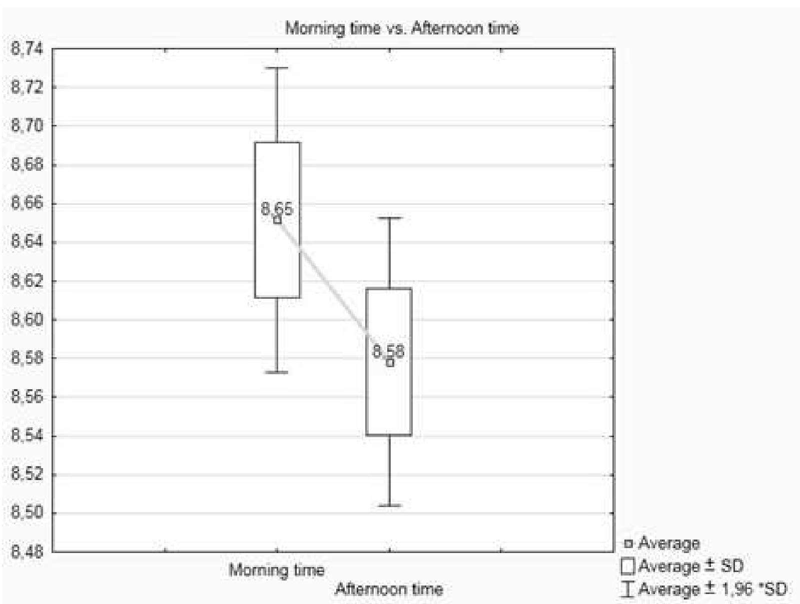
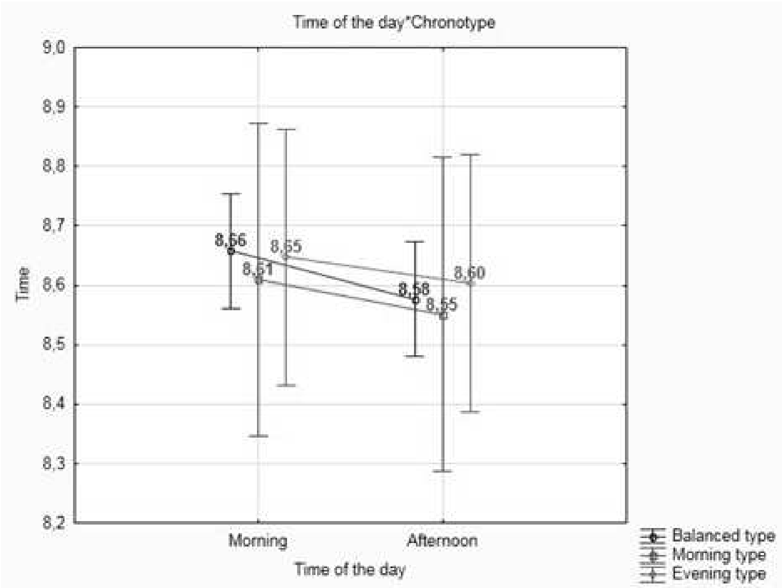


TABLE 1
The comparison of morning and afternoon time in seconds (s).

	M	SD	Me	Min	Max	$R_{max-min}$
Morning time (s)	8.65	.18	8.63	8.32	9.07	.74
Afternoon time (s)	8.58	.17	8.58	8.24	8.98	.75

Legend/Legenda: Morning time - Vrijeme postignuto ujutro; Afternoon time . Vrijeme postignuto poslijepodne; **M** - Mean (Aritmetička sredina); **SD** - Standard deviation (Standardna devijacija); **Me** - Median (Medijana); **Min** - Minimum (Minimum); **Max** - Maximum (Maksimum); **$R_{max-min}$** - Variation margin (Varijaciona margina).

FIGURE 3
Influence of test time of the day and chronotype on performance.



were not statistically significant (test time of the day x chronotype ($F = .03$; $p = .97$) (Figure 3).

DISCUSSION

The main reason of this study was to find if the time of the day and chronotype affect the level of speed abilities. We first examined the level of speed abilities in terms of time. We found that level of speed abilities was statistically significantly higher in the afternoon than in the morning that demonstrated influence of circadian rhythms on the performance changes. The same findings were published by Schlank and Pupiš (2007) in speed-strength abilities during the day at ski jumper. Based on the research results we concluded that the player has reached the highest performance during the day at noon. Gereková (2009) dealt with the changes in performance, speed and strength abilities biathlete during the day on the basis of circadian rhythms and concluded that the best time for the development of speed skills in volunteer was about 18 o'clock in the evening. A significant drop in performance occurred at 21.00 o'clock. This is confirmed by Paugschová ez al. (2009), who have dealt with biorhythmically changes in the development of power and speed abilities of soldiers. They concluded that the best performance of subjects was recorded in the afternoon.

In the implementation of our experiment must be considered in addition to circadian rhythms also effect of an individual chronotype. Venugopal, Gupta, and Patel (2010) conducted a study to monitor the effect of time of day on the various parameters such as body temperature (body temperature fluctuations closely correspond to the performance fluctuations) and concluded that the peak body temperature was recorded in the afternoon. We agree with Jančoková et al. (2011) that the results of previously conducted studies show a higher performance achieved in the late afternoon or evening, around the time of 4.00 to 8.00 PM, than in the morning from 07.00 to

10.00 AM. Singh and Subramanian (2012) conducted research on a sample of 19 athletes of the Indian national team, and concluded that their performance was highest during the evening meeting at the time of 4.00 to 5.00 PM.

Secondly, we investigated the effect of chronotype on level of speed abilities. The players of this study were young, who tend to be balanced in terms of chronotype. For this reason, we believe that the chronotype did not affect the level of speed abilities of the players. The time of players has not showed a main effect of chronotype. The similar study realized Barbosa and Albuquerque (2008) and concluded that the subjects of their study were mostly young, a population with a greater tendency for being afternoon types. In this case, it could be suggested that the better performance of individuals who trained in the afternoon was a result of a synchronic effect and not related to training time-of-day training. Lastella et al. (2010) found that triathletes at the elite level tend to show either morning or neither preference. There were no E-types within this sample of elite triathletes. This finding supports the notion that E-types do not select sports which require early morning training.

The results from the present study revealed that junior ice hockey players performance is higher at noon and the test time of the day and chronotype did not mainly influence it. We should expand our study on effect of training time on level of speed abilities. These findings could help us to improve effect of training on sport performance. Despite of recognized results about chronotype, we agree with Vančová and Pivovarniček (2013) that a scientific challenge is a question of confirmation or rejection of the detection that human´s chronotype influences the effectivity in sport and work activity not only in sport but also in general everyday life during the day in term of diurnal and circadian rhythms.

CONCLUSION

The main finding of this study is that there is no main influence of time of the day and chronotype on average time of players. We recorded the difference between morning and afternoon level of speed abilities in favor of the afternoon. The observed difference was significant ($p < .01$). Our results are similar to Barbosa and Albuquerque (2008) who concluded that there is no main effect of test time and chronotype on LTM performance. They found main effect of training time of the day and that there is no interaction between LTM test time-of-day and chronotype, indicating the absence of a synchronic effect.

In terms of representativeness of the research it would be needed to carry out research on a larger sample of players, over a longer period of time and not just in the specific group of sportsmen. Many authors who have dealt with similar theme focused on exploring of body temperature, therefore we consider necessary to focus on exploring this indicator in relation to circadian rhythms.

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