

SELECTIVE ASSESSMENT OF MUSCLE MECHANICAL PROPERTIES THROUGH LOADED FUNCTIONAL MOVEMENTS

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(Original scientific paper)

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Abstract

It has been generally accepted that muscles could have different mechanical capacities, such as those for producing high force, velocity, and power outputs. Nevertheless, the standard testing procedures applied in both research and routine evaluations of muscle function have been typically conducted under a single mechanical condition, such as under a single external load. As a result, the observed outcomes do not allow for distinguishing among the different muscle capacities. Therefore, the outcomes of most of the routine testing procedures have been of limited informational value, while a number of debated issues in research have originated from arbitrarily interpreted experimental findings regarding specific muscle capacities. A solution for the discussed problem could be based on the approximately linear and exceptionally strong force-velocity relationship typically observed from various functional tasks (e.g., maximum jumping, cycling, running, pushing, lifting, or throwing) performed under different external loads. These findings allow for proposing a novel method for testing various functional movement tasks by applying just 2 distinctive external loads. Specifically, the force-velocity relationship determined by 2 points could provide the parameters depicting the maximum force (i.e., the force-intercept), velocity (velocity-intercept), and power (calculated from the product of force and velocity) output of the tested muscles. Therefore, the proposed 'two-loads method' applied in both research and routine testing could provide a deeper insight into the mechanical properties and function of the tested muscles and resolve a number of debated issues in the literature.

Key words: *muscles performing; force-velocity; muscle capacities; power capacities*

Introduction

Assessments of muscle function have been extensively employed both in research and in routine testing in sports, physical education, physical medicine, rehabilitation, ergonomics, and other human movement related areas. Since the time of seminal studies of Fleishman (Fleishman, 1964), it has been believed that the standardized research and testing procedures should reveal partly independent capacities of the involved muscles to produce certain components of the movement performance. Nevertheless, the contemporary research and routine testing procedures are based on the tests performed through either a single or very few trials performed under a single movement condition. The single outcomes of such tests of muscle function, such as the exerted force, cycling frequency, movement time, or jump height) cannot distinguish among different muscle capacities. Therefore, the further text will present a novel 'two-load method' that could markedly improve informational value of routine tests of muscle function.

Shortcomings of standard tests of muscle capacities

Important muscle mechanical capacities can be derived from their classical force-velocity and, consequently, power-velocity relationships (Hill, 1938). Specifically, these relationships reveal that the capacity to exert a high force decreases with the movement velocity and, as a result, the highest force can be produced at zero velocity, while the highest velocity can be achieved at the force (or resistance) close to zero. Conversely, the maximum power (i.e., the product of force and velocity) is produced when acting against moderate resistance at, as a consequence, moderate velocity. These capacities could be partly independent when comprehensively assessed from various tests and conditions (Fleishman, 1964; Jaric, 2015; Samozino, Rejc, Di Prampero, Belli, & Morin, 2012). They could also be selectively altered due to the applied training or rehabilitation interventions (Cormie, McGuigan, & Newton, 2011; Kaneko,

Fuchimoto, Toji, & Suei, 1983). The discussed multi-factorial structure of mechanical capacities of muscles inevitably leads to a major methodological shortcoming of the contemporary routine procedures for testing muscle function not only in sports, but also in various medical areas. Since the tests are typically conducted under a single mechanical condition, they provide a single outcome. Therefore, the muscle capacities, such as those for producing high force, velocity, and power outputs cannot be distinguished from single outcomes of such tests. That inevitably creates a fundamental problem in the contemporary literature both regarding the procedures for testing of muscle function and interpretation of their outcomes. Namely, there are hundreds of manuscripts published on testing particular maximum performance functional movements, but we still do not know how to interpret their results. A notorious example could be the maximum height of various vertical jumps that has been indiscriminately interpreted as either an index of muscle force (Kawamori et al., 2006), or velocity (Yamauchi & Ishii, 2007), or power (Cormie et al., 2011), or as a relationship among them (Markovic & Jaric, 2007).

Force-velocity relationship of muscles performing functional tasks

Of essential importance for the present study is the force-velocity relationship of muscles performing loaded functional movements (e.g., cycling, jumping, lifting, running, throwing, pushing) that proved to be exceptionally strong and close to linearity [see Jaric (Jaric, 2015) for review]. Specifically, manipulation of external loads typically provides a range of force (F) and velocity (V) data that allow for applying a linear regression model:

$$F(V) = F_{\max} - aV, \quad (1)$$

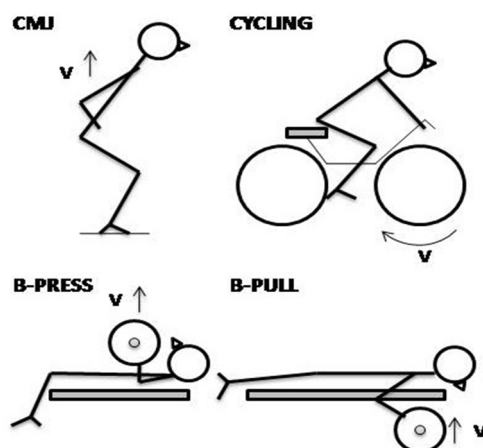
where a is the slope, while F_{\max} (i.e., F-intercept observed under zero V) corresponds to the maximum F (see Figure 1a). The V-intercept:

$$V_{\max} = F_{\max}/a, \quad (2)$$

reveals the maximum V of the tested muscles at zero F. Finally, due to the linearity of the relationship the maximum P (i.e., the maximum product of F and V) is observed at $F_{\max}/2$ and $V_{\max}/2$:

$$P_{\max} = F_{\max} * V_{\max}/4. \quad (3)$$

Such results have been consistently observed from cycling (Driss & Vandewalle, 2013; Driss, Vandewalle, Le Chevalier, & Monod, 2002; Nikolaidis, 2012; Vandewalle, Peres, Heller, Panel, & Monod, 1987), jumping (Cuk et al., 2014; Feeney, Stanhope, Kaminski, Machi, & Jaric, 2016; Giroux, Rabita, Chollet, & Guilhem, 2015), running (Morin, Samozino, Bonnefoy, Edouard, & Belli, 2010; Rabita et al., 2015), leg push offs (Meylan et al., 2015; Samozino et al., 2012; Samozino, Rejc, di Prampero, Belli, & Morin, 2014; Yamauchi, Mishima, Nakayama, & Ishii, 2009), lifting (Garcia-Ramos, Jaric, Padiar, & Feriche, 2016; Nikolaidis, 2012; Sreckovic et al., 2015) etc. As shown in Figure 1, most of the cited studies revealed the correlation coefficients of the linear model applied to individual sets of data well above 0.95. Of importance could also be that the parameters depicting the maximum force, velocity, and power of the tested muscles (i.e., the regression parameters F_{\max} , V_{\max} , and P_{\max} , respectively) proved to be at least moderately valid (Cuk et al., 2014; Driss et al., 2002; Feeney et al., 2016; Giroux et al., 2015) and highly reliable (Cuk et al., 2014; Feeney et al., 2016; Garcia-Ramos et al., 2016; Giroux et al., 2015; Meylan et al., 2015; Sreckovic et al., 2015). The same parameters can also detect the differences among various populations regarding the discussed muscle capacities (Nikolaidis, 2012; Ravier, Grappe, & Rouillon, 2004; Vandewalle et al., 1987; Yamauchi et al., 2009).



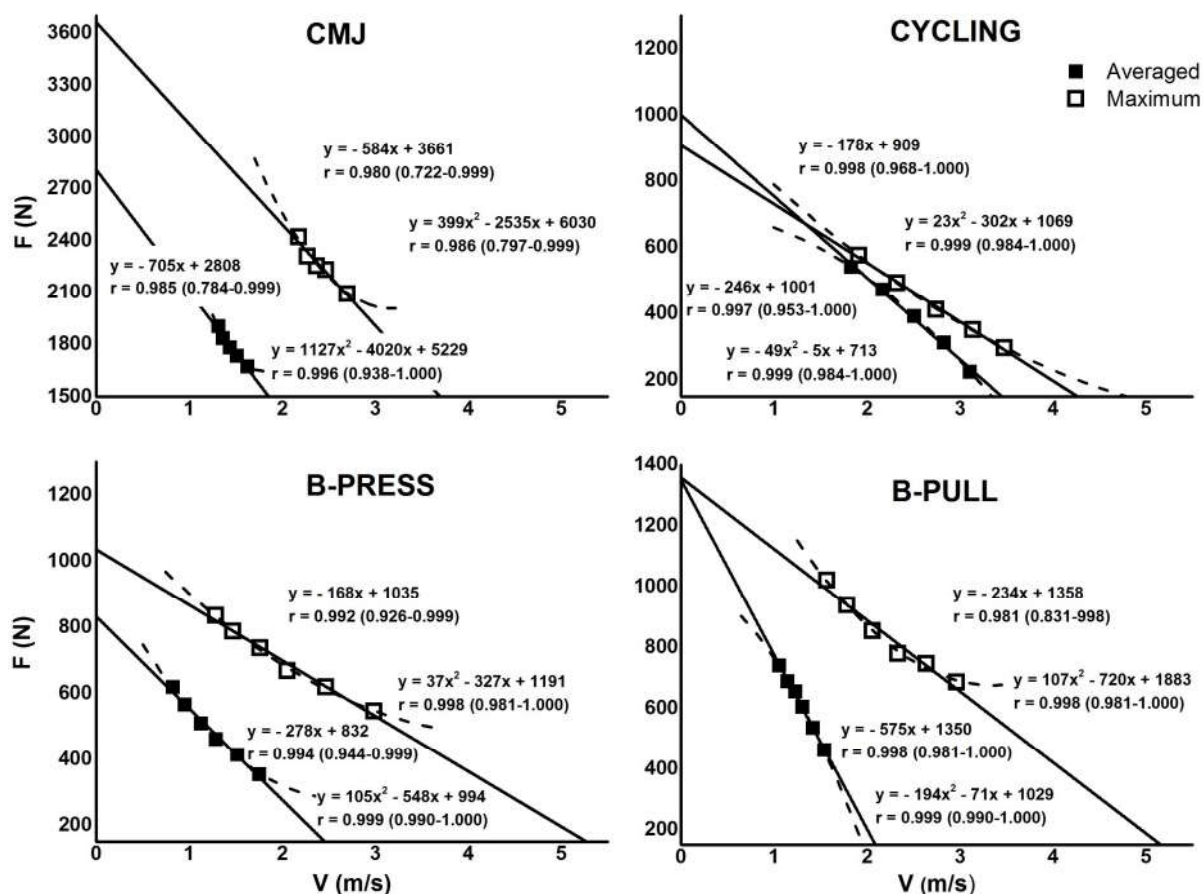


Figure 1. Upper panels illustrate 4 maximum performance functional tests conducted under different loads. Lower panels show the both the maximum and averaged values of the force and velocity data (data averaged across the subjects) and the corresponding linear regressions observed from the same tests (Zivkovic et al, submitted)

Recent research has been frequently employing both the linear model of the force-velocity relationship and the resulting parabolic power-velocity relationship obtained from loaded functional movements. The relationships were able to investigate the role of muscle mechanics in running performance (Morin et al., 2010; Rabita et al., 2015), explore the optimum load magnitude for maximizing muscle power output (Jaric & Markovic, 2013), reveal the imbalance of force and velocity capacities of the tested muscles (Samozino, Edouard, et al., 2014; Samozino et al., 2012), evaluate the bilateral deficit (Samozino, Rejc, et al., 2014; Yamauchi et al., 2009), and discern among the mechanical and neural mechanisms that could contribute to observed mechanical outputs (Bobbert, 2012, 2014). Finally, the discussed linear force-velocity relationship and, consequently, the parabolic P-V relationship could considerably simplify both the testing and modelling procedures in various areas of human movement studies (Jaric, 2015).

'Two-loads method' for testing muscle force, velocity, and power capacities

It has been often argued that the procedure of obtaining the linear force-velocity relationship from loaded functional movements procedure could be developed into a routine method for testing muscle mechanical capacities in both sports, and various ergonomic and rehabilitation areas (Driss, Vandewalle, & Monod, 1998; Jaric, 2015; Meylan et al., 2015; Nikolaidis, 2012; Ravier et al., 2004; Sreckovic et al., 2015). However, the same procedure can be somewhat time demanding, prone to fatigue, and cumbersome due to a typically large number of loading conditions and regression modelling.

The solution for the problems discussed above could be based on the already presented properties of a typically observed force-velocity relationship. First, note that the force-velocity relationship obtained from a series of loaded functional movements is typically exceptionally strong. Therefore, the number of the different loads applied should not have a meaningful effect upon the observed force-velocity relationship. Second, the relationship *per se* is typically a linear one. As a result, the magnitude of the applied loads should also play a minor role. Therefore, a simple 'two-load method' has been proposed *the capacities of*

tested muscles to provide a high F , V , and P output could be distinguished through functional movements tested against just two external loads (Jaric, in press).

An example of the two-load approach is illustrated in Figure 2. A typically strong and linear individual force-velocity relationship was obtained from 6 applied loads (i.e., 6 experimental points) when testing the bench press throws (Sreckovic et al., 2015). Therefore, the shape of the same relationship observed from just 2 of the most distinctive loads (i.e., the two-load method) is almost identical. Of essential importance here is that the line parameters corresponding to F_{\max} , V_{\max} , and P_{\max} directly reveal the muscular force, velocity, and power producing capacities in the same way as the parameters obtained from the regression models do (see eq. 1-3). The data obtained from our recent study (Zivkovic et al; submitted) suggest an exceptionally high concurrent validity of the parameters obtained from the two-loads method with respect to the same parameters obtained from the linear regression model applied on a number of loads loading conditions.

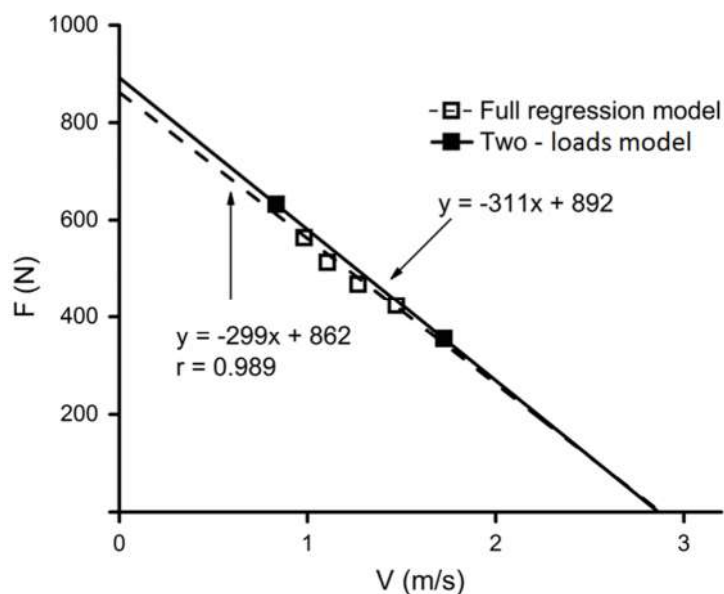


Figure 2. Force-velocity (force-velocity) relationship obtained from a linear regression model applied on 6 experimental points observed from bench press exercise performed against 6 different loads (Zivkovic et al, submitted). The same relationship is also shown through a two-loads model as a line determined by the first and last experimental point (dashed line and filled squares).

Finally, it may be important to contrast the force-velocity relationships obtained from the two-load method with the results of routine testing methods typically based on a single loading condition. The single load method would provide just a single point out of 6 shown in Figure 2. That single point apparently does not allow for the assessment of the shape of force-velocity relationship since its slope cannot be defined. As a result, the tested muscles could be either relatively strong but slow (i.e., high F_{\max} and low V_{\max}), or weak but fast (low F_{\max} and high V_{\max}). Moreover, the muscle capacities observed from the same point cannot be interpreted since its position relative to the maximum force (i.e., at zero velocity), velocity (zero at zero force), and P (the middle section of the line) of the tested muscles cannot be assessed. Therefore, the addition of just one more load should discern among the force-, velocity-, and power-producing capacities of the tested muscles.

Limitations and further research

Regarding the limitation of the proposed two-load approach, note that the force-velocity relationship observed from *in vitro* muscles and single-joint movements is generally considered to be curvilinear, while the linear shape has been observed only from functional multi-joint tasks. Nevertheless, the functional movement tasks are not only extensively used in routine testing, but also generally considered to be more ecologically valid and more familiar for subjects than single joint movement tests typically performed using isometric and isokinetic devices (Jaric, 2015). It should be also noted that regarding the individual parameters F_{\max} , V_{\max} , and P_{\max} obtained from the discussed two-load model, two of them allow for the calculation of the third one (see eq. 3). Therefore, despite both the apparent and distinctive physiological

meaning of the obtained F , V , and P producing capacity of the tested muscles, they are not fully independent. The future routine testing procedures will also require standardization of the applied loads. It is likely that more distinctive external load could provide more reliable and valid outcomes, but, nevertheless, further research is needed. Adaptation of movement pattern to altered load [e.g., typical in countermovement jumps (Mandic, Jakovljevic, & Jaric, 2015)] could also alter the obtained force-velocity relationship. The type of the applied load should also be considered since different combinations of the inertial (i.e., acceleration dependent) and gravitational loads (i.e., a constant one) could have distinctive effects upon the force, velocity, and power outputs (Leontijevic, Pazin, Kukolj, Ugarkovic, & Jaric, 2013). As a result, both the force-velocity relationships patterns and its parameters could be load type specific. Finally, the basic properties of the F_{\max} , V_{\max} , and P_{\max} parameters obtained from the two-loads method, such as their reliability, validity, and sensitivity, certainly need further evaluation.

Conclusions

When compared to the single loading condition typically applied in routine sport and other testing procedures, the functional movements (e.g., maximum jumping, running, cycling, rowing, lifting, throwing) tested against different external loads could provide an elaborate and ecologically valid assessment of distinctive muscle capacities. Here we argue that the functional tasks tested against only 2 distinctive external loads could distinguish among the force-, velocity-, and power-producing capacities of the tested muscles. Such testing could reveal both the muscle capacities and their imbalances. For example, if an athlete reveals a high F_{\max} relative to V_{\max} , he would be relatively 'strong' but 'slow', an opposite outcome would reveal a 'fast' but 'weak' athlete, while relatively low values of both F_{\max} and V_{\max} would reveal an athlete who 'lacks power'. Since the training methods that specifically target the muscle force, velocity, and power are generally known, the proposed two-load method should allow for optimization of the individualized training and rehabilitation procedures. Therefore, it could be concluded that the two-load method should be routinely applied in future research and testing procedures based on functional movements that allow for manipulation of external loads.

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RESTRICTED BLOOD FLOW RESISTANCE TRAINING: THE OPTIMAL TRAINING PROTOCOL TO INCREASE MUSCLE MASS AND STRENGTH

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(Original scientific paper)

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Abstract

Increases in muscle mass and strength are effects that are not easily achievable in clinical tests, since they require a prolonged period, no shorter than 2 months in duration, of high intense resistance training (HIRT) of $\leq 70\%$ of one repetition maximum (1RM). However, HIRT shouldn't be recommended for the different population, like elderly or convalescents, as it increases the risk of injury to the skeletal system, soft tissue, as well as the circulatory system. We conducted literature review with aim to investigate the effects of restricted blood flow resistance training (RBFRT) on strength and hypertrophy of skeletal muscle and to provide guidelines for its uses. Seven electronic databases were searched to identify relevant articles. Studies were deemed eligible for inclusion if they met the following criteria: (1) were an experimental trial published in an English-language refereed journal; (2) applied treatment method was RBFRT; and (3) monitored variables were strength and/or hypertrophy of skeletal muscle. A total of ten studies were identified as eligible for further analysis. The training should reflect the dynamic mode, with controled contracton, up to 1 second in duration for both concentric and eccentric phase of movement with 20% to 30% of 1RM. The best results are achieved when performing 3 to 4 working sets until the muscle failure, with short rest periods between, no longer than 60 seconds. Increase in muscle size was outstanding in all studies and ranged from 3.5 % to 7.8% after only one week of training but high frequency, 7 days per week and two training per day, and even up to 16% ($P < 0.01$) after two weeks of training. Strength increase ranged from 6% to 26.6% after treatment, regard to training frequency and trained limb. This training program is suitable for athletes, convalescents and especially for older people which is not recommended to exercise with high intensity loads.

Key words: KAATSU, RBFRT, occlusion, resistance training, hypertrophy

Introduction

Resistance training has long been acknowledged as an effective stimulant resulting in hypertrophy and an increase in skeletal muscle strength (American College of Sports Medicine position stand, 2009). According to ACSM recommendations, high-intensity resistance training i.e. HIT ($\geq 70\%$ 1RM) with a low number of repetitions before reaching muscle fatigue (8-12 repetitions maximum) can lead to changes in the functional and morphological characteristics of muscular tissue in favor of hypertrophy and an increase in muscle strength (ACSM, 2009).

Increases in muscle mass and strength are effects that are not easily achievable in clinical tests, since they require a prolonged period, no shorter than 2 months in duration, of HIT (Roth *et al.*, 2000). However, HIT high should not be prescribed for older adults as it increases the risk of injury to the skeletal system, soft tissue, as well as the circulatory system (Abe, Kearns & Sato., 2006). In fact, following HIT an increase in arterial stiffness, one of the indicators for atherosclerosis, has been found in healthy young persons (Miyachi, Donato, Yamamoto, Takahashi, Gates *et al.*, 2003; Miyachi, Kawano, Sugawara, Takahashi, Hayashi *et al.*, 2004; Kawano, Tanaka & Miyachi, 2006). Further, since HIT is used more often by athletes they also run a higher risk of injury (Fry, Kraemer, Van Borselen, Lynch, Triplett *et al.*, 1994). There are evidences that HIT is frequently linked with orthopedic complications (Miyachi *et al.*, 2004; Roth, Martel, Ivey, Lemmer, Metter *et al.*, 2000), such as pain in the joints and lower back. In contrast, a medium-intensity resistance training is recommended as a measure against ageing, increasing muscle strength and endurance (Nakajima, 2007). These findings indicate that HIT ($\geq 70\%$ 1RM) should only be administered with greater

care, both for athletes and for physically active people in general, and especially when considering children, older adults (ACSM, 2009), convalescents or individuals with cardiovascular diseases.

On the other hand, conventional training using intensities lower than 70% 1RM is considered less efficient for increasing strength and achieving muscle hypertrophy (McDonagh & Davies, 1984; Kraemer, Adams, Cafarelli, Dudley, Dooly *et al.*, 2002). For the reasons noted above, new methods of training need to be explored which would have the same or even better effect regarding strength and hypertrophy gains, yet with minimal side-effects for the musculoskeletal and cardiovascular systems.

Studies conducted over the last decade have demonstrated that low-intensity resistance training (LI-RT) with a blood flow restriction can lead to hypertrophy and increase in strength of skeletal muscles using only 20–30 % 1RM (Takarada, Tsuruta & Ishii, 2004; Karabulut, Abe, Sato & Bembem, 2010; Yasuda, Fujita, Ogasawara, Sato & Abe, 2010). Depending on the demographic context where the studies were conducted, this type of training method is termed KAATSU in Japan (Sato, 2005), which translates as “additional pressure”, whereas in the Europe and US it is termed Blood Flow Occlusion Training (BFOT) or Restricted Blood Flow Resistance Training (RBFRT) (Loenneke, Wilson & Wilson, 2010; Fahs, Loenneke, Rossow, Thiebaud & Bembem, 2012). The low-intensity restricted blood flow resistance training (LI-RBFRT) method, named either KAATSU, BFOT or RBFRT, it is a new resistance training method which stimulates skeletal muscle fibers growth and can contribute to hypertrophy as well as to an increase in muscle strength, even at low resistance intensity (Sato, 2004). Here, occlusion is caused using a special belt or elastic band, placed on the proximal end of the extremity, the "root" of the arm or leg, during dynamic muscle contractions to decrease venous and arterial blood flow through the active extremities (Sato, 2004; Loenneke *et al.*, 2010; Fahs *et al.*, 2012).

The novelty of this training method compared to other principles known to date is that this is a short-duration, low-intensity training which results in an increase in strength and muscle hypertrophy. A number of studies so far have found that one of the prerequisites for gaining muscle mass and strength is in fact functional stress, that is, mechanical stress caused by HIT (Fluck & Hoppeler, 2003; Goldberg, Etlinger, Goldspink & Jablecki, 1975; in: Jones & Rutherford, 1987; Baldwin, Valdez, Herrick, MacIntosh, & Roy, 1982; in: Adams & Haddad, 1996), in addition to other factors such as protein synthesis, diet, physical activity and growth factors (Sandri, 2008). By using this method, functional stress of the recruited muscle is achieved more quickly. The advantage of the LI-RBFRT method in relation to conventional methods is that similar, or even better, results in terms of hypertrophy and muscle strength gains can be achieved more quickly using a low-intensities from 20% to 50% 1RM.

Therefore, it was the aim of this literature review to identify the possibilities of using LI-RBFRT for achieving hypertrophic effects and increasing muscle strength in different target groups, as well as to establish an optimal protocol of this type of training.

Methods

Study Selection

In order to perform a literature review about the effects of the LI-RBFRT the following electronic databases were examined: PubMed /Medline, PEDro, DOAJ, SPONET, ScienceDirect, Google Scholar and ERIC. Studies inclusion criteria for further analysis did not imply a date of publication. The reason for this decision is the fact that the RBFRT is a relatively new training method, and there are very few papers on this topic. The following keywords were used for searching the database: *restricted blood flow training, low intensity resistance training, effects, kaatsu, occlusion, skeletal muscle size, hypertrophy, strength, mass gain.*

Founded research topics, abstracts and full texts were read and analyzed. The accepted research for final analysis had to met three criteria: 1) the study design was experimental; 2) applied treatment method was LI- RBFRT and 3) the strength and hypertrophy of skeletal muscle were variables for monitoring the treatment.

Data Abstraction

Studies that met the established criteria were analyzed and presented only if the following parameters were presented: a reference (author's name, year of publication and type of research study); participants' data (sample number, age and sex, experience in strength training, health status, classification of respondents per group); apparatus for applying occlusion (applied pressure/mmHg, dimensions of strips); training methods and applied region; duration of treatment (weekly and daily training frequency, intensity,

repetitions, series, duration of the contraction, pause between sets); variables for monitoring the effects of training, research results and the effects of the treatment.

Results with Discussion

Research abstraction

The process of data collection, analysis and elimination is presented in Figure 1. Collecting of research based on selected keywords identified 215 papers. Researches that were immediately excluded on the basis of title and duplicated works were 167, while 48 papers were included in further analysis. Out of these 48 studies, 38 were excluded because they missed one or more of the parameters presented in the Data abstraction section (i.e. 1) the methods of training included treatment without occlusion or only with limb occlusion but without resistance training and 2) outcome variables were not of interest of this review. Finally, the remaining 10 papers met all the established criteria: the experimental character of the papers, RBFRT as a treatment method and muscle hypertrophy or strength as dependent variables.

Subjects Characteristic

The studies involved a total of 174 participants. The largest sample size ($N = 48$) was found in the study of Barcelos et al. (2015) and the smallest ($N = 1$; a pilot study) in the work of Abe et al. (2005). From a total of 10 studies, female participants were included only in two (Ishii et al., 2005; Patterson & Ferguson, 2011), where Patterson & Ferguson (2011) involved both genders.

Participants in all studies were adults. The youngest participants in the analyzed papers were included in the studies of Lowery et al. (2014) and Barcelos et al. (2015) with a mean age 23 ± 5 and 24 ± 6 , respectively, while the oldest were included by Patterson & Ferguson (2011), where the mean age of older adults was 67 ± 3 years.

Experience of participants in strength training was one of the most important factors for this study, because of the metric characteristics of the RBFRT treatment, as it is generally known that greater increase in strength and muscle cross-sectional area could be seen after several weeks of resistance training in non-trained subjects compared to trained individuals (Ahtiainen, Pakarinen, Alen, Kraemer & Häkkinen, 2003). Regarding this, one of the exclusion criteria that was used by the authors in the studies taken into consideration in this review was that subjects were not engaged in resistance training programs 3 to 12 months immediately prior to the start of their studies. Thus, the resistance training experience of the majority of participants was minimal or not existed for the past year. In one study it was mentioned that the group of participants had experience in resistance training for a minimum of one year because they want to investigate the effects of RBFRT on trained subjects (Lowery et al., 2014).

Further, the health status of respondents in most studies was normal, with no significant problems or classification of diseases. Only in one out of 10 studies the observed health anomaly was stable ischemic heart disease or SIHD (Nakajima et al., 2010).

Some studies did not include a control group, since it was a case study of one subject (Abe et al., 2005); some authors have considered that the control group is not required (Nakajima et al., 2010; Takada et al., 2012), while the rest of them had control groups. Due to the specificity of the RBFRT method and little experimental data on this topic, we did not want the existence of control group to be the excluding criterion in this review. Basically, the control groups in the analyzed studies were not subjected to any treatment, as it could also be the case in some studies where other experimental groups could serve as a control, for example a group trained with the intensity of 80% of 1RM (Karabulut et al., 2010).

Occlusion system application

One of the questions we would like to answer in this review is the type of the applied occlusion system. Eight out of 10 studies (Abe et al., 2005; Ishii et al., 2005; Yasuda et al., 2005; Nakajima et al., 2010; Yasuda et al., 2010; Karabulut et al., 2010; Takada et al., 2012; Barcelos et al., 2015) used dedicated devices for the RBFRT. Abe et al. (2005) and Yasuda et al. (2005) used the Kaatsu Master device (Sato Sports Plaza, Tokyo, Japan), while Ishii et al. (2005) used the KAATSU Sportswear (PHENIX Co. Ltd., Tokyo, Japan). In one of the remaining two studies the system for blood flow occlusion was not specified (Patterson & Ferguson, 2011) and in the second (Lowery et al., 2014) an ordinary elastic band was used, like the one which is used by power lifters as a brace for the knee i.e. knee wraps (Elite FTS, London, Ohio; 76 mm wide) on the model of work (Wilson et al., 2013). It was found out that LI-RBFRT has positive effects on increase in muscle strength and muscle growth, independently of the type of blood flow restriction system

used. Further, based on fact there is only one study which used a simple, unconventional bands, we cannot compare effectiveness of those different methods, even there has been noticed a positive results after both methods were applied.

Applied pressure

In addition to the apparatus used for blood flow occlusion, studies are very different compared to the value of applied pressure on the limbs. Based on this criteria we can extract these values from the amplitude of 30mmHg in the study (Yasuda et al., 2010), up to 250mmHg in the study (Nakajima et al., 2010).

Pressure induced by dedicated apparatus is very easy to control, because everything is digitalized. Lowery et al. (2014), were used subjective assessment methods of pressure with 6-7 grade of 10 or Borg scale of subjective assessment (Nakajima et al., 2010).

When applications dedicated apparatus for the blood flow occlusion is used, a normal procedure demanded respect for the general principles that first authors have used, which implied that the pressure held constant during the training. Initially is set to 100mmHg, and is increased to 180 mmHg after which the slightly raised or stay at the same level in accordance with the subjective feeling of the respondents, or the tolerance of the ischemic pain which occurs in the course of the occlusion.

Maximum pressure is 238 ± 8 mmHg in the final stage of the experiment (Takarada et al., 2000a; Takarada et al., 2000b). In studies that we considered they used these basic principles, easy adaptation to the increasing pressure, where the pressure is increased by 10 mmHg from training to training according to a weekly or daily frequency of training, (Yasuda et al., 2005; 2010); or followed by 20 units of mmHg (Abe et al., 2005; Barcelos et al., 2015).

Again we must note that when applying different levels of pressure and the regime, they come to positive results when it comes to positive impact of LIBFRT to increase muscle strength and hypertrophy.

Trained muscles

In 6 of the 10 studies research was conducted only in the lower extremities (Abe et al., 2005; Yasuda et al., 2005; Nakajima et al., 2010; Patterson & Ferguson., 2011; Takada et al., 2012; Barcelos et al., 2015), of which the two studies (Patterson & Ferguson., 2011; Takada et al., 2012) were examined the muscles performing the plantar flexion, while the other 4 conducted an analysis of the thigh muscle following this exercises - squat, leg presses, leg flexion and extension.

In the remaining 4 of 10 studies region over which is test performed was upper part of the body. In one study researches investigated the strength and hypertrophy of mm. pectoralis-through flat bench press exercise (Yasuda et al., 2010), in another was tested a power of mm.biceps brachi (Lowery et al., 2014), while in the other two studies included research on the muscles of both body regions (Ishii et al., 2005; Karabulut et al., 2010).

Interesting thing is that, the scientists were investigating training methods with external load in 9 out of 10 studies, while only one study used methods of training without external, additional, load (Ishii et al., 2005). In all studies, for the training process is used a dynamic type of muscle contraction.

Training variables

Training volume

The principle for the exercises in a dynamic mode was reflected in the performance of 3 to 4 working sets the maximum number of repetitions, which is usually accounted for 15 reps (Yasuda et al., 2005; Yasuda et al., 2010; Karabulut et al., 2010; Takada et al., 2012; Lowery et al., 2014; Barcelos et al., 2015), while the two authors have worked with the first "warm up set" of 30 reps (Abe et al., 2005; Nakajima et al., 2010).

The duration of treatment in most studies was different. The shortest duration of treatment was 7 days (Abe et al., 2005), while the longest treatment was 3 months, almost 13 weeks (Nakajima et al., 2010).

Frequency

Weekly training frequency is also varied and most depended on the length of the whole treatment. If the treatment lasted longer, weekly or daily frequency would be lower and vice versa. In 3 studies weekly frequency of training was 2 times (Nakajima et al., 2010; Lowery et al., 2014; Barcelos et al., 2015), in 4 studies 3 times a week (Ishii et al., 2005; Karabulut et al., 2010; Patterson & Ferguson., 2011; Takada et al., 2012), in two studies weekly frequency amounted to as much as 6 times per 2 training sessions per day,

the treatment lasted two weeks (Yasuda et al., 2005; Yasuda et al., 2010), and finally in one study, a case study, training had a weekly frequency of 7 times, twice a day for treatment of 7 days (Abe et al., 2005).

Intensity

The intensity of the load (IL) in training, is measured as a percentage of the 1RM. In 4 studies IL amounted to 20% of 1RM (Abe et al., 2005; Yasuda et al., 2005; Karabulut et al., 2010; Takada et al., 2012), in one amounted to 20-30% of 1RM (Nakajima et al., 2010;), in one study, 25% of 1RM (Patterson & Ferguson., 2011), in one study, 30% of 1RM (Nakajima et al., 2010), and in one study were used loads of 20% and 50% (Barcelos et al., 2015).

Rest intervals

Rest intervals after running series in four studies were lasted for 30 seconds (Abe et al., 2005; Yasuda et al., 2005; Yasuda et al., 2010; Takada et al., 2012) while in four studies lasted 60 seconds (Nakajima et al., 2010; Karabulut et al., 2010; Patterson & Ferguson., 2011; Barcelos et al., 2015), in one study there was no rest between exercises, because circuit training was made, practical on average the respondents needed a 10 seconds to install for the second exercise, and this may be considered as a rest period (Ishii et al., 2005), while only one of the 10 studies did not include information about the pauses duration between working sets (Lowery et al., 2014).

Contraction characteristics

Data on the duration of individual contractions, concentric and eccentric are listed in the 3 studies as follow, 1.5 seconds (Nakajima et al., 2010), for 2 seconds (Takada et al., 2012), and 1 second in the study (Barcelos et al., 2015). The essence of this method of work was to induce muscle fatigue with low intensity and a huge volume of work in terms of repetitions. It should be noted that several factors are responsible for neuromuscular adaptation when it comes to strength training, such as the accumulation of metabolites (lactic acid, ADP, etc.), as well as reduced oxygen supply to the muscle that contracts. All this causes recruit a large number of muscle fibers that lead to neuromuscular adaptations and increasing muscle strength (Karabulut et al., 2010). Some authors have studied the impact of the accumulation of metabolic waste and the level of metabolic stress on the muscle adaptations (Goto et al., 2005; Schoenfeld, 2013) and came to the conclusion that a higher metabolic stress after mechanical stress applied to the muscle, causing a large number of muscle fibers recuperation, increased secretion of hormones and cell swelling and all that are indicators or mechanisms for increase muscle strength and hypertrophy (Ahtiainen, et al., 2003)

Effects of LI- RBFRT training on muscle strength and hypertrophy based on different training modalities

In a study (Goto et al. 2005) after 12 weeks of resistance training group which did not have a rest within work sets, i.e. which is less rested, recorded higher amounts of lactate in the blood, the level of human growth hormone (HGH), epinephrine and norepinephrine, resulting in a greater increases in 1RM ($P < 0.01$), maximal isometric strength ($P < 0.05$), and muscular endurance ($P < 0.05$) with knee extension than the other experimental group (with rest regimen). The no rest group showed a marked increase ($P < 0.01$) in muscle cross-sectional area, whereas the rest and CON groups did not. Although the volume and intensity were relatively equal in both experimental groups (Goto et al. 2005), basis of which we can conclude that the best regime for muscle hypertrophy and increase in muscle strength is fewer rest periods between sets. Results that occurred after the new applied exercise programs are staggering compared to the current knowledge about strength training. Previous reports on training high-intensity load (~ 70-100% of 1 RM) indicate that it takes 2 months of continuous training in order to show indicators of significant scope hypertrophy (Roth *et al.*, 2000) measured by non invasive methods such as (MRI, ultrasound or measuring the volume). However, one study showed that the significant increase in muscle hypertrophy occurred after 6 weeks of resistance training (Abe et al., 2000).

In some studies, already after one or two weeks of training with low intensity were observed significant changes in the morphology of the muscle and its strength (Abe et al., 2005; Karabulut et al., 2010; Yasuda et al., 2005; Yasuda et al., 2010). This raises the hypothesis that the changes that the scientists measured occurred due to accumulation of fluid, both intra- and extracellular, or in the muscle. But if that is indeed the case, if it is for all the "hypertrophy" of muscles responsible waterlogging there would be no significant changes in tests of maximal strength of the participants, which was also observed in all experimental groups with RBFT analyzed studies.

Also, in the study (Abe et al., 2005) was also recorded accrual of relative strength and we know that it is equal to the maximum muscle strength in relation to its mass (strength / body weight). In this regard, if its cause of increasing "hypertrophy" was the accumulation of water in or around the muscles, it would make sense then the relative strength decreases. But in this study that wasn't the case. Thus, the authors concluded that the change in strength occurred because of an increase in muscle hypertrophy and not regarded by accumulation of water. One proof of this is the invasive measurement method, by muscle biopsy, used in the study (Yasuda et al., 2005), where the data obtained in the experimental group for the CSA of muscle fibers of type II, indicate an increase by as much as 27.6% ($p < 0.05$) and Type I increased by (5.9%), although there was no statistical significance it is important to note. In the control group which trained with the same intensity of 20 % 1RM but without occlusion, there were not occurred a positive changes, (Type I and Type II / - 2.1% and - 0.5% respectively). Mean fiber CSA in the experimental group was +17.0%, while in the control was recorded decrease of 0.4%. Further, they concluded that skeletal muscle and fiber hypertrophy, especially type-II fiber, occur after high frequency LI- RBFRT training.

In relation to all the parameters of training volume that we considered in the table 1 (duration of treatment, weekly and daily training frequency, the number of series) the greatest improvement in strength gain was in the study (Barcelos et al., 2015) ($1 \times 50 \% = 20.6 \%$; $3 \times 50 \% = 20.9 \%$; $1 \times 20 \% = 26.6 \%$; $3 \times 20 \% = 21.6 \%$) compared with the control group after 8 weeks of training. The smallest gain in strength was in the study (Yasuda et al., 2010) in the 1RM test of flat bench press ($P < 0.05$). Further, and other authors have noted an increase in muscle strength between the stated values, compared the final test to a pre-test and they all had a statistically significant difference ($P < 0.05$).

Increase of muscle mass was outstanding in all the studies and ranged in percentages 3% (Ishii et al., 2005), 7.8% (Abe et al., 2005) after only one week of training but high frequency, 7 days per week and two training per day, and even up to 17 % ($P < 0.01$) after two weeks of training of mm. pectoralis with higher training frequency (Yasuda et al., 2005).

Conclusions

Although applied LIBFR training program differed at many authors in terms of training variables like volume, intensity and frequency, a stunning results have occurred when it comes to so far well-known in the field of weight training and its effect on hypertrophy and increase in strength. All results indicate that this method was effective and less invasive than others, i.e. that the risk of injury is a very small, almost non-existent (Nakajima, Morita & Sato, 2011). Skeptics would say that this training is not good for people with cardiovascular disease, those who suffer from high blood pressure, atherosclerosis, permeability of blood vessels, due to restricted blood flow, but on the contrary, this method can prove that the venous arterial blood flow increased after occlusion compared to the value before the same (Patterson & Ferguson., 2011).

In order to bring a positive change through these training methods may be used by different regimes and programs in terms of the duration of treatment, weekly and daily frequencies and intensities. Already after 8 trainings were observed positive changes in terms of increased strength and muscle hypertrophy. According to currently fashionable lifestyle, where it is reasonable to train 3-4 times a week, with what the duration of treatment in this case should be extended to two weeks in order to see the results of the training. The training should reflect the dynamic mode, in 3-4 working sets with the load intensity of 20 to 30% of 1RM and duration of contraction of at least 1 second to 1 second concentric and eccentric contraction respectively, for the breaks between working sets of 30 to 60 seconds maximum.

Each working set should be performed under occlusion of blood flow, the tape or belt should not be removed until the end of last working set. The applied occlusion apparatus should be set on the most proximal part of the limb. The duration of the training session last between 5 and 7 minutes. Each working set should be performed to the maximum number of repetitions with the predicted load. The last repetition is determined on the basis of impaired performing techniques - if we can't do the full amplitude of movement at the same rate of contraction, than is considered that muscle fatigue is occurred and we need a break.

This training program is suitable for athletes, convalescents and especially for older people which is not recommended to exercise with high intensity loads.

Instructions for future researchers: It is necessary to do more research on the subject of LIBFR training with trained individuals, or individuals of proven strength sports such as (powerlifting, weightlifting or bodybuilding) in order to see the effects of this training method in this specific population.

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BIODYNAMICAL FACTORS OF RUNNING SPEED DEVELOPMENT

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(Original scientific paper)

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Abstract

Development of maximal running speed follows certain rules, which are based on the level of motor abilities, morphological characteristics and the degree of biomechanical efficiency and rationalisation of movement. In the development of locomotive speed there are three basic phases: phase of acceleration, phase of maximal speed and phase of deceleration. Variables that to the greatest extent generate the change of speed are length and frequency of stride. In the first phase an athlete develops 80-90% of his maximal speed. Sprinters generally achieve their maximal speed. After 80-90 metres speed begins to decrease. During the acceleration phase both: frequency and length of stride increase. The duration of contact in sprinters stride is shortening and the time of flight increases. With a shorter duration of the contact phase the type of strength changes as well. During the acceleration, the duration of contact phase is relatively long; the most important motor ability is power-strength of concentric modality. In the subsequent phases of sprinting the duration of contact is shorter and the importance of elastic energy increases significantly.

Key words: Running Speed; Biomechanical factors; Neuro – muscular factors; muscular coordination

Introduction

All movements at work, in sport activities and everyday life demand a high degree of efficiency. These processes strive towards strong synchronisation, automation and high level of rationalisation. People execute movements according to specific biomechanical conditions and on a basis of interaction between the managing system (central neural system) and the managed system (locomotive apparatus). Interaction between these two systems is a result of motor control, which main task is providing coordination and optimisation of movement, efficiency of movement and motor learning. Maximum speed, which is produced during movement, depends on various factors. These factors are related to morphological and physiological characteristics, energetic mechanisms, age, gender, motor abilities, inter- and intra-muscular coordination and optimal biomechanical technique of movement. Locomotive speed in the form of sprinting is one of the most important abilities, which defines the successfulness of athletes in many sport disciplines. From the genetic (hereditary) motor programme aspect, speed can be classified into primary phylogenetic human movements. In specific sports situations, speed is being manifested in a form of the »three-segment model«. The model consists of speed, strength and coordination. Pondering of individual segments of this model depends on the particularities of specific sport disciplines.

Biomechanical factors of speed

Maximum running speed is a product of the frequency and the length of stride. Both variables are mutually dependant; they are also linked to the processes of central regulation of movement, to the morphological characteristics, motor abilities and energetic processes. The relationship between the frequency and the length of a stride is individually defined and automated. Changing one variable results in changes of the second. When a length of a stride is increased, the frequency decreases and vice versa. With increased speed both variables increase.

Frequency of stride depends on:

- Functioning of central-neural system
- Inter- and intra-muscular coordination
- Central and peripheral neural fatigue

The length of stride depends on:

- Morphological characteristics (length of lower extremities)
- The reactive force of surface (impulse at take-off)
- Duration (time) of contact phase
- Dynamic flexibility in hips
- Take-off distance
- Touchdown distance

Development of maximal running speed follows certain rules, which are based on the level of motor abilities, morphological characteristics and the degree of biomechanical efficiency and rationalisation of movement. In the development of locomotive speed there are three basic phases: phase of acceleration, phase of maximal speed and phase of deceleration. Variables that to the greatest extent generate the change of speed are length and frequency of stride. In the first phase an athlete develops 80-90% of his maximal speed. Sprinters generally achieve their maximal speed. After 80-90 metres speed begins to decrease. During the acceleration phase both: frequency and length of stride increase. The duration of contact in sprinters stride is shortening and the time of flight increases. With a shorter duration of the contact phase the type of strength changes as well. During the acceleration, the duration of contact phase is relatively long; the most important motor ability is power-strength of concentric modality. In the subsequent phases of sprinting the duration of contact is shorter and the importance of elastic energy increases significantly.

In the phase of maximum speed both frequency and the length of stride are relatively constant, the proportion between the contact and flight phases of sprinters stride is also stabilised. The zone, where sprinters achieve their absolute maximum speed is very limited. In principle, the best sprinters can sustain this phase for 10 to 20 metres. The zone of maximal speed is located somewhere between 60 and 80 metres in men and between 50 and 70 metres in elite women. Maximal speed is always a product of optimal stride length and the frequency of stride. Donatti (1996) and Mackala (2007) state that there are no differences in the length of stride between elite and sub-elite sprinters, with differences existing only in the frequency of stride. Therefore, frequency of stride is one of the most important variables of maximal speed (Mero, Komi, & Gregor 1992, Delecluse et al., 1995, Donatti, 1996). In the last phase of sprinting run, between the 80 and 100 metres, velocity begins to decrease on a scale of 0.5 to 1.5 metres per second. Deceleration is caused by central and peripheral fatigue. Central fatigue is manifested as an error in the muscle activation, meaning that the number of active motor units and the frequency of neuro-muscular impulses decrease. This results in a lower degree of inter- and intra-muscular coordination, which is eventually being manifested with the decrease in frequency of steps, particularly in the last 10 metres of 100-m sprint. Central fatigue is correlated to the smaller activity of cortical and sub-cortical centres (Semmler, & Enoka, 2000). Increased fatigue at the end of the 100-m sprint is also caused by peripheral nerves and metabolic processes in the muscles. In the last 10-metres the duration of contact and the length of stride increase. The control of movement is during this phase of speed at the lowest level. This mostly depends on the quality of sprinters technique, as the disruption of these parameters is smaller in best sprinters than in the runners of medium quality.

Neuro – muscular factors of speed

Take-off action in sprinting stride is a key generator for development of maximal speed. Movement of sprinters is evaluated according to their horizontal velocity. The largest inhibitor in this movement is gravitational force; therefore, sprinters need to primarily develop sufficiently large vertical reactive force on the surface in the take-off action, which in itself consists of three phases. The first phase is placing a foot on the surface, followed by the amortisation phase and extension phase. Take-off action of stride in sprinters is the best example of eccentric-concentric muscular cycle (stretch-shortening cycle). In eccentric phase a certain amount of elastic energy is being accumulated in the muscular-tendon complex, which can then be utilised in the second phase. When looking at the production of reactive force onto a surface, muscles in the eccentric phase need to develop as large force as possible in as short time as possible. Transition time needs to be as short as possible and has an important effect on the efficiency of eccentric-concentric contraction. Tendons and ligaments, which resist the extension, can store up to 100 % more elastic energy than muscles (Luhtanen, & Komi 1980, Mero, Komi, & Gregor, 1992). Pre-activation of the gastrocnemius (calf muscle) is extremely important for the mechanics of take-off; this muscle is being activated 80 milliseconds prior to foot touching the surface - Komi, 2000 (Figure 1).

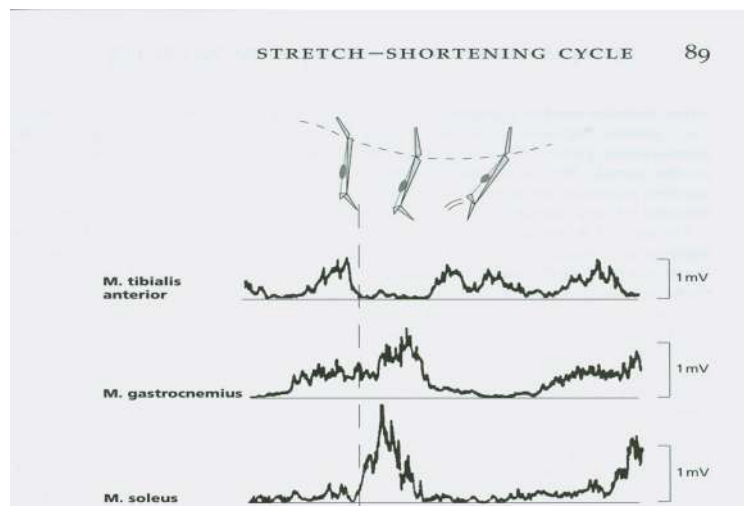


Figure 1. Stretch- shortening cycle the sprint contact phase (Komi, 2000)

Pre-activation creates a stiffness of plantar flexors (muscles) in the moment when the front part of the foot touches the surface. Increased stiffness of the muscles together with the minimal amplitude of movement in an ankle joint enables better transfer of elastic energy from eccentric to concentric contraction (Mero et al. 1986, Kyrolainen et al., 2001). When loaded during the sprint, tendons elongate up to 3-4% of their length, any elongation above this limit represents a potential danger for rupture. Tendons and ligaments act as springs, which store elastic energy. Excessive elongation of tendons results in transformation of elastic energy into heat, namely into chemical energy. High temperature of cells – fibroblasts and collagen molecules, which are the building material for tendons, could facilitate the possibility for injuries of this part of locomotive apparatus (Huiling, 1999).

In the second phase an extension of muscular – tendon complex takes place (Figure 2), whereas previously stored elastic energy is being utilised in a form of efficient propulsion of sprinters stride.

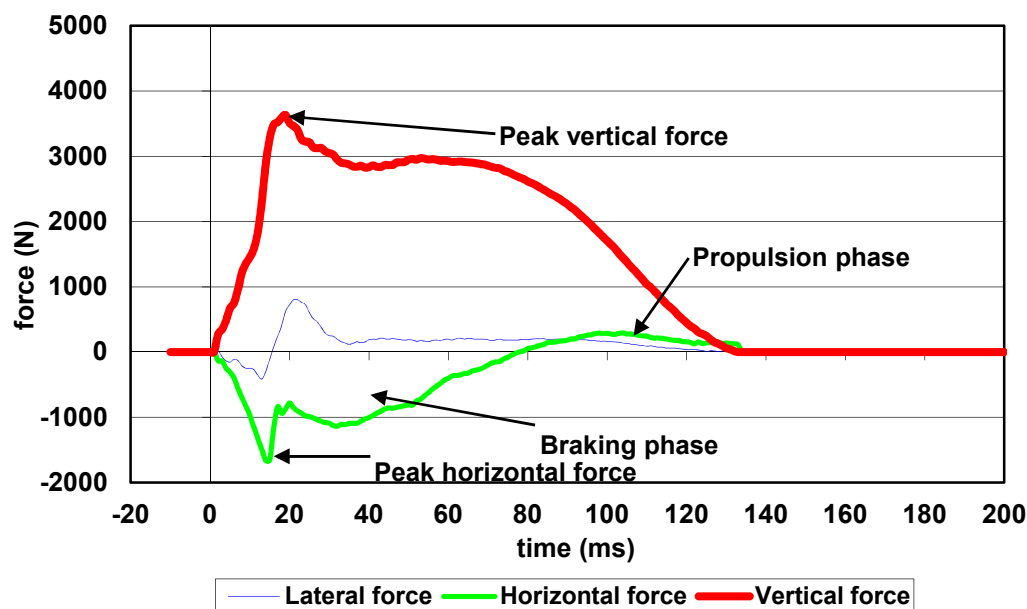


Figure 2. Force-time curves during the sprint contact phase (Čoh, 2002)

The main absorber in this phase is the quadriceps (thigh muscle). Increased co-activation of agonists and antagonists (m. vastus laterali, m. biceps femoris, m. gastrocnemius and m. tibialis) increases the stiffness of knee- and ankle joints. In this way, the entire leg is being prepared for contacting the surface. Increased stiffness of the ankle joint in the sprint reduces the consumption of chemical energy in the following muscles: m. gastrocnemius – m. lateralis – m. medialis and m. soleus (Kuitunen, Komi, &

Kyrolainen, 2002). Muscular activation of plantar flexors and the knee extensors increases in the pre-activation phase in proportion with the increase of speed. In addition, pre-activation of m. triceps surae together with the stretching reflex facilitates high degree of stiffness of muscles in the extension phase of the take-off.

Extension of muscular and tendon complex is managed and coordinated with two motor reflexes: monosynaptic stretch reflex and the polysynaptic reflex of Golgi tendon organ. These two reflex systems form a recurring coupling for maintaining the near optimal muscle length (reaction to stretching) and the reaction to excessive elongation of tendons. Receptors of stretch reflex – muscle spindles are placed parallel to muscle fibres. When muscle is being extended as a result of external force acting on it, muscle spindles also extend. As a result of muscle spindle extension, alpha motor neurons are being activated, which in turn activate reflex contraction of elongated muscles as a reaction to stretching. Golgi tendon organs are placed serially with muscle fibres. These receptors react exclusively to the forces, which are being developed in the muscles and do not react to any changes in length. If muscle effort increases rapidly, Golgi tendon complex prevents muscular contraction. Subsequent decrease of muscular effort prevents injuries to muscles and tendons (Jacobs, Ingen Schenau, 1992; Zatsiorsky, & Kraemer, 2006). In the phase when foot is placed on the surface and in the amortisation phase, extensors are being elongated and they produce contraction in the same muscle on the basis of the stretch reflex. At the same time the effort of large muscles activates Golgi tendon organ, which prevents activity of the muscle. As a result of specific training, activation of Golgi tendon organ is being inhibited and thus athletes can withstand large forces at landing without decreasing produced force of the muscles. As reversible contraction of muscles represents an integral part in many sports movements, it needs to be specially trained and taught. Jump training with reversible contraction has nowadays become an integral part of speed training in sportsmen. These so-called plyometric jumps and plyometric training produce high quality results in the development of take-off strength. In order for such training to be successful, a long term all-around preparation with different means and methods of strength training is required. On the other hand, plyometric jumps can cause serious injuries by athletes.

The time from a foot being placed on a surface until the end of take-off in the stride of sprinters lasts between 80 – 100 milliseconds. The cumulative contact time is shorter in elite sprinters. The shorter the time of contact, the better the frequency and the higher force take off on a surface. The relationship between the contact phase and the flight phase in sprinters stride is 20: 80. The largest reactive force of the surface is noticed 30 to 40 milliseconds after the first contact with the surface (Mann, Sprague, 1980). According to Mero, Komi, & Gregor (1992), the vertical reactive force of the surface in sprinters reaches 150 to 250 % of their body weight. The largest reactive force of the surface is in sprinters developed in the middle phase of the contact – the phase of maximal amortisation. In order to develop maximal locomotive speed, the largest possible force needs to be developed in the shortest possible time. Mastering the optimal mechanics (technique) of sprinting run is a condition for the utilisation of the force, which is being generated by the neuro-muscular system.

Intra- and inter-muscular coordination of speed development

In order to understand the dynamics and the changes of stride frequency and length in the training of maximal speed, the function of central neural system needs to be explained. Muscle force is not only defined by the amount of included muscle mass, but also by the degree of participation of individual muscle fibres. In order to manifest muscle force, muscles need to be activated in a certain way. Coordinated movement of several muscle groups depends on inter-muscular coordination. Basic characteristic of elite sprinters is efficient coordination of activated fibres in individual muscles and muscle groups. These sprinters have better inter- and intra-muscular coordination. Neural system generates muscle force in three ways: with activation and deactivation of individual motor units, with a frequency of releasing of motor units and with synchronisation of motor units. All three ways are based on the motor units, which represent basic elements in the working of neuro-muscular system. Every motor unit consists of a motor-neuron, which is located in the spinal cord, and from the muscle fibres, which are innervated. From the contraction point of view, motor units can be divided into slow and fast twitch. Slow motor units are specialised for extended use at a relatively low speed. They consist of small motor-neurons with a low threshold of release and they are adapted to aerobic activities. Fast muscular or motor units are specialised for relatively short lasting activities, which require strength, speed and a high degree of force development. They consist of large motor-neurons with a high threshold of release, axons with high speed of implementation and muscle fibres,

which are adapted to powerful anaerobic activities. Motor units follow the “all or nothing” law, meaning that any motor unit in any time is either active or inactive. The fastest speed of shortening of fast muscle fibres is four times faster than in slow muscle fibres (Zatsiorsky, & Kraemer, 2006). Human muscles in general consist of motor units with slow or fast action. Sprinters and athletes, who are required to develop large speed or force in a unit of time, have predominantly motor units with fast actions.

In volitional contractions, the activation of muscle fibres depends on the size of motor-neurons with a “size principle” being applied. First, small motor-neurons with a low threshold of excitation are being activated. With increasing demands for development of large force, larger motor-neurons with the fastest contraction twitch and highest threshold of excitation are being recruited as last. Mixed muscle types consist of motor units with slow and fast activation regardless of the degree of muscular effort and the speed being manifested. Only highly trained athletes manage to activate motor units with fast activation. Training of maximal locomotive speed is related to high coordination of movement. In a cycle of sprinters stride, there are more than 60 lower-leg muscles active, which have to work in a synchronised and coordinated way. In execution of precise movements, motor units usually do not work at the same time. In order to produce maximal force, which is one of the key factors of maximal speed, the largest amount of slow and fast motor units needs to be recruited as well as the maximal frequency of release and simultaneous work of motor units in a period of maximal voluntary effort. The prime goal in speed training is a creation of optimal movement model, which is based on the coordination of different muscle groups.

Controlling maximal speed

Speed is a motor ability with a strong genetic endowment related to the central-neural system. Shortage of neuro-muscular coordination is one of the limiting factors of speed as the possibility for optimal control of movement decreases with the increase in speed of movement. The larger the speed, the higher is deviation from the ideal movement model. Control of movement is at its lowest level under conditions of maximal speed. Maximal speed belongs to the category of so-called terminal movements, which have precisely set structure with a defined beginning and end of movement (Latash, 1994). Terminal movements differ according to their dynamic and kinematics volumes. Every terminal movement requires its adequate motor program. Motor program is defined as a group of simultaneous and successive commands to muscles in order to start and later end a desired movement. On the level of central neural system and spinal cord, motor programme is represented with a group of efferent signals, which travel down the motor nerves to muscles. It is known that the large number of various fast movements is controlled as the “open loop” process with centrally stored programme and without any feedback information (Schmidt, 1990). The most important functions in these movements are cerebellum and spinal cord. High speed of movement does not allow any analyses or correction. Precise movement control lies therefore in the work of cerebellum and relies on the information, which arrives there mostly via proprio-receptors that are located in joints and connective tissues of muscles. Spinal reflexes of muscular-tendon source in the area of spinal cord also play an important part in movement control. Any change in the length and tension of muscles is being transferred via stretch reflex path. Stretch reflex serves as a servo-mechanism, which enforces excitation effect on alpha motor neurons, thus increasing the precision of control of muscle group work. One of the most important problems in motor control is the role of agonist and antagonist muscles and their direct effect on kinematics and dynamics of movement through appropriate type, intensity and time sequence of muscle force effect. In fast terminal movements, such as sprinting, development of force is a key factor of movement efficiency. Variables of motor programme are force of agonist muscles, maximal force of antagonist muscles, time delay of antagonist muscles, time of achieving the maximal force of antagonist muscles, co-activated relationship of muscles in the function of their place in kinetic chain, length of a movement, terminal position, starting position, time length of a movement and the speed of a movement (Ilic, 1999).

Development of maximal running speed requires very subtle inter-muscular coordination of muscle groups of lower extremities. The most important are the following muscles: m. gluteus maximus, m. tibialis anterior, m. soleus, m. gastrocnemius, m. rectus femoris, m. biceps femoris, m. vastus lateralis.

Identifying strategic muscles, which generate the take-off force, is very important from the sports training point of view in order to optimise technique and prevent injuries. In the take-off phase muscles develop the reaction force with a magnitude of 280 to 350 kp in a time interval of 85 – 95 milliseconds (Čoh, 2002). Some studies from the field of electromyography and isokinetics of sprinters stride have revealed that biceps femoris (hamstring muscle) is one of the most important muscles in developing

maximal speed (Semmler, & Enoka, 2000, Čoh, 2002). This muscle often gets injured during sprinting, therefore its prevention with adequate training is very important. Training of maximal speed is from the aspect of physical preparation of athletes related to running technique, which is particularly difficult to control in the conditions of maximal speed. Optimal neuro-muscular coordination is the main limiting factor of maximal speed. Therefore, the forming of correct dynamic stereotype is a long term process, which has to have precisely defined technique and has to begin at an early age of the athletes.

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RELIABILITY AND VALIDITY OF A NEW AGILITY TEST

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(Original scientific paper)

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Abstract

The subject of this thesis is analysis of all metric characteristics of tests used for the evaluation of agility with reference to three available tests and one newly developed prototype test of agility. The intention is to make more quality option for testing and evaluation of all results from available tests and emphasise that all tests used for the evaluation of agility are very important in modern sports. Testing was conducted by 24 FC Solin football players U-15 and U-16. All of them were being tested as follows: Slalom, Zig-zag, 5x10 tests. All tests are highly confident and verified as well and we can use them like a platform for comparison and upgrading the newly developed prototype test of agility (Square test). Square test has been developed to present the agility in frontal and lateral motion with direction alterations and it's including all the segments which are necessary for quality testing.

Key words: reliability, agility, metric characteristics

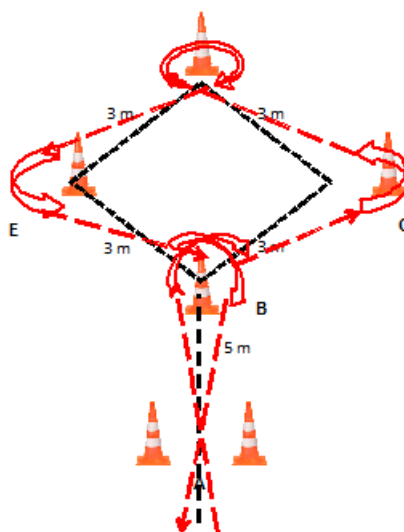
Introduction

Although in general, motor abilities undoubtedly affect the results of sporting achievements, individual contributions of different motor dimensions are varied and unequal in each individual sports activity (Metikoš et al., 2003). One of the motor abilities which is vital for football is agility. Agility is a complex motor ability (Jeffreys, 2006). Although in the community of sport scientists there is no consensus on a clear definition of agility, Sheppard and Young (2011) proposed, as a result of a critical review of the literature and scientific research, the following definition of agility, "the rapid movement of the whole body with the change of speed or direction of movement as a response to stimulus". This definition of agility takes into account the two main components of agility - (1) the rate of change of movement direction (BPSK) and (2) perceptive factors and factors of decision-making, proposed by Young et al. (2011). Simply put, it can be said that agility is the ability to quickly adapt movement depending on changes in the game and the ability to effectively movement direction. This ability integrates speed, coordination and balance capabilities. The goal of agility training is to improve the players' changing of the direction of movement in all trajectories, with the ball and without it. Agility applied to football is the ability to quickly change directions in unpredictable and changing situations of the game. Since the change in direction of movement occurs unpredictably, agility is thus the measure of the ability to limit the time between the decision of new movement and the execution of that movement. Additionally, agility can be defined as the ability to quickly and effectively move the body in space in terms of sudden stops and changes of direction (Metikoš et al ..., 2003). Agility is, in a large percentage, genetic. It follows that the progress of a footballer, in terms of motor abilities, depends on the extent of influence of the individual subcomponents on the manifestation of agility. Since agility is an important component of success in sports, it occupies a high position in equations of specification of different sports. Nonetheless, to successfully train agility, it is very important to understand the structure of the players' movement in a football game. Only then can exercises that improve this ability be constructed. When developing a particular movement or group of movements while knowing that generally the most responsible for their execution is speed or frequency of motion, that movement or a group of movements will be more difficult and slower to create exercises for than for a movement or group of movements for which morphological structure is more important. Therefore, before planning the agility training, the impact of all sub-components should be well considered and work on development of those elements that make quality implementation of agile movement difficult. The best way to determine someone's motor potential is through tests for assessment of motor abilities. Since motor abilities are latent (undetectable), it is impossible to find a single test that would sufficiently and precisely evaluate a motor

ability. Hence, more tests to assess the same motor abilities are used, with multiple repetitions of the same test and the disadvantages mentioned are partially avoided. Following the above, the authors have developed a new test for assessing agility in terms of frontal and lateral movement with changes in the direction of movement. The test is called "The Square", whose metrical properties will try to be determined. The aim of this study is to identify the specific metrical characteristic of the newly-constructed test as well as those of three standard tests.

Methods

Testing was carried out on a sample of 26 participants, aged 15 to 16, who train and play for NK Solin in the cadet category. The participants train 4 times a week and play in football matches on weekends. In addition to training, they also attend 2 hours of physical education a week. The sample of variables consists of three standardized tests for assessing agility: 1. Slalom test, 2. ZIG-ZAG test, 3. 5x10 test; 4. Square test - sprint around cones of a square shape, with frontal and lateral changes in direction that is a newly-developed test for assessing agility:



Picture 1. Square test for assessing agility (with and without the ball)

Description of the newly-developed test:

Between the first pair of cones (A) and the second cone (B) the distance is 5m. Distance between the other cones within the rhombus (BC, CD and DE) is 3m. The respondent is in a standing start (without the ball or the ball in front of him) just behind the starting line (A). Task performance (without the ball): the subjects task is to, on the sign of "prepare", come to the starting line, which the first pair of cones (A) signify and, when they are ready to start running to the other cone (B) which is passed from the inner side and then continues to run to third (C) cone. Rounding that cone (C) from the outer side they continue to the cone (D) around which they turn and continue towards the cone (E). This cone (E) is crossed from the outside and from it the subject proceeds to the cone (B), passing by it on the inside and running at maximum speed between the first cones (A). The task is performed with maximum speed and repeated three times. Task performance (with the ball): the subjects task is to, on the sign of "prepare", come with the ball in front of them to the starting line, which the first pair of cones (A) make and when they are ready, to start running and leading the ball to the second cone (B) which they pass by from the inner side and continue to guide the ball toward the third cone (C). From the outside rounding the third cone (C), then moving on to the next cone (D) around which the subject spins and then follows to lead the ball in front of them and to cone (E). Passing the cone (E) on the outside, they go to the second cone (B), which is again rounded from inside, and running at maximum speed, the subject should then go on to pass between the first pair of cones (A). The task is performed at maximum speed and repeated three times. The task is completed when the subject takes the ball past the first pair of cones (A) i.e. the finish line. The examiner, with a stopwatch in hand, is standing near the first pair of cones (A) on the start / finish line.

Test result is the time required to perform three cycle completions. Every proper attempt is registered with notes: 1. The respondent must, each time, be sure to pass the given cones (with or without the ball) 2. The task must be run at maximum speed 3. Respondent must pass through the finish line (with or without

the ball) 4. An attempt is considered faulty if the accuracy of performing only one cycle is violated by committing one of the aforementioned errors. Respondent is granted one attempt before official measurement in order to familiarize with the test.

The obtained data was entered in the program Statistica 10.0. For the purpose of this thesis the following were calculated: the parameters of descriptive statistics for all three items per individual test and the average value of the results of the individual tests obtained by Borts summation method as follows: arithmetic mean (AS), standard deviation (SD), minimum and maximum scores (Max and min), and curvature and symmetry of the distribution (skew. and Curt.). Intercorrelation matrix between the items was also calculated for each test. Two ways of determining the reliability are shown (Spearman- Brown coefficient and Crombach alpha). The normality analysis was calculated using Kolmogorov - Smirnov test. To determine the difference between player positions One way ANOVA was utilized. Furthermore, using univariate analysis of variance, the validity of tests to assess the speed and agility was also determined. For the purposes of determining the factor validity of tests, intercorrelation matrix of tests were transformed into a matrix of principal components, and the projections of variables - tests on the first principal component (Guttman-Kaiser criterion) were given.

Results and Discussion

Table 1. Descriptive indicators of the sample of respondents (N = 26)

	AS	Min	Max	SD
Age	16,01	15,3	16,11	0,55
Height (cm)	1,81	1,73	1,95	0,061
Weight (kg)	69,15	57,00	78,00	5,746
BMI	21,18	18,61	23,15	1,264
Years of training	7,11	5,3	10,00	1,20

Key: A (arithmetic mean), Min (minimum score), Max (the maximum score), SD (standard deviation), BMI (body mass index)

Reliability is a standard metric characteristics of a test relating to its accuracy as a measuring instrument or the ability of the test to, when repeatedly measuring the same subjects, get the same results. The problem of reliability is most often associated with the problem of the result consistency in repeated measurements. In each measuring process, the results are affected by the *systematic* and *non-systematic* factors, in addition to the size of the object of measurement. Systematic factors may cause an increase or decrease of the results and can be controlled and removed (fatigue, development, learning, etc.). Unscientific factors can cause random variation of the measurement results and, as such, directly affect the unreliability of measurement because changes that these factors cause are not a result of changes in the object of measurement itself. In this work two methods for determining the reliability of the measuring instrument were used: Spearman-Brown coefficient and Crombach alpha.

Table 2. Reliability of the measuring instrument (N = 26)

test	CA	SB
Slalom	0,97	0,96
Zig-Zag	0,90	0,91
5x10m	0,89	0,90
Square	0,92	0,92

Key: CA (Cronbach alpha reliability coefficient), SB (Spearman-Brown reliability coefficient)

Values of reliability coefficients range between 0.89 and 0.97. The closer the values are to one, the higher is reliability of the measuring instrument. As it can be seen from Table 2. all values CA and SB for all specific tests with the ball are extremely high, thus confirming that all of these tests are very reliable.

Homogeneity has an important role in describing the measuring instruments because the diagnostic value of the test depends on it. Homogeneity is a property of composite tests that shows how the results of the respondents in all items depend on the same object of measurement or the equivalent combination of different objects of measurement. The first requirement of homogeneity is easily visible from the initial

measurements, while the second can be roughly determined by additional analysis (Table 3). However, precise conclusions can be made when three items from each test are reduced to the main component. Correlation of the items should be very high in order to meet the requirement of homogeneity of the measuring instrument.

Validity is measurement characteristic of the instrument that indicates whether it measures the specific object of measurement. There are different types of validity:

Factorial validity determines which object of measurement is tested by a specific measuring instrument, or to what extent each of its factors determines the variability of the obtained results. With factor validity, the conclusions about the object the measurement are based on the results of the factor analysis.

Table 3. The homogeneity and factor validity of the measuring instrument

	Slalom	Zig-Zag	5x10m	Square
IIC	0,92	0,80	0,76	0,81
Ball 1	-0,95	-0,85	-0,93	-0,93
Ball 2	-0,99	-0,95	-0,88	-0,96
Ball 3	-0,97	-0,96	-0,94	-0,90
Expl.Var	2,82	2,54	2,51	2,59
Prp.Totl	0,94	0,85	0,84	0,86

Key: IIC (inter-item correlation), Expl.Var. (Distinctive value), prp.Totl. (Amount of explained variance of all variables)

After a review of Table 3, and IIC, it is visible that the homogeneity of the measuring instrument is high. Furthermore, the projections of items on the first major component are extremely high, further confirming that the tests are homogeneous. One significant component was obtained by factor analysis for all tests; the quantity of explained variance and dimensions of distinctive values are high, thus the factor validity of the tests can be also confirmed.

Pragmatic validity (prognostic validity) of a test shows how well, or how much successfully can surely be predicted in a practical activity based on the results of that test. The problem of pragmatic validity is reduced to the determination of some measure of association between the variables obtained by measuring certain groups of entities by a test, and the variable that describes success of these entities in an activity.

Table 4. Pragmatic validity of the newly-developed test

	Wilks' Lambda	Partial Lambda	F	p-value
Square	1,00	0,61	4,67	0,01

Discriminant analysis with a value of $p = 0.01$ (Table 4) has shown that with the newly-developed test Square, groups of respondents, or the players of various player positions, differ (Differences between the player positions).

Table 5. Pragmatic validity of the newly-developed test

	M	D	G	F
M		0,78	0,42	0,01
D	0,78		0,30	0,01
G	0,42	0,30		0,00
F	0,01	0,01	0,00	

Key: M (midfielders), D (defensives), F (forwards), G (goalkeepers)

By reviewing Table 5 it can be concluded that forwards are the most different, in comparison to other player positions. Although, there are differences in other player positions too, they are only statistically significant with forwards.

Conclusion

Metric characteristics of the tests were determined by calculating: *reliability* - Cronbach alpha reliability coefficient (CA), Spearman-Brown reliability coefficient (SB), inter-item correlation (IIR) and Cronbach alpha coefficient (α), *homogeneity* - analysis of variance (F test) and corresponding level of significance (p), *sensitivity* - arithmetic mean (AS), standard deviation (SD), minimum and maximum scores, skewness (SKE), kurtosis (KUR) and the Kolmogorov-Smirnov test (D max), *factor validity* – by using the factor analysis defined were the test that best describes the area of specific agility and *pragmatic validity* - applying t test for independent samples, the difference between player positions for respondents of the same age groups was established. The correlation between items of the newly-developed Square test is high, which is the first requirement for homogeneity of the measuring instrument. The correlation of items with the first principal component, which is the second requirement for homogeneity of the measuring instrument, indicates a pronounced homogeneity of all tests. Proper distribution of all tests indicates excellent sensitivity of all four tests that assess agility. One significant component was obtained by factor analysis for all tests, also, the quantity of explained variance and dimensions of distinctive values are high, which confirms the factor validity of all four tests. Following all of the obtained results, and observing them through the four dimensions (reliability, homogeneity, factor validity and pragmatic validity) of metric characteristics for assessing agility, it can be concluded that the newly-constructed Square test has a high efficacy and exceptional discerning results. In future measurements and research, the sample size should be increased and expanded which would then bring about more detailed results and better conclusions about the value of the Square test.

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THE SUBJECTIVE EXERCISE EXPERIENCES OF RHYTHM ACCOMPANYING EXERCISE – GENDER DIFFERENCES

UDC:796.412-055

(Original scientific paper)

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Abstract

Music is one of the most popular factors that increase motivation. The practical question is can we improve motivation for aesthetic exercise with accenting rhythm during learning new aesthetic elements and is there any gender differences in subjective exercise experience while learning new rhythmic gymnastics elements. It is supposed that learning strategies targeted with rhythm accompanying exercise can improve active involvement of the learner. Forty one students of physical education and sport participated in this study. The aim of the present research was to: (1) identify the differences in SEES between male and female university students involved in learning rhythm based aesthetic elements; (2) identify possible changes in SEES subscale before and after rhythm accompanying exercise. Subjects were asked to complete the SEES questionnaire prior and after an exercise trial by circling the number on a seven-point scale next to each item (great, awful, drained, etc) to indicate the degree to which they are experiencing each feeling at a certain point of time. To determine the differences between groups before and after physical activity in SEES subscales we use T-test for dependent groups, and to determine the gender differences T-test for independent groups. Significant differences before and after physical activity for SEES subscales in both groups were not found, but gender differences were noted in Positive Well-Being after activity in favour of male student and in Fatigue before and after physical activity in favour of female students

Key words: *students, rhythmic gymnastics, Subjective Exercise Experiences Scale*

Introduction

Rhythm and character of music play significant role in exercising and could be increasing factor of motivation (Priest & Karageorghis, 2008). In physical education (PE) classes it is extremely beneficial to evoke pupils' enjoyment, especially when exercises are obligatory part of the PE curricula.

Previous investigations have already detected that carefully selected music improves exercise performance (Atkinson, Wilson & Eubank, 2004; Elliott et al 2004) and just rhythmical elements of music are identified as a key characteristics of music causing bodily response (Karageorghis & Terry, 1997; Karageorghis, Jones & Low, 2006). It is well known that boys and girls prefer different physical activities.

Mazzardo (2008) states that the main reason for the existence of significant differences between genders is the fact that boys, in general, choose activities that develop manipulative, but also locomotor skills (basketball, handball, soccer), while the girls mostly choose to participate in activities that have great potential for development of the locomotor skills (gymnastics, swimming, dancing). Therefore, it could be expected that girls will favour aesthetic activities more than boys in PE but allowing boys not to learn aesthetic movement at all could produce alienation for aesthetic movements in general.

Nilges (2000) encourages physical education teachers to pay serious attention to how gender identity and meaning is constructed within and around body movement and devises teaching strategies that promote new degrees of equity and self-identification for all individuals.

The practical question is can we improve motivation for aesthetic exercise with accenting rhythm during learning new aesthetic elements and is there any gender differences in subjective exercise experience while learning new rhythmic gymnastics elements. It is supposed that learning strategies targeted with rhythm accompanying exercise can improve active involvement of the learner. And active involvement of the learner is the basis of expressive performance characteristic for aesthetic activities. Emotionally experienced activity will dominate in the expressive performance (Miletic et al., 2012).

Subjective Exercise Experiences Scale – SEES (designed by McAuley & Courneya, 1994) was chosen

for current investigation because of relative shortness in final version and the way in which the initial construction of this measurement was made (Whissel et al., 1986).

In the final stage of construction, 7 expert judges, all doctoral level researches in the area of psychosocial responses to exercise and physical activity indicated the suitability for each item as a subjective experience likely to be positive or negative influenced by exercise participation. New 46 chosen items were identified by at least six of the seven judges. After that, 46 items were administrated to 454 university students enrolled in 13 physical activity classes.

Factor analysis emerged three-factor structures: Positive Well-Being (PWB); Psychological Distress (PD) and Fatigue (F) aspects of the exercise experience. According to these results, authors reduced the final SEES scale on 12 items (four items that had the strongest loadings on each factor).

The aim of the present research was to: (1) identify the differences in SEES between male and female university students involved in learning rhythm based aesthetic elements; (2) identify possible changes in SEES subscale before and after rhythm accompanying exercise.

Methods

The subjects were divided in two subgroups: female (N=18) and male (N=23), intended the rhythmic gymnastics first-level course consisted of basis body elements and apparatus manipulation. During learning process, an effort was made to accent rhythm of performance and to focus learners on rhythmically performance of new learned elements.

SEES questionnaire has 12 items chosen to assess three-aspects of exercise experience: Positive Well-Being (PWB); Psychological Distress (PD) and Fatigue (F).

Subjects were asked to complete the SEES questionnaire prior and after an exercise trial by circling the number on a seven-point scale (with 1 *I feel not at all*; 4 *I feel moderate* and 7 *I feel very much so*) next to each item (great, awful, drained, positive, crummy, exhausted, strong, discouraged, fatigued, terrific, miserable, and tired) to indicate the degree to which they are experiencing each feeling at a certain point of time.

Student T-test for dependent groups was used to determine the differences between groups before and after physical activity in SEES subscales: fatigue, positive well-being and psychological distress.

Student T-test for independent groups was used to determine the gender differences.

Results and Discussion

Student T-test for dependent groups was used to determine the differences between groups before and after physical activity in SEES subscales: fatigue, positive well-being and psychological distress. Significant differences before and after physical activity for SEES subscales (graph 1 and 2) in both groups were not found.

This is a pilot study for tracking effects of rhythm accompanying exercise on subjective exercise experience of learner. In previous investigations aimed to measuring subjective exercise experience (Abazović Miletić & Kovacic, 2014; Miletić, 2012.) the questionnaires were provided to learners before and after one training unit. In this investigation, students were learning new elements, and most of them were focused on learning new techniques of movements.

It could be presumed that their subjective exercise experience was correlated more with their technical mastery more than with experience of rhythm. Therefore, future investigations with more training units that can allow learners to fill the rhythm more than thinking of mastering new skill are necessary to determine effects of rhythm based learning process.

Gender differences, according to *Student t-test* (Table 1), were noted in Positive Well-Being after activity in favour of male student and in Fatigue before and after physical activity in favour of female students. Increase of after activity Positive Well-Being among male students are in accordance with previous investigations (Miletić, 2012) confirming that male students who participated in aesthetic classes had generally positive attitude for participation in this classes. Bozanic & Miletić (2011) founded that male aesthetic performance does not different from that of the females given the same training. Along with results obtained in this study, they should be encouraged to participate in aesthetic activities. Consequently, rhythm accompanying learning classes can increase good mood and improve motivation for aesthetic activities.

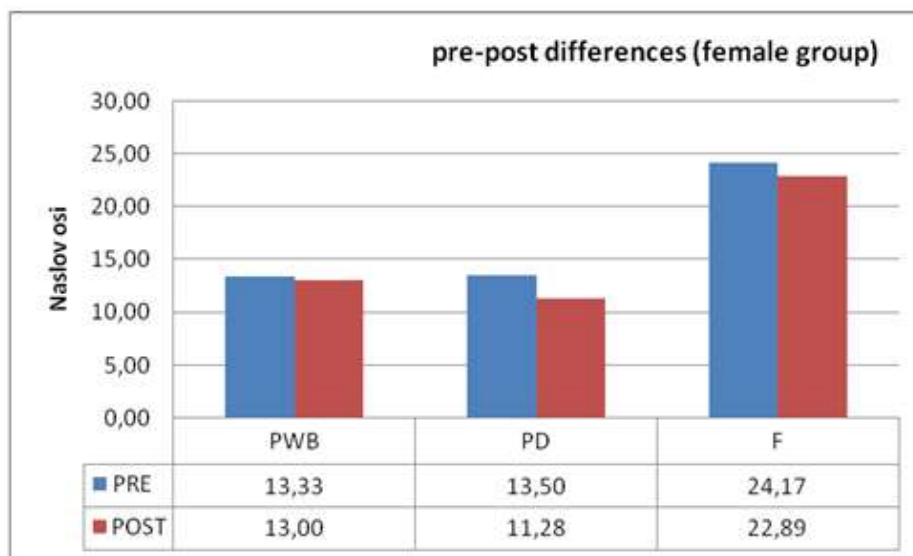
Not-increased Positive Well-Being among female students after activity is probably caused with extraordinary experience of Fatigue before and after training unit and significantly higher than male students.

Pronounces subjective experience of Fatigue among female student is an after effect of coeducation in university curricula and according to post interview, correlated with before investigation overload experience.

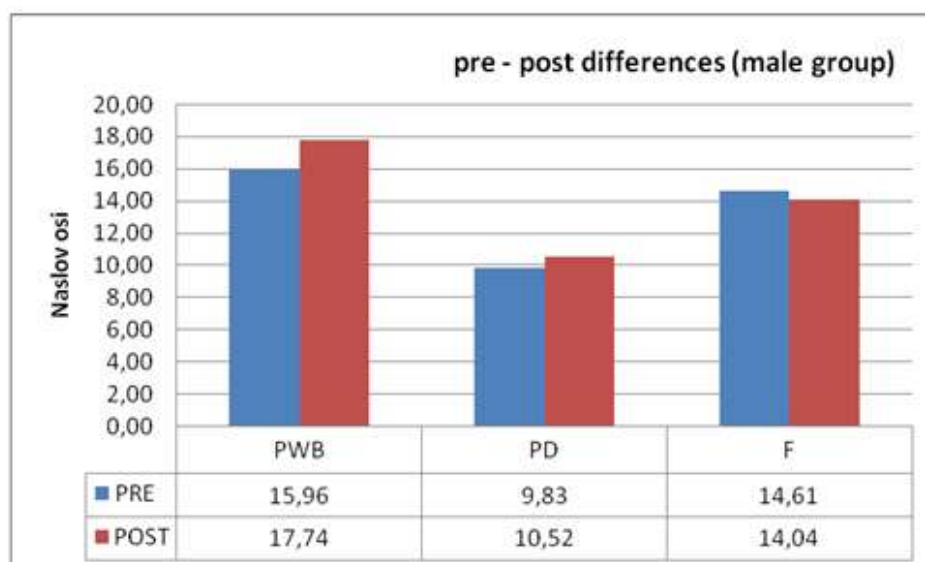
Table 1 Descriptive statistics and *Student t-test* (gender differences)

	Fatigue		Positive well – being		Psychological distress	
	PRE	POST	PRE	POST	PRE	POST
Female (N=18)	24.2±4.1**	22.9±5.2**	13.3±6.9	13.0±6.3*	13.5±7.5	11.3±6.9
Male (N=23)	14.6±6.3	14.0±4.9	16.0±5.9	17.7±5.2	9.8±5.9	10.5±6.9

Legend: PRE (before physical activity), POST (after physical activity)



Graph 1. *Student t-test* differences calculated before and after rhythm accompanying exercise in Fatigue (F), Positive well-being (PMB) and Psychological distress (PD) for females



Graph 2. *Student T-test* differences calculated before and after rhythm accompanying exercise in Fatigue (F), Positive well-being (PMB) and Psychological distress (PD) for males

Nevertheless, future investigation of self experience of fatigue should be accompanied with measurable variables for training load. Also, further investigations on children are needed to improve PE curricula with involving more obligatory aesthetic activities for both genders.

In conclusion, increasing of Positive Well-Being after rhythmic gymnastics activity suggested positive affect of rhythm accompanying exercise.

In spite of general opinion that male students did not enjoy rhythmic gymnastics classes, the results obtained suggested that it is possible that music and rhythm increased emotionally experienced activity and contributed to better physical well being.

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NEW MEDIA AND BREN D COMPONENTS AND STRATEGIES

UDC:658.8:316.472.4
(Original scientific paper)

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Abstract

Brand and branding as important management priorities relate to defining a clear identity, implementing a proper marketing program, market positioning, as well as maintaining and increasing its value. Relationship that brands have with people basically changed the process of digitization of the media. In this sense, mobile marketing primarily due to its unique characteristics (high response rate, availability anytime, anywhere and the relatively low price etc.) Influence marketers use the mobile phone in the marketing communication process. In this regard, implementing a successful marketing campaign is critical acceptance of the mobile device by consumers as a new way of thinking. For marketers failure to increase the engagement of users, to add value and ultimately increase their return on investment in marketing, it is essential that they understand the attitudes and intentions of customers to mobile marketing..

Key words: social media, m-marketing, sms marketing, advertising MMS

Introduction

One of the best definitions of a brand is from the Marty Neumeier's book, *The Brand Gap*: "A brand is a person's gut feeling about a product, service, or organization." Simple, right? And so it is much more than the logo on your business card. Brand is the "sum total" of all of the experiences, impressions, and knowledge a person has about your product, service, or organization. It is really about the perceived emotional and functional benefits (that gut reaction) vs. the actual benefits or attributes of your product or service. If you are in business and have customers, you already have a brand of sorts, even if you are not very clear about what it stands for and even if you are not working to define and shape it in the eyes of your customers. A brand is the basis of your position in the market and your competitive advantage (Gistbrands, 2016). Brand strategy is a long-term plan for development of a successful brand in order to achieve specific goals. First, let's clear up the biggest misconception about brand strategy: Your brand is not your product, your logo, your website, or your name. In fact, your brand is much more than that – it is the stuff that feels intangible. But it is that hard-to-pin-down feeling that separates powerhouse and mediocre brands from each other. So to help you rein in what many marketers consider more of an art and less of a science, we have broken down seven essential components of a comprehensive brand strategy that will help keep your company around for ages. For comprehensive branding strategy seven components are important (Hubspot, 2016):

1) Purpose - "Every brand makes a promise. But in a marketplace in which consumer confidence is low and budgetary vigilance is high, it is not just making a promise that separates one brand from another, but having a defining purpose," (Forbes, 2009). While understanding what is necessary for your business promises when defining your brand positioning, knowing *why* you wake up everyday and go to work carries more weight. In other words, your purpose is more specific, i.e it serves as a differentiator between you and your competitors (Hubspot, 2016).

According to business strategy insider, purpose can be viewed in two ways (Branding strategy insider, 2014):

(a) Functional: This concept focuses on the evaluations of success in terms of immediate and commercial reasons -- i.e. the purpose of the business is to make money.

(b) Intentional: This concept focuses on success as it relates to the ability to make money and do good in the world.

2) Consistency - The key to consistency is to avoid talking about things that don't relate to or enhance your brand. Added a new photo to your business' Facebook Page? What does it mean for your company? Does it align with your message, or was it just something funny that would, quite frankly, confuse your audience? In an effort to give your brand a platform to stand on, you need to be sure that all of your messaging is cohesive. Ultimately, consistency contributes to brand recognition, which fuels customer loyalty. To see a great example of consistency, let's look at Coca Cola. As a result of their commitment to consistency, every element of their marketing works harmoniously together. This has helped them become one of the most recognizable brands in the world.

3) Emotion - Customers are not always rational. How else do you explain the person who paid thousands of dollars more for a Harley rather than buying another cheaper, equally well-made bike? There was an emotional voice in there somewhere, whispering: "*Buy a Harley.*" But why? Harley Davidson uses emotional branding by creating a community around their brand. They began HOG - Harley Owners Group - to connect their customers with their brand (and each other).

4) Flexibility - In this fast-changing world, marketers must remain flexible to stay relevant. On the plus side, this frees you to be creative with your campaigns. You may be thinking, *Wait a minute, how am I supposed to remain consistent while also being flexible?* Good question. While consistency aims to set the standard for your brand, flexibility enables you to make adjustments that build interest and distinguish your approach from that of your competition. In other words, "effective identity programs require enough consistency to be identifiable, but enough variation to keep things fresh and human."

5) Employee Involvement - As we mentioned before, achieving a sense of consistency is important if you wish to build brand recognition. And while a style guide can help you achieve a cohesive digital experience, it is equally important for your employees to be well versed in the way they should be communicating with customers and representing the brand. If your brand is playful and bubbly through Twitter engagements, then it wouldn't make sense if a customer called in and was connected with a grumpy, monotone representative, right?

6) Loyalty - If you already have people that love you, your company, and your brand, don't just sit there. Reward them for that love. These customers have gone out their way to write about you, to tell their friends about you, and to act as your brand ambassadors. Cultivating loyalty from these people early on will yield more returning customers - and more profit for your business. Sometimes, just a thank you is all that's needed. Other times, it's better to go above and beyond. Write them a personalized letter. Send them some special swag. Ask them to write a review, and feature them prominently on your website. (Or all of the above!)

Social media has exploded as a category of online discourse where people create content, share it, bookmark it and network at a prodigious rate. Examples include Facebook, MySpace, Digg, Twitter and JISC listserv on the academic side. Because of its ease of use, speed and reach, social media is fast changing the public discourse in society and setting trends and agendas in topics that range from the environment and politics to technology and the entertainment industry. Since social media can also be construed as a form of collective wisdom, we decided to investigate its power at predicting real-world outcomes. Surprisingly, we discovered that the chatter of a community can indeed be used to make quantitative predictions that outperform those of artificial markets. These information markets generally involve the trading of state-contingent securities, and if large enough and properly designed, they are usually more accurate than other techniques for extracting diffuse information, such as surveys and opinions polls. Specifically, the prices in these markets have been shown to have strong correlations with observed outcome frequencies, and thus are good indicators of future outcomes. (Arxiv, 2010).

New media offer the possibility of unlimited and constant interaction through which users can create, share and exchange content, and in terms of the brands, they are the starting point for a new era in personal interaction and contribute to the transparency of the companies (Mangold and Faulds 2009). New media occur in various forms (Buzzle, 2012): Internet, podcasts, e-books, blogs, Internet TV, e-mail, mobile phones and so on. In the process of branding used different types of m-marketing communication tools, but hereinafter will be analyzed applying (Unique Content Solution, 2013): SMS marketing and advertising MMS and Push notifications (Push Notifications). Social media are computer-mediated tools that allow people or companies to create, share, or exchange information, career interests, (Buettner, 2016) ideas, and pictures/ videos in virtual communities and networks.

The variety of stand-alone and built-in social media services currently available introduces challenges of definition; however, there are some common features (Obar, Jonathan A.; Wildman, Steve (2015):

- (1) social media are Web 2.0 internet-based applications,
- (2) user-generated content (UGC) is the lifeblood of the social media organism,
- (3) users create service-specific profiles for the site or app that are designed and maintained by the social media organization, and
- (4) social media facilitate the development of online social networks by connecting a user's profile with those of other individuals and/or groups.

Social media depend on mobile and web-based technologies to create highly interactive platforms through which individuals and communities share, co-create, discuss, and modify user-generated content. They introduce substantial and pervasive changes to communication between businesses, organizations, communities, and individuals. (Kietzmann, Jan; Kristopher Hermkens, 2011). These changes are the focus of the emerging field of technoself studies. Social media differ from traditional or industrial media in many ways, including reach, frequency, usability, immediacy, and permanence. Social media operate in a dialogic transmission system (many sources to many receivers). (Pavlik & MacIntoch, John and Shawn, 2015). This is in contrast to traditional media that operates under a monologic transmission model (one source to many receivers).

1. SMS is highly effective for reaching out to customers. SMS messages are likely to be opened within just five minutes of being received. This makes SMS great for appointment reminders, limited time contests and coupon promotions. SMS marketing is the sending of short messages to mobile phones of potential customers. SMS messages are easy to understand and accessible to nearly everyone who owns a mobile phone. That is why, appear as the ultimate channel for the introduction of mobile consumers in the brand program. The contents of messages can be addressed to a specific offer, promotional code, certain news, a link to a particular website, etc. The effectiveness of SMS marketing is conditioned by the existence of a mobile website where customers right from their mobile device may access (Pitney Bowes, 2015). SMS offer marketers a channel not only to start a conversation with customers, but also to get additional information about their views and opinions. Text communication can be divided into three mobile levels: informative, promotional and relationship management with customers. All three levels have an important role for the further continuation of the conversation with the client (Ohe next web, 2013). Now that we have background on why SMS marketing is so powerful let's take a look at some statistics regarding this marketing stream before we dive into how to get started. (95% of text messages are read within the first 5 minutes; 70% of Americans would like to receive offers from their favorite businesses right on their cell phones; the average Americans look at their cell phone 150 times per day, 2% of text messages with value are forwarded on to friends and family; 22% of text messages with value are forwarded on to friends and family; the average redemption rate for a mobile coupon is 20%. (Slicktext, 2016) According to research by eMarketer and ComScore still the largest number of respondents, 78%, its smart phone used to send text messages, 54% use it to download applications, 53% used a search engine, 39% accessed the social network or blog 33% played a game and 28% listened to music. (Ohe next web, 2013). According to research conducted by SlickText, in the UK almost 99% of respondents read the text SMS messages on their phones in the first 5 minutes after you get with an average response time of 90 seconds (SlickText, 2013).

In the Republic of Macedonia, in terms of SMS marketing, T-Mobile Macedonia offers instant viewing service which allows interested customers to send promotional messages and special offers incentives to users who have consented to receive this kind of information (T-Mobile, 2013). Users of T-Mobile are registered Instant info for getting advertising messages (via SMS, MMS, e-mail and call) to determine their interests and who would like to be informed, such as: sports, fashion, cars, food, nightlife, etc. Unlike T-Mobile, Mobigo as SMS marketing company in the country offers a slightly different service. Namely, while T-Mobile customers choose a category of interest in Mobigo consumers can choose brands they want to receive notifications on. For this service, users subscribe to each brand separately, by sending an SMS registration (which cost 5 day + 18% VAT once). By sending an SMS to receive regular discounts and promotions from selected brand in T-Mobile, this service is completely free of charge.

SMS is 160 characters of plain text. Now, that text can be text, a phone number, even a link, but it has to be plain text. MMS on the other hand, multimedia messaging service, again, just if you forgot, MMS is a lot of different things. You can put pictures. You can put video. Also, a lot of people don't realize that in an MMS you can also put text. One of the cool things about MMS is that text is unlimited. Instead of 160 characters, you can use as many characters as you want with an MMS message. SMS - short messaging service. Say that six times fast. MMS - multimedia messaging service. Say that six times fast is even worse. Multimedia is obviously one word, that's why there's one M.

2. Multimedia Messaging Service (MMS) - is a communications technology developed by 3GPP (Third Generation Partnership Project) that allows users to exchange multimedia communications between capable mobile phones and other devices. An extension to the Short Message Service (SMS) protocol, MMS defines a way to send and receive, almost instantaneously, wireless messages that include images, audio, and video clips in addition to text. When the technology has been fully developed, it will support the transmission of streaming video. A common current application of MMS messaging is picture messaging (the use of camera phones to take photos for immediate delivery to a mobile recipient). Other possibilities include animations and graphic presentations of stock quotes, sports news, and weather reports. (Searchmobile computing, 2016). The first step is for the sending device to encode the multimedia content in a fashion similar to sending a MIME message (MIME content formats are defined in the MMS Message Encapsulation specification). The message is then forwarded to the carrier's MMS store and forward server, known as the MMSC (Multimedia Messaging Service Centre). If the receiver is on a carrier different from the sender, then the MMSC acts as a relay, and forwards the message to the MMSC of the recipient's carrier using the internet. Once the recipient's MMSC has received a message, it first determines whether the receiver's handset is "MMS capable", that it supports the standards for receiving MMS. If so, the content is extracted and sent to a temporary storage server with an HTTP front-end. An SMS "control message" containing the URL of the content is then sent to the recipient's handset to trigger the receiver's WAP browser to open and receive the content from the embedded URL. Several other messages are exchanged to indicate the status of the delivery attempt. Before delivering content, some MMSCs also include a conversion service that will attempt to modify the multimedia content into a format suitable for the receiver. This is known as "content adaptation". (En.Wikipedia, 2016). MMS messages are often in the form of slides, so that multimedia purposes are divided into sequences and broadcast by the script and the timing of the publisher. MMS interactive marketing is a form of advertising, where creativity plays a very important role, because this way marketers can send more creative and personalized messages (Becker and Arnold, 2010, p. 25), where:

- Recounting the story with interesting pictures, sound and video to delight, entertain, inform and engage potential customers.
- Integrating links to mobile websites in messages to the service secretaries interactive voice (IVR call services), applications and other outlets, the viewers can get more information.
- Offering attractive coupons with images, sound and video.

The difference though for SMS marketing is that MMS is much more expensive than SMS. So when you are looking at your next SMS or MMS marketing campaign, you have to look at, do you want to send pictures, video, and maybe even longer text than 160 characters, and if so, you are going to pay premium for that, or are you okay with sending 160 characters?

3. Push notifications (Push Notifications) - Push notifications allow companies to send personally tailored and timed messages to deployed many customers or less targeted, depending on the message you want to convey. Thus customers can be categorized according to their location, device they use, or their level of commitment. In terms of marketing, push notifications are a good tool for creating brand awareness of and contact with customers. (Unique Content Solution, 2013). Push notification is a feature that allows an application to notify mobile phone users about new messages or events without the need to open the application. Incoming message can be received even for applications that are not currently open. In this regard push notifications are similar to text messages that appear on the phone screen (Warpily, 2013). This method was originally presented to the iPhone (iPhone) in 2007, and later more phones on the Android platform. The most effective part of this type of mobile advertising is that it is cheaper than other techniques for mobile advertising and causing no interruption of existing active applications on the user's phone.

Research Methodology

For the purpose of this paper we used mainly secondary data sources - modern literature in the field of marketing, domestic literature relating to various aspects of explaining consumer behavior and marketing other domestic and foreign specialized magazines, reports, newsletters and publications governmental and non-governmental organizations, data, obtained by the Search Tools on the Internet (current world news and knowledge). For the purpose of this paper was conducted quantitative, descriptive research. The purpose of this research is by analyzing the habits of using mobile devices to determine the attitudes of users of smartphones for mobile marketing in the country.

The survey was conducted using the on line questionnaire, made and distributed only to the users using smartphones in the period October-December 2015. The survey covered 510 respondents. The survey was conducted by the method of testing undisguised structured questionnaire. The questionnaire consisted of fifteen questions and most of the questions are structured closed. In the initial part of the survey focus was on basic demographic data (sex and age). The next questions are related to activities that most respondents use the smartphone as well as preferences for activities for which users often use smart phones. Further explanation will be made on a more detailed review of the issues.

Analysis of survey results

According to the analysis, the survey included 510 respondents, and the further processing is excluded questionnaires from 30 respondents because of the non-relevance of the answers. Of the other 480 respondents, 40.5% were male and 59.5% were female.

Figure 1. Respondents (male/female)

Source: Own research October - December 2015

Most of the respondents in this study were aged 28 to 38 years, 52.4%. The age category of respondents 18 to 28 represent 31.6% of respondents, age category of 38 to 48 represent 14.5% and quite insignificant portion of respondents representing 1.5% of the age group above 48 years.

Figure 2. Age category of respondents

Source: Own research October - December 2015

According to the survey, respondents most often used their smartphones to make calls 51%, then to check the social networks 42%, the third ranked search the Internet with 4.1% and ranked fourth among other activities 29% of respondents (eg., photography, listening to music, downloading mobile applications, reading news, etc.).

Figure 3. Smartphones most often used by respondents

Source: Own research October - December 2015

The survey results show that very few of the respondents their smart phones use them to buy 4.7% (mostly buy tickets for trips, sports equipment, bookings in hotels, etc.), against a 95.3% percentage of respondents do not purchase through their smartphones, they usually buy, respondents said they made purchase through their smart phones.

Figure 4. Buying via Smartphone

Source: Own research October - December 2015

According to the survey, most respondents 42.1% are neutral on that web pages they visit are optimized for mobile devices. However, many of them 32.9% agree with this statement, while the percentage of those who disagree with this statement is 17.0%, a small percentage of those who strongly agree 4.1%, and strongly disagree 2.9% of respondents.

Most of the respondents included in the survey do not receive and would like to receive Push notifications for their favorite brands 52.1%. Of the other respondents 20.6% receive and wish to continue to receive push notifications; 14.3% of respondents did not receive such messages, but would like to receive, while 13% receive push notifications about brands, but do not want to receive.

Figure 5. Push notifications brands

Source: Own research October - December 2015

Research has shown that most of the respondents (52.6%) do not want to receive messages on their smart phones. Many of the respondents (31.4%) want to receive only one message per day, 2-3 messages per day wish to receive 10.1% of respondents, 3-5 messages per day are interested to receive 5% of respondents and more than 5 messages per day wish to receive only 1.4% of respondents.

Figure 6. Number of received messages

Source: Own research October - December 2015

Most of the respondents included in the survey do not receive and would like to receive Push notifications for their favorite brands 52.1%.

Of the other respondents 20.6% receive and wish to continue to receive push notifications; 14.3% of respondents did not receive such messages, but would like to receive, while 13% receive push notifications about brands, but do not want to receive.

Figure 7. Push notifications/receive/not receive

Source: Own research October - December 2015

According to the survey, most respondents 42.1% are neutral on that web pages you visit are optimized for mobile devices.

However, many of them 32.9% agree with this statement, while the percentage of those who disagree with this statement is 17.0%. There is a small percentage of those who strongly agree (4.1%), while strongly disagree 2.9% of respondents.

According to the survey responses to advertising messages they receive, most of the respondents (63.2%) occasionally read advertisements that are posted on their smartphones, 35.4% do not read these messages, but only 1.4% of respondents read the messages immediately after receiving.

Figure 8. Response to the received advertisements

Source: Own research October - December 2015

Mobile marketing offers wide opportunities and ways of targeting consumers, especially when talking about targeted advertising, in the Republic of Macedonia because already there are companies that provide this service. This is one more reason for Macedonian companies that have not yet optimized websites for mobile devices to do so in 2016. The skepticism among companies about this innovative approach must be overcome through education and information about the benefits of this kind of advertising.

Conclusion

Given the results of the research in this paper, we can draw the following conclusions:

- Most often respondents used their smartphones to make calls, then to check social networks and third ranked search online. Very few of the respondents use their smart phones to buy, and a much higher percentage (95.3%) of those who do not purchase through their smart phones.
- According to the survey, most respondents 42.1% are neutral on that web pages you visit are optimized for mobile devices. However, many of them (32.9%) agree with this statement, while the percentage of those who disagree with this statement is 17.0%. A small percentage of those who strongly agree (4.1%) and strongly disagree (2.9%) claim that websites are optimized for mobile devices.
- The majority of respondents included in the survey do not want to receive Push notifications for their favorite brands 52.1%. Of the other respondents 20.6% receive and wish to continue to receive push notifications; 14.3% of respondents did not receive such messages, but would like to receive, while 13% receive push notifications about brands, but do not want to receive.
- The majority of respondents (52.6%) do not want to receive advertising messages on their smartphones. Much of 31.4% of the respondents do not want to receive more than one message per day, while two messages a day wish to receive 10.1% of respondents. The percentage of those wishing to receive three messages per day is 4.5%, while a very small percentage of 1.4% is for those who want to receive over four messages a day.
- The majority of respondents (61.2%) occasionally read advertisements that are posted on their smartphones. Much of the respondents (25.4%) completely ignore these messages, while 10.1% of respondents read advertising messages when they have time. A very small percentage of 2.1% of respondents read advertising messages while there are only 1.2% of respondents that read the messages immediately.

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COMPARISON OF THE EFFECTIVENESS OF THE DIAGONAL STRIDE CROSS-COUNTRY SKIING TECHNIQUE AND THE DOUBLE POLE CROSS-COUNTRY SKIING TECHNIQUE

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(Original scientific paper)

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Abstract

The objective of this research was to compare the diagonal stride and the double pole cross-country skiing techniques. The two chosen techniques are the alternatives used by professional cross-country skiers. The methodology was formed so that we would be able to compare altogether the 26 measurements undergone by the 7 subjects. In order to determine the significance of the differences between lactate levels after finishing the section by means of the diagonal stride and by means of double pole cross-country skiing, the Paired-Samples T Test (t , $\alpha = 0.05$) was used. For the calculation of the effect size, we used Cohen's d coefficient. The statistical analysis was carried out IBM® SPSS® Statistics V19 software. We found the statistically and materially significant differences between the average lactate values one minute after finishing the section. After the section was completed in the diagonal stride manner, 10.24 mmol.l-1 values were measured, whereas by using the double pole technique, the lactate level was 7.75 mmol.l-1, which confirmed both the statistically and materially significant differences ($p < 0.05$, or Cohen's $d = 2.15$ ($r = 0.73$)). However, we did not find any materially or statistically significant differences in the time results. Our research shows that at the comparable speed of the racer, from the point of view of energy coverage, the double pole technique seems to be more effective.

Key words: *Diagonal Stride Cross-Country Skiing Technique, Double Pole Cross-Country Skiing Technique*

Introduction

Although being a traditional ski discipline, cross-country skiing has been undergoing dynamic changes in recent years. New materials, different trail grooming and new technologies have been changing the character of this sport.

These changes have directly resulted in the higher speed of the racers on the trail, also relatively reduced by the trail profile. This fact is reflected in the competitions where the double pole technique has been increasingly given priority, since today's reality allows applying this running technique on almost any trail profile. It is no longer impossible for a racer to win the cross-country world cup in the classic style using the complete ski-skating style equipment, only applying the double pole technique. Similarly, it is a common practice that the world cup racers are choosing this running technique for a classic sprint race or winning long-distance competitions on 50 to 90km using only their upper body. For these reasons and due to the incoming "double pole trend", we have decided to compare these two cross-country skiing techniques under the VEGA 1/0414/15 grant. The objective was to classify classic cross-country skiing into the diagonal stride technique and the double pole technique as well as to compare their metabolic effects on the body. Clearly, if locomotion using just one's arms is to be designated as *running*, it may sound contradictory. It is also interesting to note the comparison of the time results between the two techniques and the fact that the research took place in the real racing trails conditions. The facts already mentioned above set a completely new trend for cross-country skiing and need to be addressed.

Motion characteristics of cross-country skiing

“There are only a few endurance sports events where the level of technical and motor performance has a comparable limiting impact on overall performance as it is in the case of the cross-country skiing” (Ilavský, Suk, 2005, p. 56).

All body muscles are actively involved in the motion, which radically increases fitness and coordination demands and thus the effect on the body as well. Therefore, the choice of the practical and effective technique is to play a key role. Confirming these facts, Ilavský (2000) states that the functional demands of cross-country skiing derive from the fact that practically all muscles are involved in the motion.

Classic cross-country skiing style

This notion covers the diagonal stride technique, the one-step double pole technique and the double pole technique. “In the classic cross-country skiing style, the choice of the means of running depend on the ground profile, snow conditions and physical as well as technical levels of the runner” (Bolek et al., 2008, p. 101).

Double Pole Cross-country Skiing Style

In the double pole running style, only the upper body is primarily involved, which is the main difference between this technique and the diagonal stride and the one-step double pole techniques. To a great extent, the arm, back and abdominal muscles are involved in the work.

The reason why racers prefer this running style for a wide spectrum of events is the fact that grip wax is not necessary to propel the skis and thus they glide faster.

In the case of cross-country skiers the load intensity is above the level of the anaerobic threshold (AT). Generally, the blood lactate concentration level at 4 mmol.l⁻¹ is considered to be the AT (Hamar, 1997; Pupiš, 2005); however, different authors (Saltin et al. 1995; Kučera & Truksa, 2000; Soumar, Soulek & Kučera, 2006) point out to the fact that the level is considerably lower in the case of endurance skiers (approximately 3.3 mmol.l⁻¹) whereas in the case of 800m and 1,500m athletic runners, the value is significantly higher (as high as 5.5 mmol.l⁻¹). Bielik et al. (2006) admits higher values in the case of athletes' endurance as well. Certainly, the skier's movement is of a dynamic character, which has to be considered during training as well, because the standard endurance trainings of an anaerobic character may limit the movement dynamics (Brodžani 2002; Czaková, 2011, 2013; Pupišová, 2013, 2014).

Methodology

Our cross-country research involved 7 subjects. The research lasted one week. The measurements were taken on the official tracks at Skalka pri Kremnici with an altitude of 1,248 masl. We chose a racing circuit with a 41m height difference and the length of 1.400m, thus creating ideal conditions for our research.

The measurements took place as follows: two to three sections at the maximum effort with a break interval of 25min between the sections. The first experimental group ran in the diagonal stride technique at first and then shifted to the double pole technique. The second experimental group ran in reverse order so as to show how the order of the chosen techniques might influence the results. Subsequently, we changed the order of techniques again in the last test. Before the measurements, we had integrated a 4-min special load at the level of the anaerobic threshold.

The double pole technique was carried out with the skate-skiing equipment. Faster skis and longer poles provided us with all the real benefits of using this technique in practice.

The lactate level in the capillary blood was assessed through the Biosen C-line Clinic analyzer. The blood samples were obtained from a finger one minute after finishing the section.

Data Analyses

We chose the following descriptive statistics characteristics – for measurements of central tendency we used the arithmetic mean (\bar{x}) and for measures of variability the standard deviation (SD). We used also minimal (min) and maximal (max) value of individual's parameters. The Paired-Samples T test was used to establish the significance of the differences of lactate level after 1400 m long race of diagonal stride skiing technique and double pole skiing technique. The normality of the distribution of each indicator was determined through the Shapiro-Wilk test. In all statistical analyses, the rate of the type I error (α) was set at 0.05. The effect size of the means of each indicator was determined by Cohen's coefficient d ,

calculated as follows: $d = |M|/SD$, where M is the mean of differences, and SD is the standard deviation of differences (Yatani, 2014). The coefficient d was interpreted as follows: $d = 0.20$ – small effect, $d = 0.50$ – medium effect, $d = 0.80$ – large effect (Cohen, 1988). The statistical analysis was carried out by IBM® SPSS® Statistics V19 software (Statistical Package for Social Sciences) (Vančová et.al, 2015 a,b).

Research Results

During three sets of tests (26 comparative measurements of time results on the 1,400m long racing section and the capillary blood drawing for the purpose of assessing the lactate level in the capillary blood), we recorded statistically significant differences in the average lactate concentration one minute after finishing the section ($p < 0.05$). As we can see in Table 1, lactate values are significantly lower in the case of the double pole technique not only in the statistical values, but also in the absolute values in comparison to the diagonal stride technique. The value after finishing the section by means of the diagonal stride technique averaged $10.24 \text{ mmol.l}^{-1}$, while for the double pole technique, the figure was only 7.75 mmol.l^{-1} (the difference 2.49 mmol.l^{-1} , $p < 0.05$). In the case of this particular indicator, we recorded materially significant differences as well, when Cohen's $d = 2.15$ ($r = 0.73$) and thus the values differed considerably after the section carried out with the double pole technique in comparison with the values after the section in the diagonal stride technique. In the case of the other data, we did not record any statistically or materially significant differences in the values of the lactate concentration after finishing the section by means of the diagonal stride or double pole technique.

Table 1 Comparison of Diagonal stride skiing technique and Double pole skiing technique

	Diagonal stride skiing technique	Double pole skiing technique
Lactate average (mmol.l^{-1})	10.24	7.75*
Lactate minimum (mmol.l^{-1})	7.4	5.0
Lactate maximum (mmol.l^{-1})	12.9	9.7
Lactate SD	1.36	0.91
Time average (min)	4:30.2	4:32.4
Time minimum (min)	4:08.3	4:08.1
Time maximum (min)	4:59.2	4:58.9
Time SD	19.3	14.8

* – significant difference (average lactate level) $p < 0.05$

Despite this fact, when performing the empirical assessment, we can see the differences in the measured values. We measured the difference of 2.49 mmol.l^{-1} in the average values of the lactate level, whereas the comparison of the minimal values revealed the difference of 2.4 mmol.l^{-1} for the benefit of the double pole technique. A similar trend is also visible in the maximal values which, in the case of the diagonal stride technique, reached as much as 12.9 mmol.l^{-1} , while for the double pole technique, the figure was 9.7 mmol.l^{-1} (thus, the difference was 3.2 mmol.l^{-1} , once more for the benefit of the double pole technique). Similarly, we assessed the time results reached by the skiers on the individual 1,400m sections carried out in the double pole or diagonal stride techniques. Again, there were no statistically or materially significant differences. The average time result in the diagonal stride technique was 4:30.2 min; in the case of the double pole technique, the time was 4:32.4 min, which means that the difference was 2.2 sec for the benefit of the diagonal stride technique. Among the 26 measurements, the best time result recorded was 4:08.1 min, reached by using the double pole technique, while the diagonal stride technique choice caused just a 0.2 sec slower performance. In a similar way, we recorded the insignificant difference in the case of the slowest performances when the slowest time was 4:59.2 min by using the diagonal stride and 4:58.9 min by means of the double pole technique, thus with a difference of 0.3 s for the benefit of the double pole technique. As already mentioned, none of these differences was statistically or materially significant.

The current trend in cross-country skiing has proven to be right from the point of view that the double pole cross-country skiing activates small muscles groups, which is a prerequisite for lower lactic acid production and related lactate accumulation. During the research all our subjects claimed that they subjectively perceived the double pole technique as a more demanding one. This feeling can be connected with the fact that the athlete may find this technique more intensive since from the point of view of subjective perception, the shoulder girdle muscles are dominantly involved, which can be perceived as more strenuous.

Conclusions and Recommendations

The research established higher values of “the lactate response” when opting for the diagonal stride cross-country skiing technique. Although the double pole technique was subjectively more strenuous, the objective load-intensity indicators proved the opposite.

The choice of the double pole technique in practice is very specific. We have to consider whether the trail profile and snow conditions are to be the advantage for choosing the double pole technique and also if the racer’s strength and state of mind is sufficiently prepared to manage such a strenuous choice. The knowledge gained indicates that it is inevitable to regularly implement a training focused on the use of the double pole technique already for young runners, as we see a substantial difference in the movement structure between the diagonal stride and the double pole techniques. According to the research results, if one set of muscle group is dominantly involved, the metabolic response is lower, being a prerequisite for more economical movement execution.

This was the key and winning choice already made in many cases; therefore for the racers’ training, we recommend focusing on the double pole technique development as well as the use of specific means and methods for special strength development.

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ACTN3 GENOTYPE AND ISOKINETIC CHARACTERISTICS OF THE KNEES OF SOCCER PLAYERS U17

UDC:796.332.012.11-053.6

(Original scientific paper)

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Abstract

The aims of this study are to determine the ACTN3 genotype and isokinetic characteristics of the knees of soccer players U17. Material and methods: 27 soccer players, aged 16-17 years, were included in this study. The examination was conducted in two days in PZU Kineticus. We determined the ACTN3 genotype from abstracted genomic DNA (RR –speedy muscle fibers, XX-endurance muscle fibers and RX variant – mixed muscle fibers) with taking venous blood and its distribution according with player position. We measured the peak TQ/BW, AG/ANT (H/Q) and deficits in flexion and extension of both knees with isokinetic test on Biodex Pro 4, according with player position. We used descriptive statistics and correlations ($p < 0.05$). Results: The most frequent variant of ACTN3 genotype was RR variant (48,3%), than RX (30%) and XX (26%). The RR variant was mostly represented (57%) in middlefield players and XX variant (37%) in forwards. 59% of players were with insignificant and 41% with significant differences in flexion and extension of both knees, especially in forwards. H/Q of right knee, especially of defenders (67,73%), were above normal values. Discussion: ACTN3 genotype profile could help in process of selection and specialization of young soccer players, suggesting that RR variant of ACTN3 genotype should be mostly presented in forwards. The high H/Q in right knee and mostly represented deficits in flexion of left knee suggested a new strategy and changes in strength training of young soccer players. Conclusions: The distribution of ACTN3 genotype in soccer players was according with the data from the literature, with surprisingly high XX variant in forward players. H/Q of right knee, especially in defenders, was above normal values. The forwards were with the most significant differences between the knees. The most frequent deficits were in flexion, especially in left knee.

Key words: ACTN3 genotype, isokinetic characteristics, soccer players, aged 16-17 years

Introduction

ACTN3 genotype profile could help in process of selection and specialization of young soccer players (1). The most wanted variant is RR variant of ACTN3 genotype. Santiago et al. presented the most relevant study of ACTN3 genotype profile in soccer players of Primera league (10). There are no relevant data about this genotype in younger soccer players.

On the other side, there are relevant studies about isokinetic characteristics of knees of younger soccer players (2,4,5).

The aims of this study are to determine the ACTN3 genotype and isokinetic characteristics of the knees of soccer players U17 of our National team.

Material & methods

We recruited 27 soccer players, aged 16-17 years, from U17, in this study. The study is cross-sectional one, conducted in two days in PZU Kineticus.

We determined the α -actin – 3(ACTN3) R5677X genotype from abstracted genomic DNA (RR, XX and RX variant) with taking venous blood and its distribution according with player position (goalkeeper, defenders, forwards and midfielders).

After a warming up on bicycle for 10 minutes and stretching of quadriceps and hamstrings, we made a isokinetic test on Biodex pro 4 of both knees on 60,180 and 300 deg/sec. We measured the peak TQ/BW

(%), AG/ANT (H/Q %) and deficits in flexion and extension of both knees on 60 deg/sec, according to the player position.

We used descriptive statistics, t test and correlations ($p < 0.05$).

Results

The distribution of frequency of ACTN3 genotype in soccer players, U17, is presented on Fig.1. The RR variant of genotype is the most presented (44%) between soccer players U17.

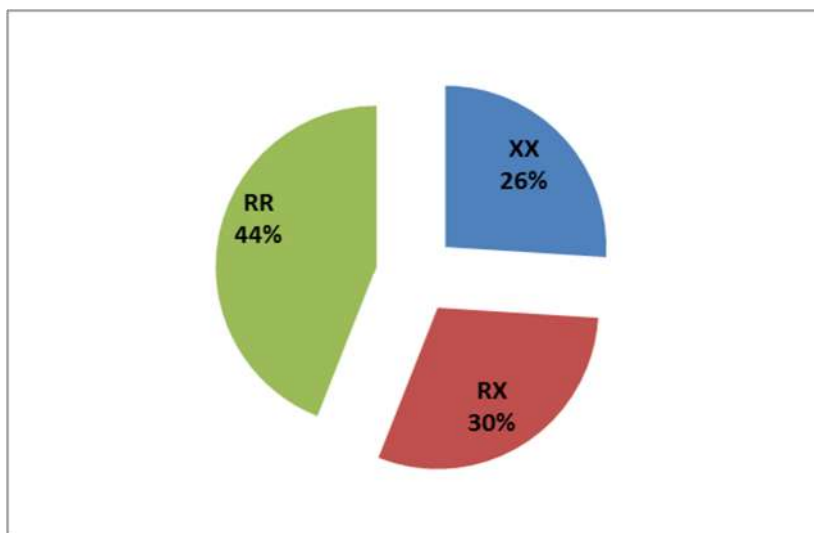


Fig.1 Distribution of frequency of α -actin – 3 (ACTN3) R577X genotype in soccer players, U17.

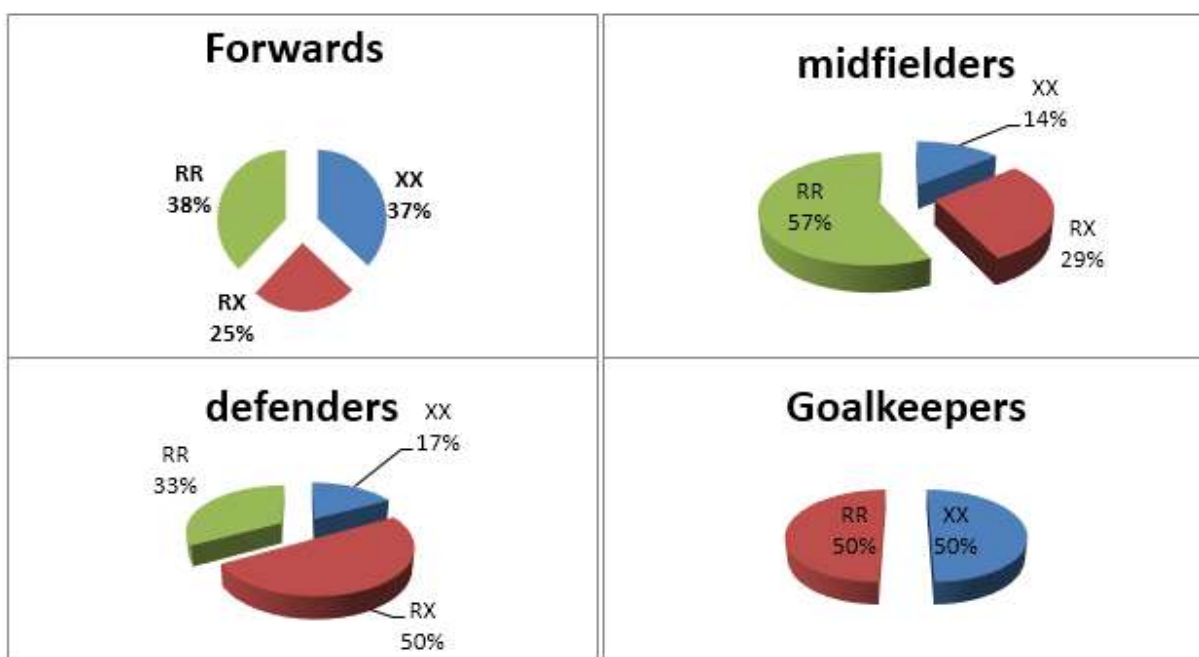


Fig.2 Distribution of frequency of α -actin – 3 (ACTN3) R577X genotype according to the position of the players in soccer players, U17.

Peak TQ/BW of extension and flexion of soccer players U17 are presented on Fig.3. There are no significant differences (n.s) between right and left knee in flexion and extension.

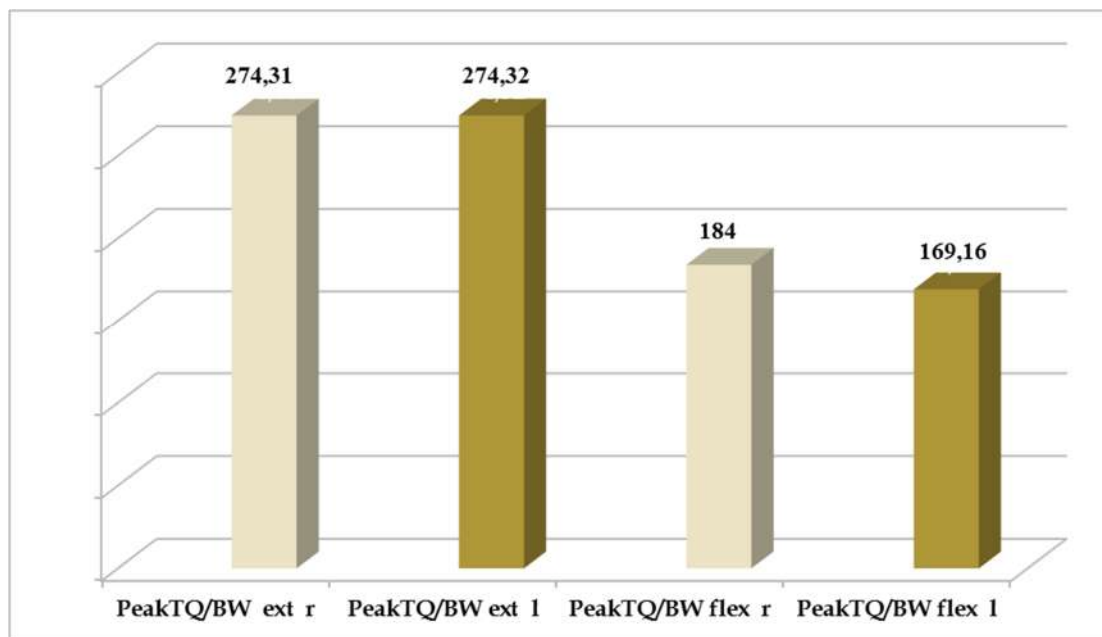


Fig.3 Peak TQ/BW of extension and felxion in both knees of soccer plyers U17.

PeakTQ/BW of extension and flexion of soccer players U17 according to the situation of the player are presented on Fig.4. There are no significant differences (n.s) between right and left knee in flexion and extension according with the position of the player.

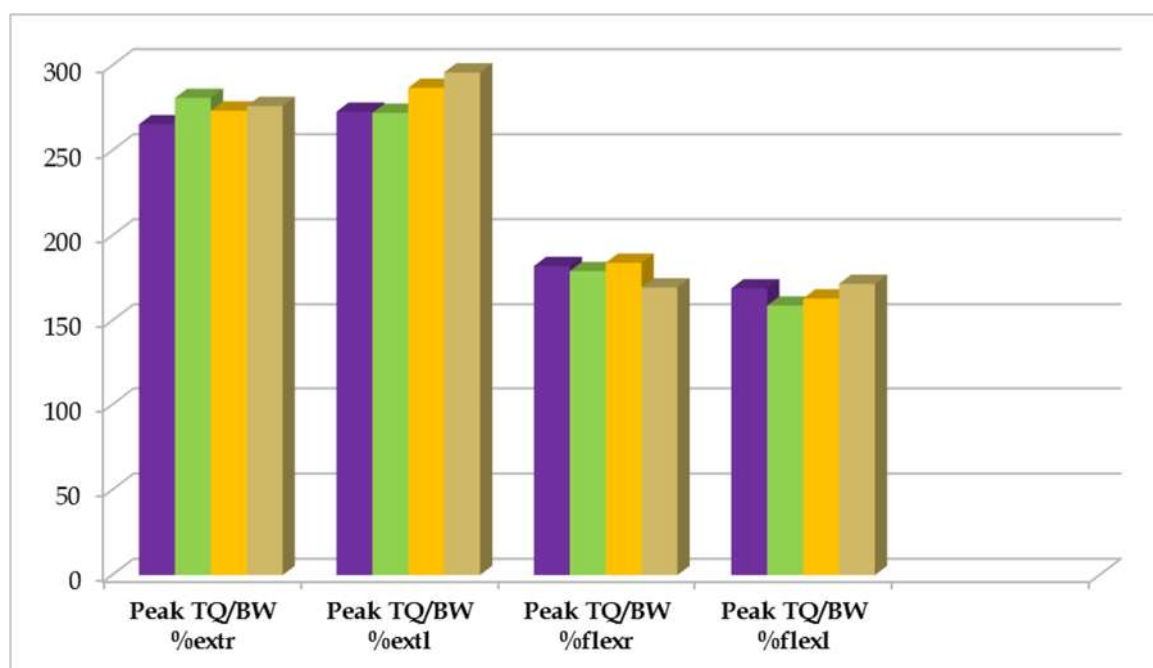


Fig.4 PeakTQ/BW of extension and felxion in both knees of soccer players U17 according to the position of the player.

H/Q (AG/AnT) in both knees of soccer players U17 are presented in Fig.5. There are no significant differences of H/Q between knees.

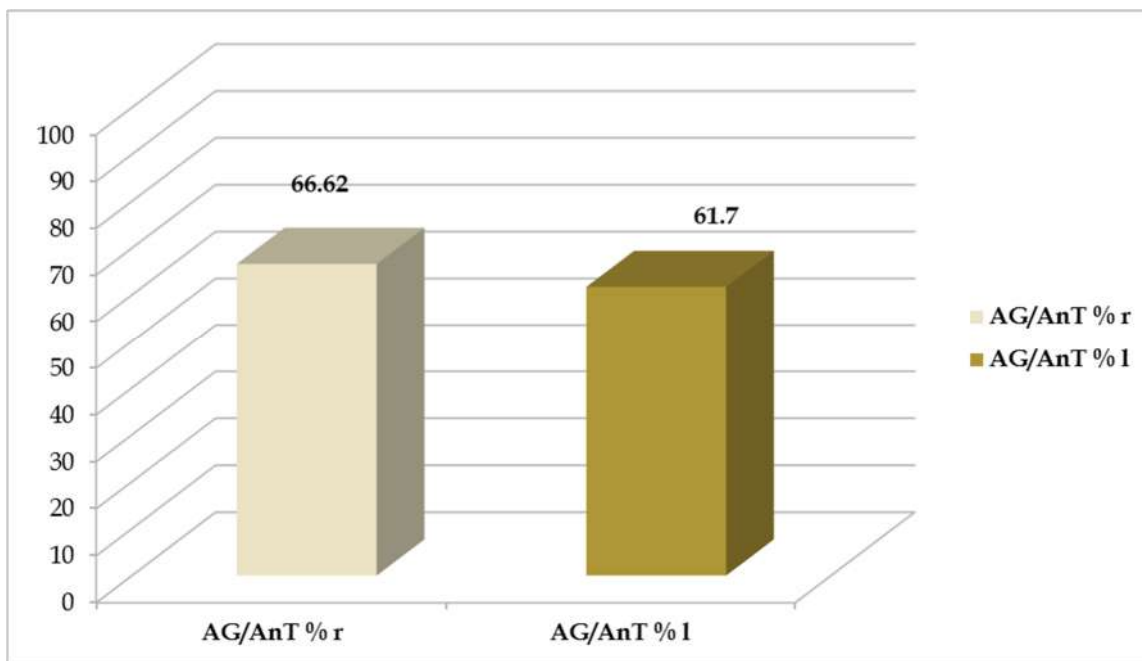


Fig.5 H/Q (AG/AnT) in both knees of soccer players U17.

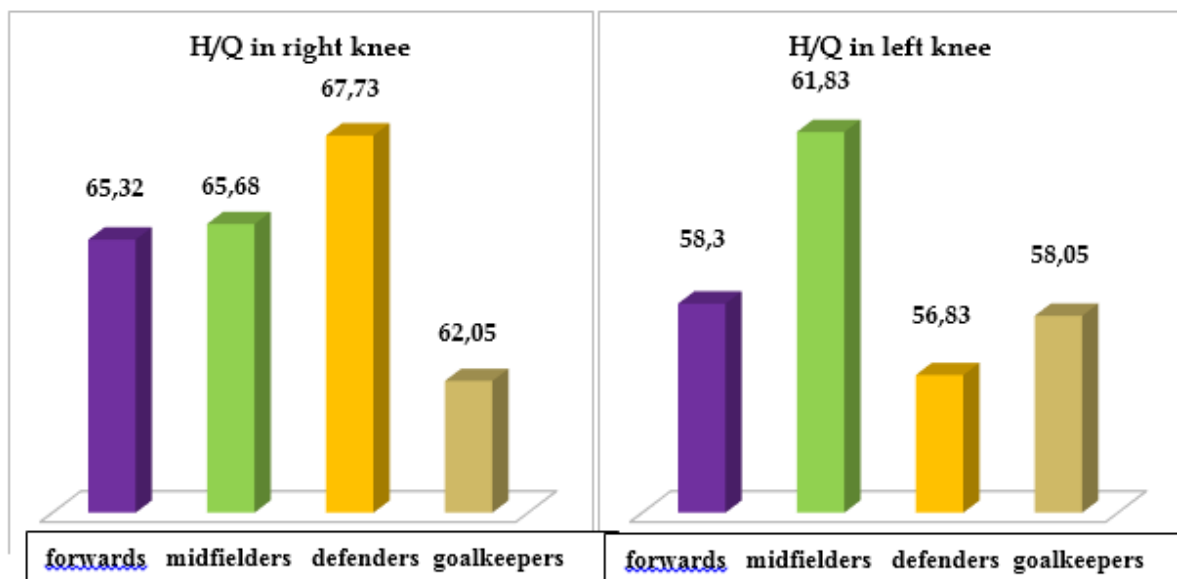


Fig.6 H/Q (AG/AnT) in both knees of soccer players U17 according to the position of the player.

H/Q (AG/AnT) in right and left knee according with the position of soccer player are presented in Fig.6. There are no significant differences in H/Q in both knees according with the position of the player.

The deficits between right and left knee are significant in 59% of the soccer players U17 (Fig.7). 20 % of all significant deficits are above 25 % (Fig.8).

The frequency distribution of the significant deficits in flexion and extension between the both knees according with the position of the player, the side of the deficit and position of the player and the side of deficit are presented on Fig. 9,10 and 11.

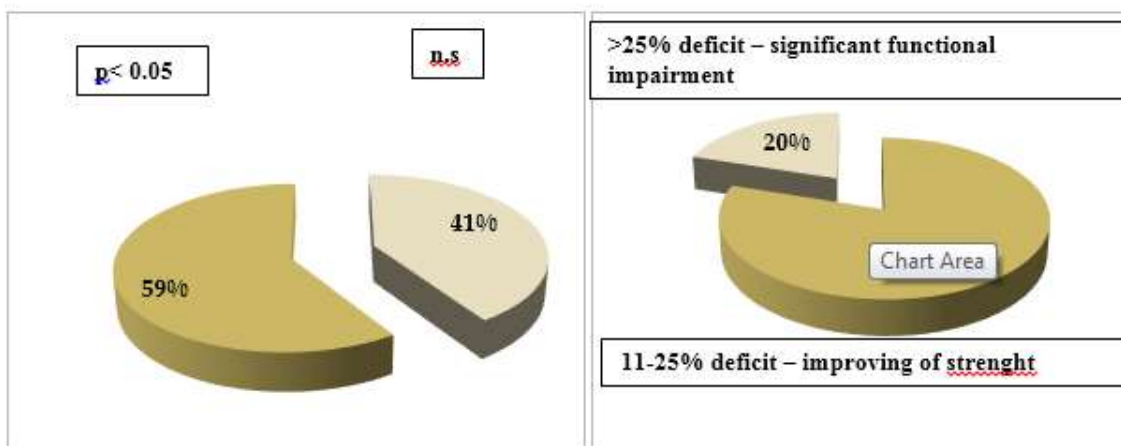


Fig.7 Distirbution of frequency of the significant deficits between rgiht and left knee.

Fig.8 Distirbution of the frequency of significant deficits between both knees according with the degree of the deficit

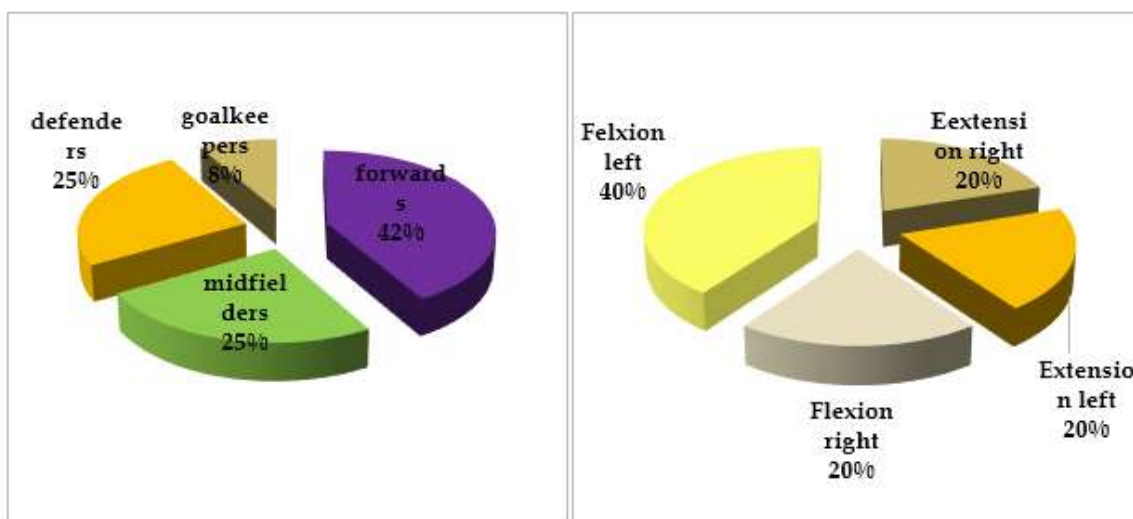


Fig.9 Distirbution of frequency of the significant deficits between the both knees according with the position of the player

Fig.10 Distirbution of the frequency of significant deficits between the both knees according with the side of the deficit

Discussion

Although “the fast gene“ (RR variant) is the most frequent one in our study, according to the data from other countries, the distribution of variants of this gene according with the position of the player in our study is a surprising for us: RR variant is the most frequent in midfielders (57%), with surprisingly low frequency in forwards(38%) and defenders (33%) (3, 9). On the other side, XX variant is the most frequent in forwards (37%) – We should ask: “what kind of selection model is this???”

An insignificant differences in relative maximal strength of extension and flexion and H/Q between both knees, in all players and between different position of the players, suggest maybe for a relatively balanced strength training of muscles of both knees in flexion and extension (7,8).

According to the insignificantly higher values of H/Q of right knee, especially in defenders,we speculate that the right leg in soccer is more engaged in soccer tasks and the new strategies is necessary for an improvement of strength of right quadriceps (6).

The data from this study, about the distribution of significant deficits between the both knees (59% in all players) and the deficits that suggest functional impairment (20% of all deficits), although without any support of the studies, assert a necessity of more frequent isokinetic testing of both knees. These tests should

suggest a correction in strength training and an individual approach, redounding the most directly to prevention of injuries.

The most deficits of forwards in this study, taking account their position and tasks in game, could be explained by the higher representation of XX variant than RR variant of ACTN3 R577X genotype among these players, although significant correlations between variants of ACTN3 R577X genotype and deficits was not found in this study.

The most frequent deficits in flexion of both knees in this study, especially left one, suggest a necessity of a new set of strategies in strength training of hamstrings of soccer players.

Conclusions

Distribution of the variants RR, RX and XX of ACTN3 577X genotype of soccer players U17 is in accordance with the data from the literature for the distribution of this genotype in professional soccer players.

“The fast gene“ (RR variant) is the most frequent one, although less frequent than in other countries, reported in relevant studies.

There are insignificant differences in relative maximal strength of extension and flexion and H/Q between both knees, in all players and between different position of the players.

59% of all deficits between both knees are insignificant and 20 % of them suggest functional impairment.

The forwards are with the most deficits (42%) in this study.

The most frequent deficits in this study are the deficits in flexion of both knees, especially left one.

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DIFFERENCES IN BALL VELOCITY USING DIFFERENT KICKING TECHNIQUES AMONG YOUNG FUTSAL PLAYERS

UDC:796.33.063.012.574-053.6

(Original scientific paper)

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Abstract

The main purpose of this research was to determine difference in kicking velocity between players of different age and players of the same age, but different biological age in futsal. The research was conducted on 40 young players ranging in age between 12 and 15, that play for MNK „Vrgorac“ from Vrgorac. All the subjects have been divided into U13 and U15, inside of each age are 2 groups based on biological age. Kicking speed has been analyzed based on biological age. All the subjects have been submitted to a series of 12 tests that evaluate kicking velocity of different kicking techniques. Preferred and non-preferred leg was measured in all subjects by Pocket radar. The results have shown difference between both groups in all kick types in favor of biologically more mature players. In this study biologically older futsal players performed faster kicks.

Key words: *kicking, velocity, futsal, young players*

Introduction

Futsal by its classification belongs to complex sports and activities. During the very dynamic futsal match there are a lot of different individual and team actions that players perform so that they could win the match. Often in futsal, you can hear that someone was a „better „opponent but lost because scored fewer goals. Over the course of the match each team shoots as many times as can in order to score the goal. Game is played for goals and winner is decided by the number of goals, therefore it is extremely important to possess good shooting skills. With good shooting skills, using different techniques ball can be kicked with great speed and power so that opposing goalkeeper has less time to react. Ball kicking speed is one of the major aspects of kicking success. Speed of impact is determined by a complex sequence of concentric contraction of hip flexor and extensor knee and activation of extensor hip and knee flexors that assist in controlling movement. In their study, Noguchi et al. 2012 concentrated on relationship between power and kicking, and reported the importance of the power of hip flexor muscles and the front thigh muscles. The kick is movement of open kinetic chain that requires the integration of strength, mobility, stability and precision. According to previous studies (Young and Rath 2011, Dorge et al. 2002) for good kicking power there are several important things such as strength of the feet, the intensity of the deep muscles of the trunk, the strength of the leg adductor and rotator muscles of the pelvis. The quality of ball, the contact with the ball of the foot and motor skills are the determinants of the speed, direction and rotation of the ball. The main objective of this study was to determine differences in ball kicking speed with players of different age groups, and players of the same age group, but different biological age in youth futsal.

Methods

Research was conducted on the sample of 40 young futsal players, members of Futsal club Vrgorac from Croatia. Respondents train 3 times a week and play one competitive match during weekends. Sample of variables used in this research are:

1) Tests that evaluate anthropometric characteristics – body height, body weight and sitting height. From these variables, additionally was calculated BMI (body mass index) and APHV (age at peak height velocity) according to Mirwald et.al. (2002).

2) Ball kicking speed with dominant and non-dominant leg using three different techniques (instep kick, side-foot kick, toe kick) on stationary ball.

3) Ball kicking speed with dominant and non-dominant leg using three different techniques (instep kick, side-foot kick, toe kick) after dribbling.

In this research for determination of the ball speed Pocket radar system was used. It was previously evaluated as reliable (Grgantov et. al. 2013). Basic statistical parameters were analyzed (mean, standard deviation, minimum and maximum values of the measurement results, measure the shape and curvature distribution) of all variables. Normality of distribution was tested by Kolmogorov - Smirnov procedure. The differences between the players of different chronological and biological age were analyzed using the T-test for independent samples. After completing the measurements, the data were entered in the program Statistica for "Windows Ver.12.0".

Results and Discussion

Table 1. Descriptive statistics of players divided by age groups

	U – 13 (N=25)		U – 15 (N=15)	
	MEAN ± SD	Range	MEAN ± SD	Range
Years	12,2 ± 1,1	9,9 – 13,8	14,2 ± 0,59	13,1 – 14,9
Body height (cm)	155,6 ± 8,7	140,9 – 171,0	173,8 ± 9,56	155,0 – 187,0
Body weight (kg)	46,8 ± 9,04	32,6 – 38,4	63,05 ± 11,05	39,3 – 86,6
BMI	19,2 ± 2,81	15,4 – 26,4	21 ± 3,16	16,4 – 27,3

MEAN- arithmetic mean, SD-standard deviation, BMI Body mass index, Range- minimum i maximum result

Table 1 shows a very large range of height and weight within both age groups of respondents, which can be reminder of the impact of biological and chronological age. Chronological age is the age in years, while the biological age represents the age at the cellular level. These two ages expressed in years may not be necessarily the same. It can be noticed that there is a significant difference between the two groups of players. The younger age groups have lower values of an average height and weight what was expected. Similar results were obtained in the study (Malina et al. 2005).

Table 2. Differences in ball kicking speed between younger and older futsal players

	U13	U15	t-value	p
IK NDL	41,8	61,8*	-3,6	0,00
IK DL	57,8	78,1*	-5,1	0,00
TK NDL	47,5	67,3*	-4,1	0,00
TK DL	57,9	73,7*	-2,9	0,01
SK NDL	37,1	53,7*	-3,1	0,00
SK DL	51,9	67,3*	-3,1	0,00
IK NDLD	49,1	61,9*	-3,1	0,00
IK DLD	60,8	74,9*	-3,9	0,00
TK NDLD	51,7	64,4*	-3,6	0,00
TK DLD	61,5	76,7*	-3,5	0,00
SK NDLD	47,1	61,3*	-3,8	0,00
SK DLD	54,3	72,3*	-4,3	0,00

LEGEND: IK NDL- instep kick non-dominant leg, IK DL- instep kick dominant leg, TK NDL- toe kick non-dominant leg, TK DL-toe kick dominant leg, SK NDL-side foot kick non-dominant leg, SK DL-side foot kick dominant leg, IK NDLD- instep kick non-dominant leg after dribbling, IK DLD- instep kick dominant leg after dribbling, TK NDLD- toe kick non-dominant leg after dribbling, TK DLD-toe kick dominant leg after dribbling, SK NDLD-side foot kick non-dominant leg after dribbling, SK DLD-side foot kick dominant leg after dribbling, *p<0,05 statistically significant differences

Table 2. presents differences between two age categories in shooting speed. It can be seen that older players shoot faster in all measured variables. These results are expected considering few years of age difference. There are several specific periods in child development. There are two phases of quicker development from birth until six years of age and in puberty. Also, there are two relatively slower phases of development from six years of age until puberty and after puberty. During the period of two years in puberty young players and their bodies come through all sort of changes. Their hormones, especially testosterone, rise very high. The boys enter puberty roughly around the age of 12, and there is a sudden and

rapid growth and development. The beginning of puberty is characterized by a rapid increase in the child's height (5-7 cm per year) and a weight (5-6 kg per year), and the phase of the largest growth increment in height is around 9.5 cm per year, and the weight around 8.5 kg per year. Although the rate of maturation and the achieved level of growth and development is affected by the genetic factors of growth, also, there are extremely important and environmental conditions, as illustrated by the fact that the growth of height and weight of children and adults from century to century increases. Results obtained in this study are in a way similar to previous study from Katis, Kellis and Lees 2015 who also found correlation between ball speed and growth and development. Other studies such as one from Helsen et. al. from 2005. suggest that majority of young players across Europe tend to be biologically older. They are often selected as “talented” because they demonstrate certain dominance (physical and/or morphological) against biologically younger players. Ball kicking speed could be one of the defining factors for success and therefore, whoever demonstrates higher ball velocities could potentially be more successful.

Table 3. Differences in ball kicking speed between young players of same chronological U-13 and different biological age

	U13 A	U13 B	t-value	p
IK NDL	40,9	43,8	0,37	0,71
IK DL	54,9	63,8	1,53	0,14
TK NDL	42,0	59,3	2,93*	0,01
TK DL	54,5	65,1	1,77	0,09
SK NDL	34,4	42,8	1,09	0,29
SK DL	46,1	64,3	2,62*	0,02
IK NDLD	46,6	54,3	1,51	0,14
IK DLD	56,2	70,6	3,55*	0,00
TK NDLD	50,0	55,3	1,16	0,26
TK DLD	55,1	75,1	5,40*	0,00
SK NDLD	44,5	52,6	1,75	0,09
SK DLD	49,3	64,9	3,38*	0,00

LEGEND: A – biologically younger players, B – biologically older players, IK NDL- instep kick non-dominant leg, IK DL- instep kick dominant leg, TK NDL- toe kick non-dominant leg, TK DL- toe kick dominant leg, SK NDL- side foot kick non-dominant leg, SK DL- side foot kick dominant leg, IK NDLD- instep kick non-dominant leg after dribbling, IK DLD- instep kick dominant leg after dribbling, TK NDLD- toe kick non-dominant leg after dribbling, TK DLD- toe kick dominant leg after dribbling, SK NDLD- side foot kick non-dominant leg after dribbling, SK DLD- side foot kick dominant leg after dribbling, t-value – value of t-test *p<0,05 statistically significant differences

It can be seen that in all measured variables more mature players had faster shots than biologically younger players. Analysis showed significant differences with 5 different kicks. Variable TK NDL is toe kick with non-dominant leg. This type of kick is popular in futsal because it doesn't require a lot of preparation and can generate high power with small activation of the body. Because futsal is so dynamic and fast, often there isn't a lot of space for kicking so this type is very useful for players. Technique for this kick is relatively simple and the players with higher leg power can shoot faster kicks. It can be assumed that players with more thigh muscle mass (biologically older players) using this technique can produce more power and therefore kick faster toe kick with non-dominant leg. Side-foot kick with dominant leg SK DL is the most commonly used kick in futsal. Even though it is widely used for passing it is often used for shooting. Contact with the ball is made with the medial part of the foot, and to do so leg must do external hip rotation. With this kick there is the largest contact area among all shots and this kick type is the most precise one. Three of the six variables for kicks after dribbling showed statistically significant differences between the two groups. Instep kick with dominant leg after dribbling IK DLD is the kick that is often used in the game. It is commonly used in full speed and after dribbling when there is enough space to shoot this way. That kick generates some of the highest ball speed velocities in futsal. Contact with the ball is established while the foot is in dorsal flexion and there is no external rotation of the hip. This shot requires optimum stability and mobility of the foot and muscle strength of the upper leg. Biologically more mature futsal players and those who enter into a phase of rapid growth have longer extremities. Therefore they generate greater acceleration on the end of levers and that ultimately produce faster kicks.

Table 4 presents differences in ball kicking speed between young players of same chronological U-15 and different biological age. In majority of kicking techniques more mature players had higher speed velocities and in two types of kicks differences were significant. Toe kicks with dominant and non-dominant leg (TK DL, TK NDL) were the ones that differentiated the players the most. If we consider the

fact that these two types of kicks are mostly generated with pure leg power it is somewhat expected that biologically older players demonstrate higher ball speed. It can be assumed that players have relatively similar technical knowledge at this stage. The results suggest the fact that in this sensitive developmental period level of techniques increases within the entire age category, and the only difference is the dominance of motor skills. In their research Malina et al. (2003), separated players according to biological maturity and more mature players achieved better results in all motor skills. All kicks depend mostly on the whole kinetic chain and strength of certain muscle groups participating in the kick. Each kick requires specific muscle activation and inter - segmental coordination of all joints involved in the movement.

Table 4. Differences in ball kicking speed between young players of same chronological U-15 and different biological age

	U15 A	U15 B	t-value	p
IK NDL	62,0	58,1	-0,45	0,66
IK DL	73,0	79,1	1,25	0,23
TK NDL	57,1	72,3	2,41*	0,03
TK DL	60,1	80,9	2,35*	0,04
SK NDL	52,6	47,0	-0,74	0,47
SK DL	61,1	64,4	0,59	0,57
IK NDLD	58,0	62,0	0,57	0,58
IK DLD	71,1	76,1	0,98	0,35
TK NDLD	60,6	64,1	0,58	0,57
TK DLD	72,6	78,9	0,91	0,38
SK NDLD	57,0	63,8	1,09	0,29
SK DLD	70,4	72,6	0,33	0,74

LEGEND: A – biologically younger players, B – biologically older players, IK NDL- instep kick non-dominant leg, IK DL- instep kick dominant leg, TK NDL- toe kick non-dominant leg, TK DL- toe kick dominant leg, SK NDL- side foot kick non-dominant leg, SK DL- side foot kick dominant leg, IK NDLD- instep kick non-dominant leg after dribbling, IK DLD- instep kick dominant leg after dribbling, TK NDLD- toe kick non-dominant leg after dribbling, TK DLD- toe kick dominant leg after dribbling, SK NDLD- side foot kick non-dominant leg after dribbling, SK DLD- side foot kick dominant leg after dribbling, t-value – value of t-test, *p<0,05 statistically significant differences

Conclusion

The main objective of this study was to determine differences in kicking velocity between players of different age and players of the same age, but different biological age in futsal. All subjects have been tested to a series of 12 kicks that evaluate kicking speed of different kicking techniques. Preferred and non-preferred leg was measured using three different types of kick (instep kick, toe kick, side foot kick) while shooting stationary ball and after dribbling the ball. The results have shown difference between both groups in all kick types in favor of biologically more mature players. In this study biologically older futsal players performed faster kicks. Main reason for these results could be biological age. During the phase of intensive growth and maturation, players who enter this phase of acceleration earlier than others have longer legs and arms, and more strength because of increased muscle mass. That way they can generate higher velocities on the end of leverage (extremity) and finally they produce higher ball speed velocities. Numerical better results achieved by biologically older respondents within both groups, suggest that all the factors that accompany puberty have a positive impact on the kicking speed in futsal. Coaches need to be aware of the individual characteristics of growth and development for their players. More mature players tend to have more explosive power, trunk strength, upper body strength and coaches must correct training schedule to meet the needs of all players.

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MOLECULAR-GENETIC PREDICTIONS IN SELECTION OF SPORT TALENTS AND ETHICAL ASPECT OF THEIR APPLICATION

UDC:796.093.11-056.7-056.45

(Original scientific paper)

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Abstract

The genetic basis of complex athletic phenotypes is still poorly understood and difficult to study. The molecular basis of genetic variation related to sport performances resides in both nuclear (nDNA) and mitochondrial DNA (mtDNA). Variabilities in skeletal lengths, skeletal breadths, limb circumferences, and bone mass is genetically determined. In nDNA, relevant gene variants include the angiotensin converting enzyme (ACE), actin 3 (ACTN3), myostatin (MSTN), insulin-like growth factor 1 (IGF-1), phosphoenolpyruvate carboxykinases (PEPCK) and erythropoietin (EPO), among others. Genetic factors account for ~40–60% of the variation in aerobic performance and cardiac function, 50–90% of the variation in anaerobic performance, 30–70% of the variation in muscular fitness, and 20–30% of the variation in muscle dimensions. Adaptive polymorphisms in mtDNA may directly affect maximum performance capacity. Four obligations of professional ethics for the researcher interacting with the application of molecular tools are: autonomy, beneficence, non-maleficence, and justice. Talent selection is difficult in children although it could guide early exposure to sport-specific training. Recent advances in scientific knowledge and the availability of modern technology could provide an opportunity for the direct genetic selection of athletic talent. Early talent identification and selection is institutionalized for many sports around the world. Although unique combinations of genetic and environmental factors result in elite-level performance, these factors are complicated and generally unpredictable. The question is whether genetic screening techniques are able to identify an innate advantage as part of talent identification programs and is the focus of this review

Key words: genetics, sport, talent, ethics

Introduction

Talent is exceptional performance that is partly innate, relatively domain-specific, found only in a limited number of individuals, and partly identifiable at an early stage of development Falk et al. (2004) emphasised the importance of early talent detection and described three aspects of talent identification (TID) - physiological, psychological and sociological. Early TID methods are designed to identify those children with favourable physiological traits suited for a particular sport based mainly on genetics.

Early TID and selection is institutionalized for many sports around the world. TID and development has become a vital component of many sport programs. This is particularly true in Australia where significant resources have gone into developing a national Talent Search program that is implemented through the Australian Institute of Sport. The significance of TID in this country probably stems from greater competition between sports for talented individuals (Hoare and Warr, 2000) within a relatively small population base compared to the sporting superpowers.

Mitochondrial DNA (mtDNA) is a 16,569 nucleotide, closed-circular molecule, located within the mitochondrial matrix, and present in thousands of copies per cell. There are 16 mitochondrial genes in which sequence variants have been shown to influence relevant fitness and performance phenotypes (Fig.2) (Wallace 2005). The mutation rate of mtDNA is higher than in nuclear DNA. It is now clear that not all mtDNA variation is deleterious. For example, parents might consider changing the mtDNAs of their children in hopes of increasing their potential for athletic performance. (Scott et al., 2009).

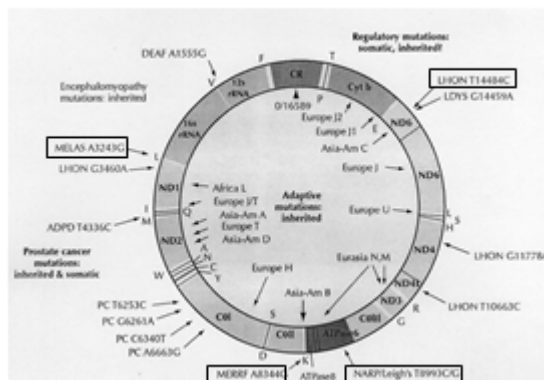


Figure 2. Polymorphisms associated with sport performances: MELAS, mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episodes; MERRF, myoclonic epilepsy and ragged red fiber disease; NARP, neurogenic muscle weakness, ataxia, retinitis pigmentosum; LHON dystonia. (Wallace, 2005)

Examples For Gene Association With Sport Performance

Peptidyl dipeptidase angiotensin-converting enzyme (ACE) is a key enzymatic component of the rennin-angiotensin system, having critical roles in the regulation of blood pressure and salt/water balance influencing endurance. The ACE gene shows a polymorphic insertion of a repetitive element in intron 16. This 287-bp insertion/deletion (I/D) polymorphism has been directly linked to inter-individual variation in plasma and tissue ACE activity. The ACE I/D polymorphism was the first specific gene variant to be associated with human physical performance (Montgomery et al., 1998). Since that time, the ACE gene has become, by far, the best-studied locus in this regard. The I/D polymorphism is associated with differences in response to training, including muscle endurance, and anabolic strength improvements. It has also been associated with the proportion of type 1 fibers in muscle, and cardiac muscle growth. The associations of ACE polymorphisms with fitness, and elite sports performance remain more controversial.

A study for maximum duration of standardized repetitive elbow flexion with a 15-kg barbell was done. After 10 weeks of military training, the duration of exercise was significantly prolonged in the 66 individuals of II or ID genotype, but not for the 12 DD homozygote. Thus, II homozygote showed an 11-fold greater improvement when compared to those with the DD genotype (Montgomery et al., 1998).

Another study of 47 individuals demonstrated that ACE II genotype carriers had a 6.3 ml/kg/min higher VO₂max, than the ACE DD group and a 3.3 ml/kg/min higher VO₂max than the ACE ID genotype group (Hagberg et al., 1998). However, the validity of any association between ACE genotype and VO₂max remains unproven.

The I-allele is also associated with a success in rapid ascent to high altitude and success in ascending beyond 8,000 m (Tsianos et al., 2005). Such effects may be dependent upon I-allele associated gains in VO₂max, or in metabolic efficiency (Bischoff et al., 2003). In general, the I-allele has been associated with elite athletic performance in endurance-orientated events (Nazarov et al., 2001), and the D allele with strength/power-orientated performance (Myerson et al., 1999).

A functional variant in Actin 3 (ACTN3) is believed to impact acceleration performance (Yang et al., 2009) via its role in skeletal muscle. The variant R577X, dbSNP rs1815739 induces a premature stop to the alpha-actinin-3 protein at amino acid 577 (which is usually an arginine). Individuals homozygous for the stop codon completely lack the ACTN3 protein, although this deficiency is not associated with any known disease. This coding sequence variation was first identified by North and colleagues (1999). Walsh et al., (2008) first hypothesized that the deficiency genotype would reduce athletic performance in sprint/power events.

Using the publicly available data from over 1000 individuals from 50 populations, Li et al. (2008) examined the between-population variation in the allele frequency of R577X. It ranged from near 0 in

African populations to over 0.8 in some American populations. The gene ACTN3 – the "speed gene", for fast-twitch muscle – makes muscles contract quickly. It's crucial for sprinters and sports requiring short, powerful movements. A variant (R577X) is needed for the slow, efficient muscle contractions required by endurance athletes, found in Type I muscle fiber types. A negative association between the ACTN3-deficient XX genotype and elite sprint athlete status has now been observed in six separate studies.

Based on these data, the scientific and sport community are interested in determining how much predictive power the R577X genotype provides in terms of identifying athletic potential? What role does the variation play in human health and fitness in non-athletes? In terms of statistics, individuals of European descent, less than a third of the population has two copies of the functional R allele (the RR genotype), while just over half the population has one copy of each of the two alleles (the RX genotype). Remarkably, the remaining 18% of the healthy European population—and in that regard more than a billion people worldwide—has two copies of the nonfunctional 577X variant (the XX genotype), resulting in complete deficiency of ACTN3 protein in their skeletal muscle (Mills et al., 2001). That fact suggests that ACTN3 can be compensated for by other factors, most likely including the closely related protein α -actinin-2.

In order to dissect the structural and biochemical changes underlying the effects of ACTN3 deficiency on muscle function, an ACTN3 knockout (KO) mouse was generated to serve as a model of human XX individuals (Chan et al. 2008). The KO mice were morphologically indistinguishable from their wild-type littermates, showed grossly normal muscle ultrastructure under light and electron microscopy, and did not demonstrate substantial loss of fast (Type 2B) fibers. Extensive studies were carried out on the effects of ACTN3 deficiency in a KO mouse model. If similar changes can be confirmed in human muscle, this transformation would provide a powerful mechanistic explanation for the negative association between ACTN3 deficiency and muscle strength and sprint performance, and also supports the notion that the loss of α ACTN3 may benefit endurance performance.

Several companies are already marketing ACTN3 gene tests directly to consumers. It would intuitively appear that testing R577X may be useful for coaches and sporting bodies, but how predictive will R577X genotype information really be? The answer to this question is still unclear, for a number of reasons. Firstly, many different genetic and environmental factors influence physical performance, with R577X genotype determining only a small proportion of overall variation. Cross section association studies estimated that R577X accounts for only 2.6% of the total variance in 40-m sprint speed in adolescent males (Moran et al., 2007). However, this percent can make a big difference for super-élite athletes. In addition to high motivation and world-class training, these rare individuals need to have a near-perfect set of genes to have a chance of winning an Olympic medal. These data emphasize that R577X is just one of a myriad of complex, interacting factors that influence muscle performance.

Myostatin is the growth factor that acts as a brake on the increase of muscle cell numbers. A person with a high levels of myostatin will have less well developed muscles and consequently less power (Hulmi et al. 2009). A mutation in the gene for myostatin expression will remove this brake, and could lead to rapid muscle growth. A German toddler already has twice the muscle density of his peers – useful if he becomes a bodybuilder. However, this mutation only takes affect during embryogenesis but would be a direct indicator of muscle mass development after birth.

Insulin-like growth factor 1 (IGF-1) is the hormone most responsible for regulating cell growth and development predisposing height. An athlete with abundant IGF-1 and other growth hormones and regulators will be tall; useful for basketball players.

Super-mice have been genetically engineered to run faster and further. They over-express a gene for the enzyme phosphoenolpyruvate carboxykinases (PEPCK-C), which is modified so that it is only active in skeletal muscles. The mice produce less lactic acid and burn more fat. They can run at 20 m a minute on a treadmill for up to six hours.

Erythropoietin (EPO) is a hormone that regulates the numbers of red blood cells. Altering the EPO receptor enables blood cells to carry higher levels of oxygen, increasing the fitness potential. The effect is similar to that of blood doping.

Available Methods

Single-nucleotide polymorphisms (SNPs) are DNA sequence variations that occur when a single nucleotide in the genome sequence is altered. A high-throughput SNP array measures the hybridization of sample DNA to the templates of two different alleles for each SNP, and the relative hybridization strength

is used to call genotypes. Several commercial SNP chips, including Affymetrix GeneChips™ and Illumina BeadChips, can genotype over one million SNPs.

Protein separation methods requires the extraction of proteins from control and experimental samples followed by processing for mass spectrometry analysis. Each sample usually contains thousands of proteins of different size and abundance therefore requiring extensive fractionation, enzyme digestion, and separation before mass spectrometry analysis.

A gene expression microarray is a glass or silicon chip attached with an arrayed series of thousands of microscopic spots of DNA oligonucleotides, each containing picomoles of a specific DNA sequence. After hybridization with fluorophore-labeled complementary DNA (cDNA) reversely transcribed from mRNA, the intensity of fluorescent light reflects the abundance of cDNA sequences and thus, indicates the abundance of mRNA sequences in the original mRNA sample. Gene expression microarrays simultaneously measure the expression levels of thousands of genes and produce a vast amount of data.

Gene-chip is a general term used to describe a new technology that can identify various allele polymorphisms or mutations. Analysing each polymorphism can be very time consuming, gene chips allow lots and lots of polymorphisms to be tested at one time very quickly. Affymetrix Inc. holds the registered trademark of GeneChip®, however this is not the only brand available.

Other molecular profiling platforms include proteomics and epigenetics analysis. The most common way to study protein modifications is via two-dimensional (2D)-gel electrophoresis. Mass spectrometry (MS) coupled with liquid chromatography (LC) and multiple reaction monitoring (MRM) has been successfully used to characterize and quantify proteins in complex mixtures. The two most common epigenetic events are DNA methylation and chromatin remodeling. Various experimental techniques have been developed for genome-wide mapping of epigenetic information.

Ethical concerns

The use of gene-based technologies for TID poses an interesting ethical situation. Will such advancement only serve to further increase the chasm gap exists in elite-level sport between the nations with scientific funding, and those without? Or, how should the sports world react to such possibilities? Is it fair that those athletes who have access to a technology that could assist them in recovering more effectively and quicker, when others do not? Should the sports world be obliged to promote the utilization of such technology to optimize conditions of equality? Alternatively, does the utilization of such technology fall outside of what the sports world can assume as its regulatory responsibility?

Identifying the moment when genetic science becomes an ethical concern for the world of sport is difficult. Arguably, what distinguishes the ethics of genetic science in sport from other forms of scientific application is the way that it interfaces with a range of fundamental moral concern about the sanctity of life, human dignity, and what it means to be human (Miah, 2004).

Primary among the ethical concerns is the issue of athlete autonomy in the genetic screening process. The principle of individual autonomy suggests that if a person does not want to know about a particular disease susceptibility or condition, then he or she should not be forced into getting that information.

The idea of pre-birth selection is not new, but has previously relied on the old-fashioned technique of “matchmaking”. Patel and Greydanus (2002) raise the issue of “gene farming” where people may seek out “athletic” gamete donors in order to produce athletic genotypes.

Another consideration is if a child is aware that they may be lacking genetic potential for a certain sport, will they be less likely to participate? This was the question raise by Bouchard et al. (1997). The ALRC (1996) also raise the concern of genetic screening limiting life choices of those who are identified as “elite” at a young age, while discouraging others from even trying.

Australian Law Reform Commission (ALRC) examined the Disability Discrimination Act 1992 and concluded that genetic testing would not contravene this act providing the tests were “sufficiently reliable and relevant to the skills and abilities required” (p 5). ALRC report also cites the Australian Sports Commission Act 1989 that allows the AIS to reasonably discriminate between persons on the basis of physical and physiological attributes in order to implement a Commonwealth program. By its nature, TID needs to be discriminatory in order to select the best performers.

Considering recent stories in the popular press regarding genetic identification and international competition, the issue of ethics will continue to remain a central theme. As new technologies move forward, it seems that it will put continued pressure on athletes, coaches, counsellors, and physicians who will no doubt depend on the contribution of genetics to tell them something about athlete performance.

Since the early 2000's, debates about the ethics of genetics in sport have been dominated by the prospect of gene doping, the use of gene transfer technology for nontherapeutic or enhancing purposes. This technology promises a new era of performance enhancement in sport, which may call into question the possibility of detecting and catching users. Despite this possibility, WADA began to investigate the prospect in 2001 and responded in 2003 by prohibiting "gene" or "cell" doping within the 2004 World Anti-Doping Code (WADA, 2003) which read: "M3. Gene doping is defined as the non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance" (p. 14).

To this extent, questions remain about how genetic and molecular modifications or knowledge should be treated in the long term.

Conclusions

- TID is an important aspect of identifying potential elite performers, particularly in countries that don't have the luxury of selecting from a large population base.
- The use of 1 gene as a guide for sport and event selection appears naïve given the complex interaction not only between genes, but between genetics and the environment.
- Genetic approaches appear most effective in individual sports rather than team sports.
- Perhaps the most likely use of genetic testing will be the identification of individuals with some inherent general capacities in psychological or motor skills that are transferrable across multiple domains
- More work needs to be done examining the influence and interaction of genes across a range of athletic parameters; and the effect of genetic screening on sport participation of children should be considered in greater depth.
- An enormous amount of research work is needed before we can predict the effects of an individual's genomic and perhaps epigenomic characteristics on his or her ability to be trained and to reach elite athlete status in a given sport.
- Differences in human phenotypes result from the interaction of genetic variation with environmental stimuli. Further, such knowledge may be both translational and transferable - opening the way to the better understanding of disease processes (e.g., those causing progressive muscle wasting, bone weakness and fracture, or excessive cardiac growth).
- There will undoubtedly come a time when it will be scientifically possible to test for sporting aptitude but we have to decide whether we are happy with such tests and the conclusions we base on them.

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HIERARCHICAL CLASSIFICATION METHODOLOGICAL MODEL FOR TEACHING SNOW PLOW TURN

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(Original scientific paper)

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Abstract

The purpose of this research was to establish the hierarchical classification of expert model on fundamental methodological exercises for teaching of the movement of snow plow turn in ski school. Through the filling out the online survey they tried to distinguish the importance of the formed model of the most important methodical exercises for snow plow turn teaching. Expert model of the most important methodical exercises captured 5 variables: SDUDPFR (sideways downhill with up and down movement, poles in front raise), SDSPP (sideways downhill, sideways plow), FSRK (fist front side raise than placed on knees), SPB (snow plow bow), PFR (poles in front raise). In order to investigate the statistic meaning of differences in ranking the methodical exercises for snow plow turn teaching, participants are divided into three groups based on the degree of skiing education they possess. In relation to above mentioned, sums of ranks (ΣR) of the most important methodical exercises for snow plow turn teaching have been calculated. Using non-parametric analogue post-hoc analysis, i.e. Kruskal-Wallis test (H-test) and appropriate empiric level of significance (p), statistic significance of sums of ranks (ΣR) of the most important methodical exercises have been tested. Significant difference between the value of ranking the most methodical exercises for snow plow turn teaching have been obtained ($H=429,43$; $p<0,001$). Those variables which were not different in statistically significant way according to sums of rank were classified in one significant group, while variables which showed statistically significant difference were classified separately. Multiple statistically significant difference based on different degree ski education between the ski experts was found in the evaluation of methodological exercise SDSPP (sideways downhill, sideways plow) ($p < 0.05$). The results of this study provide an accurate and scientifically based methodological settings for snow plow turn training. This opens the directions for future research in the form of construction of measuring instruments whose application in practice should allow better selection and choice of modalities methodical exercises for training alpine skiers of different ages and levels of ski prior knowledge.

Key words: hierarchical classification, ski experts, snow plow turn.

Introduction

Alpine skiing originated from Scandinavian countries in which people used first skis in order to move more easily and survive in harsh winter conditions. Throughout the 20th century, alpine skiing grew into a type of recreational and sports activity that gains more popularity each year. Most skiers today are of recreational type, enjoying skiing on skiing paths. Skiing became a common feature of winter holidays, so certain countries base their tourist offer on this type of activity. The evolution of skiing equipment is the result of emergence of numerous skiing techniques. Therefore, acquiring and mastering specific skiing knowledge is a very complex process, and it depends on the conditions in which the teaching takes place, level of skiing knowledge, motivation and anthropological features of the individual. It is also defined by the level of experience and work methods that skiing experts of different levels of skiing education apply. As a result, numerous authors from different skiing nations gave their concepts, specific classifications and teaching models of certain skiing techniques in contemporary skiing schools programmes (Feinberg - Densmore, L., 2000; Jurković and Jurković, 2003; Matković et al., 2004; John, 2006; Murovec, 2006; Anderson, 2007; Puškarić, 2010; Božidar et al., 2010; Lešnik and Žvan 2010). While keeping the

methodological principle of graduation, it is necessary to execute the teaching process for the alpine skiers in a methodological order, from easier towards more difficult, that is, more complex skiing elements (Kuna, 2016). The same laws apply to the usage of methodological exercises in their training, so the skiing elements and methodological exercises should follow in a logical methodological order. The first element of skiing school, in whose performance the elements of parallel and wedge position skiing technique are used, is the snow plow turn. Its performance begins during the sideways downhill on parallel skis, followed by the simultaneous “plow” of both skis and the transition of the weight onto the lower ski, and the performance of final plow turn and lowering into lower skiing position. By passing the falling line, the skier gradually joins the upper ski until reaching the middle skiing position of the slant downhill, followed by the repetition of the same movement structures on the other side. The snow plow turn can help in mastering the lighter ski slopes. Based on the results of the research in which the expert model of the most important skiing elements of the skiing elementary school (Kuna, 2012) was set, and the model for snow plow turn teaching (Kuna 2015), the idea of forming its hierarchical classification emerged. Related to this, the following aims of this research were set: a) forming the hierarchical classification of snow plow turn teaching expert model, b) determining the difference between skiing teachers and assistants of different professionalism levels in ranking the most important methodical exercises for snow plow turn teaching.

Methods

The research was conducted in several phases. Firstly, the videos of 5 most important basic turn teaching methodical exercises were filmed. Then, the online setting of questionnaire and uploading on the specialized server used in global electronic data collection and analysis was conducted. For easier understanding, the most important methodical exercises for teaching snow plow turn were described and displayed via gif image format (Graphics Interchange Format). After that, a letter of intent with a proposal of participation in the research was sent via email, and the link with the questionnaire address was sent to many e-mail addresses of skiing teachers and assistants of different professionalism levels from the Ski Associations of Slovenia, Croatia and Bosnia and Herzegovina. The data collection lasted for 6 months. With the aim of determining identification and experience in the work with alpine skiers, the examinees filled in first part of the questionnaire by writing in text and numerical value in the provided field. The choice of the offered answers on the scale from 1 to 5 ranked the displayed methodological exercises for teaching snow plow turn. After the inspection of the identification and classification variables for the examinees that filled the online questionnaire, the results of 307 examinees were chosen for data processing: 119 Slovenian, 128 Croatian and 60 Bosnian-Herzegovinian skiing teachers and assistants of different professionalism levels that filled in the entire questionnaire. Their results of ranking expert model of six most important methodological exercises for teaching snow plow turn conditioned the forming of hierarchical classification. To determine the existence of statistically significant differences among the total number of examinees, regarding the level of skiing education, the examinees were divided into 3 groups. The first group consisted of skiing experts of elite skiing education (SE): Croatian, Slovenian and Bosnian-Herzegovinian members of skiing teams and skiing demonstrators, and Slovenian skiing teachers of 3rd level (N=78). The second group of examinees consisted of skiing experts of advanced skiing knowledge (SA): Croatian skiing teachers and Slovenian and Bosnian-Herzegovinian skiing teachers of 2nd level N=128. The third group of examinees consisted of skiing experts of basic skiing education (SB), Croatian assistants of skiing teachers, and Slovenian and Bosnian-Herzegovinian skiing teachers of 1st level N=101. The expert model of the most important methodological exercises for teaching snow plow turn consisted of five exercises: SDUDPFR (sideways downhill with up and down movement, poles in front raise), SDSP (sideways downhill, sideways plow), FSRK (fist front side raise than placed on knees), SPB (snow plow bow), PFR (poles in front raise). In concordance with the set research aims: a) forming the hierarchical classification of snow plow turn teaching expert model, b) determining the difference between skiing teachers and assistants of different professionalism levels in ranking the most important methodic exercises for teaching snow plow turn, the rank sum (ΣR) of the most important methodological exercises evaluation was calculated, as well as non-parametric analogue post-hoc Kruskal-Wallis test (H) and corresponding empirical level of significance (p), with the aim of examining the statistically significant levels of their classification difference.

Results

The statistically significant difference between the values of ranking the most important methodical exercises for teaching snow plow turn ($p < 0.001$) was revealed through the obtained results of Kruskal-Wallis test (H-test) and corresponding empirical level of significance (p), shown in Table 1. Using the non-parametric analogue post-hoc analysis, a statistically significant difference between the rank sum of methodological exercises *SDUDPFR*, *FSRK*, *SPB* and *PFR* was determined for $p = 0.00$. Between the rank sum of methodological exercises *SDUDPFR* and *SDSP* statistically significant difference was determined for $p = 0.02$. Statistically significant difference between the rank sum of methodological exercises *SDSP* and *FSRK* was determined for $p = 0.00$, between *SDSP* and *PFR* statistically significant difference exercises was determined for $p = 0.03$. According to the obtained difference significances in ranking the importance of applying certain methodological exercises in snow plow turn teaching, and based on the rank sum value, the hierarchical classification was formed. Methodical exercise that is the most important in teaching snow plow turn were *FSRK* and *PFR*. During the performance of *FSRK* methodological exercise, the skier goes downhill sideways, and at the moment of plowing lowers both fists from side raise position on the future outer knee, transferring the weight center on the future outer ski, performing the snow plow turn. By placing the hands in front raise position the skier focuses on putting the skis in parallel position, hip-width apart, as well as balancing the position and central pressure on skis. At the moment of plowing, he places both hands on the future outer knee in order to transfer the body weight center onto the future outer ski more efficiently, while improving the plow turn performance and circular knee movement. While performing the *PFR* methodological exercise, the skier performs the plow bow with poles in parallel position in front of the body, shoulder-width apart. The primary value of this methodological exercise is the easier achievement of skis balance position, by holding the poles in front raise. This position facilitates the performance of necessary skiing movement, depending on the phases of skiing element. The central position on skis prevents deviations of upper body position, in relation to skis.

Second most important methodological exercises in snow plow turn teaching are *SPB* and *SDSP*. During the *SPB* performance the skier, by imitating a bird, performs the snow plow turn by holding his arms in a side raise position, at shoulder height, followed by the change of movement direction at the beginning of snow plow turn, placing the hands on knees, and lifting them into side raise position at the end of the plow turn, performing sideways downhill movement. The performance of snow plow turn by bird imitation increases performance, harmonizing the necessary vertical and circular skiing movements. Since the arms are spread and free, it is assumed that the skier achieves balance and middle skis pressure easier, and at the moment of placing the hands on the knees he pushes the lower leg against the front of the ski boot, pushing the knees in the direction of the turn, improving the circular knee movement and the efficiency of plow turn performance. *SDSP* is a methodological exercise that helps the skier harmonize the performance of sideways downhill and sideways plowing combination, in coordination with the vertical skiing movement. In this way more favorable conditions for learning the plow bow are created, shortening the teaching time, so the experts evaluated it as the most important methodological exercise. On the last place of the hierarchical classification of methodological exercise of snow plow turn teaching is the *SDUDPFR* exercise. This is an exercise that is equal to the *SDSP* exercise, regarding its elements, but it is performed with poles parallel in front raise position, in order to achieve and easily maintain correct skiing position.

Table 1. Rank sum of the most important methodological exercises for snow plow bow turn teaching (ΣR), non-parametric analogue post-hoc Kruskal-Wallis test (H) and corresponding empirical level of significance (p).

METHODICAL EXERCISES FOR SNOW PLOW BOW TEACHING					
	SDUDPFR	SDSP	FSRK	SPB	ΣR
SDUDPFR					623
SDSP	0,02				732
FSRK	0,00	0,00			868
SPB	0,00	1,00	0,13		779
PFR	0,00	0,03	1,00	0,99	838
H=60,77; p<0,001					

In the hierarchical classification, that is, the evaluation of the most important figures in snow plow turn teaching, statistically significant difference between skiing experts was determined by evaluating the *SDSP*

methodological exercise, in which SB and SE groups statistically significantly differed ($p < 0.05$) (Table 2.). The obtained difference was increased by the result of high evaluation of *SDSP* exercise by the SE group, that is, low evaluation by the SB group. Since during the performance of *SDSP* methodological exercise parallel and plow skiing elements are alternatively performed in both directions, it can be assumed that ski experts of high skiing education, unlike ski experts of low skiing education, consider the analytical methodological approach to the snow plow turn teaching most important. Comparing the range values of arithmetic means values sum for the remaining most important methodological exercises in teaching plow bow in three groups of skiing experts, it is obvious that there are no statistical differences between them. Based on this, it can be stated that skiing experts in spite of different levels of skiing education and past experience in working with skiers of different skiing knowledge, make an approximately homogeneous group that equally recognizes the importance of methodological exercises in teaching the snow plow turn technique.

Table 2. Values of arithmetic means of rank sum (AS Σ R) of the most important methodical exercises for snow plow turn teaching, Kruskal-Wallis test (H-test) and the corresponding empirical level of significance (p) in the examination of statistical difference significance between the skiing experts of elite skiing education (SE), skiing experts of advanced skiing knowledge (SA) and skiing experts of basic skiing education (SB).

METHODICAL EXERCISES FOR TEACHING SNOW PLOW BOW	SB	SA	SE	H	p
	AS Σ R	AS Σ R	AS Σ R		
SDUDPFR	157,15	158,77	145,52	1,47	0,47
SDSP	133,99 ⁺	155,74	167,25 ⁺	6,56	0,03 [#]
FSRK	165,02	145,74	155,96	2,48	0,28
SPB	166,62	148,11	151,73	2,30	0,31
PFR	147,82	163,26	147,03	2,50	0,28

Legend: ⁺ - statistical significance difference between SB and SE skiing experts, [#] - statistically significantly differed ($p < 0.05$)

Also, a need for the construction of measuring instruments occurred, whose practical application should enable better quality selection, and the choice of training modalities and training exercises in the process of education of alpine skiers of different age and level of skiing knowledge.

Discussion

The general review of the obtained results of the conducted research, with the aim of forming the hierarchical classification of the expert model of methodological exercises for snow plow turn teaching, and the examination of statistical difference significance between three groups of skiing experts of different levels of education in their evaluation, leads towards the conclusion that the obtained knowledge generally enables relatively higher quality of alpine skiers teaching process planning. In spite of the different degree of skiing education that examinees that formed the hierarchical classification of the expert model of methodological exercises for snow plow turn teaching had, the difference between them was not determined. Based on this, it can be concluded that they made a homogeneous group that recognised the importance and the contribution of the individual exercise in the alpine skiers teaching methodics. Since there are no papers of similar topic, this research is especially valuable, in the sense that it sets the basic structures of methodological settings that secure the precise guidelines for the work of skiing experts of different education. This research is a good basis for the future research in which could include skiing experts worldwide, and additionally determine and perform the evaluation of snow plow turn teaching expert model.

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DETERMINING THE FACTOR VALIDITY OF TESTS FOR EVALUATION OF CERTAIN BASIC MOTOR SKILLS FOR SUCCESSFUL BOXERS FROM THE REPUBLIC OF MACEDONIA

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(Original scientific paper)

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Abstract

The sample of 102 male students-boxers from Macedonia, aged 18-33 years, applied 21 motor test to determine the diagnostic factor validity as a metric feature of the tests applied. The validity of the tests is determined by factor analysis under the component model. The Intercorrelation matrix of motor tests is factorized with Hotteling method of main components, and the number of significant principal components is determined by the Guttman-Kaiser criteria, according to which, all characteristic roots equal or greater than 1 are considered. Based on the given results it can be concluded that most of the tests applied have satisfactory factor validity and may be applied in the diagnosis of motor skills of boxers. As a pretext for diagnosing motor skills the following reduced battery of tests is recommended: eights by leaning (coordination assessment), standing on one leg on the balance beam at length with eyes closed (to assess the balance), tapping a hand in the sagittal area (to assess the frequency of movements), deep stretching in sitting position (assessment of flexibility), raising the trunk in 30 seconds (the assessment of power), dumping medical ball(1kg.) from a position on back (to assess the explosive power) and shooting with a short stick (assessment of precision).

Keywords: *factor analysis, motor skills, boxers, diagnostic validity*

Introduction

Motor skills are primarily genetically conditioned, but are influenced by the sports training. In athletes, these skills are defined more complex, or tests assessing them have low mutual correlations. In this context, the same tests with different groups of subjects, such as athletes and the common population, do not define the same motor structures.

Given the fact that the measuring instruments are designed to assess a certain subject of measurement, which can be relatively simple (e.g. Morphology), but also very complex (e.g. some motor ability), the question arises what in reality certain measuring instrument measures, i.e. what is its validity.

Depending on the purpose of measurement, validity of measurement instruments can be viewed from two perspectives. If the purpose of measurement is to determine the state or level of a particular anthropological characteristic of a respondent, then it is called diagnostic validity. If the purpose of the measurement is forecast performance in an activity based on results collected through some measuring instruments, then it is called pragmatic or predictive validity.

The main purpose of the diagnostic validity is to determine what a particular test measures, i.e. what is the object of measurement. According to the manner of determining there are two main types of diagnostic validity that can be differentiated as follows: a priori and factor validity. A priori validity is typically used for setting up hypotheses on the subject of measurement, which confirm or reject with experimental inspection. The factor validity seeks to determine which subject of measurement is examined by certain measuring instrument, or to what extent each of its factors explains the variability of the results obtained. Since as a rule one measuring instrument is to assess one factor, then by the factor validity it is determined how well a test measures the factor for whose measuring it had been construed for. In factor validity conclusion on the object of measurement is based on the results from the factor analysis, or experimentally determined by what proportion a factor participates in the variance of the test results.

Pragmatic or prognostic validity of a test shows how well, or with what certainty can predict success in a practical activity of the foundation of the results of that test. For example what is the ability to predict success in any athletic discipline (e.g. Running 100 meters) based on the results obtained from the application of a test (e.g. Jump from place). So, the problem of pragmatic validity boils down to determining to a measure of association between the variables obtained from the measurement of a set of entities with a test (predictor or independent variable) and variables that describe the success of those entities in an activity (criteria or independent variable). In kinesiological researches criteria and predictor variables can be one-dimensional and more dimensional. In addition, they can be assessed on a qualitative or quantitative measurement scale. Depending on these characteristics of the variables the method of determining the pragmatic validity is defined (Bala, 1990; Mužić, 1986).

Although there are a number of studies in the area of motor skills and their metric characteristics thereof (KurelićN. et al, 1975; Gredelj M., et al. 1975; Metikoš et al.1989; Hofman, 1975, 1980; Popović, D. 1988; Viskić - Štalec, N. 1989), most of them are realized either on normal population, or on other socio-cultural, economic, political and geographical areas, while a small number of studies have been completed on a selected sample of athletes-boxers (Savić, M. 1986). It initiates the need with scientific processes to seek new information on the structure of latent motor abilities of boxers that can have great importance in the development of the theory and practice of the boxing sport.

Based on these considerations and the fact that so far there is no sufficient number of conducted studies that treat this issue, this research has been conducted with the main objective to determine the diagnostic factor validity as a metric feature of the applied tests to assess certain basic motor abilities of the successful boxers from R. Macedonia.

Methods

Sample of respondents

The research was conducted on a selective sample of 102 male respondents, boxers ranging in age from 18 to 33 years. The population from which the sample has been derived is defined as a population of active sportsmen and women boxers of all categories, participants, competitors in the league system, the state championship of Macedonia and participants of international tournaments, clinically healthy, and without physical disabilities and aberrated manifestation in the motor area.

The basic criteria for selection of respondents are to be actively engaged in boxing at least one year, to be included in the system of competition and have a minimum of three trainings per week. Respondents are drawn from all registered boxing clubs in the country.

The following variables or motor tests were applied for assessment of motor skills: *Tests to assess the coordination*: T-test (MTTEST), eights by leaning (MOSNAV) and Steps on left and right side (MCEKST). *Tests to assess the balance*: Standing on one leg on the balance beam at length with open eyes (MSGOCD), standing on one leg on the balance beam at width with open eyes (MSTGOS), standing on one leg on the balance beam at length with eyes closed (MSGZOD). *Tests to assess the frequency of movements*: Tapping with foot (MTAPNO), Taping with hand in the frontal area (MTAPRF), Tapping with hand in the sagittal area (MATPRS). *Tests to assess flexibility*: Deep stretching on bench (MDLPRK), Shoulder Rotation Test (MISPAL). Deep stretching in sitting position (MDLPSE). *Tests to assess the power*: Keeping the trunk horizontally with face down (MZTHPM), Raising the trunk in 30 seconds (MP30SE), Pull-up in the air on shaft (MZGIVI). *Test to assess the explosive power*: Long jump from place (MSKDAM), Dumping medical ball (1kg) from a position on back (MFMPGR), Dumping medical ball (1kg) from breast with sitting on the chair (MFMGST). *Tests to assess accuracy*: Shooting a target with a long stick (MSTMDS), Shooting a target with a short stick (MSTKST), shooting at the boxing bulb by hand (MSTBKR).

The validity of the test is determined by factor analysis under the component model. The Intercorrelation matrix on motor tests are factorized with Hotteling - Lesser method of main components, and the number of significant principal components is determined by the Guttman-Kaiser criterion, according to which all are considered characteristic roots equal or greater than 1. Normality of distribution all motor tests was tested by the method of Kolmogorov and Smirnov.

Results

The factor analysis covered three variables (test), by the structure of the set hypothetical model, the level of validity for the treated sample of respondents was determined for assessment of motor skills.

From Table 1 it can be seen that the three motor tests, which according to the hypothetical model were applied to assess the coordination, have high projections of the first main component. The value of the total explained variability was 72%, which means that the value of communality in terms of the unexplained variability is higher. Communality for all three tests is relatively high, ranging from .65 to .73. When analyzing the projection of the tests of the first and the only major component it can be seen that the test for eights by leaning (.87) has the greatest projection and validly, as well as the greatest communality of .76. The other two tests - Steps on left and right side and T-test have high projections of the first main component. Based on the results in Table 1 it can be concluded that the three tests to assess the coordination are valid for this sample of respondents.

Table 1. Tests to assess the coordination

	H1	h2
MTTEST	,805	,649
MOSNAV	,875	,765
MCEKST	,857	,734
λ - Lambda	2,15	
%	71.60	

The three tests that according to the hypothetical model which was applied to assess the balance (Table 2) have statistically significant projections of the first main component. The total explained variability was 63%, which means that the higher the value of communality regarding unexplained variability. Communality of all three tests ranges from .57 to .66. When analyzing the projection of tests of the first and the only major components it can be seen that standing on one leg on the balance beam at length with eyes closed (.81) has the greatest projection and validity, as well as the greatest communality of .66. The other two tests Standing on one leg on the balance beam at length with open eyes and Standing on one leg on the balance beam at width with open eyes have relatively high projections of the first main component.

Table 2. Tests to assess the balance

	H1	h2
MSGOCD	,757	,574
MSTGOS	,805	,648
MSGZOD	,815	,664
λ - Lambda	1,88	
%	62.84	

From review of Table 3 it can be seen that the three motor tests, which according to the hypothetical model were used to estimate the frequency of movements have statistically significant projection of the first main component. Value of the total explained variability is 72%, indicating that the value of communality higher in terms of unexplained variability (uniquity). Communality of the tests Tapping with hand in the frontal plane and Tapping with hand in the sagittal area is higher than uniqueness and ranges from .90 to .85. The communality of the test Tapping with a foot is significantly lower compared to the previous two tests .40. The analysis of the results in the table shows that the greatest projection and validity shows the test Tapping with hand in the sagittal area (.95), which also has the greatest communality of .90.

Table 3. Tests to assess the frequency of movements

	H1	h2
MTAPNO	,632	,399
MTAPRF	,926	,858
MATPRS	,949	,901
λ - Lambda	2,16	
%	71.95	

The three tests that according to the hypothetical model were applied to assess the precision (Table 4), have statistically significant projections of the first major component isolated. The value of the total variance explained is below 50%, which means that the value of the unexplained variable is higher. Community of the tests Deep stretching on bench and deep stretching in sitting position are higher than the unquity, while community of the Shoulder Rotation Test is significantly lower, indicating that this test has a great unquity and should not be applied in future research in this sample of respondents. The highest projection and validity shows the test Deep stretching in sitting position (.87) which has the highest community of .75.

Table 4. Tests to assess flexibility

	H1	h2
MDLPRK	,744	,544
MISKPAL	,386	,149
MDLPSE	,868	,754
λ - Lambda	1,46	
%	48,57	

From review of table 5 it can be seen that the three motor tests, which according to the hypothetical model were used to estimate the strength, have statistically significant correlations with the first principal component. The value of the total explained variability is 62%, indicating that the value of community is higher in terms of unexplained variability. Community of all three tests ranges from .53 to .68 and is higher than the unquity. When analyzing projection of the tests of the first and the only major component it can be seen that the test Raising the trunk in 30 seconds. (.82) has the highest projections and validity, as well as the greatest community of .78. The other two tests, Keeping the trunk horizontally with face down have relatively high projections of the first main component, which indicates that these tests are valid for this sample of respondents.

Table 5. Tests to assess the power

	H1	h2
MZTHPM	,726	,527
MP30SE	,823	,677
MZGIVI	,809	,655
λ - Lambda	1,86	
%	61,94	

The three tests that according to the hypothetical model were applied to assess the explosive strength (Table 6) have statistically significant high saturations of the first main component. The value of the total variance explained is 82%, which means that the value of community is much higher in terms of unexplained variability. Community of all three tests is high, ranging from .67 to .90. When analyzing projection of tests of the first and the only major component it can be seen that the test Throwing medical ball (1kg) from a position on back (.95) has the highest projections and validity, as well as the greatest community of .90. The other two tests, Long jump from place and Throwing medical ball (1kg) from breast in sitting position have relatively high projections of the first main component.

Table 6. Test to assess the explosive power

	H1	h2
MSKDAM	,836	,698
MFMPGR	,949	,900
MFMGST	,925	,855
λ - Lambda	2,45	
%	81,77	

The three tests that according to the hypothetical model were applied to assess the accuracy of the placement (Table 7) have statistically significant high saturations of the first main component. The value of the total variance explained is 68%, which means that the value of communality is higher in terms of unexplained variability. Communality of all three tests is high, ranging from .47 to .82. Communality of the test Shooting with long and short stick is higher than the unicity, while the communality of the tests Shooting at the boxing bulb is significantly lower, indicating that in this test dominates unicity (the error of measurement or specificities is bigger). When analyzing the projections of the tests of the first and the only major components it can be seen that the highest projections and validity is shown in the test Shooting with short stick (.90), which also has the greatest communality of .82. The other two tests Shooting with long stick and Shooting on boxing bulb have statistically significant projections of the first main component.

Table 7. Tests to assess accuracy

	H1	h2
MSTMDS	,894	,799
MSTKS	,904	,818
MSTBKR	,645	,416
λ - Lambda	2,03	
%	67,80	

Based on the results it can be concluded that the research results can be used in the rational planning and programming of the annual and multi-annual programs, selection, control of the transformation process and other similar issues in development of the theory and practice of boxing.

Conclusion

For evaluation of motor skills we have applied 21 tests, standardized movement tasks selected in accordance with the structural, the so called compromise approach of determining the structure of motor abilities (according to the results Metikos D., Prot F., Kuleshov, Horvath and E. Hofman 1982), phenomenologically nominated as: relative and absolute power (from a functional viewpoint defined as an ability to regulate the duration of excitation of the neuromuscular system); explosive power (ability to regulate the intensity of excitation); coordination of serial and parallel processor and frequency of the movement (ability to regulate the structure of the movement); flexibility, balance and accuracy (ability to regulate the tone and synergistic regulation).

The validity of the test has been determined by factor analysis under the component model. The Intercorrelation matrix of the motor tests has been factorized by the Hotteling - Lesser method of main components, and the number of significant principal components is determined by the Guttman-Kaiser-Conn's criterion, according to which all characteristic roots equal or greater than 1 have been taken into account.

Based on the results it can be concluded that most of the tests applied have satisfactory factor validity and may be applied in the diagnosis of motor skills of boxers. As a proposal for diagnosing the motor abilities, the following reduced battery of tests is recommended: Eights by leaning (Assessment Coordination), Standing on one leg on the balance beam at length with eyes closed (to assess the balance), Tapping with hand in the sagittal area (to assess the frequency of movements), Deep stretching in sitting position (assessment of flexibility), Raising the trunk in 30 seconds (for assessment of power), Dumping of medical ball(1kg) from a position on back (to assess the explosive power) and Shooting with a short stick (assessment of precision).

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RELATIONS BETWEEN LEISURE TIME, THE FREQUENCY OF DOING PHYSICAL ACTIVITY AND MEMBERSHIP IN SPORTS CLUBS AMONG PUPILS

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(Original scientific paper)

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Abstract

The aim of this research was to analyse the relations between the amount of leisure time and membership in sports clubs among elementary school pupils, focusing on gender differentiation. The sample included a total of 157 students (78 boys). By testing significance of differences between proportions of the students who self-reportedly have free time and are members of sports clubs ($p_1=0,64$) and the ones who self-reportedly do not have leisure time and are members of sports clubs ($p_2=0,26$), a statistically significant difference was determined ($p<0,001$). Moreover, by testing significance of differences between proportions of the female students who self-reportedly have leisure time and are members of sports clubs ($p_1=0,33$) and the ones who self-reportedly do not have free time and are members of sports clubs ($p_2=0,67$), a statistically significant difference was determined as well ($p<0,001$). The results show gender differentiation as well, where boys who have more free time are more likely to become members of sports clubs, while the situation with girls is reversed. Taking into consideration the significance of physical activity, especially during puberty, which is a critical period of habit formation, results clearly indicate that membership in sports clubs is a predictor of the development of a variety of child development areas. These results are in accordance with a series of timely and adequate actions aimed at creating and maintenance of desirable habits, and preventing the negative consequences of the lack of physical activity.

Key words: membership in sports clubs, habits, students, physical activity

Introduction

A leisure time is a social phenomenon that requires a detailed approach in all aspects of life. Thus, scientific disciplines focused on human behaviour put emphasis on it as well (Mlinarević and Gajger, 2010). According to the researches dealing with this phenomenon, it can be concluded that it is not uniquely defined. Among numerous definitions, that of Dumazedier (1962, 29), who is considered to be one of the most eminent representatives of the sociology of leisure, stands out. In his opinion, “leisure consists of a number of occupations in which the individual may indulge of his own free will – either to rest, to amuse himself, to add to his knowledge or improve his skills disinterestedly or to increase his voluntary participation in the life of the community after discharging his professional, family or social duties”.

When taking into consideration the development of society, leisure activities have gone through several stages from the tribal society to modern times (Previšić, 2000, 405):

a) *the domination of free time without the concept and praxis of work in the expression of primitive cultures;*

b) *unlimited and undefined work time and leisure time;*

c) *the prevail of work time over leisure time;*

d) *the shortening of work time and an increase in leisure time*

In times when the demands of a modern human being living in consumer society are ever growing, free time is given to us as a prize, i.e. it must be bought (Polić, 2003). In this situation we ask ourselves what free time is free from and what it is free for. Commercialisation of free time has helped profitable industries, such as “the industry of entertainment“, tourism and sport to develop; and in their eyes free time is primarily seen as time free of work. However, in modern times leisure time is seen as profitable also if it is spent studying of creating. This is how non- work is distinguished from wasting time. Although the difference is

sometimes elusive, there are cases in which it is deliberately blurred in order to commercialise free time and annul its revolutionary power in society. Thus, we can ask ourselves the following question: Are sports competitions a part of leisure activities (a game) or a part of work time? (Polić and Polić, 2009). Whatever the answer, leisure time with all of its contents has become a dominant part of everyday life and the quality of spending it has become the topic of researches (Badrić and Prskalo, 2011). In modern times, a large proportion of population lives in urban areas. Such situation is unfavourable from both ecological and kinesiological point of view. Leisure time is increasingly spent in sedentary behaviours which consequently lead to a variety of disorders, primarily obesity and anxiety. However, adequate kinesiology programs help reducing the consequences of the lack of physical activity (Prskalo et al., 2009). Children and teenagers have more free time in comparison with adults and the content of leisure activities significantly contributes to shaping their identity and the future quality of life. Due to their specific bio psychosocial status, they should spend their free time in an organized manner. It certainly can not be left to chance (Previšić, 1989). Jedud and Novak (2006) see it as a means of empowerment of young people and as a sphere of the realization of interests of an individual or a group, and since an individual spends his/ her free time in accordance to personal wishes and possibilities, it provides him/ her with the sensation of liberty and personal control, enabling him/ her to achieve self determination. According to Bouillet and Uzelac (2008), leisure time should represent the peak of pleasure and happiness, which makes it indispensable in modern world value system.

The role of school in creating leisure time activities for children is crucial, but unfortunately insufficiently effective since there are not enough school activities which can be done in free time. Nevertheless, regardless of numerous organizational, professional and material limitations, schools do organize some extracurricular activities, and among them, sports activities (Mlinarević i Gajger, 2010).

According to the recommendations of the World Health Organization, children and youth should accumulate at least 60 minutes of moderate-intensity physical activity daily. Maršić and Paradžik (2006) stated that in Croatia the number of physically inactive pupils and citizens is still large and that achieving the desirable level of physical activity in the population is definitely not an easy task.

Researching the structure of leisure time of elementary school children, Arbunić (2006) came to the conclusion that the amount of activity depends on the time of day and the age of the pupils. The amount of physical activity with respect to overall leisure time declines with age (Thompson et al., 2009; Kvesić et al., 2015), and gender differences in physical activity levels are also noticeable in favour of male students (Mota and Esculas, 2002).

Škegro, Čustonja and Milanović (2009) put emphasis on two most common types of leisure - time physical activities: membership in sports clubs, recreational associations, boy scouts and other institutions and individual physical exercise.

In the focus of Hartman's (2003) research was the participation of school children in extracurricular activities. 181 children (92 boys) were included in the study sample. The results showed that 51% of the children were physically active, out of which 83,9% were members of some sports club, and 16,1% were members of school sports club. The results stress the significance of ensuring adequate material, professional and organisational conditions in order to obtain an adequate and desirable level of physical activity of the students.

Kokko, Kannas and Villberg (2009) was research profiles of childrens and youth sports clubs in Finland in relation to health promotion in view of the policy in the clubs and the perception of the coach. The study included 27 sports clubs, 273 sports professionals and 240 coaches. The survey was conducted HPSC questionnaire which proved valid and reliable where the particles in the questionnaire related to politics in clubs, ideology, practices and environmental factors. The results showed that only a small number of clubs in making a significant impact on overall health promotion.

A significant and worryingly high number of children, both members and non-members of sports clubs, do not consider physical activity to be an appealing choice when it comes to spending leisure time (Miholić Jenko, Hraski and Juranić, 2015), which is a problem since attitudes are a significant predictor of the choice of leisure time activities. Attitudes towards P.E. and sport are a frequent subject of kinesiology researches. The reason can be attribute to the assumption of the possibility of predicting behaviour based on attitudes, i.e. the assumption regarding the cause and correlation between attitudes and behaviour. Markuš (2011) determined that researches showed correlation between attitudes and behaviour, but the extent of it is still to be determined.

Pano and Markola (2012) was research the factors what affectihg on children's attitudes towards physical activity. Significant variables considered social class, gender, race, physical identity and self-perception of the body. The study included 1062 high school students aged 14-18 years from 6 different public high schools of Albania. The results indicate that the 14,21 % of respondents are concerned with physical activity and sport regularly, 39 % participate in physical activity or sport once a week, and 36 % are active rare. Motivation for activity is fun (35.87 %) and 33.08 % of them "improving their physical image ". The lack of free time (53.57 %) and lack of sports facilities (20.43 %) are the main reasons why they do not deal with physical activity and sport. There is also a lack of information on the benefits of participation in physical activity and sport for this age.

Geind , Quennerstedt and Eriksson (2013) was research the importance of sports clubs in improving on the health of young people, where sports clubs participating in the study were not professional clubs, membership in clubs was voluntarily and outside the regular school program. Programs that are implement in these clubs was in accordance with the recommendations of the WHO. In order for clubs to become a significant factor in improving health should be a comprehensive approach activities being carried out in areas with specified objectives and purposes.

In the focus of the research of Tomac, Šumanović and Rastovski (2013) was the attitude of 8th grade students toward P.E. They determined that students who are physically active express affinity toward physical education, while the affinity decreases with girls and students whose favourite subjects are Maths and foreign languages.

Žnidarec Čučković and Ohnjec (2014) also described the interests of children and youth in the context of doing physical activity and sports in order to detect their attitudes. They concluded that motion receives its own dimension separated from the context of play and entertainment. Moreover, the attitude toward different organised sports activities is fairly strict. Among other things, Prskalo (2013) finds physical activity to be an activity without an alternative.

In accordance with the abovementioned, the following aim of this research was formed: to determine the correlation between the amount of students` free time and membership in sports clubs on the sample of elementary school students (grades 5-8), with gender differentiation.

Methodology

This research was conducted in accordance with Ethical Standards for Research Involving Children. The children included in the sample are elementary school students of Split-Dalmatia County. In accordance with the aim of the research, the sample comprised 157 students (grades 5-8) – 78 boys and 79 girls. After obtaining parental consent, the research was conducted via a questionnaire designed specifically for this research. The questionnaire contained the following questions: “*Do you have enough free time?*“, “*Are you a member of a sports club?*“ (nominal scale with two categories) and “*Would you like to continue doing physical activity / sports in the future?*“ (nominal scale, three categories) The students were given 10 minutes to anonymously answer the abovementioned questions about the perceived amount of free time.

Using z-test significance of differences between observed proportions, of categories of boys who self-reportedly have/ do not have free time and are members of sports clubs were examined. The results are obtained by using the software Statistica 12.0. (StatSoft, Tulsa, OK, USA). The type I error was set at $\alpha=5\%$.

Results and Discussion

Within a table 1 and table 2, insight into frequencies of self-reported structure and amount of free time for boys and girls is given.

Table 1: Frequencies and the self-reported proportions of the amount of free time

Free time	Boys (n ₁ =78)				
	Yes (n _{1,1} =66)		No (n _{1,2} =12)		
Club Membership	Yes	No	Yes	No	
Future life	No	0 (0%)	2 (2,56%)	0 (0%)	1 (1,28%)
	Yes	40 (51,28%)	16 (20,51%)	7 (8,97%)	2 (2,56%)
	Maybe	2 (2,56%)	6 (7,69%)	1 (1,28%)	1 (1,28%)

Free time (“*Do you have enough free time?*“), membership in a club – Club membership (“*Are you a member of a sports club?*“) on a nominal scale with two categories and - Future life (“*Would you like to continue doing physical activity / sports in the future?*“ on a nominal scale with three categories for male students.

Table 2: Frequencies and the self-reported proportions of the amount of free time

Free time	Girls (n ₂ =79)			
	Yes (n _{2,1} =63)		No (n _{2,2} =16)	
Club membership	Yes	No	Yes	No
Future life	No	1 (1,27%)	0 (0%)	1 (1,27%)
	Yes	26 (32,91%)	3 (3,80%)	6 (7,59%)
	Maybe	15 (18,99%)	0 (0%)	6 (7,59%)

Free time ("Do you have enough free time?"), membership in a club – Club membership ("Are you a member of a sports club?") on a nominal scale with two categories and - Future life ("Would you like to continue doing physical activity / sports in the future?" on a nominal scale with three categories for female students.

By using z-test, significance of differences between proportions of the students who self-reportedly have free time and are members of sports clubs ($p_1=0,64$) and the ones who do not have leisure time and are members of sports clubs ($p_2=0,26$), a statistically significant difference was determined ($p<0,001$). Moreover, by testing significance of differences between proportions of the female students who self-reportedly have leisure time and are members of sports clubs ($p_1=0,33$) and the ones who do not have free time and are members of sports clubs ($p_2=0,67$), a statistically significant difference was determined as well ($p<0,001$).

The results of some other researches (Beigle et al., 2006; Badrić and Prskalo, 2011) show gender differentiation as well, where boys who have more free time are more likely to become members of sports clubs, while the situation with girls is reversed.

Conclusion

Numerous researchers around the world have focused on leisure time of children and youth since the structure of leisure time is a predictor of health and optimal child development. In times of modern technology, such as computers and mobile phones, sedentary behaviour prevails given that using technology requires no or very little physical activity. According to studies, organised physical activity, among which membership in sports clubs is considered to be the best, is a desirable form of exercise due to a series of reasons, such as professional leadership and adequate material conditions. By testing significant differences between proportions of the students who self-reportedly have free time and are members of sports clubs ($p_1=0,64$) and the ones who do not have leisure time and are members of sports clubs ($p_2=0,26$), a statistically significant difference was determined ($p<0,001$). Moreover, by testing significant differences between proportions of the female students who self-reportedly have leisure time and are members of sports clubs ($p_1=0,33$) and the ones who do not have free time and are members of sports clubs ($p_2=0,67$), a statistically significant difference was determined as well ($p<0,001$). The results show gender differentiation as well, where boys who have more free time are more likely to become members of sports clubs, while the situation with girls is reversed. In times when both the number of overweight children and the number of disorders connected with insufficient physical activity have been rising due to the lack of physical activity, and the attitude of students about physical activity does not show satisfactory and desirable results, this research will help to set goals for the future actions in order to prevent negative outcomes. The significance of physical activity for children and youth, especially during adolescence, is particularly stressed through membership in sports clubs. Since the results of this research show that female students are more inactive than the male students, these results could serve as a timely appeal causing adequate actions aimed at creating and maintenance of desirable habits, and preventing the negative consequences of the lack of physical activity.

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TENNIS ELBOW: ITS ORIGINS AND TREATMENT

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(Original scientific paper)

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Abstract

Tennis elbow or lateral epicondylitis is a type of repetitive strain injury, resulting from tendon overuse and failed healing of the tendon. The extensor carpi radialis brevis muscle plays a key role. This disease is a very common cause of the elbow pain in people and athletes between the ages of 30 and 50 years old. Aim: The aim is to present origins and treatment of tennis elbow or lateral epicondylitis. Material and methods: The study included 90 patients having tennis elbow, and they were divided to two groups according to different conservative treatment. Clinical and radiographic examinations (X-ray, ultrasonography and MRI) were analyzed during the evaluation. In this retrospective study 2 patients were followed with colour Doppler ultrasound. Results: Exactly 80 patients became symptom-free and regained normal function after 1 year. 6 patients in group 1 and 4 patients in group 2 returned 1 year later complaining persistent pain of the area of elbow, and minimized the participation in sportive activities. Conclusion: Conservative therapy is the best choice for treatment of tennis elbow.

Key words: tennis elbow, sport injuries, treatment.

Introduction

Tennis elbow is a condition that causes pain around the outside of the elbow. It is clinically known as lateral epicondylitis. The forearm muscles and tendons become damaged from overuse, repeating the same strenuous motions again and again. The extensor carpi radialis brevis muscle plays a key role. Any activity, including playing tennis, which involves the repetitive use of the extensor muscles of the forearm can cause acute or chronic tendonitis of the tendinous insertion of these muscles at the lateral epicondyle of the elbow (fig. 1). The pathophysiology of lateral epicondylitis is degenerative. Histological findings include granulation tissue, microrupture, degenerative changes, and there is no traditional inflammation. Lateral epicondylitis in tennis players is caused by the repetitive nature of hitting thousands of tennis balls, which leads to tiny tears in the forearm tendon attachment at the elbow (Faro F, Wolf JM, 2007).

Lateral epicondylitis is a common musculoskeletal condition. One in three people have tennis elbow at any given time. In tennis players, about 38% have reported current or previous problems with their elbow. It is often caused by other activities that place repeated stress on the elbow joint, such as other athletes, golfers, baseball players, bowlers, gardeners, carpenters, mechanics or playing the violin. The condition is more prevalent in tennis players and individuals over 40. Men and women are equally affected. Symptoms of lateral epicondylitis consists of pain on the other part of the elbow, point tenderness over the lateral epicondyle (a prominent part of the bone on the outside of the elbow), pain from gripping and movements of the wrist (especially wrist extension and lifting movements), pain from activities that use the muscles that extend the wrist. Symptoms associated with tennis elbow include: radiating pain from the outside of

the elbow to the forearm and wrist, pain during extension of wrist, weakness of the forearm, a painful grip while shaking hands or torquing a doorknob, and not being able to hold relatively heavy items in the hand (Nirschl RP, 1992).

Tennis elbow cannot be diagnosed from blood tests and by X-rays. It is usually diagnosed by the description of pain and findings from a physical exam, such as worsening of the pain with passive wrist flexion and resistive wrist extension (Cozen's test). Ultrasonography and magnetic resonance imaging are other valuable tools for diagnosis.

From all tennis elbow cases 80-95% are treated by conservative methods (relax the affected arm, cold compress for a few minutes several times a day, orthotics, physiotherapy, non-steroid anti-inflammatory drugs, corticosteroid injection) (Coombes BK, Bisset L, Vicenzino B, 2010). Surgery may be used as a last resort to remove the damaged part of the tendon. Surgical techniques can be done by open, percutaneous or arthroscopic surgery. Tennis elbow left untreated can lead to chronic pain that degrades quality of daily living (Nirschl RP, Ashman ES, 2004).

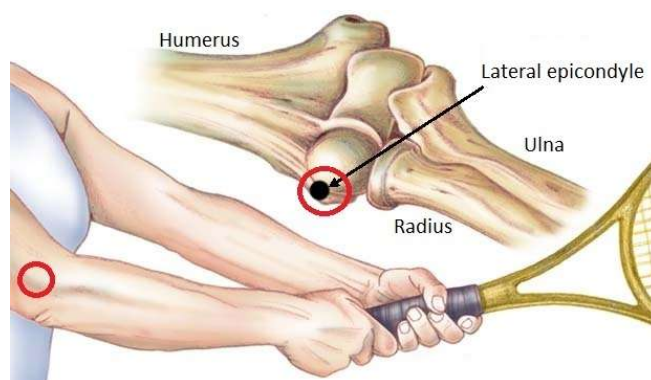


Fig. 1. Tennis elbow

Aim

The aim of this work is to show origins and treatment in patients and athletes with tennis elbow.

Patients and methods

The study was worked out at the University Orthopaedic Surgery Clinic, Faculty of Medicine in Skopje. During the years 2010 to 2014, 90 patients between ages 20 to 50 years were observed for lateral epicondylitis. The patients complained of suddenly pain localized around the outside of the elbow. The patients were divided to two groups of 45 patients each. All patients were treated with conservative treatment: relax the arm, cold compress, orthotics, physiotherapy, non-steroid anti-inflammatory drugs, corticosteroid injection. Group 1 was treated combination conservative methods and corticosteroid injection (fig. 2), and group 2 was treated only with conservative methods end without corticosteroid injection. Due to the variations of development of the elbow, the symptoms and clinical findings had to substantiate the X-Ray, ultrasonography and MRI evidence in order to diagnose tennis elbow or lateral epicondylitis. Also, at the University Cardiology Clinic 2 patients were followed with colour Doppler ultrasound because of pain, swelling and palpable cooler upper limb.



Fig. 2. Corticosteroid injection

Results

According to sex both groups consisted of 49 (54%) male patients and 41(46%) female patients. The average age of the patients was 38 years. Follow-up examinations were also carried out in the 90 patients treated by the previously reported conservative methods. Patients treated with conservative methods and corticosteroid injection (group 1) had lower complete recovery at 1 year. Patients treated only with conservative methods also had recurrence rate at 1 year. These patients had resumed normal daily activities six months after completion of the various modalities of conservative treatment, and had attained freedom from pain within a year. They demonstrated full ability to participate in vigorous activities at work and sport. Thus, they did not return further for examination, except for 6 patients in group 1, and 4 patients in group 2 who returned 1 year later and complained of enlargement of the area of the elbow. This area was sensitive, more often tender on palpation, with the elbow fully extended – which is the origin of the extensor carpi radialis brevis muscle from the lateral epicondyle. To complete diagnosis we used X-ray and ultrasonography in all 90 patients. Magnetic resonance imaging was done only in 4 patients (two in each group), confirmed excess fluid and swelling in the affected region in the elbow. Colour Doppler ultrasound showed normal vascularization of the upper limbs in both investigated patients. In these patients with further investigations proved seropositive rheumatoid arthritis as the reason for the beginning of lateral epicondylitis.

Discussion

The term tennis elbow first appeared in an 1883 paper by Mayor called Lawn-tennis elbow. In tennis player, 40% have reported current with their elbow. Less than one quarter (24%) of these athletes under the age of 50 reported that the tennis elbow symptoms were “severe” and “disabling,” while 42 % were over the age of 50. Tennis elbow is more prevalent in individuals over 40, and equally affects both sexes. In our study the average age of the patients was 38 years. 54% were male, and 46% were female patients. (Nirschl RP, 1992).

Studies show that trauma such as direct blows to the epicondyle, a sudden forceful pull, or forceful extension cause more than half of these injuries. It has also been known that incorrectly playing tennis may cause early stages of tennis elbow as shock is received when mishitting the ball (Bisset L, Paungmali A, Vicenzino B, Beller E, 2005). Ciriax proposes that there are microscopic and macroscopic tears between the common extensor tendon and the periosteum of the humeral epicondyle. Kaplan noted the constriction of the radial nerve by adhesion to the capsule of the radiohumeral joint and short extensor muscle of the wrist.

Diagnosis is made by clinical signs and symptoms, X-ray (usually normal), medical ultrasonography (displays thickening and heterogeneity of the common extensor tendon, calcifications, intrasubstance tears, and marked irregularity of the lateral epicondyle), and MRI (excess fluid and swelling in the affected region in the elbow, such as the connecting point between the forearm bone and the extensor carpi radialis brevis) (Bisset L, Paungmali A, Vicenzino B, Beller E, 2005).

Many papers and studies report that 80-95% of all tennis elbow cases can be treated without surgery. In some cases, severity of tennis elbow symptoms mend without any treatment, within six to 24 months, but untreated elbow can lead to chronic pain that degrades quality of living. Corticosteroid injection may be effective in short term, little benefit after a year, compared to a wait and see approach (Krogh TP, Bartels EM, Ellingsen T, Stengaard-Pedersen K, Buchbinder R, Fredberg U, Bliddal H, Christensen R, 2013). In our study, we have conservative treatment of all respondents with excellent result. Only in few cases symptoms persist for 1 year. Complications from repeated steroid injections include skin problems such as hypopigmentation and fat atrophy leading to indentation of the skin around the injection site. Response to initial therapy is common, but so is relapse (25% to 50%) and, or prolonged, moderate discomfort (40%) (Coombes BK, Bisset L, Brooks P, Khan A, Vicenzino B, 2013).

The most important is prevention. Increased incidence with increased playing time is statistically significant only for respondents under 40. Individuals over 40 who played over two hours had a two fold increase in chance of injury. Those under 40 had a 3.5 times increase compared to those who played less than two hours per day. Poor technique increases the chance for injury much like any sport. Therefore, an individual must learn proper technique for all aspects of their sport. Other ways to prevent tennis elbow are: decreases of playing time if feeling pain, stay in good physical shape, strengthen the muscles of the forearm, the upper arm, the shoulder and upper back (Lo MY, Safran MR, 2007).

Conclusion

The goals of treatment are to reduce pain, promote healing, and decrease stress and abuse on the injured elbow. A big part of managing the condition is educating the patients, athletes and coaches about the condition and the importance of not over training. It is important to manage the young tennis players training program to change technique and alleviate the problem.

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BONE TUMORS AND TUMOR-LIKE LESIONS ASSOCIATED WITH KNEE TRAUMA

UDC:616.718-006:616-728.3-001

(Original scientific paper)

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Abstract

Bone tumors and tumor-like conditions are rare entities of bones, and most are located around the knee. It is continuous dilemma if the bone lesion originates from the trauma. Our team has been consulted for 17 knee trauma associated with bone lesions. Lesions of bone were diagnosed as: tumor-like lesions; benign bone tumors; benign soft tissue tumor; aggressive bone tumor; malignant bone tumors. Three patients had foot thrombophlebitis and for their treatment has been consulted cardiologist. From 13 patients with tumor-like lesions and benign bone tumors only 4 were operated. Corticosteroids were applied in the bone cysts in 2 patients. Patients with aggressive bone tumors had their lesions excised and bone cement was used for the defect. Malignant bone tumors were treated with preoperative neoadjuvant and following surgery postoperative chemotherapy regimen. Bone lesions can be easily overseen. The fact that more than 60% of bone tumors are in the vicinity of the knee makes the diagnostic decision of knee trauma more difficult.

Key words: bone tumors, knee, trauma.

Introduction

In the modern world we live in a society obsessed by sport. At recreational level, this allows an escape from the pressures of modern life. At all levels, injury is a constant threat, and, of all injuries, those of the knee fulfill the athlete's greatest fear of spending a long time out of action. This is confirmed by a study from Sheffield, which showed the knee to have been the most commonly injured joint and soccer and rugby to have the highest risks (Steve Bollen., 2000), (Nicholl JP, Coleman P, Williams BT., 1991).

In the same time, more than 60% of bone tumors and tumor-like lesions are located in the knee or its vicinity. Male adolescents or young active persons are at the highest risk of injury and bone tumors, too (Larson SE, Lorentzon R., 1974), (Samardziski M, Janevska V, Vasilevska Nikodinovska V, Atanasov N., 2015).

Our experience confirmed that trauma "revealed" most of the inactive bone tumors and tumor-like lesions (or "leave me alone" lesions) and in cases with aggressive or malignant tumor just provoked the pain, swelling or induced pathological fracture in already affected bone. In these cases, history of the illness showed mild or irritant pain, swelling or even "night pain" before the trauma of the knee.

Material and methods

In the period from 2014 to 2015 the bone tumor team at the Clinic for Orthopedic Surgery has been consulted for 17 knee trauma associated with bone lesions. The patients' age varied from 11 to 63 years (average 32). Lesions of bone were diagnosed as: tumor-like lesions (8 patients); benign bone tumors (4 patients); benign soft tissue tumor (1 patient); aggressive bone tumor (2 patients); malignant bone tumors (2 patients) (Table 1). Of all respondents, three were with foot thrombophlebitis and for their diagnosis (cardiac ultrasound and vascular Doppler investigation) and treatment has been consulted cardiologist.

All patients underwent appropriate diagnostic protocol. Patients with tumor-like lesions and benign bone tumors (total of 13) were diagnosed and followed-up. Standard diagnostic protocol consisted of basic laboratory findings, radiographs of the lesion site in two or more planes, Technetium bone scan, CT, CT angiography (if necessary) and MRI.

Table 1. Diagnosis and treatment of the patients in our study

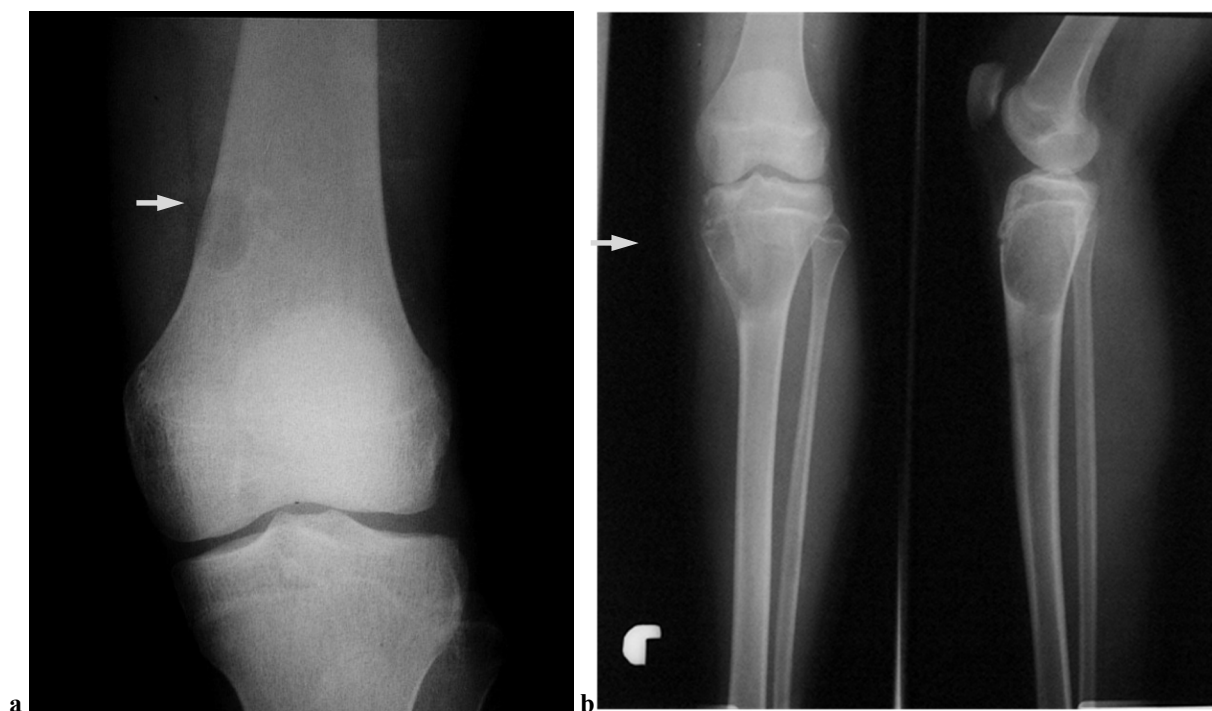
Bone lesion	Type	Number	Treatment
Tumor-like lesions	Simple cyst	2	Corticosteroid application
	Non ossifying fibroma	6	None, follow-up
Benign bone tumor	Osteochondroma	4	Excision
Benign soft tissue t.	Hemangioma	1	None, follow-up
Aggressive bone tumor	Giant cell tumor	2	Curettage + bone cement
Malignant bone tumor	Osteosarcoma	2	Preoperative chemotherapy, surgery, postoperative chemotherapy
Total		17	

Patients with aggressive bone tumors (giant cell tumors), before the biopsy were diagnosed with standard diagnostic protocol (as described above) and then treated case dependent following strict multidisciplinary protocols (respectfully) with surgery and chemotherapy.

Patients with malignant bone tumors (high-grade osteosarcoma), before the biopsy were diagnosed with standard diagnostic protocol (as described before) and then treated case dependent, following strict multidisciplinary protocols with neoadjuvant chemotherapy surgery and post operative (adjuvant) chemotherapy. Depending on the response to neoadjuvant chemotherapy, patients were classified as “good or poor responders” and followed certain chemotherapy regimen. All of these patients were diagnosed and treated multidisciplinary, following the directions of the “sarcoma consillium” (Wittig JC, Bickels J, Priebat D, Jelinek J, Kellar-Graney K, Shmookler B, Malawer M. 2002), (Samardziski M, Zafiroski G, Tolevska, C, Zafirova-Ivanovska B, Kostadinova-Kunovska S, Kalicanin-Markovska M., 2009).

Results

Both patients with bone cyst were treated with multiple application of corticosteroid in the cyst. One of these patients is considered for further operative treatment, due to “activity” in the bone cyst. Four of the patients with osteochondroma had their tumors excised. The rest 7 patients had their symptoms due knee trauma and their bone lesions were considered as non active (“leave me alone”) entities. There was no indication for operative treatment considering the bone lesion but knee trauma was different problem. Some of them had internal knee injuries as: menisci lesions, anterior cruciate ligament or cartilage problems. These patients were operated accordingly.



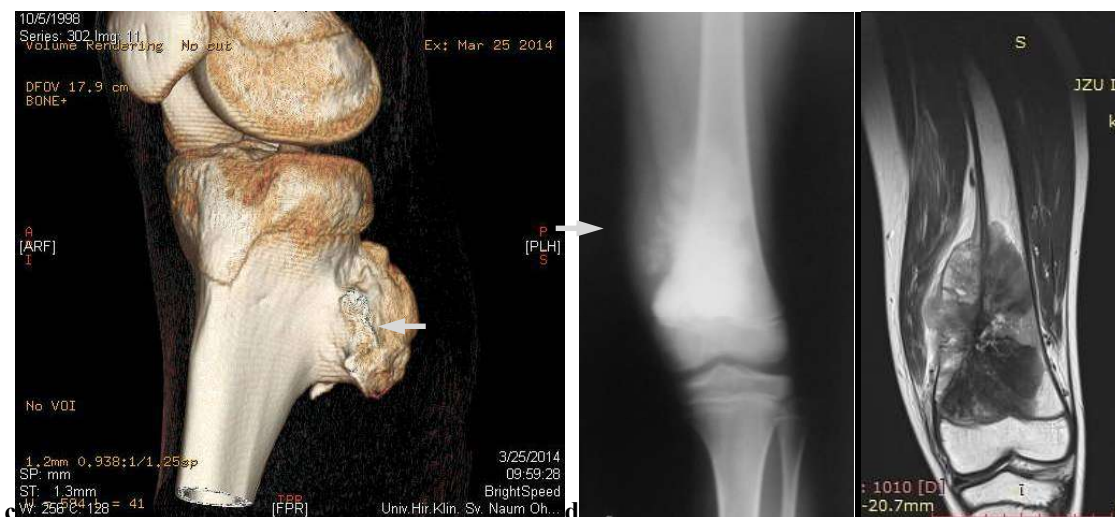


Figure 1. a) distal femur non ossifying fibroma (“leave me alone” lesion), **b)** aneurismal bone cyst of proximal tibia (“active bone cyst”), **c)** proximal medial tibia osteochondroma, **d)** x-ray and MRI of distal femur osteosarcoma.

Both patients with giant cell tumors (aggressive bone tumors) were operated, the tumor curetted and the bone defect was packed with bone cement (metal-met acrylate). One of these patients had recurrence of high tumor activity. Considering the need of radical tumor resection and special knee endoprosthesis reconstruction, the patient is scheduled for operative treatment abroad.

Knee trauma just provoked the pain, swelling or induced pathological fracture in already affected bone in 2 patients with osteosarcoma. After the biopsy both patients were diagnosed with high-grade osteosarcoma. A special multi-modal (poly-chemotherapy) protocol with neoadjuvant chemotherapy surgery and post operative (adjuvant) chemotherapy was applied. Both patients were “bad responders” after the neoadjuvant chemotherapy and histology of the excised tumor showed more than 20% of viable tumor. Such result will define final treatment and long-term prognosis of these patients is bad.

Discussion

The exact etiology of bone tumors and tumor-like lesions is unknown (Prichard DJ, Finkel MP., 1975). Trauma as cause of bone tumor is posing an academic dilemma that provokes discussion decades ago. Despite advances in the understanding of cancer, from the late 1800s until the 1920s, cancer was thought by some to be caused by trauma. This belief was maintained despite the failure to cause cancer in experimental animals by injury. In 1923 Foster discussed the problem without definite conclusion (Foster. SD., 1923). People often think that a knock or injury to a bone can cause a cancer. But research studies do not support this. It is more likely that an injury causes swelling, which shows up a cancer that is already there. Or a bone affected by cancer may be weakened and so is more likely to become damaged in an accident. Doctors may then spot the tumour when they are investigating the accident. It seems that trauma is the knee factor in revealing the existence of the bone lesion or the tumor (Fletcher CDM, Unni KK, Mertens F., 2002), (Miller RH., 2003). Extensive imaging of the lesion must be done following strict protocol of diagnosis. This includes radiographs of the lesion in 2 planes, Technetium bone scan, CT, and MRI investigations (Perdikakis E, Skiadas V., 2013).

Systematic analysis of this imaging finding will lead to logic conclusion if the lesion is primary problem or just circumstantial diagnosis after knee trauma (Samardziski M, Zafiroski G, Janevska V, Miladinova D, Popeska Z., 2004). In most of the cases included in our study, lesions of the knee structures were primary problem. Considering all of the data taken in the history of the knee trauma, mechanism of the injury, onset of the symptoms and other imaging results will result in diagnosis of an inactive (“leave me alone”) bone lesion. These patients should be followed by the examiner with plain radiographs for some reasonable time. In such cases indication for operative treatment primary would be the knee trauma (Özkan EA, Göret CC, Özdemir ZT et al., 2015), Vlychou M, Athanasou N., 2008), (Alyas F, James SL, Davies AM, Saifuddin A., 2007).

Conclusion

Many people think that a knock or injury to a bone can cause a cancer. Scientific research studies do not support this. It is more likely that an injury causes swelling, which shows up a cancer that is already there. Most of the literature showed the knee to have been the most commonly injured joint and most of the malignant bone tumors happened to be located at the knee area. Bone tumors are very rare conditions and associated with knee trauma could be misdiagnosed and that can lead to catastrophic treatment results.

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SPLENECTOMY IN SPORT INJURY OF THE SPLEEN: A CASE REPORT

UDC:616.411-089.873:796.012.6

(Original scientific paper)

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Abstract

The spleen is one of the most vascular organs in the body, so any trauma to the spleen can cause fatal injury in just a matter of minutes if not recognized and treated. Among the abdominal injuries on sport activities, one should always consider spleen injuries. In this study we analyze a case of an adult who suffered from splenic laceration, caused from an immediate fall to the ground while playing soccer. He had a severe spleen injury, felt pain in the abdomen, in the left side of the chest and the left side of the arm, accompanied with feeling of dizziness, nausea, vomiting, paleness and dyspnea. After having the results of the abdominal examination, CBC, CT, sonography, a review by a cardiologist, the surgeon decided to perform a splenectomy, which prevented the hemorrhage and the maintained of the hemodynamic stability.

Key words: *spleen injury, contact injury, sport injury, splenectomy*

Introduction

The spleen is one of the most interesting and the most elusive organ in the human body, just as Galen had quoted about it as “the organ full of mystery”. The spleen is located at the left upper quadrant of the abdomen. It lies completely beneath the ribs and is surrounded by the stomach, pancreas and kidney. The normal size and weight vary somewhat; in adults, the approximate size of the spleen is 12 cm in length, 7 cm in width, and 3 to 4 cm in thickness. The average spleen weight in an adult is 150 g, with a range of 80 to 300 g. (Beauchamp R, Holzmann M, 2012). The spleen has important functions which are associated with the blood and the immune system: hematopoietic functions during early fetal development; mechanical filtration, which removes senescent erythrocytes and likely contributes to control of infection; the maintenance of normal immune function and host defenses against certain types of infectious agents (Guyton A, Hall J, 2016).

As the spleen is a solid organ, in most cases it gets injuries as a result of blunt abdominal trauma. The main factor of the spleen injuries are as follows: a car accident trauma, an immediate fall on the ground on the left side of the body – which is a case of our study. The given damage has many forms but its size its significant on deciding whether the damage would be slight or great and according to it, there are many forms of the given spleen injury: contusion, hematoma, laceration and avulsion (Clarke PJ, Morris PJ, 2000). According to the scale of the damage there exist 5 forms of the damage as follows (Moore EE, Cogbill TH, Jurkovich GJ, et al, 1995):

Case presentation

A 25 years old male adult sustained an injury in a recreational sport activity, while playing a soccer game with his friends. In a duel, he tackled and fell and landed firmly on the left side. Firstly, he didn't feel an immediate pain so continued to play and, after having finished the first half, he felt a slight dizziness and an abdominal pain. He looked pale, had difficulties in breathing and needed an assistance for standing up. In this situation he endured about 45 minutes, until he got to the Emergency department. During the examination, the patient said that he felt abdominal pain and discomfort, dizziness, nausea and a constant feeling of vomiting. Also he explained that he felt pain in the left side of the chest, associated with a pain the left shoulder.

Splenic Injury Scale*

	Grade	Description of Injury
I.	Hematoma	Subcapsular, nonexpanding, <10% of surface area
	Laceration	Capsular tear, nonbleeding, <1 cm parenchymal depth
II.	Hematoma	Subcapsular, nonexpanding, 10%–50% of surface area; intraparenchymal, nonexpanding, <2 cm in diameter
	Laceration	Capsular tear, active bleeding, 1–3 cm parenchymal depth that does not involve trabecular vessel
III.	Hematoma	Subcapsular, >50% of surface area or expanding: ruptured subcapsular hematoma with active bleeding; intraparenchymal hematoma >2 cm or expanding
	Laceration	>3 cm parenchymal depth or involving trabecular vessels
IV.	Hematoma	Ruptured intraparenchymal hematoma with active bleeding
	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)
V.	Hematoma	Completely shattered spleen
	Vascular	Hilar vascular injury that devascularizes spleen

*Reprinted with permission from Moore EE, Shackford SR, Pachter HL, et al. Organ injury scaling: spleen, liver, and kidney. *J Trauma*. 1989;29:1664–1666.

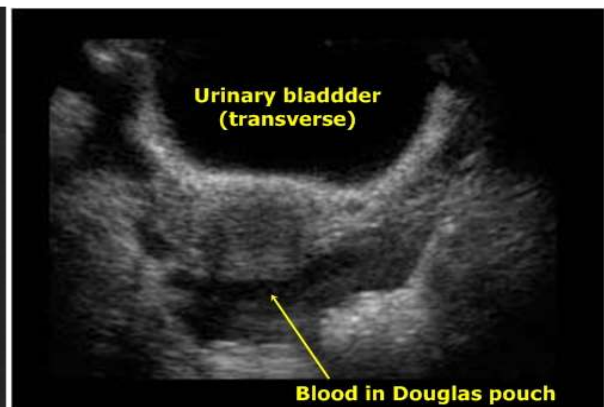
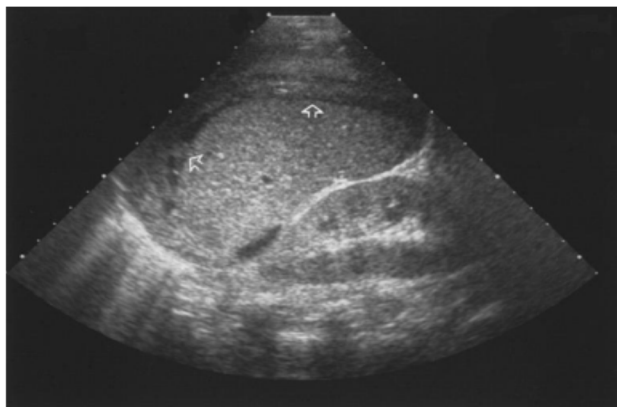


Figure 1. Ultrasonography of the Hematoma

Figure 2. Ultrasonography of the Blood in Douglas pouch

Abdominal and pelvic computed tomography (CT) scans with contrast were performed and interpreted as showing “an abdomen full of fluid (blood) probably from a splenic laceration” (Figure 3). More specifically, the report indicated that the patient had sustained “laceration of the spleen . . . with extensive free fluid due to hemorrhage into the peritoneal cavity . . . down into the pelvis.”

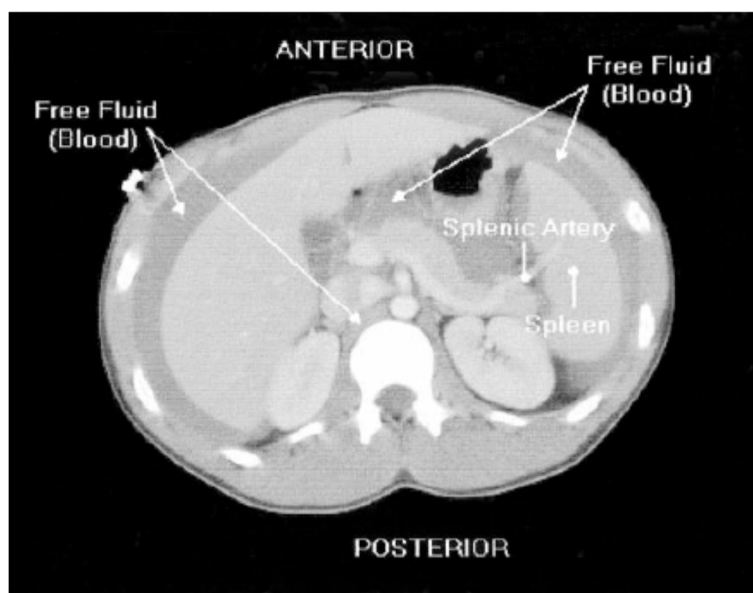


Figure 3. CT scan with contrast - Free Fluid (Blood) in Abdomen

The physician, during the examination, recognized the paleness of his skin, his blood pressure was 110/60 mm Hg, while his heartrate was 115 and the rate of breathing was 22. The abdomen was soft and not distended, but remarkable tenderness was noted in the left upper quadrant. No external trauma or ecchymosis was noted in the abdominal region. The spleen was not palpable. Examinations by a cardiologist (anamnesis and physical examination, ECG) do not determine the existence of acute suffering of the heart. The complete blood count, the abdominal and pelvic computed tomography (CT) scans were requested, in order the physician to have a complete internal insight. According to the blood results, there were significant descended blood parameters (hemoglobin, hematocrit and the number of the red blood cells – RBC). The ultrasonography interpreted as showing “an abdomen full of fluid (blood) probably from a spleen laceration” (Figure 1, 2).

Treatment

The surgeon decided to take the patient to the operating room urgently for diagnostic laparotomy. The Laparotomy sec. Rio-Branco was performed under general anesthesia. The patient’s systolic blood pressure was 90 mm Hg. A total of 1400 mL of blood was found and aspirated at the time of exploration. Once the spleen was located and appropriately visualized, the surgeon initially identified spleen laceration. It began from the lateral side of the spleen, going towards to the hilum. The surgeon decided to perform a splenectomy. Thus, the results of the hemostasis were put under control and the hemodynamic stability was maintained. At the time of wound closure, the patient’s systolic blood pressure had improved to 115/90 and his pulse was 75 and regular. The attending surgeon classified the subject’s case as a grade IV splenic laceration.

The patient was discharged from the hospital 7 days postoperatively, at which time he was tolerating a full liquid diet and had resumed bowel function. In the ensuing weeks, the patient appropriately recovered his appetite, energy, and strength and returned to activities of daily living. The skin closure was removed after 10 days of the operation.

Discussion

The spleen is the intra-abdominal organ most frequently injured in blunt trauma. Suspicion of a splenic injury should be raised in any patient with blunt abdominal trauma. History of a blow, fall, or sports injury to the left chest, flank, or left upper abdomen is usually associated with splenic injury. The diagnosis is confirmed by abdominal CT in the hemodynamically stable patient or during exploratory laparotomy in the unstable patient (Russel, R, 1997). In general, the injury patterns vary at adults and children, despite similar mechanisms of injury. This is due to anatomical differences, used safety equipment and the body vs. force mass. According to one study (of center for disease control and prevention, 2016), for the adults there is an increased percentage of the injuries received from a car and motorcycle accidents, from an immediate fall to the ground, altercations and crushes. On the other side, for children we differ a great percentage injury got from a sporting mishaps, bicycle accidents and falls.

Spleen injuries are treated by splenic removal (splenectomy), splenic repair (splenorrhaphy), or splenic resection (partial splenectomy) or no operatively, depending on the extent of the injury and the condition of the patient. Because of the immunologic functions of the spleen, interest in the past few decades has turned to save the spleen (Schwartz SI, Shires GT, Spencer FC, et al, 1999).

As with the patient described in this case report, urgent surgical intervention is indicated when the patient has a life-threatening condition. This is typically characterized by a high splenic injury grade, shock (due to a large hemoperitoneum), tachycardia (heart rate at or above 100 beats per minute), and hypotension (systolic blood pressure at or below 100 mm Hg). A low hematocrit (less than 30%) would play an important role in decision making in the absence of these more acutely life-threatening findings. However, a decrease in hematocrit may lag several hours behind other diagnostic factors (Shanmuganathan KM, 2002).

Conclusion

Among abdominal injuries in sports, we always have to consider spleen injuries. Therefore, its early diagnosis and prompt splenectomy are crucial and decisive in saving the patient's life.

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RELATIONS OF ORAL CARE AND DIETARY HABITS OF STUDENTS WITH LONG-TERM PARTICIPATION IN SPORT

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(Original scientific paper)

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Abstract

The aim of this study was to determine the relations between oral hygiene and dietary habits in students with long-term participation in sport. Questionnaires of oral health activity (OHAQ, Aranza, Milavić & Galić, 2016) and certain dietary habits were applied on a sample which included 658 male and female participants, students at the University of Split, Croatia. Female students had more desirable oral hygiene behavior and certain dietary habits than male students. There were no differences between male and female participants regarding the frequency of consumption of alcoholic beverages and smoking, and all students reported more frequent consumption of alcoholic beverages in comparison to smoking and, there were no significant differences in the level of oral hygiene habits and certain dietary-consumer habits between groups of students which have participated in long-term organized sports activities and those which have not. The obtained results indicate that kinesiologists and coaches have a very small impact on adoption and development of oral hygiene and certain dietary-consumer habits of adolescents.

Key words: *university students, oral hygiene, OHAQ questionnaire, smoking, consumption of alcoholic beverages*

Introduction

Adequate oral hygiene is extremely important for health of teeth and parodont. Only regular and adequate oral hygiene practices can lead to satisfactory plaque control and prevent plaque-associated diseases: dental caries, gingivitis and periodontitis (Badovinac et al., 2013). Oral health is an important component of general health and has a number of psychosocial impacts on the quality of life.

Nutrition plays a great role in oral health (González A.M., González B.A. & González E., 2013). As soon as the first tooth erupts, its maturation (calcium incorporation) continues, and both diet composition and food consistency come to the fore. Mechanical effect of food on the teeth is manifested in its abrasive effect on the chewing surfaces, which in turn reduces retention of impurities. Moreover, such food requires stronger chewing, which has a beneficial impact on jaw development and salivation, and considerably reduces the effect of the acids created in the mouth, which directly results in decreased tooth caries incidence. The modern way of life (practice of eating “while standing”, “fast food”) is just one of the reasons why, although aware of the importance of good nutrition, we eat poorly.

Al-Hussaini et al. (2003) conducted a study on a sample of 410 students at the Kuwait University Health Sciences Centre, with the aim of determining the extent of dental health knowledge, oral hygiene habits and attitudes towards dental health. The results showed that 64.6% of students believed that the main reason for tooth decay is inadequate toothbrushing. Only 19.3% of students believed sugar can cause caries. Moreover, 50% of students did not know if sugar-free drinks were harmful to their teeth, and 29.5% of them did not know the measures for preventing gingival bleeding.

Doctors of dental medicine play a significant role in dental and oral health protection (Bertolami, 2001) and have an important task in improving the level of health education, and that is why during their studies, knowledge and attitudes about oral health are important for prevention, control and treatment of dental diseases (Formicola et al., 2008).

Dental students are highly motivated in maintaining their dental health (Cortes et al., 2009), due to better informedness and greater knowledge about oral health behavior (Rong, Wang & Yip, 2006).

Oral hygiene education is a precondition for health hygiene habits, whereas the relation between knowledge and behavior is very weak (Pellizzer et al., 2007). On a subject sample which included 302 male and female Croatian students, mean age 17 ± 0.5 years, it was estimated that different demographic and social factors affect oral health, and therefore its improvement is more affected by the level of professional care than by patient's knowledge. The authors believe that persons who accept this knowledge, will also adopt preventive measures of personal hygiene.

High perception of oral health, and low perception of oral disease were estimated on a population of young people aged 18 to 28 years in Croatia (Špalj, 2005).

Similar data regarding oral hygiene habits were obtained in Turkey (Peker & Alkurt, 2009), Israel (Brook et al., 1996), and Kuwait (Al-Ansari, Honkala E. & Honkala S., 2003).

Better results were obtained in industrialized European countries (Italy, Austria, Germany, France) (Kuusela et al., 1997), Switzerland (Kronenberg et al., 2001), Spain (Cortes et al., 2002), Greece and Japan (Polychronopoulou & Kawamura, 2005), and Scandinavian countries Norway (Astrøm, 2002) and Denmark (Vigild & Schwarz, 2001).

Study conducted on 267 Turkish dental students showed a significant difference of improvement of oral hygiene behavior and oral hygiene habits with the increase of education level, and dental health protection was better in female as opposed to male students, i.e., better in non-smokers in comparison to smokers (Peker & Alkurt, 2009).

Knowledge, attitudes and habits related to oral health that were tested on a sample of 132 college students in Israel show that their knowledge comes from dental medicine doctors, parents and media, and only 20.6% was learned through formal education in school (Brook et al., 1996).

Study conducted on Swiss high-school graduates about oral health behavior, knowledge and informedness showed that acquisition of knowledge is based on continuous repetition. Systematic monitoring and repeated instruction on dental hygiene during education is necessary (Kronenberg et al., 2001). A very low level of oral health was found in American adolescents from rural areas who visited doctor of dental medicine rarely, mostly because of financial issues, ignorance about the importance of oral health or fear of pain. They visited doctor of dental medicine mostly for esthetic intervention on their teeth (Dodd et al., 2014).

In meta-analysis about oral health among Greek dental students there were significant differences reported in frequency of dental check-ups in last few decades. The frequency of dental check-ups increased from 39% of students in 1981 to 80% in 2010 (Mamai-Homata, Koletsi-Kounari & Margaritis, 2016). Similar results were reported for Belgian dental students between 1989 and 1994, showing better understanding of the importance of regular dental check-ups (Van Nieuwenhuysen, Carvalho & D'Hoore, 1998).

In a study investigating oral hygiene activities (Aranza et al, 2016) in Croatian students from the University of Split, 4 scales of satisfactory metric characteristics were constructed which measure oral health activity dimensions, and which can show the direction for integration and planning of the activities and coordination of efforts for projecting future dental education. Furthermore, gender differences were found among the subjects. Female students had significantly higher results in almost all measures in which significant differences in relation to male students were determined. Furthermore, female students brush their teeth more regularly than their male colleagues, they have a basic approach to oral hygiene, and they use dental floss and have preventive check-ups at dental medicine doctors more often. Female participants who reported more frequent incidence of tooth pain, used basic oral health activities less, and they less frequently practiced toothbrushing or dental floss. On the other hand, more frequent use of dental floss lead to decreased incidence of tooth pain.

To achieve optimal sports performance, young athletes require good oral health in order to reduce the risk of pain, inflammation and infection, and therefore the use of painkillers and antibiotics. Increased intake and frequency of consuming carbohydrate-rich foods in athletes, and consumption of energy drinks which contain high levels of acids and sugar can contribute to development of caries in athletes, as well as dental erosion caused by acids in the mouth.

A doctor of dental medicine should encourage an athlete to consult an experienced sports dietitian to ensure the principles of sports diet are adequately applied for the type, frequency and duration of exercise in relation to oral health of individual athlete (Broad & Rye, 2015).

Due to mouth breathing, many athletes experience dryness and decreased salivation, i.e., the amount of saliva in the mouth. They should drink water to quench their thirst and get hydrated as often as possible and in small sips, and to limit the consumption of sugar-sweetened beverages (Mobley, 2003).

Aside from parents and school teachers, sports coaches are often the persons who considerably shape adolescents' behavior. Sports coaches work with young athletes on a regular basis and for a long period of time. In doing so, they are responsible not only for acquisition of skills of a certain sport, but also for overall development of adolescents, as well as adoption of proper hygiene-dietary behaviors. It would be reasonable to assume that long-term participation in sport, with continuous impact of educated expert coaching staff, could "produce" significant changes of behavior in adolescents, especially in the area of certain "health" behaviors and adoption of adequate hygiene habits.

The aim of this study was to determine the relations between oral hygiene and dietary habits of students with long-term participation in sport.

Methods

The subject sample included 658 participants, mean age 21.33 ± 2.61 years, 66.72% of which were female and 33.28% were male students from 9 faculties of the University of Split, Croatia. Body mass index (BMI) of female participants was 21.06 ± 2.12 , whereas that of male participants was 23.48 ± 2.26 .

Data used in this study were gathered in a broader research investigating oral hygiene and dietary behaviors of students of the University, and can be divided as follows: measures of oral hygiene activity, measured by the OHAQ questionnaire by Aranza, Milavic, and Galic (2016); measures of certain dietary and consumer habits of students connected to oral health, variable of previous long-term participation in organized sports activity.

Scales of oral hygiene activity measured basic oral health activity, orientation to doctor of dental medicine, regularity of toothbrushing and use of dental floss in students. By very short scales of certain dietary habits, the frequency of eating candy and frequency of eating late in the evening were measured. Only one item per measure was used to determine frequency of smoking and frequency of consumption of alcoholic beverages.

The long-term participation in organized sports activity variable was determined by a question in the general questionnaire in which students were required to answer the question whether they have participated in some sport for three or more years.

The Ethics Committee of the University of Split, Department for Health Studies, approved the project and all materials of this study. The questionnaire was applied in regular class groups and students participated in this study on a voluntary and anonymous basis. Less than 1% of the overall sample was excluded from the statistical data analysis, mainly because the participants had not answered a great number of items of the questionnaire.

Basic metric characteristics of the scales of oral hygiene activity and certain dietary habits measures were determined on the overall subject sample.

Student T-test was applied to determine possible gender differences between groups of students with previous long-term participation in sport and those without previous long-term participation in sport.

Results and Discussion

Basic metric characteristics and basic descriptive indicators of measures used in this study are presented in Table 1.

By analyzing Table 1, it can be seen that the scales have satisfactory metric characteristics, which allows further application of parametric statistical procedures. The results of students' *oral hygiene activity* show a moderately high level of *regularity of toothbrushing* and practice of *basic oral health activity*, moderate *orientation to DMD* and low frequency of *use of dental floss*. Students' results also show they *eat candy* frequently, and very rarely *eat late in the evening*. Students more frequently consume *alcoholic beverages*, as opposed to *smoking cigarettes*.

Differences in results of *dietary habits* according to gender are also presented in Table 2.

By analyzing Table 2, significant differences between male and female participants can be seen in all measures of *oral hygiene activity*, and all measures of *oral hygiene activity* were more frequently applied, and more desirable, by female participants in comparison to male participants. The measured dietary habits were more distinct and more desirable in the female sample in comparison to the male sample. Female students ate candy less frequently, as well as food late in the evening, as opposed to their male colleagues.

Table 1. Descriptive indicators and basic metric characteristics of variables of students' oral hygiene and dietary habits

VARIABLE	AM	SD	M	CRONBACH 'SALFA	D * (K-S test)	MIN	MAX	SKEW	KURT
BASIC OH ACT.	3.50	0.73	3.50	0.64	0.087*	1.33	5.00	0.73	0.13
ORIENT. TO DMD	2.93	0.94	3.00	0.68	0.087*	1.00	5.00	0.94	0.23
REG.ToothBRUSHING	3.56	0.96	3.67	0.68	0.118*	1.00	5.00	0.96	-0.40
USE OF DENT. FLOSS	2.35	1.24	2.00	0.81	0.148*	1.00	5.00	1.24	0.61
CANDY	3.08	1.13	3.00	0.68	0.088*	1.00	5.00	-0.05	-0.80
E_NIGHT	4.12	1.00	4.50	0.65	0.238*	1.00	5.00	-0.98	0.07
SMOKING	3.58	1.64	5.00	-	0.312*	1.00	5.00	-0.58	-1.34
ALCHOCOL	2.54	1.41	2.00	-	0.195*	1.00	5.00	0.44	-1.10

Legend: AM – arithmetic mean; SD – standard deviation; M – median; CRONBACH'S ALPHA – coefficient of internal consistency; D – coefficient of the K-S test; * – significance of coefficient of the K-S test; SKEW – measure of asymmetry of distribution; KURT – measure of peakedness of distribution.

Table 2. Differences in results of *dietary habits* according to gender

VARIABLE	FEMALE STUDENTS (N=439)		MALE STUDENTS (N=219)		t-test	P
	AM	SD	AM	SD		
BASIC OH ACT.	3.62	0.74	3.27	0.66	6.01***	0.000
ORIENT. TO DMD	3.00	0.96	2.78	0.89	2.82**	0.005
REG.ToothBRUSHING	3.73	0.92	3.22	0.96	6.65***	0.000
USE OF DENT. FLOSS	2.52	1.28	2.00	1.08	5.15***	0.000
CANDY	3.17	1.13	2.90	1.12	2.92**	0.004
E_NIGHT	4.19	0.99	3.98	1.00	2.54*	0.011
SMOKING	3.57	1.66	3.60	1.61	-0.19	0.85
ALCHOCOL	2.57	1.41	2.47	1.42	0.85	0.40

Legend: AM – arithmetic mean; SD – standard deviation; * – statistically significant at the level $p < 0.05$; ** – statistically significant at the level $p < 0.01$; *** – statistically significant at the level $p < 0.001$.

Frequency of smoking and consumption of alcoholic beverages was the same in both subject samples. By further review, it has been established that 51.03 % female and 49.77% male students did not smoke, and only 14.12 % female and 13.70% male students did not consume alcoholic beverages.

The results of this study indicated high prevalence of addictive substances use in the adolescent population included in the study. More than half of the participants smoke every day or sometimes, male students on average consume more cigarettes and smoke more frequently. High percentage of participants consume alcoholic beverages, male students do it more frequently and on weekends, whereas female students consume alcoholic beverages on special occasions or never get drunk. Regarding the type of alcoholic beverage, male students more often drink beer, whereas female students drink hard liquor.

Greblo & Šegregur (2009), on a sample of adolescents from Rijeka, Croatia, found significant differences between genders in the prevalence of risk behaviors, including smoking and consumption of alcoholic beverages. More than half of the participants in their study smoke every day or sometimes, male students on average consume more cigarettes and smoke more frequently. High percentage of participants consume alcoholic beverages, male students do it more frequently and on weekends, whereas female students consume alcoholic beverages on special occasions or never get drunk. Regarding the type of alcoholic beverage, male students more often drink beer, whereas female students drink hard liquor.

In France, the prevalence of smoking among students was 32% for male and 35% for female population (Stephoe et al., 2002) whereas USA data from 1999 show prevalence of 28% for both sexes (Rigotti, Lee & Wechsler, 2000).

A study conducted on student population from University of Beograd, Serbia, showed that 68% of students consumes alcoholic beverages sometimes, about 13% drink once a week, and almost 2% drink every day (Pekmezović et al., 2011).

Harvard scientists conducted a research on university student population in the USA on two occasions, during 1993 and 1997, and came to the conclusion that USA students have the highest level of risk behavior compared to any other category in the world (Wechsler et al., 1998).

As for Europe, research conducted on student population from seven European countries showed that the highest number of students who never consume alcoholic beverages or sometimes consume alcoholic beverages was found in Turkey (73% male and 88% female students), whereas the lowest values were reported in Denmark (8% male and 15% female students) (Stock et al., 2009).

Among students of the University of Zagreb, School of Medicine, about 17% of them have never consumed alcoholic beverages (Trkulja et al., 2003).

Among Spanish students, the percentage of those who consumed alcoholic beverages more than once a week was 49% for male and 64% for female students, whereas among Bulgarian students, the percentage was 46% for male and 28% for female students (Wechsler et al., 1998).

Due to the gender differences found among the participants of this study in measures of *oral hygiene activity* and measures of *certain dietary habits*, all statistical analyses applied later were conducted separately for the male and the female subsample.

Prior to determining the differences in the level of the measured variables between the groups of students with long-term participation in sport and those without long-term participation in sport, it had been determined that there were no significant differences in BMI between those two groups, in neither the female nor the male subsample.

Table 3 Differences in results of oral hygiene and dietary habits according to long-term participation in sport

VARIABLE	FEMALE				t-test	P	MALE				t-test	P
	WITHOUT PARTICIPATION IN SPORT (N=229)		LONG-TERM PARTICIPATION IN SPORT (N=209)				WITHOUT PARTICIPATION IN SPORT (N=56)		LONG-TERM PARTICIPATION IN SPORT (N=163)			
	AM	SD	AM	SD			AM	SD	AM	SD		
BASIC OH ACT.	3.65	0.72	3.59	0.76	0.86	0.39	3.33	0.70	3.25	0.65	0.78	0.44
ORIENT. TO DMD	2.97	0.96	3.03	0.96	-0.67	0.50	2.87	0.95	2.75	0.88	0.85	0.40
REG. TOOTHBRUSHING	3.65	0.90	3.81	0.94	-1.84	0.07	3.38	0.97	3.16	0.95	1.49	0.14
USE OF DENT. FLOSS	2.48	1.24	2.57	1.32	-0.72	0.47	2.01	1.09	2.00	1.08	0.04	0.97
CANDY	3.19	1.15	3.16	1.13	0.34	0.74	2.94	1.25	2.89	1.07	0.28	0.78
E_NIGHT	4.09	1.03	4.30	0.93	-2.16*	0.03	3.84	1.00	4.03	1.00	-1.25	0.21
SMOKING	3.59	1.64	3.57	1.67	0.10	0.92	3.70	1.51	3.56	1.64	0.53	0.60
ALCHOCOL	2.58	1.43	2.56	1.39	0.12	0.90	2.64	1.48	2.42	1.39	1.03	0.30

Legend: AM – arithmetic mean; SD – standard deviation; * – statistically significant at the level $p < 0.05$.

In the female subsample, only one significant difference between the groups of students with and without long-term participation in sport was found, in the *eating late in the evening* variable. Female participants with long-term participation in sport less frequently ate late in the evening, in comparison to those without long-term participation in sport.

Moreover, there was a noticeable tendency of female students with long-term participation in sport for more frequent and regular toothbrushing. In all other variables, there were no significant differences. It would be justified to assume that long-term participation in sport at early age in female students lead to adoption of a more desirable dietary habit, and therefore to a higher level of awareness of *eating late in the evening*. In the male subsample, there were no significant differences found between groups of male students with long-term participation in sport in comparison to those without long-term participation in sport.

Generally, the obtained results indicate a very small “impact” of long-term participation in sport to oral hygiene activity and certain dietary-consumer habits of students. This shows that kinesiologists and coaches, and those persons who carry out organized sports activities, have a very small impact on adoption and development of oral hygiene and certain dietary-consumer habits in adolescents.

It is possible that adolescents develop these behaviors and habits at an early age, in the environment of their primary family or wider social community, so it is not even possible for kinesiologists-coaches to change the already firm attitudes, behaviors and habits.

This study has some limitations regarding the quality of the measures used, therefore it is recommended for future research to determine all forms of dietary habits in detail, but also to precisely determine the duration of participation in sport and the type of sport (individual-team; contact-non-contact, etc.) in adolescence. Furthermore, with the aim of determining at what point adolescents acquire and adopt certain

behaviors and habits, it is recommended for a similar research to be repeated on younger adolescents, e.g., primary and/or secondary school students.

Conclusion

In general, there were no significant differences found in the level of oral hygiene and certain dietary-consumer habits between students with and those without long-term and organized participation in sports activities. Such behaviors and habits are beyond “impact” of kinesiologists – sports coaches, possibly for two reasons: firstly, it is possible that kinesiologists – sports coaches do not teach desirable oral hygiene and certain dietary-consumer habits to children and adolescents at all; secondly, it is possible that adolescents have adopted such attitudes, behaviors and habits earlier so kinesiologists – sports coaches cannot change the adopted attitudes, behaviors and habits. In any case, it is the authors’ opinion that kinesiologists – sports coaches should become more engaged in teaching and adoption of desirable oral hygiene and dietary behaviors and habits in adolescents or at least in adoption of certain dietary-consumer habits, especially those related to consumption of tobacco cigarettes and alcoholic beverages. Furthermore, kinesiologists – sports coaches should also become more engaged in stress management of adolescents they coach, in order to reduce their “need” for unconstructive behavior in coping with stress, behaviors such as consumption of cigarettes and alcoholic beverages. It would be advisable for sports federations to include expert nutritionists and experts for oral health prevention into the regular system of licensing and education of sports coaches, so they could help coaches’ education, and thus indirectly create preconditions for, and allow, adoption of desired habits and behaviors of adolescents.

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RELIABILITY AND VALIDITY OF THE LATERAL ENDURANCE TRUNK TEST

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(Original scientific paper)

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Abstract

Adequate trunk muscle endurance may play an important role in injury-free performance among athletes and it has important role in whole population for prevention of Low Back Pain. The aim of this study was to create the new measurement test for endurance of the lateral trunk muscles. The Side Plank test is the most common test that it is used for testing the endurance of the lateral trunk muscles. The problem of that test is the big influence of the shoulder complex muscle strength and endurance, what can produce negatively effects on the side plank test results. The research was conducted on the 21 participant (15 males and 6 females). Participants are healthy student population from 20 to 21 years old. We measured muscle endurance of both trunk sides for three times in one day. The aim of this research was first to find the reliability parameters of this measurement protocol and the second aim was to compare the results of left and right lateral trunk muscles. Whit these two hypotheses we can answer is the reliability of this new measurement protocol is satisfied and is this new test for lateral trunk muscle endurance can find the differences between two sides of trunk (pragmatically validity). McGill et al. (2003) suggested that a difference between left and right endurance time of the trunk flexors, extensors and lateral flexors muscles would predict who is at greater risk of back problem. Reliability parameters of both sides of trunk were satisfied. We can conclude from this parameters and descriptive statistics from each item that the three measurements must be conducted on the different days. We find no significantly differences between the results of both lateral trunk sides.

Key words: core stability, muscle endurance, new measurement test

Introduction

Adequate trunk muscle endurance may play an important role in injury-free performance among athletes and it has important role in whole population for prevention of Low Back Pain (LBP). Over the past two decades, lumbar spine stability has become an integral part of the low back pain assessment and treatment strategies, especially given its potential link to injury mechanisms and the ongoing clinical efforts directed toward enhancing stability in patients (Grenier et al, 2007). Human body has a naturally conscious focus on the phasic part of any movement (moving the limbs), while the stabilizing function is on the subconscious and automatic level. Therefore, stability of the human body is often compromised and not easily retrained. It is suggested that corrective stabilization training should be a primary step in any rehabilitation exercise program (Akuthota et al., 2008; Kobesova et al., 2012; Frank et al., 2013). Assuming that core stability and basic extremity locomotor function are mainly under the subcortical CNS control, if CNS control is adequate, and muscles are activated in balance, then each posture and each spontaneous movement automatically bring all the joints into a functionally centered position (Kobesova and Kolar , 2014). McGill et al. (2003) suggested that a difference between left and right endurance time of the trunk flexors, extensors and lateral flexors muscles would predict who is at greater risk of back problem. As no exercise can evaluate all muscles involved in lumbar spine stability, evaluation in the 3 planes has to be done separately. Side bridge exercise protocols have been suggested to evaluate torso muscles in frontal plane (Pagé et al, 2012). The Side Plank test (McGill et al, 1999.) is the most common test that it is used for testing the endurance of the lateral trunk muscles. The problem of the Side Plank test is the big influence of the shoulder complex muscle strength and endurance, what can produce negatively effects on the side plank test results. Ledoux et al. (2012) suggested the lateral isometric hold test on a 45 degrees Roman chair that could be used as an alternative to the side bridge test. The Ledoux test was developed as an

alternative to the side bridge test to evaluate endurance time in older adults and adults with upper limb injuries (who could not attain support off the floor). Also Ledoux (2012) test creates the possibility to assess maximal voluntary contraction in the same position. The trunk, from the anterior superior iliac spine and up, was unsupported. When we talk about younger population, the preadolescents, their joint positions especially of the shoulder complex are not centered (Paušić et al, 2011). Therefore the aim of this study was to create the new measurement test for endurance of the lateral trunk muscles, also without the influence of the shoulder complex but in different side position more appropriate for pre-adolescents.

Material & methods

Twenty-two healthy subjects (15 men, 6 women; mean age \pm SD: 20.51 \pm 0.90) participated in this study. All participants were volunteers and gave their informed. This research was pilot study prior the pre-adolescent testing.



Figure 1. The Side Plank Test (SPT) (McGill et al, 1999.) Figure 2. The Lateral Endurance Trunk Test (LETT)

To establish the validity of the new measurement protocol for lateral trunk muscle endurance the participants are measured in both side plank tests (Figure 1. and Figure 2.). In the new test, the Lateral Endurance Trunk Test (LETT), the trunk, from the anterior superior iliac spine and up, was unsupported. Arm support was allowed prior to the endurance task during positioning. On the researcher's cue, the participants removed their arms from the support and folded them across the chest with hands placed on the opposite shoulder. During the endurance task, participants were asked to keep their trunk and head in line with their upper lower limb while the other lower limb was supporting on the knee. The goal for all participants was to hold this position as long as they could. In order to ensure that participants abide by instructions, the same assistant observed the entire task for every participant and gave them verbal feedback to ensure proper position based on thorough observation. Failure to comply with instructions resulted in a warning by the assistant and the task was ended if the participant failed to follow instructions two times. Verbalized encouragement was provided throughout the test.

Statistical analysis consisted of the calculation of reliability coefficient (ICC – inter class coefficient, ICC_(3,1)) for three repeated measurements in the same day for both tests. Coefficient of correlation was established for comparing the results of both tests, the SPT and LETT. Student t-test for independent groups ($p < .05$) assessed differences between left and the right LETT and SPT endurance time of the lateral trunk flexor muscles. One-way ANOVA assessed no statistically differences between the genders in all measurements, therefore all participants are taken as one sample. Statistical analysis was performed using SPSS software version 13.0 (Dell, USA).

Results

Mean endurance times for all three measurements for SP test and LET test are listed in the Table 1. and Table 2. The endurance time is decreasing between the measurements. In the first measurement of both tests and both sides the best endurance time is gated. There was no significant difference in endurance times between the SP test performed on the left side and the SP test performed on the right side (Table 3.). Also there was no significant difference in endurance times between the LPT test performed on the left side and the LPT test performed on the right side (Table 3.).

The reliability study on all subjects found that the repeated tests, on the same day, produced good reliability coefficients from 0.412 and 0.663 for side plank test (SPT) according to McGill, and very good

reliability coefficients from 0,778 to 0,853 for new lateral endurance trunk test (LETT) (table 1. And Table 2.).

The correlation coefficients between the same attempts of measuring the test between the two similarly test, the SP and LET, show different types of correlation intensity. Right side measurements have statistically significant correlation coefficients (from 0,51 to 0,65), and left side measurements have just one statistically significant correlation coefficient (between the second attempts, $r=0,60$).

Table 1. Descriptive statistics and reliability coefficient for Lateral endurance trunk test (LETT)

Variables	Mean	Min	Max	StaDev	ICC _(3,1)	Variables	Mean	Min	Max	StaDev	ICC _(3,1)
LETT_R1	117,86	54,90	276,83	55,22	0,853	LETT_L1	102,23	43,52	264,64	56,83	0,778
LETT_R1	95,12	26,40	197,51	42,77		LETT_L1	81,75	37,68	148,51	31,84	
LETT_R1	91,62	38,20	255,52	55,85		LETT_L1	81,56	30,50	209,53	38,09	
LETT_R	109,26	61,13	243,29	45,25		LETT_L	95,55	54,33	206,67	36,02	

Table 2. Descriptive statistics and reliability coefficient for Side Plank Test (SPT)

Variables	Mean	Min	Max	StaDev	ICC _(3,1)	Variables	Mean	Min	Max	StaDev	ICC _(3,1)
SPT_R1	74,19	24,51	123,97	27,46	0,663	SPT_L1	77,77	52,38	101,31	13,48	0,412
SPT_R2	59,50	36,87	90,74	13,75		SPT_L2	58,55	25,35	86,57	15,81	
SPT_R3	50,01	33,33	77,56	14,49		SPT_L3	51,14	34,85	72,42	12,50	
SPT_R	61,24	35,88	87,97	15,16		SPT_L	62,49	42,78	78,12	9,49	

Table 3. Student t-test for independent groups (variables)

Variables	Mean Right side	Mean Left side	t-value	df	p
LETT_R / LETT_L	109,26	95,55	0,9768	32	0,336
SPT_R / SPT_L	61,23	62,49	-0,289	32	0,774

Discussion

We can conclude from the reliability parameters and descriptive statistics from each item that the three measurements must be conducted in different days. The fatigue of muscles was evident in all of subjects and therefore they have the best endurance time just in first attempt of both tests. While in second and in third attempts the results were decreased. The repeated tests, on 5 consecutive days, produced excellent reliability coefficients 0.99 for the side bridge on the left and right sides (McGill et al, 1999). In one other research (Evans et al, 2007) ICCs for the side bridge endurance tests conducted with 24 subjects with two repeated measurements at least 10 min rest between them, were all ≥ 0.81 .

We find no statistically significant differences between the results of left and right lateral trunk endurance in both tests. Mc Gill et al. (2003) suggested that a difference between left and right endurance time of the trunk flexors, extensors and lateral flexors would predict who has a greater risk of back problem. From this point of view the subjects in this study haven't got risk for back pain syndromes. Page et al (2012) conducted the study in order to identify muscles evaluated during a lateral isometric hold task. Although the fatigue indices suggest that ipsilateral external oblique and contralateral L5 erector spine are significant contributors, all recorded muscles were active during the lateral isometric hold task. The lateral isometric hold, while different from the side bridge assessment for endurance because it does not involve support of the floor, seems to be adequate for the evaluation of lateral trunk flexors.

Conclusions

The new measurement test for lateral trunk endurance (LETT) would have better reliability if the repeated measurements will do on three consecutive days. Like the similarly test for lateral endurance without support of arm seems to be adequate for the evaluation of lateral trunk flexors. The participant have achieved better endurance time in the LETT than in standard side plank test therefore we can conclude that this new test is easier than standard side plank test and it is adapted to the younger population.

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THE EFFECTS OF A THREE AND HALF DAY LONG PROCESSED SUGAR-FREE DIET

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(Original scientific paper)

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Abstract

Blood glucose levels are evaluated as a part of this preliminary study. The primary step included measuring blood glucose levels during and after 3 ½ days on processed sugar free diet. The secondary step measured the blood glucose levels before and after a 30-minute exercise. The preliminary research did not aim to link the two steps. In both steps however, an average decrease in the blood sugar levels is evident. Based on the finding from this preliminary study a diet low in processed sugars along with a physically active life style resulted in lowering blood glucose levels. These results have a potential of being used as prevention tools to communicate avoidance of possible adverse health problems in adults and children.

Key words: *processed sugar, blood glucose, health, diet, exercise*

Introduction

Consumption of processed sugar is associated with countless health problems in children and adults as it affects health, quality of life, and may cause premature aging (Freese et al. 2016; Malhotra, 2015; Kahn, 2014). This preliminary study was conducted in order to test if the glucose blood sugar levels would decrease in a group of individuals who volunteered to follow a three and a half day long diet without processed sugar. In addition, another scenario in which measuring of blood glucose levels was conducted a month after the dietary portion of the experiment was concluded. In this scenario blood glucose levels were measured before and after 30 minutes of light exercise. The study involves a group of volunteer college students, a population which is heavily linked with daily stressors associated with on the go dietary intake, long hours of sitting, psychological strains highlighted by academic pressure, and common expectations associated with all of the above.

Method of work

Subject of the research

Table 1. Research participant data

Sugar free group	Age	Mean	Number
Males	62-21	31	5
Females	52-18	27	11
Range	62-18	28	
Total			N=16
Control group (CG)			
Males	40	40	1
Females	19-22	21	4
Range	40-19	27	
Total			n=5
TOTAL for ALL	62-19		N=21

A volunteer group of twenty college students and a professor were used, totaling 21 individuals from a College campus located in Southern California. The participants' age and sex are presented in Table 1.

Materials used for blood glucose testing are Blood Glucose Meter: One Touch Ultra2, One Touch Ultra Delica, One Touch Ultra 25 test strips, One Touch Delica Lancets all distributed by LifeScan, Inc. and Alcohol Prep Pads.

Goals of the research

This preliminary experiment aimed to explore if the blood glucose levels could be lowered in a short period of time or specifically within three and a half day long diet lacking processed sugar. Additional aim of this study was to measure if the blood glucose levels will fluctuate before and after 30 minutes of a light exercise a month after the diet portion of the experiment was concluded.

Responders of the research

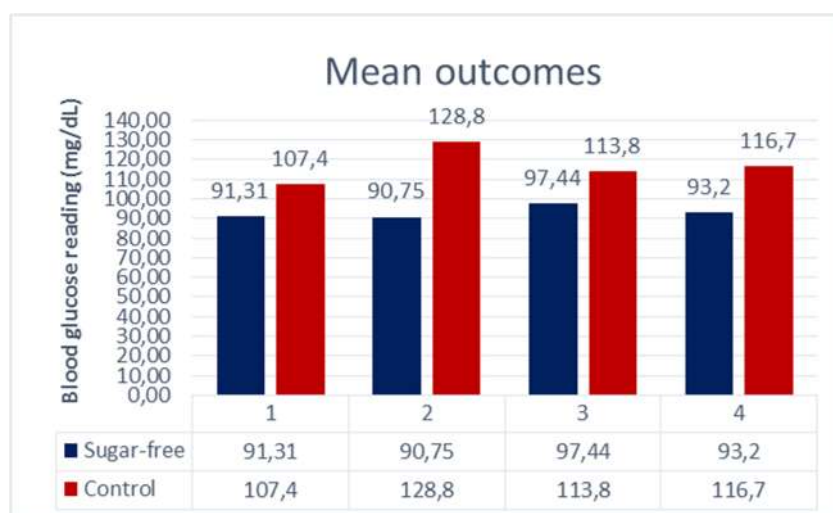
A sample of college students enrolled in Medical Anthropology course and their professor from Southwestern College, Chula Vista, California volunteered for this preliminary study. The subjects were divided into two groups. The first and a larger group (n=16) volunteered to go on a processed sugar free diet. The control group (n=5) decided not to engage in dietary alteration and continued their normal daily diet.

Temporal and spatial determination of the research

This short preliminary research portion that concerned dietary alteration was carried from March 07, 2016 until March 10, 2016 when the last glucose measurements were taken after which the participants were no longer asked to follow the processed sugar free diet. The very last measurements concerning this portion of the experiment were taken following week on March 15, 2016. Before and after exercise blood glucose measurements were recorded on later date almost a month later on May 12, 2016.

Results of the research

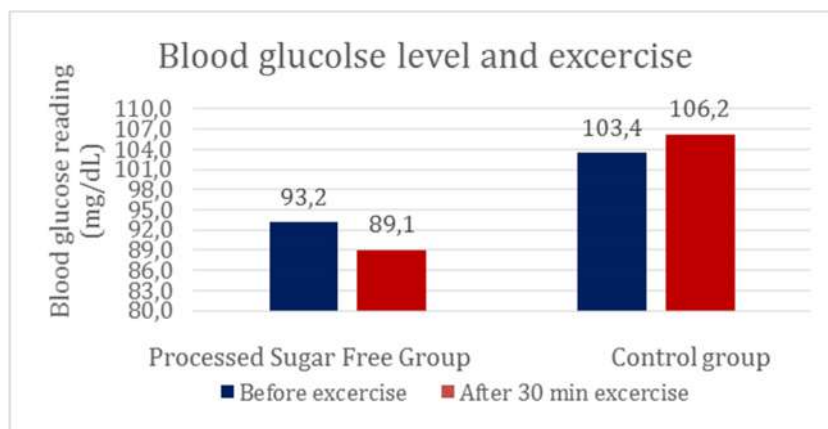
The results show the mean difference in blood glucose levels readings of 38.05 mg/dL on the last day of the restricted diet. The control group mean reading was 128.8 mg/dL, while the group on the processed sugar free- diet mean readings were 90.75 mg/dL (Graph 1). The average glucose levels remained lower even after the diet portion of the experiment was completed resulting in an average drop of 16.36 mg/dL. Average readings between the groups spanning from March 7 to March 15, 2016 resulted in (93.2 mg/dL and 116.7 mg/dL) a mean difference of 23.5 mg/dL.



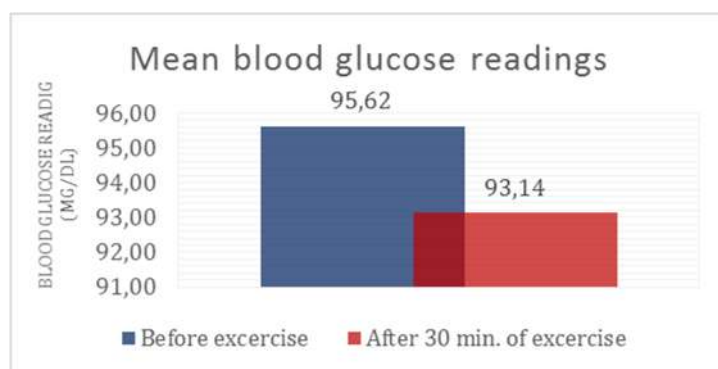
Graph 1.

The second part of the experiment recorded blood glucose levels, before and after, 30 minutes brisk walk. The data indicates that 16 individuals who were on processed sugar free diet a month before continued showing lower blood glucose readings before (93.2 mg/dL) and after exercise (89.1 mg/dL) when compared to the control group whose readings before exercise were 103.4 mg/dL and after 106.2 mg/dL (Graph 2)

showing an increase in the blood glucose levels. Mean outcomes for all of the individuals combined showed a lowering of blood glucose levels from 95.62 to 93.15 mg/dL a difference of 2.48 mg/dL (Graph 3).



Graph 2.



Graph 3.

Conclusion

Health problems associated with contemporary day diet among adults and children suggest that humans, in general, consume large quantities of sugar and such changes in our dietary preferences result in health decline. It is becoming clear that dietary restriction alone is simply not enough, and that changes in physical activity must be taken into consideration if we are to prevent and or life-style related diseases (Freese et al. 2016; Makhotra et al. 2015; Khan and Sievenpiper, 2014).

In this short preliminary study a group of 21 individuals (5 males and 16 females) from Southern California were volunteer participants in a short experiment aimed at exploring if the blood glucose levels could be lowered within a three and a half day long diet without processed sugar. In addition to the original question above, the experiment also explored if the effect of 30 minutes long walk. The outcome of this preliminary study was an eye opener.

Not only did the glucose levels drop during the sugar free stage that lasted from Monday morning (3/8/2016) through Thursday afternoon (3/10/2016), but they also remained lower even five days after (3/15/2016) the part of the experiment concerning refined sugar free diet was terminated. The control group was averaging 113.8 mg/dL and the refined sugar free group averaged 97.44 mg/dL showing a total of 16.36 mg/dL points lower readings among diet restricted individuals. The readings during the dietary restrictions provided even stronger correlations of 16.09 mg/dL and 38.05 mg/dL collected during the 2nd and the 3rd day of the diet respectively. The difference in readings between the days being 21.96 mg/dL suggesting that blood glucose steadily decreased in the restricted diet group. When all of the individual readings were included in the experiment and were then divided into processed sugar free group and control group the means resulted in readings of 93.2 mg/dL and 116.7 mg/dL a difference of 23.5 mg/dL. Thus, potentially indicating that a short-term processed sugar dietary restriction resulted in measurable decrease of the blood glucose levels.

The results of this preliminary experiment also clearly indicate that a mild physical activity lasting only 30 minutes resulted in decreased levels of glucose in blood 2.48 mg/dL for all of the individuals included in the 1st part of the experiment. However, once the group that was in a refined sugar free diet and the control group were evaluated separately the outcome was remarkable. The diet participants (n=16) showed a decrease in their blood glucose levels from 93.2 mg/dL to 89.1 mg/dL a drop of 4.1 mg/dL, while the control group measured 103.4 mg/dL prior and 106.2 mg/dL post exercise identifying an increase in the blood glucose levels of 2.8 mg/dL. Therefore, it should be highlighted that processed sugar and lack of a mild exercise in this study suggest that blood glucose levels (measured a month after the dietary restriction part of the experiment was completed) are on average higher in the control group and that glucose levels increased after exercise, while it decreased in the original dietary restricted group.

The results of this study, even though preliminary, strongly suggest that dietary restrictions directly connected to lower intakes of processed sugar have a tremendous importance on positively influencing blood glucose levels. This study results also show that light exercise results in lower blood glucose levels. There is a strong possibility that the two mentioned above when combined may have positive influence overall health and a wellbeing. In addition, it is important to highlight that lack of exercise and daily ingestions of dietary choices loaded with processed sugar may theoretically result in health problems, malnutrition and behavioral problems on a long run.

Even though intention of this study was not to evaluate how blood glucose levels will change with refined sugar free diet and exercise combined the results of it suggest that there possibly may be a link that needs to be further explored. A further longitudinal research is needed to clarify if and to what degree the blood glucose levels will decrease on refined sugar free diet over a period of time and if it will remain constant when combined with a light exercise. Tremendous potential exists if these two factors together are taken into consideration, as they may be the essential parts in prevention of possible future health risks in children and adults.

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SOME RELATIONS BETWEEN THE MOTORIC TESTS FOR ASSESSMENT OF COORDINATION AND EXPLOSIVE POWER WITH THE MEASURES OF THE SUCCESSFUL PERFORMANCE OF THE GYMNASTIC ELEMENT, FORWARD DISMOUNT WITH STRADDLE LEGS ON RINGS

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(Original scientific paper)

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Abstract

For the purpose of implementing the aims of this research, a procedure has been conducted consisting of 68 examinees, i.e. male first-year students from the Faculty of Physical Education in Skopje. A total of 20 manifest motoric variables have been applied on this sample section of examinees, out of which 12 refer to coordination assessment and 8 refer to motoric tests for the assessment of explosive strength. The evaluation of the technical performance of the gymnastic element forward dismount with straddle legs on rings has been executed by 4 qualified referees who are well acquainted with the subject of assessment. Using the method of regressive analysis, the effectiveness of the applied evaluation tests for coordination and explosive strength assessment on the successful performance of the gymnastic element forward dismount with straddle legs has been affirmed.

Key words: rings, coordination, explosive strength, regressive analyses

Introduction

It is undoubtedly pointless to be physically active if the process of that activity cannot be controlled, or if the achieved result cannot be objectively assessed. For that reason, there are justifiable assumptions that in order to participate in a certain sports discipline successfully, the integrity and the anthropological dimensions of the person in question are of paramount importance.

In the past researches, the anthropological space has been examined globally and partially. In sports gymnastics however, are realized the researches in manifest and latent space which relate to the affirmation of the connection between the anthropometric variables and the motoric tests and abilities through the successful performance of the gymnastic elements and the achieved results in sports gymnastics (Pop-Petrovski V. (1997), O. Mitevski (2000), E.Petkovic (2004) K. Spasovska (2008, 2013).

Starting from the fact that motor abilities are one of the main factors in the resolving of motor abilities, in this case in sports gymnastics, the process of determining the motor space structure as a segment of the anthropological space of a person has been preoccupying the thoughts of many national and international professionals for years. However, despite the numerous researches and the extensive data thanks to the advance of technology, they are still not sufficiently explored and are constantly in the research professionals' focus.

In sports gymnastics in most cases there are exercises with complex structure. In the case of some elements and exercises on certain apparatus the success rate is determined mostly by particular motor abilities; in some exercises there is a bigger influence by the anthropometric variables, while in other cases, besides the enumerated factors, the cognitive and conative abilities have a major influence as well. Being familiar with the structure of gymnastic elements and my experience of several years obtained through the regular practical classes of sports gymnastics, knowing that it is a sport which demands that the student have high motor abilities, I have tried to validate the practical knowledge through statistical mathematic method, hoping that I would find out more specifically which coordination factors and explosive strength, as segments of motor abilities of a person, are important in the process of acquiring the gymnastic element forward dismount with straddle legs.

Therefore, diagnosing the success in sports gymnastics which is the focus of this paper, is discovering the relations in the motor space between the coordination and explosive strength of certain body parts with the successful performance of the gymnastic element forward dismount with straddle legs on rings. Tracking and recording them has provided us with insight into perceiving the success in the process of education.

Working Methods

In this research based on sample section of examinees consisting of 68 first-year male students from the Faculty of Physical Education in Skopje, 20 manifest motor variables have been applied, out of which 12 refer to coordination assessment of certain body parts (full body coordination(3), legs coordination(3), coordination of quick complex movements(3) and reorganization of dynamic stereotypes(3), as well as eight (8) tests for the assessment of explosive strength (type of jumps (3) and type of throw (5)).

Most of the tests for the assessment of the motor abilities for coordination and explosive strength were measured based on Metikos D's recommendations (1989). While the tests: crossing parallel bar, jumping over horizontal rope, climbing and descending on Swedish climbers, long jump backwards and the test climbing and descending stairs backwards are measured based on the recommendations of Gredelj M., Metikos D., Hosek A. I Momirovic K. (1975)

The test jumps up-down-far represents type of the original version of Godik M.A (1988), and is taken from the doctoral dissertation of Pop-Petrovski V. (1997).

The evaluation of the technical performance of the gymnastic element forward dismount with straddle legs on rings, with standardized criteria has been executed by 4 qualified referees who are well acquainted with the subject of assessment. Using the method of regressive analysis, the effectiveness of the applied evaluation tests for coordination and explosive strength assessment on the successful performance of the gymnastic element forward dismount with straddle legs on rings has been affirmed.

RESULTS

Chart 1 shows the results from the regressive analysis for the impact of some motor variables for assessment of the coordination, like predictive system above the variable forward dismount with straddle legs on rings as criterion.

With inspection on chart 1 you can see that the predictive system for coordination is significantly and highly (0.62) connected with the criterion KRSRA – forward dismount with straddle legs. The variability of the criterion with the system is explained 39%. With the predictive system we can predict the success of the criterion.

Chart 1 Results of regressive analysis of the criterion KRSRA – forward dismount with straddle legs with the predictive system for coordination

Variables	r	Part-r	BETA	t-test	Q
MKOPOD	-0.45	-0.31	-0.42	-2.40	0.02
MKOVOZ	-0.26	-0.04	-0.04	-0.30	0.77
MKOPPP	-0.41	-0.21	-0.27	-1.60	0.12
MKNPHJ	0.02	-0.19	-0.21	-1.43	0.16
MKNKSS	-0.24	-0.05	-0.06	-0.40	0.69
MKNCVS	-0.23	-0.04	-0.04	-0.29	0.77
MKBPIP	-0.23	0.09	0.10	0.64	0.53
MKBKSKR	-0.22	-0.07	-0.07	-0.52	0.61
MKBOSN	-0.03	0.35	0.37	2.78	0.01
MRSDNA	0.29	0.10	0.10	0.73	0.47
MRPONA	-0.27	-0.12	-0.13	-0.87	0.39
MRKSSN	-0.30	-0.04	-0.04	-0.27	0.79
Delta	RO	DF 1	DF 2	F	Q
0.39	0.62	12.00	55.00	2.92	0.00

Significantly and low partial regressive coefficients criterion has with the variables for full body coordination MKOPOD (-0.42) – mobility on the mat and with the variable for coordination of fast complex movements MKBOSN (0.37) – eight with leaning.

With these coordination tests it can be predicted the success of the criterion KRSRA – forward dismount with straddle legs.

The connection of the overall predictive system of the motor variables for explosive strength and the successful performance of the gymnastic element on rings, KRSRA – forward dismount with straddle legs is 0.58 (chart 2), which explains the common variability between the predictive system and the criterion’s variable about 34%. Such a connection is very significant on level of $Q=0.00$. With the predictive system for explosive strength the successful performance of the criterion’s variable can be predicted.

Analyzing the predictive variables for explosive strength individually can be noted that the criterion positively, significantly and low is connected only with the variable MSGDD (0.45) – jumps, up, down, far. With this predictive variable for explosive strength – type of jumps can be done prediction of the criterion.

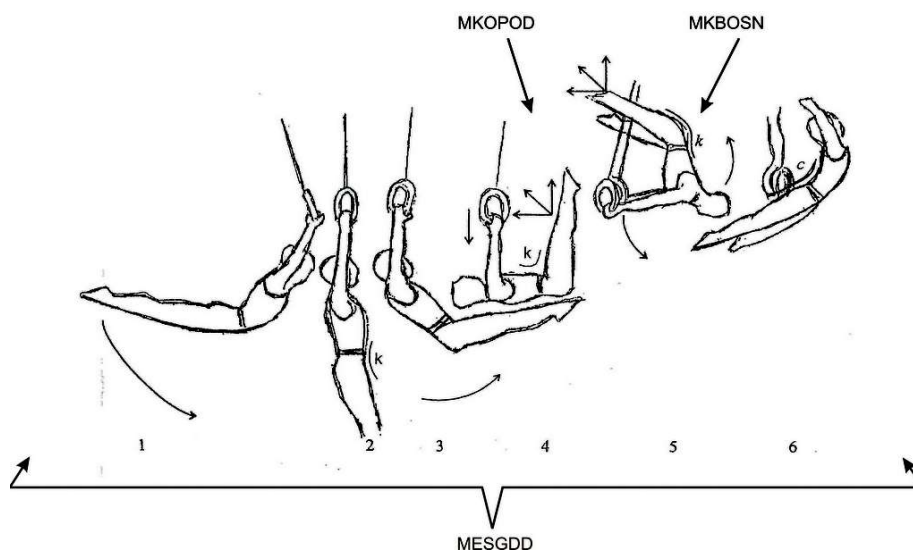
Chart 2 Results of regressive analysis of the criterion KRSRA – forward dismount with straddle legs with the predictive system for explosive strength.

Variables	r	Part-r	BETA	t-test	Q
MESSDM	0.19	0.05	0.05	0.35	0.72
MESGDD	0.50	0.46	0.45	3.95	0.00
MES20M	-0.13	-0.05	-0.04	-0.37	0.71
MESFMNR	0.04	-0.10	-0.09	-0.76	0.45
MESFMNN	0.20	0.12	0.11	0.95	0.35
MESPVNY	0.31	0.21	0.26	1.68	0.10
MESPVNP	0.24	-0.02	-0.03	-0.19	0.85
MESPVNR	0.20	0.04	0.06	0.30	0.76
Delta	RO	DF 1	DF 2	F	Q
0.34	0.58	8.00	59.00	3.81	0.00

To show the partial impact of the predictive variables which have significant influence on the technique’s performance we will try to analyze the technique of performance of the element.

From swinging in the air when the body moves in the back is slightly bent backwards. From this position the movement of the body and legs to the vertical is accelerated under the influence of the gravity force. After the vertical is performed bending at the hip joint and the legs continue to move faster than the corpse.

Picture 1 Forward dismount with straddle legs on rings



When the body comes in front is in bent position, which means the legs and the corpse are at an angle of 90 degrees position. At this point it’s performed fast opening with his legs upwards and backwards, and simultaneously are activated the abductors in the hip joint, in other words the legs are widely spread aside. The moment when the body moves backwards is under the influence of partial predictors for coordination

of the whole body (MKOPOD – coordination on the mat) and of the test for coordination of fast complex movements (MKBOSN – eight with leaning).

When the shoulders will pass the height of the rings a pushing is done with straighten arms on the rings downward and forward. Once the gymnast leaves the apparatus before the upper vertical, the body in an upright or slightly bent position falls downward, or in other words the gymnast performs the landing. The successfully performed landing is a result of the test for explosive power of the type of jumps, MESGDD, up, down, far (pic.1).

From chart 3 for frequency of the assessments it can be noticed that during the performance of this element the number of those students who managed to perform it the best way possible is as high as 11. This means that the 16.18% received grades from 9.00 to 10.00. An equal number of students received grades from 8.00-8.99. The total number of students who were assessed as having high score is 32%, which indicates that for the students this element was a difficult task. The largest number of students 64% of this gymnastic element mastered on low level with little assistance and errors in the technical performance.

The resulting significant connection in the regressive analyzes of the tests for coordination and explosive strength with the criterion shows the need to develop the coordination and the explosive power to a higher level and the need to learn and master the art of performing at a higher level of this gymnastic element.

Chart 3 Frequency of assessments for the element KRSRA – forward dismount with straddle legs

Ocenki	F	%	Kumulativno %
5.00-5.99	2	2.94	2.94
6.00-6.99	21	30.88	33.82
7.00-7.99	23	33.82	67.64
8.00-8.99	11	16.18	83.82
9.00-10.00	11	16.18	100

Conclusions

According to the received results we can come up with a conclusion that to successfully perform this element despite the other motor abilities, it is necessary that the mentioned motoric tests for full body coordination, fast complex movements and explosive strength, type of jumps and throws with the arms and legs should be developed on the required level, and then to start the process of learning and mastering the technique.

With proper guidance of the students towards the development of these motor abilities on required level before starting the process of learning, or mastering the technique are created conditions for faster and more efficiently mastering the technique of the element.

Because in the previous researches different results were obtained in different samples of examinees with different level of motor abilities as well as different level of knowledge of the sports gymnastics every research will have its own contribution towards the determination of the impact of certain factors of the anthropological status (different motor abilities, morphological, sociological, conative and cognitive dimensions) on the success in sports gymnastics.

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MENISCAL TEARS

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(Original scientific paper)

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Abstract

Meniscus is the most commonly injured structure in the knee joint. Meniscal tear patterns include vertical tears, oblique, complex and horizontal. Aim: The aim of this study is to present the distribution of different types of meniscal tears diagnosed and treated with arthroscopy. Material and methods: Between 2013 and 2015, at the University clinic for orthopaedic surgery, 137 patients with meniscal tears and average age of 26 ± 15 years were diagnosed and treated with arthroscopy. Results: Out of 137 patients with meniscal tear, 109 (79.6%) patients had medial meniscal tear and 28 (20.4%) had lateral meniscal tear. Male female ratio was 3:1. Distribution of vertical, oblique, horizontal and complex medial meniscal tear was 16 (14.7%), 83 (76.1%), 6 (5.5%) and 4 (3.7%) respectively. Distribution of vertical (longitudinal and radial), oblique, horizontal and complex lateral meniscal tear was 5 (17.9%), 18 (64.3%), 2 (7.1%) and 3 (10.7%) respectively. Conclusion: Arthroscopy is essential for diagnosis and treatment of meniscal tears. In our study, medial meniscus is more frequently injured than lateral meniscus and horizontal meniscal tears appear less then oblique and vertical meniscal tears.

Key words: *Meniscal tears, Arthroscopy, Knee*

Introduction

The knee joint is the biggest joint in the human body. Despite bones (femur and tibia), a number of soft tissue structures are part of this most complex joint such as: menisci, ligaments, articular cartilage, articular capsule, infrapatellar fat pad, burse and tendons of the surrounding muscles.

Anatomy of meniscus

The menisci are two semilunar-shaped fibrocartilaginous structures, which are interposed between the femoral condyles and tibial plateaux. They are triangular in cross section and are attached to the lining of the knee joint along its periphery. There are two menisci: medial and lateral. Their unique anatomy is comprised of circumferentially oriented collagen fibres which provide resistance to hoop stresses and radially oriented fibres which resist shear forces (Cole BJ, Carter TR, Rodeo SA, 2003). The lateral meniscus is C-shaped with a short distance between its anterior and posterior horns. The medial meniscus is U-shaped with larger separation of the two horns (Maffulli N, Longo UG, Campi S, Denaro V, 2010), (Shirayev T, Anderson SE, Hope N, 2012), (Fan R, Ryu R, 2000).

Menisci are mostly avascular in adults. After the second decade only the peripheral 10% to 30% of the meniscus is vascularized, with a limited blood supply arising from a perimeniscal capillary plexus. The inner 70% to 90% of the meniscus is avascular and is nourished by the synovial fluid through diffusion (Arnoczky SP, Warren RF, 1982).

The meniscus has functions in load bearing, load transmission, shock absorption, joint stability, joint lubrication, and joint congruity (Henning CE, Lynch MA, 1985).

Diagnosis of meniscal tears

Meniscus is the most commonly injured structure in the knee joint. Clinical examination is the first step in establishing clinical diagnosis of meniscal tear. Varieties of clinical test are used for conducting clinical diagnosis of the injured knee. Several tests such as: McMurray, Apley, Steinmann, Thessaly, are most frequently used for diagnosis (Abdon P, Lindstrand A, Thorngren KG, 1990), (Yan R, Wang H, Yang Z, Ji ZH, Guo YM, 2011), (Solomon DH, Simel DL, Bates DW, Katz JN, Schaffer JL, 2001).

Magnetic resonance imaging (MRI) is additional diagnostic method frequently used for diagnosis and better visualization of the soft tissue structures, especially injured menisci. It is the most appropriate screening tool before therapeutic arthroscopy. MRI gives substantial benefit to orthopedics, traumatology and sports medicine.

Arthroscopy is final diagnostic method for meniscal tears. It gives direct visualization of the knee and its structures, so the diagnosis is accurate (Crawford R, Walley G, Bridgman S, Maffulli N, 2007), (Munshi M, Davidson M, MacDonald PB, Froese W, Sutherland K, 2000).

Treatment

Arthroscopy is minimally invasive operative technique. It is used for partial meniscectomies which involve avascular areas of the meniscus, without ability to heal. On the other hand, only peripheral tears which are in the vascular zone are amenable to repair techniques.

Meniscal tear patterns include vertical tears (longitudinal and radial), oblique, complex (or degenerative) and horizontal (Picture 1). Usually these tears are not repairable, and meniscal debridement is unlikely to restore meniscal complete function (Binfield PM, Maffulli N, King JB, 1993), (Maffulli N, Chan KM, Bundoc RC, Cheng JC, 1997), (Harper KW, Helms CA, Lambert HS, 3rd, Higgins LD, 2005).

When meniscal repair is not possible, partial meniscectomy is indicated (Metcalf RW, Burks RT, Metcalf MS, McGinty JB, 1996).



Picture 1. Vertical, oblique and horizontal meniscal tears

Aim

The aim of this study is to present the distribution of different types of meniscal tears diagnosed and treated with arthroscopy.

Material and methods

Between 2013 and 2015, at the University clinic for orthopaedic surgery, 137 patients with meniscal tears and average age of 26 ± 15 years were diagnosed and treated with arthroscopy.

All the patients had knee injury, positive clinical tests for meniscal tear and MRI confirmation.

Method of arthroscopic examination was used for final diagnosis. Arthroscopy was done in endoscopic operating room with arthroscope and arthroscopic instruments, using standard knee portals.

Results

Out of 137 patients with meniscal tear, 109 (79.6%) patients had medial meniscal tear and 28 (20.4%) had lateral meniscal tear. Male female ratio was 3:1.

Distribution of vertical (longitudinal and radial), oblique, horizontal and complex medial meniscal tear was 16 (14.7%), 83 (76.1%), 6 (5.5%) and 4 (3.7%) respectively. (Table 1)

Distribution of vertical (longitudinal and radial), oblique, horizontal and complex lateral meniscal tear was 5 (17.9%), 18 (64.3%), 2 (7.1%) and 3 (10.7%) respectively. (Table 1)

Table 1. Distribution of meniscal tears

Tear	Medial meniscal tear		Lateral meniscal tear	
	Number	%	Number	%
Oblique	83	76.1	18	64,3
Vertical	16	14.7	5	17,9
Horizontal	6	5.5	2	7.1
Complex	4	3.7	3	10.7
Subtotal	109	79.6	28	20.4
Total	137			

Discussion

Injury of the meniscus is one of the most prevalent injuries in the human body. Meniscal tears occur mostly in sports due to a shear force between the femur and tibia. In younger patients, this is typically a twisting force on a weight loaded flexed knee. These are often “bucket-handle tears”, in which there is a vertical or oblique tear in the posterior horn running toward the anterior horn, forming a loose section which remains attached anteriorly and posteriorly. In older patients, tears are generally due to degeneration associated with ageing and tend to be horizontal tears. The difference in tear type between these populations is explained by the three dimensional fibrous structure of the meniscus: horizontal delamination occurs in degenerative injuries, while the fibrous structure is ruptured in a vertical fashion in younger patients (Helms CA, Laorr A, Cannon WD, 1998), (Solomon L, Warwick D, Nayagam S, 2005).

Meniscal tear incidence may be as high as six per 1000 population with a 2.5 to 4 time’s male predominance. Injury peaks at 20–29 years of age (Metcalf RW, Burks RT, Metcalf MS, McGinty JB, 2004).

Partial meniscectomy is one of the most commonly performed orthopaedic surgical procedures. Once a meniscal tear has been diagnosed it should be operated. This doesn't have to be done urgently, although patients with a painful locked knee may want surgery as soon as scheduling permits. Arthroscopic surgery is the only way to treat the tear since there are currently no medications, braces, or physical therapy treatments that have been shown to promote healing in the avascular tears (Makris EA, Hadidi P, Athanasiou KA, 2011).

Meniscectomy is accomplished by using a variety of small instruments that cut and suck out only the torn portions of the meniscus. The remaining meniscal rim is then balanced and contoured to provide a gradually tapered transition into the area of the resection. The surgeon tries to leave as much normal meniscal cartilage as possible since this is an important shock-absorbing structure.

A repair allows the entire meniscus to be saved. The key to a successful repair is that the meniscus must be able to heal itself; the repair serves only as a means of securely holding the tissue together long enough for biologic process to occur (Metcalf MH, Barrett GR, 2004), (Garrett WE Jr, Swiontkowski MF, Weinstein JN, et al, 2006).

Conclusion

Arthroscopy is essential for diagnosis and treatment of meniscal tears.

In our study medial meniscus is more frequently injured than lateral meniscus and horizontal meniscal tears appear less than oblique and vertical meniscal tears.

Defining the types of meniscal tears, gives us a clue which type can prevent long term sequelae.

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