STUDENT RESEARCH CONFERENCE 2017

BRATISLAVA, APRIL 6, 2017

Proceedings

2017

Comenius University in Bratislava
CONTENTS

FULLTEXTS

Flóra BERGENDIOVÁ
LIFE QUALITY ASSESSMENT OF PHYSICALLY HANDICAPPED STUDENTS FROM THE PERSPECTIVE OF PHYSICAL EDUCATION AND SPORTS................................................................. 5

Michal CLEMENTIS
MAXIMAL POWER IN CYCLING AFTER SUBMAXIMAL LOAD IN DIFFERENT FREQUENCIES...................................................................................................................... 16

Nina CSONKOVÁ
RELATIONSHIP BETWEEN COORDINATION ABILITIES AND PERFORMANCE AT CANOE DISCIPLINE FREESTYLE KAYAKING............ 25

Pavol GREGORA
SELECTED PARAMETERS OF ELITE FOOTBALL TEAMS IN THE TOP EUROPEAN COMPETITION........................................................... 34

Milan KOVÁČ, Matej VAJDA
SALIVARY CORTISOL RESPONSE DURING ACCUMULATION, INTENSIFICATION AND COMPETITION PERIOD IN THE ELITE OLYMPIC WEIGHTLIFTERS................................................. 41

Jana LUPTÁKOVÁ
EFFECT OF ARTISTIC GYMNASTIC TRAINING IN PREPARATORY PERIOD ON GENERAL AND SPECIFIC JUMPING ABILITIES.............................. 50

Martin MIKULIČ
THE INNOVATIVE TRAINING TOOL TO IMPROVE GAME PERFORMANCE IN SOCCER - THE FUNCTIONAL MOVEMENT SYSTEM.......................................................... 59

Dávid OLASZ
INFLUENCE OF DIFFERENTIATED STRENGTH PROTOCOL ON SPEED AND ACCURACY OF TENNIS SERVE IN FEMALE PROFESSIONAL TENNIS PLAYERS................................................ 69

Róbert OLLÉ
EFFECT OF PLYOMETRIC TRAINING DURING EXERCISE DROP JUMP-JUMP ON RATE OF FORCE DEVELOPMENT OF ELITE WOMEN'S VOLLEYBALL PLAYERS................................................... 86
Katarina PÉLIOVÁ

INFLUENCE OF TABATA AND MINI TRAMPOLINE WORKOUT ON BIOCHEMICAL PARAMETERS OF WOMEN................................................. 94

Oliver POÓR

MUSCLE POWER AND VELOCITY DURING TRUNK ROTATIONS AFTER 6 WEEKS OF TRAINING IN CANOEISTS.............................................. 105

Tomáš PUPKAY

THE CHANGES IN THE LEVEL OF MAXIMAL IZOMETRIC FORCE AFTER MODEL LOAD IN ELITE KARATEKAS, JUDOKAS, WRESTLERS.......................................................................................... 113

**ABSTRACTS**

Michal BÁBELA

THE HISTORY OF NORDIC WALKING AND HEALTH BENEFITS OF NORDIC WALKING ……………………………………………………………… 122

Matej HALAJ

DEVELOPMENT OF STRENGTH-SPEED ABILITIES USING CLUSTER SETS WITH MAXIMUM POWER OUTPUT........................................... 124

Michal KRÁLIK

STRENGTH TRAINING AS A SUPPLEMENTAL THERAPY OF ANDROGEN DEFICIENCY OF THE AGING MALE................................................. 125
LIFE QUALITY ASSESSMENT OF PHYSICALLY HANDICAPPED STUDENTS FROM THE PERSPECTIVE OF PHYSICAL EDUCATION AND SPORTS

Flóra BERGENDIOVÁ

Department of Sport Educology and Sport Humanities, Faculty of Physical Education and Sports, Comenius University in Bratislava

Supervisor: Janka Peráčková

ABSTRACT

The quality of life affects the entire human population, all age groups, healthy, sick and disabled people. The aim of our study was to broaden the knowledge of life quality assessment of physically handicapped students from the perspective of physical education and sport. The standardized questionnaire SQUALA was selected as the main research method, particularly his second part, which is aimed at evaluation of subjective satisfaction with individual indicators of quality of life of every individual. The research sample consisted of 25 physically handicapped students from a Secondary Vocational school on Mokrohajska Street in Bratislava. Based on their physical education and sports performance, the students were divided into two groups: regularly active in sports (36 %) and occasionally active in sports (64 %). Despite the fact, the statistically significant differences were not detected, the results showed that the boys and students who were regularly active in sports proved a higher level of satisfaction in the most of the domains of quality of life- physical health, mental health, social relationships and environment. The lowest level of satisfaction was achieved by our respondents in health indicators, physical self-sufficiency, love and study, irrespective of sports.

Key words: quality of life, physical disability, physical education and sport activity

1 INTRODUCTION

Quality of life of handicapped people is multifactorial and multidimensional phenomenon comprising many aspects of reflection in a real life. It is related to a diverse character causing disorder, disability, handicaps and defects. These facts may vary in a degree of significance and importance for different people (Nemček 2011). Although, a subjective experience of a human being and assessment of one’s health remain crucial, using objectively measurable factors, significant and evaluative aspects at the individual level play an important role (Labudova 2012). Based on the definition of quality of life, a variety of factors can be noticed particularly with physically handicapped people, which influence the quality of their life. Therefore it is important to know and understand specific needs and desires of every handicapped person; creating such environment and conditions can ensure social, political, economical and cultural possibilities, so they can be able to select the way of life comparable to the one of health individuals and in this way it might provide them with an opportunity to live a well-rounded life with the rest members of the society. Many foreign authors, such
as Bogdan, Taylor (1989) point at the fact, that a physically handicapped person is the best specialist in perceiving one’s specific needs and thus assessing the quality of one’s life. One of the most significant factors influencing the life quality of people with a physical handicap is primarily a depth and a type (nature) of a particular disability. Various disabilities can be manifested as the result of a limited chance to participate in leisure activities, mostly movement activities. The results of those activities are affected by the will of individuals themselves, their possibilities, opportunities being available at the particular moment and social support in a family and people who are close to them (Ješina, Hamřík et al. 2012).

Physical education and sport have a unique place in the life of people and prevalingly in the life of a physically handicapped person. To achieve a level of self-sufficiency and self-realization, the person has to have a command of endeavour and self-denial, exercise, at home, in the nature or physiotherapy centre (Nagy 2012). Sport has a significant positive impact on a group of healthy population and mainly disabled population, which prevalingly influences also the quality of life. The author presumes that physically handicapped people are being integrated into the community of intact people thanks to physical education and sport, where they can gain new experience, physical fitness and gather new contacts and social relationships. Therefore, more attention should be paid to physical activities of persons with a disability than to ordinary population, because an appropriate physical activity can contribute to reducing and eliminating of health restrictions emerging from the physical disability (Srdečný 1981). Hošek (2000) emphasizes that certain standards and customs are being created mostly during organized physical education and sport. Physical education and sport are a suitable means for participation in a social life and affect the overall raising of quality of life and health for handicapped people. Furthermore, the author states, that physical education and sport enrich the human body not only physically, but also its savouring. The most valuable savours are those that are obtained by individuals, when taking one’s initiative and created using one’s body while doing a sport. It is clear that a regular physical education and sport activity significantly enhances subjective satisfaction with quality of life of handicapped people. Therefore, the individuals that enjoy more sedentary lifestyles should be aware of the fact, that this phenomenon represents important means of strengthening health and its satisfaction (Nemček 2014).

While investigating a relationship of quality of life and sports among older people, Nemček (2011) found out that sport did not play a crucial role among the aged people. They stated that physical education and sport did not have any impact on enhancing their life
satisfaction. Another study (Labudová, Nemček, Bardiovský 2014) reveals dominant sport aspects among physically handicapped people (n= 60), which showed that the most of respondents, 32,7 % of men and 34,8 % of women, have chosen an aspect “to have an opportunity of a social contact“. Women with a physical disability enjoy doing sports not only for a “social contact“ but also because of “a personal example for the others“ (30,4 %) and self-fulfilment (30,8%). Men would like to improve their health by doing a sport (29,8 %) and found new friends (28,1 %). Finding friends was the main reason of participation in a sport event in the age category 19-25 years. Bardiovsky (2010) who published the opinions of physically handicapped people in a wheelchair, found out that 40 % of all respondents considered their life valuable and useful and 58 % know what the ultimate goal of their life is. Those people ended up in the wheelchair after an injury and even though 68 % were assigned to the average zone of life meaningfulness.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The aim of this study was to broaden knowledge related to life quality assessment of physically handicapped students from the perspective of physical education and sport.

2.2 Hypothesis of the study

H1 It was assumed that a significantly higher satisfaction level would be shown in the domain of quality of life – physical health:

a) H1a- among physically handicapped students, who perform physical education and sport activity regularly comparing to physically handicapped students who do sports occasionally or do not perform any physical education or sport activity.

H2 It was assumed that a significantly higher satisfaction level would be shown in the domain of quality of life – mental health:

a) H2a - among physically handicapped students, who perform physical education and sport activity regularly comparing to physically handicapped students who do sports occasionally or do not perform any physical education or a sport activity.

H3 It was assumed that a significantly higher satisfaction level would be shown in the domain of quality of life - social relationships:
a) H3a - among physically handicapped students, who perform physical education and sport activity regularly comparing to physically handicapped students who do sports occasionally or do not perform any physical education or sport activity.

2.3 Tasks of the study

T1 – To analyze and compare a satisfaction level in the domain of quality of life - physical health:

a) T1a - among physically handicapped students, who perform physical education and sport activity regularly and among those who occasionally do sports or do not perform any physical education or sport activity.

T2 – To analyze and compare a satisfaction level in the domain of quality of life - mental health:

a) T2a - among physically handicapped students, who perform physical education and sport activity regularly and among those who occasionally do sports or do not perform any physical education or sport activity.

T3 – To analyze and compare a satisfaction level in the domain of quality of life - social relationships:

a) T3a – among physically handicapped students, who perform physical education and sport activity regularly and among those who occasionally do sports or do not perform any physical education or sport activity.

3 METHODS

Participants

Research sample consisted of 25 physically handicapped students from a Secondary vocational school on Mokrohajska Street in Bratislava. 68 % (n=17) of the participants involved in the study were male students and 32 % (n=8) were female students who were selected from various observed grades. There were divided into two groups based on a sport they performed. The first group (36 %) was formed by the physically handicapped students who are regularly active in sports (using a club membership) and the second group (64%) consisted of physically handicapped students who are occasionally active in physical education and sport activity. The youngest respondent was 17 years old and the oldest one 24 years old, while the average age was 19.2 years old. 32 % of physically handicapped students live at home in family environment. 64% of respondents live in a dormitory during the week.
and 4 % live in an orphanage. All respondents suffer from a disability, 84 % have a congenital disorder and 16 % of respondents inherited the disability during their life.
Procedure

The data were collected using the main research method: the standardized questionnaire SQUALA (Subjective Quality of Life Analysis), in particular its second part, evaluating the subjective satisfaction with various indicators of quality of living of each individual. It is related to a general life quality questionnaire, which is aimed at collecting information among health population and also persons with various disabilities, mostly of a psychological nature. The questionnaire captures subjective human perspective on one’s life situation by evaluating satisfaction/dissatisfaction with various life quality indicators. Questionnaire - Subjective Quality of Life Analysis – SQUALA (Zannotti, Pringuey 1992) is comprised of 23 indicators, concerning external and internal peculiarities of everyday life, so-called domains. As for purposes of this study, the questionnaire was partially modified, while some indicators of satisfaction (sexual life, participation in political affairs, faith, justice and money) were excluded and they were enriched by another indicator, such as “sports in leisure time”. The respondents assigned their subjective satisfaction to each indicator using 5 degree assessment scale in a particular field and thus specified to what extent they are satisfied with a life indicator. 1 point value (high satisfaction) is equal to the highest satisfaction and at the same time the highest level, 5 point value (complete disappointment) expresses absolute insignificance of a particular factor in their life. Assigned score values score 1-2 indicated a positive evaluation, 3 neutral and 4-5 as a negative evaluation. For more comprise results interpretation, investigated indicators (containing in SQUALA) of life quality were incorporated into individual domains according to WHO classification (1997) as follows:

1. **Physical health** – to be satisfied with health, physical self-sufficiency, sleep, a rest in leisure time, with food.
2. **Mental health** - to be satisfied with psychological well-being, love, beauty and art.
3. **The degree of independence** – to be satisfied with care of myself.
4. **Social relationships** – to be satisfied with family relationships and relationships with other people and children.
5. **Environment** – be satisfied with the environment in which I live, with hobbies in my free time, with sports in my free time, with sense of security, with a study.

The questionnaire was supplemented by the personal data of respondents such as: sex, age, type of disability and performance rate of physical education and sport activity.
**Statistical analysis**

Available data were processed through primary mathematical statistical methods and described using primary logical methods (a logical analysis and synthesis and comparative methods). For better orientation, the results will be displayed also using percentages and graphs. Another method used was Mann-Whitney rank test which is used during non-paired experiments assessment while comparing two different selected samples.

### 4 RESULTS AND DISCUSSION

**Fig. 1 The level of satisfaction in individual domains of life quality of physically handicapped people**


At the level of satisfaction, the results did not show statistically significant differences in individual domains of life quality of handicapped students from a sport perspective (fig. 1). Despite of our results evaluation, it could be stated that boys and students regularly active in sports proved a higher level of satisfaction in all domains of quality of life -physical health, mental health, social relationships and environment Although all respondents suffer from a disability, the fact the highest level was assigned to a domain of the degree of independence, i.e. caring for yourself, pleasantly surprised us. On the other hand, the lowest level of satisfaction was shown by girls and persons occasionally active in sports, in a domain of mental health.
Fig. 2 The level of satisfaction in a domain of quality of life – physical health of physically handicapped people from a sport perspective

   4. Rest in leisure time  5. Food

Differences in satisfaction in a domain of quality of life–physical health of students with disabilities were not statistically significant. Therefore the hypothesis H1 was not supported. It was shown that physically handicapped students doing sports on a regular basis achieved a higher level of satisfaction in all indicators of physical health, compared to peers performing sports occasionally. Physically handicapped students who are regularly active in sports are the most satisfied with resting in leisure time (1.44) and with food (1.55), while occasionally active in sports are the most satisfied with sleep (1.81) and food (1.81). The lowest level of satisfaction was gained in health and physical self-sufficiency indicators irrespective of sports. These results surprised us, as the most of respondents used a mobility aid (wheelchair, crutches) and they were dependent on help of other people.
The level of satisfaction in a domain of life quality – mental health of physically handicapped people from a sport perspective


Nor the previous relation or comparison of the level of satisfaction of mental health among physically handicapped students performing sports regularly and occasionally did not provide statistically significant differences. (fig. 3). Therefore the H2 hypothesis was not supported. The results show that our probands, regardless to a gender and performing of physical education and sport activity, are the least satisfied with the indicator of love in a domain of mental health. In our opinion, it can be related to the fact that respondents are at the age of older adolescence which not only require family love but also building new partnerships.

The level of satisfaction in a domain of quality of life – social relations of physically handicapped people from a sport perspective
The evaluation of level of satisfaction with social relationships among physically handicapped students did not bring statistically significant differences (fig. 4). Therefore the hypothesis H3 was not supported. In spite of the fact, that the picture points at slightly positive perception of satisfaction with social relations of all respondents, results still show that the youth regularly active in sports achieved a higher level of satisfaction in the particular domain. They are the most satisfied with relationships with other people (1.55), subsequently with family relationships (1.77) and with relationships with classmates (1.88). The highest difference can be seen in satisfaction with relationships with other people. This fact can be reflected in a case, when regularly active youth spend more time doing organised or non-organized physical education or sport activity, and thus have higher presumptions for building positive relationships with other people, while occasionally active in sports have limited opportunities in building new relationships.

![Fig. 5 The level of satisfaction in a domain of quality of life – environment of physically handicapped people from a sport perspective](image)


The obtained results showed us that all respondents are satisfied with the environment in which they live, together with hobbies performing in their free time. The indicator of sports in free time points at interesting finding, thus the regularly active youth achieved a higher level of satisfaction comparing to occasionally active people in sports. Both groups of respondents agreed that they are the ones who are the least satisfied with their study. Nemček (2014) who dealt with the issues of life quality of hearing-impaired people from a sport
perspective, found out that from 152 deaf respondents only 28.3 % were actively engaged in a sport activity and 71.7% of them preferred more sedentary lifestyle. She revealed that individuals actively engaged in sports with hearing defects show significantly higher satisfaction with the environment comparing to non-sporting individuals. It is clear that regular physical education and sport activity significantly enhances subjective satisfaction with life quality of physically handicapped persons.

**CONCLUSION**

Based on gained results of our research it may be noted:
- boys and regularly active students in sports proved a higher level of satisfaction almost in all domains of environment of quality of life-physical health, mental health, social relationship,
- girls and occasionally active students in sports showed the lowest level of satisfaction in the domain of mental health,
- regularly active physically handicapped students gained a higher level of satisfaction in all indicators of physical health, comparing to occasionally active peers,
- our respondents, regardless to gender and performing physical education and sport activity, are the least satisfied with the indicator of love in a domain of mental health,
- although all respondents positively evaluated their satisfaction with social relationships, regularly active youth achieved a higher level of satisfaction in the particular domain.

**References**


POSÚDENIE KVALITY ŽIVOTA ŽIAKOV S TELESNÝM POSTIHNUTÍM Z HĽADISKA VYKONÁVANIA TELOVÝCHOVNEJ A ŠPORTOVEJ ČINNOSTI

Flóra BERGENDIOVÁ

Katedra športovej edukológie a športovej humanistiky Fakulty telesnej výchovy a športu
Univerzity Komenského v Bratislave

Školiteľ: Janka Peráčková

ABSTRAKT

Kvalita života zasahuje celú ľudskú populáciu, všetky vekové kategórie, zdravých, chorych aj postihnutých. Cieľom našej práce bolo rozšírenie poznatkov o posúdení kvality života žiakov s telesným postihnutím z hľadiska vykonávania telovýchovnej a športovej činnosti. Za hlavnú výskumnú metódu získavania údajov sme si zvolili štandardizovaný dotazník SQUALA, konkrétne jeho druhú časť, ktorá hodnotí subjektívnu spokojnosť s jednotlivými indikátormi kvality života každého jednotlivca. Výskumný súbor tvorilo 25 žiakov s telesným postihnutím Strednej odbornej školy na Mokrohájskej ulici v Bratislave. Na základe vykonávania telovýchovnej a športovej činnosti sme ich rozdelili na dve skupiny, na pravidelné (36 %) a na príležitostne športujúcich (64 %). Napriek tomu, že nám nevyšli štatisticky významné rozdiely, výsledky nám poukázali na to, že skoro vo všetkých doménach kvality života- telesné zdravie, psychické zdravie, sociálne vzťahy a prostredie prejavili vyššiu úroveň spokojnosti chlapci a pravidelne športujúci žiaci. Najnižšiu úroveň spokojnosti dosiahli naši respondenti v indikátorech zdravie, fyzická sebetačnost', láska a štúdium bez ohľadu na športovanie.

Kľúčové slová: kvalita života, telesné postihnutie, telovýchovná a športová činnosť
MAXIMAL POWER IN CYCLING AFTER SUBMAXIMAL LOAD IN DIFFERENT FREQUENCIES

Michal CLEMENTIS

Department of Sports Kinanthropology, Faculty of Physical Education and Sport, Comenius University in Bratislava

Supervisor: Dušan Hamar

ABSTRACT

The aim of this study was to clarify the impact of submaximal endurance exercise to ability to produce maximum power in different pedaling frequencies. 16 cyclist completed two tests. First test was a measurement of maximal aerobic capacity. Second test was conducted in three steps: 1) determination of maximal power in different frequencies (90, 100, 110, 120, 130 rpm) by 5 sec maximal load with 2 min rest 2) 40 min submaximal load 80 % VO2max 3) again determination of maximal power in different frequencies (90, 100, 110, 120, 130 rpm) by 5 sec maximal load with 2 min rest. Cyclists did tests on ergometer Ergocycle with two days rest between the sessions. Paired t-test was used for the evaluation of results. There were found statistically significant differences in every pedaling frequency. Surprisingly, there was no power loss after submaximal exercise, but there was a significant increment of maximal power. It seems that to induct adverse changes in maximal power it is needed to increase the intensity of previous exercise.

Key words: cycling, maximal power, fatigue, different frequencies

1 INTRODUCTION

From the physical view, power is a product of force and speed. The force is relatively easily to measure by tensometres. The speed, at which is given force applied to the pedal, is described as the pedaling frequency. It is defined as the number of revolutions per minute - rpm. It became the subject of numerous studies and it is still under current review (Fonda & Sarabon 2010) Frequency of pedaling has been described as significantly determining factor resulting in reaction forces. With increasing cadence the force in active phase decreases and negative force of resting leg increases (Bolourchi & Hull, 1985).

By the shifting gears it is possible to produce the same power by different combinations of force and pedal speed. By the appropriate gear, the cyclist have an option to remain the same frequency after the speed was changed. Due to the high variability of disciplines, or load of varying intensity and duration respectively, it is necessary to define the term optimal pedaling
frequency. Timmer (1991) states the optimal frequency of elite cyclists from 90 to 110 rpm. Another author mentions about 110 rpm (Enoka, 2001).

Already Hagberg et al. (1981) dialed with the ability to produce maximum power at different frequencies. They tested 25 mountain bike cyclists (experimental group) and 60 students of sport (cycling not more often than twice per week, control group). During the 10-second maximal sprints and with 4 minutes rest they pedaled with frequency from 50 to 140 rpm (Fig. 1). Researchers found significant differences between all frequencies.

![Fig. 1 Power during 10-second maximal sprints in different frequencies (Hagberg et al., 1981)](image)

Dorel et al. (2005) investigated on the elite French sprinters optimal pedaling frequency also in terms of maximum power. The optimal pedaling frequency of the sprinters was 129.8 ± 4.7 rpm. In this cadence on 200-m track, the sprinters were able to produce the average power 1600 ± 116 W.

Almost the same conclusions were formulated by Gardner et al. (2007). They focused on a track cyclists. The goal group completed a 6-second lasting sprints on the ergometer. Or they was tested on bikes with flying start in 65-meter sprints in different frequencies. The optimal frequency of track cyclists was 128 ± 7 rpm or 129 ± 9 rpm on the bike. This study shows that the track cyclists have a higher optimum pedaling frequency as the other cyclists (Hagberg et al., 1981; Hamar et al. 1992). They indicated optimum frequency of road cyclists, sport students in terms of maximum power from 90 to 100 rpm.
The frequency, at which cyclists produce maximum power, was addressed by numerous authors (Hagberg, et al., 1981; Timmer, 1991; Hamar, et al., 1992; Enoka, 2001; Dorel et al., 2005; Gardner et al., 2007). However, it has always been studied only in the state without fatigue, which is typical for the final spurt of road cyclists.

The current intensity or energy demands in road cycling respectively depends on several factors, for example climbs, wind, position in the peloton, or distance from the finish. The load has mostly aerobic character. The average oxygen consumption during the race is about 50 % VO₂max. This number seems surprisingly low. But it has to be considered that in the average intensity are counted downhills or flat passages, where cyclists who are hidden in the peloton have low energy demands for the performed load. Ebert et al. (2006) state that the average intensity in road races is 188 W ± 30 W in flat stages, 262 W ± 30 W in criterium and 203 W ± 32 W in the mountain stages.

The average heart rate on stage races indicates the relatively low intensity. By the research of Fernadez - Garcia (2000) heart rate reach to 134 ± 18.6 bpm in the Tour de France, and 133.8 ± 17.9 bpm at the Vuelta a Espana. However, with reaching the finish, or in climbs the intensity increases.

The phenomenon of increasing intensity depending on the position from the finish was studied by Menaspa et al. (2015). Six professional riders were recorded during the last 60 min, 10 min, 5 min and 1 min before the end of the race. They used the SRM system, which is commonly used for training and research purposes (Haakonssen et al., 2013). In the last 10 min riders produced 316 W ± 43 W, 95 rpm ± 4 rpm and 50.5 km.h⁻¹ ± 3.3 km.h⁻¹. In the last minute speed and pedaling frequency significantly increased to 487 W ± 58 W, 102 rpm ± 6 rpm and 55.4 km.h⁻¹ ± 4.7 km.h⁻¹. It can be noted that with approaching finish, the intensity is rising closer to anaerobic threshold. Trained cyclists are able to pedal more than hour with intensity close to anaerobic threshold (more than 20 km climb with an average slope 7 % or more).

With increasing intensity of the exercise the anaerobic energy demands also increases. This is a result of the involvement of glycolytic muscle fibers that are less resistant to fatigue. It can be expected that the ability to produce the maximum power will be affected by this phenomenon. Within the context of accumulation of blood lactate, which is cumulated when the intensity of the exercise is above the anaerobic threshold, it is also reasonable to assume, that cyclists will not be able to produce maximum power at high speeds muscle contraction. This is resulting in decrease of the pedaling frequency, which they are able to produce maximum power.
Cyclists usually face the question, which gear or which frequency of pedaling to choose, so that they can develop a maximum speed or performance in the final spurt respectively. When the frequency is selected poorly, the cyclists may feel hardening of the feet (in the case of very slow rate) or failure to press on the pedal with sufficient force (too quick frequency). Current knowledge specify only the optimal pedaling frequency at which is the maximum power produced without fatigue, which is typical for the final spurt in the race. The results of the work will enable it to formulate recommendations with optimal pedaling frequency at which is the top power produced after submaximal load.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The aim of the study is to determine the effect of submaximal load on the ability to produce maximum power at different pedaling frequencies.

2.2 Hypothesis of the study

After 40 minutes of submaximal load, the ability to produce maximum power can be expected to decline. This will be significantly higher at high (120, 130 rpm) than at low (90, 100 rpm) pedaling frequencies.

2.3 Tasks of the study

1. Test maximum aerobic power to determine the individual intensities in the tests.

2. Realizing the testing of ability to produce maximal power before and after prolonged submaximal load.

3. Record, compare and evaluate the selected parameter values.

3 METHODS

Participants

For the purpose of the study, there were 16 male cyclists selected. Everyone raced in the Slovak road cycling cup in the 2015/2016 season. Average age was 24.7 years of decimal age and average VO₂max was 65.2 ml.min.kg⁻¹.

Procedure

In the first measurement, subjects did maximal aerobic test on the ergometer Ergocycle, using spirometry Cosmed K4B². It is a portable machine, made by the Italian company Cosmed, which uses measurement system „breath-by-breath“. Spirometry was used to determine individual experimental intensity, or for find the corresponding value of
power at 80 % VO2max respectively.

In the second measurement, after two days, subjects completed a series of 5 sec maximum sprints in frequencies 90, 100, 110, 120 and 130 rpm (in a random order) with two minutes of rest. Length of the rest should be sufficient to restore muscle CP, which should theoretically cover the energy deficit arising from 5 seconds maximum sprint. During the rest, subjects freely pedaled at zero resistance. Then, they completed a 40 minutes submaximal load at 80 % VO2max, with freely choose pedaling frequency. After submaximal load, followed by 2 minutes rest, they did the maximum 5-second sprints again, as before the load.

**Statistical analysis**

The following statistical methods were used:
- Basic statistical characteristics of position and dispersion (median, min. Value, max. Value, arithmetic mean, standard deviation)
- Parametric paired t-test to assess the significance of differences between two averages for dependent samples

4 RESULTS AND DISCUSSION

*Fig. 2 - Maximal power of cyclists (n=16) before and after 40 min of cycling in 80 % VO2max in different pedaling frequencies (90, 100, 110, 120, 130 rpm)*
As is visible on Fig. 2 - the cyclists achieved the highest maximum power at 110 rpm. Specifically 1531.3 W. For other frequencies they achieved lower power Tab. 1.

Tab. 1 Average maximal power in different frequencies before and after submaximal load

<table>
<thead>
<tr>
<th>pedaling frequency [rpm]</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
<th>130</th>
</tr>
</thead>
<tbody>
<tr>
<td>before exercise [W]</td>
<td>1406.4</td>
<td>1512.7</td>
<td>1531.3</td>
<td>1511.8</td>
<td>1467</td>
</tr>
<tr>
<td>after exercise [W]</td>
<td>1529.1</td>
<td>1620.6</td>
<td>1604.3</td>
<td>1574</td>
<td>1536.1</td>
</tr>
</tbody>
</table>

Maximum power at different frequencies, which was produced by cyclists before the load, corresponds with the findings of previous researches (Timmer, 1991; Enoka, 2001).

Hagberg et al. (1981) found lower frequency at which cyclists produce maximum power. However, this study was conducted on mountain bikers. It is known that the mountain bikers pedal with slower frequency. This was also confirmed by Gregory John et al. (2007). In international mountain bike competition, the cyclists raced with average frequency only 74.3 rpm in flat passages.

Surprisingly, after the load there was an increase in maximum power at all measured frequencies. This unconfirmed the hypothesis that predicted higher or lower decrease in maximum power. The explanation may be found in low intensity of a given load. Apparently, 80% VO_{2}max is not sufficiently high intensity that results in a fatigue of fast muscle fibers. Contrastly, this intensity seemed to warm-up muscles and the cyclists were then able to develop more power. The average value of blood lactate was after load 6.8 mmol.l^{-1}. This suggests that the anaerobic glycolysis was involved to energy production or the fast fibers were involved.

However, induced metabolic changes have apparently rather positive effect on the ability to produce maximum power. On the short sprint (5-second maximum load) muscle preferably use creatinphosphat if it is available (Bogdanis et al. 1996). Then probably equal longer load or lower intensity load will not affect the ability to produce maximum power.

In the results of the study, there can be observed a decrease in the frequency after submaximal load at which the cyclists produced the maximum power. However, the difference between 100 rpm and 110 rpm is only 16 W and it is not significant.

Tab. 2 Average increase of maximal power in different frequencies

<table>
<thead>
<tr>
<th>pedaling frequency [rpm]</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
<th>130</th>
</tr>
</thead>
<tbody>
<tr>
<td>increase of maximal power after exercise [W]</td>
<td>122.65</td>
<td>107.88</td>
<td>72.95</td>
<td>62.2</td>
<td>69.1</td>
</tr>
</tbody>
</table>
The maximum power after the load does not rise in the same way in all frequencies. In Tab. 2 it is visible, that the maximum power increased more in slower frequencies. The differences are small, and the maximal power is achieved at 100 rpm and 110 rpm. The maximal power in this frequencies is significantly higher than at other pedaling frequencies.

The results also highlight the importance of a thorough warm-up before the maximum power loads. Warm-up was the subject of numerous scientific studies. Trend of recent periods give an emphasis on quality of warm-up, especially before the sprint disciplines. In a large study of warm-up, the Bishop (2002) mentions the positive effects that are mainly based on temperature-related mechanisms (decreased stiffness, increased nerve-conduction rate, altered force-velocity relationship, increased anaerobic energy provision and increased thermoregulatory strain).

According to the source DISQUS (2017), the twice formal Tour de France champion Contador A. has long warm-up before the time trial. It took 22 minutes in which he rode for 7 minutes over the anaerobic threshold.

Traditionally, according to the Elias et al., (2011), track-cycling warm-up lasts 51 minutes. It began with 20 minutes of cycling with a gradual intensity increase from 60% to 95% of maximal heart rate; then four sprints were performed at 8-min intervals.

Thoroughly warm-up or ideal temperature for maximum performance is supported by the study of Faulkner et al. (2012). They examined the use of special shorts which kept the temperature of the thigh muscles in passive recovery. By using this shorts, cyclists reached the performance for 9% at second Wingate test after 30 minutes of recovery.

CONCLUSION

The research was aimed to clarify the impact of submaximal load to the ability to produce maximum power at different pedaling frequencies. Monitoring of 16 cyclists showed that the maximum power raised after 40 minutes of submaximal load (intensity 80% VO2max) in every monitored frequency. Before the load cyclists achieved maximum power at 110 rpm. After the load, the frequency at which cyclists produced maximum power dropped to 100 rpm. However, the difference in the maximal power between 100 rpm and 110 rpm was not significant. The need to modify the frequency at the end of the race due to produce higher power, is therefore very poor. These results indicate, that after long performance (intensity under anaerobic threshold) there is no need to change gears in terms of maximum power.
References


MAXIMÁLNY VÝKON PRI RÓZNYCH FREKVENCIÁCH PEDÁLOVANIA PO SUBMAXIMÁLNOM ZAŤAŽENÍ

Katedra športovej kinantropológie, Fakulta telesnej výchovy a športu, Univerzita Komenského v Bratislave

Školiteľ: Dušan Hamar

ABSTRAKT

Cieľom štúdie bolo objasniť vplyv submaximálneho vytrvalostného zaťaženia na schopnosť produkovať maximálny výkon pri rôznych frekvenciách pedálovania. Štúdie sa zúčastnilo 16 cyklistov, ktorí absolvovali dva testy. Prvým testom bolo meranie maximálnej spotreby kyslíka. Druhý test bol vykonaný v troch krokoch: 1) 5-sekundové maximálne šprinty pri rôznych frekvenciách (90, 100, 110, 120, 130 rpm) 2) submaximálne zaťaženie 40 min, 80% VO2max 3) znovu stanovenie maximálneho výkonu v 5-sekundových šprintoch pri rôznych frekvenciách (90, 100, 110, 120, 130 rpm). Testovanie prebiehalo na ergometri Ergocycle s dvojdňovou prestávkou medzi meraniami. Na vyhodnotenie výsledkov bol použitý párový t-test. Po zaťažení boli pozorované štatisticky významné rozdiely v maximálnom výkone pri každej frekvencii šliapania. Prekvapivo po submaximálnom zaťažení nedošlo k poklesu, ale k výraznému zvýšeniu maximálneho výkonu. Štúdia naznačuje, že na negatívne ovplyvnenie maximálneho výkonu je potrebné absolvovať intenzívnejšie zaťaženie.

Kľúčové slová: cyklistika, maximálny výkon, únava, frekvencia šliapania
RELATIONSHIP BETWEEN COORDINATION ABILITIES AND PERFORMANCE AT CANOE DISCIPLINE

FREESTYLE KAYAKING

Nina Csonková

Department of Outdoor sports and Swimming, Faculty of Physical Education and Sport,
Comenius University in Bratislava

Supervisor: Dušan Kutlík

ABSTRACT

Performance in canoeing disciplines is based on the physical condition of the kayaker, technique and mental ability to adapt to the racing condition. Freestyle kayaking performance is consisting of different abilities where coordination abilities play a big role. The aim of this study was to identify the relationship between special coordination abilities and kayak freestyle performance.

Our monitoring group consisted of 16 international senior kayak freestyle paddlers in the age group (26 ± 3 years). Special coordination abilities were measured at the swimming pool two days before competition. Our monitored group performed special kayak freestyle tests. Following tests were selected: front bow standing in time, numbers of cartwheels in 30 seconds, split-to-split in 60 seconds. Special freestyle performance was measured during ECA Euro Cup tour 2013 in Slovakia, Čunovo by official ICF judges. The data obtained were measured by the Spearman Correlation (r) correlation test. The results of the study show significant relations between special kayak freestyle performance and test of special coordination abilities; front bow standing was (r = 0.69; p < 0.01), numbers of cartwheels in 30 second (r = 0.88; p < 0.01), split-to-split in 60 seconds (r = 0.91; p < 0.01).

Keywords: freestyle kayaking, special performance, special coordination abilities, top athletes

1 INTRODUCTION

Sport performance is formed gradually. It is a result of natural growth and development of the individual person, environmental impact and customized sport training. To increase performance we have to take it into a wider context (Dovalil, 2002).

According Moravec (2007), sport performance is a result of specific motion activities. Its aim is to solve the tasks which are defined by the rules in the final manifestation of athletes that affect the effects of other external factors.

Hirtz (1985) characterized coordination abilities as complete, relatively independent power control conditions of physical activities which are awarded on the movement and develop activities based on the dominant reconciliation, but influenced functional
neurophysiological mechanisms (therefore it can be developed by systematic training). It is a prerequisite allowing perfectly, or less perfectly mastered the technique.

General coordination presents abilities of efficiently execution of motion skills regardless of the sport specializations. Every athlete should do general sport skills development to gain the adequate level of general coordination. There is a presumption that athlete with better general coordination can faster acquire the special coordination skills of his sport specialization. It is necessary to reach high level of general coordination because it is the base of special coordination development. Development of general coordination lies in practicing of new moves from various sports disciplines and games that positively affects the ability of the musculoskeletal system. Special coordination presents abilities to execute motion in selected sport discipline fast and without the mistakes, easy and right. Special coordination is connected with skills and abilities, which the athlete use during his training, or competition in his sport discipline. Special coordination can be gain by regular performing of motion skills and technical moves during whole sport carrier (Perič, 2010).

Szanto (2010) define canoeing as a sport which requires coordinated action between the paddler (athlete), the paddle as the propulsion tool, the kayak as the vehicle providing buoyancy and the water as the medium of transport.

Freestyle kayaking is one of the canoeing disciplines. Kayaker performs various acrobatic maneuvers and figures in water features as a hole or wave (Halašová, 2011).

According International canoe federation – ICF (2015) canoe freestyle is a whitewater discipline where competitions take place on river features called playspot. These can be breaking or partially breaking standing waves, holes and stoppers typically formed at the bottom of small drops or weirs where the water flows back on itself. In ICF events, athletes have a set time to perform as many different moves as possible. Finals are judged on three 45-second runs. One the best one is counted. Kayak freestyle is a constantly evolving discipline, with new tricks being developed to complement and improve on existing moves.

According Halašová (2011) freestyle kayak discipline requires special freestyle skills, good level of condition, coordination and mental abilities. Special performance in freestyle kayaking depends on a number of various factors. It's a sport performed in nature, we can mention changing natural conditions such as type of playspot, amount of water flow and it’s characteristic, water temperature. Furthermore, it is the level of paddling technique, condition and coordination skills.
In our study we monitor special coordination abilities, which we consider are the most important skills in freestyle kayaking. The aim is to identify the relationship between kayak freestyle performance and special coordination skills.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The aim of this study was to identify the relationship between special coordination abilities and kayak freestyle performance.

2.2 Hypothesis of the study

We supposed to find significant relationship between coordination abilities and kayak freestyle performance.

2.3 Tasks of the study

1. Select the tests of coordination abilities.
2. Perform selected test with subjects.
4. Identify relationships between freestyle performance and coordination abilities.

3 METHODS

Participants

Our tested group consisted of 16 freestyle kayakers in the age group 26 ± 3 years. Their international ranking was top 30. The average body height was 178.8 ± 5.1 cm, average body weight was 73.3 ± 7.3 kg, average sport age was 11 ± 2.9 years.

Procedure

The tests of coordination abilities were selected after consultation with kayak freestyle experts and based on their years of experience in the field of this sport. This tests were carried out two days before Euro Cup where the sport performance was measured. Tests were providing at swimming pool, in paddlers own freestyle kayaks. Each athlete had enough time to recover before test. Test were performed in following order: T1, T2, T3. Sport performance was measured at Euro Cup 2013 in Čunovo, Slovakia. Event took a part in slalom course in right channel.

Tests:
1. Numbers of cartwheels in 30 second. The aim is to make as many cartwheels as possible in 30 seconds. According ICF (2010) definition, cartwheel is: two consecutive ends in the same rotational direction, and both ends at a vertical angle between 45° and 100°.

Only attempt with two finished ends is counted. Kayaker starts from flat position. When kayaker starts the first end examiner turns on stopwatches and starts to count attempts. This test identify kinesthetically differentiation skills.

2. Front bow standing in time [seconds]. Kayaker has to keep balance on a front bow. Examiner starts stopwatch when the subject is standing on a front bow and is ready to start. When stern touch the water examiner stops the stopwatch. This test identify dynamic balance.

3. Split-to-split in 60 seconds. According ICF (2010) definition, splitwheel is: two consecutive ends, with a change of direction in between each and both ends at a vertical angle between 45° and 100°. Kayaker starts from flat position. When kayaker starts first end examiner turns on stopwatches and starts to count attempts. Four ends combination with changed direction is counted as one, two end combination is counted as half of attempt. This test identify orientation skill.

**Sport performance:**

Kayak freestyle performance is evaluated by points, from 0 to around 1500 - 2000 points (but it can go even higher). Freestyle ride is performed in playspot which can be hole or wave. Official judges are judging each ride and score it with points. The ride lasts 45 seconds. The kajak freestyle performance for our study was measured during ECA competition of Euro Cup 2013 in Slovakia, Čunovo by three official ICF judge. The score of best placed ride was counted.

**Statistical analysis**

Descriptive statistics (arithmetical average, median, standard deviation, minimum and maximum value) were used to analyze obtained data. To clarify the relationship between the monitored variables we used Spearman's correlation coefficient. The statistical significance is at level of 1% and 5%.

**4 RESULTS AND DISCUSSION**

Data of monitored parameters are showed in Table 1. Arithmetical average in performance of first test T1 was 12.6 ± 2.6, in T2 was 106.8 ± 38.1, in T3 was 5.2 ± 1.8. Average value of sport performance gained by subject was 1214 ± 319.7 points. Spearman's correlation coefficient outputs is showed in Table 2. Significant relationship (p < 0.01) between sport performance and coordination abilities were proven in all three tests.
Table 1 Data of monitored parameters.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AV</td>
<td>12.6</td>
<td>106.8</td>
<td>5.2</td>
<td>1214</td>
</tr>
<tr>
<td>SD</td>
<td>2.6</td>
<td>38.1</td>
<td>1.8</td>
<td>319.7</td>
</tr>
<tr>
<td>ME</td>
<td>12.5</td>
<td>96.5</td>
<td>5.5</td>
<td>1301.5</td>
</tr>
<tr>
<td>Min.</td>
<td>8</td>
<td>56</td>
<td>2</td>
<td>652</td>
</tr>
<tr>
<td>Max.</td>
<td>16</td>
<td>198</td>
<td>7.5</td>
<td>1678</td>
</tr>
</tbody>
</table>

Notes: AV - arithmetical average; Me - median; SD - standard deviation; Min - minimum; Max - maximum; T1 - number of cartwheels in 30 sec., T2 - front bow standing, T3 - numbers of split-to-split in 60 sec.

Table 2 Relationship between tests of special coordination abilities and special kayak freestyle performance.

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>special freestyle performance</td>
<td>r = 0.826**</td>
<td>r = 0.693**</td>
<td>r = 0.851**</td>
</tr>
</tbody>
</table>

** p < 0.01

Notes: T1 - numbers of cartwheels in 30 sec., T2 - front bow standing, T3 - number of split-to-split in 60 sec.

According Perić and Dovalil (2010), high level of coordination abilities creates good conditions for sport technique development. Sometimes it's hard to find difference between general and special coordination abilities and technical skills of certain discipline in training practice. General coordination doesn’t try for perfect mastery of the physical activities, its essence is to create a wide motion fund, which becomes a starting point for special coordination of the sporting disciplines. It's creating a basis for perfect mastery of the technique of different skills, which are applied into competitions in the certain sport discipline.

In freestyle kayaking is about 30 different figures with bonuses which athletes can chose and combine in ride. Selected test represent basic movements and figures in freestyle kayaking. Each figure is a combination of vertical and horizontal angles of kayak in fluid motion. Test 1
3 substitute basic movements of paddler and kayak which all figures are created from. This tests represent specific coordination abilities of freestyle kayaking which contain all coordination skills. For easier understanding we categorized this tests as a special coordination tests of kinesthetically differentiation skills, dynamic balance and orientation skill.

Test 1 mirror kinesthetically differentiation skills combined with power endurance as well. Significant relationship were proved at the level of 1% significance (r = 0.826). Cartwheel is most basic vertical move and good technique of this figure ensure strong basement for other moves. To perform combination of cartwheels in fast fluid motion require high level of special kinesthetically differentiation skills and endurance in power.

Test 2 is a special test of dynamic balance performed in kayak on flat water. To keep kayak in vertical position requires very good level of dynamic balance, fast reactions and good strength abilities of belly muscles. The significance relationship at the level of 1% significance (r=0.693) between sport performance and dynamic balance was found.

Test 3 is most difficult test. It combines basic vertical movements with direction changes and combinations. This requires all range of coordination skills specially high level of orientation skill. In our group of kayaker we found 1% level of significance relationships ( r= 0.851) between sport performance and orientation skills. Fast direction change is needed to perform figures in ride without any hesitation.

High level of coordination abilities, specially of specific coordination, which mirror special freestyle skills, secured successful technical performance of figures in ride.

We suppose special coordination abilities are one of the main factor in structure of sport performance in freestyle kayaking. We propose to carry out further studies that would let us clarify all factors determining the structure of sport performance. Future appropriate research can be applied to a larger number of subjects.

**CONCLUSION**

Our assumption was confirmed but there is open space for further study.

Freestyle is a new sport with luck of verifiable information. There were not many scientific researches done. We need to develop freestyle kayaking and gain more informations about it.

The present study is the first to investigate the relationships between kayak freestyle performance and coordination abilities of top athletes. This paper presents the findings of mutual relationships between kayak freestyle performance and the level of selected coordination abilities – specific kinesthetically differentiation skills, dynamic balance and orientation skill.
Taking into account the results of our research, we recommended:

- increase coordination abilities
- focus on specific coordination skills on the water – specific conditions
- develop specific kinesthetically differentiation skills, dynamic balance and orientation skill.
- carry out further studies that would let us clarify the factors determining the structure of sport performance
- apply further study to a larger number of subjects and use more test to identify all coordination abilities

Our study present research results which can serve as a quality source of information for further research on structure of freestyle kayaking performance.

References
VZŤAH MEDZI ŠPECIÁLNYMI KOORDINAČNÝMI SCHOPNOSTAMI A ŠPORTOVÝM VÝKONOM V KANOISTICKEJ DISCIPLÍNE
KAJAK FREESTYLE

Nina Csonková

Univerzita Komenského v Bratislave, Fakulta Telesnej Výchovy a Športu,
Katedra športov v prírode a plávania

Školiteľ: Dušan Kutlík

ABSTRAKT

Športový výkon v kanoistike je založený na pohybových schopnostiach kajakárov, ich technickej zručnosti a mentálnej schopnosti sa prispôsobiť podmienkam súťaženia. Športový výkon v kajak freestyle sa skladá z viacerých schopností, pričom špeciálne koordinačné schopnosti majú na výkon veľký vplyv. Cieľom našej práce bolo identifikovať vzťah medzi špeciálnymi športovými schopnosťami a výkon v kanoistickej disciplíne kajak freestyle. Sledovaná skupina sa skladala zo 16 medzinárodných seniorských kajakárov vekovej skupiny 26 ± 3 ročných. Špeciálne koordinačné schopnosti sa sledovali na bazéne dva dni pred pretekmi. Sledovaná skupina vykonávala testy na vlastných freestylových kajakoch. Špeciálne koordinačné schopnosti sme sledovali nasledovnými testami: výdrž v stoji na špičke za čas, počet cartwheelov za 30 sekúnd a počet prevedení figúry split-to-split za 60 sekúnd. Špeciálny výkon sa hodnotil počas ECA pretekov série Európskeho pohára 2013 na Slovensku, v Čunove, kvalifikovanými rozhodcami ICF. Sledované dáta boli vyhodnotené testom závislosti – Pearson Koreláciou (r). Výsledky nám poukazujú na významný vzťah medzi špeciálnym výkonom a špeciálnymi koordinačnými testmi v testoch: stoj na špic bol (r = 0,69; p < 0,01), počet cartwheelov za 30 sec. (r = 0,88; p < 0,01), split-to-split za 60 sec. (r = 0,91; p < 0,01).

Kľúčové slová: kajak freestyle, špeciálny výkon, špeciálne koordinačné schopnosti, elitní športovci
SELECTED PARAMETERS OF ELITE FOOTBALL TEAMS IN THE TOP EUROPEAN COMPETITION

Pavol GREGORA

Department of sports games, Faculty of Physical Education and Sport, Comenius University in Bratislava

Supervisor: Pavol Peráček

ABSTRACT

The secret of successful teams, which are being placed on the top positions in the Champions League, the Europa League and the European Champions are often the subject of many discussions between experts. In our work we are looking for some answers on the basis of statistical data collected from watching the matches. The aim of the research was to compare 16 best teams in the three elite European competitions (the Champions League, the Europa League and the European Champions). We assume that the average possession of a ball in the Champions League, Euro 2016 and the Europa League is not significantly different. We used a data acquisition software InStat 3.0 where we observed selected parameters. The group consisted of 16 best teams from the Champions League competition, the top 16 teams from the competition Europa League and the 16 best teams from the European Champions in the season 2015/2016. To evaluate the acquired data we used the non-parametric method of Mann - Whitney U - test. In comparison of the successful passes we did not find statistically significant differences between clubs playing in the Champions League, teams playing at EURO 2016 and teams playing in the Europa League. Teams playing the Champions League, the Europa League and EURO 2016 did not significantly differed in possession of the ball.

Despite the fact that we could not prove statistical differences between selected competitions, factually teams that are ranked among the top four in the Champions League reached the selected parameters of high value and therefore if coaches want to achieve the best results it is very important to improve in these parameters. Therefore, in the training process we recommend the experts to use small forms of preparatory and positional games.

Key words: football, Champions League, Europa League, EURO 2016, possession ball

1 INTRODUCTION

Learning from matches in top events sets the trend in which modern football is heading. About how to be successful at the tournament itself or in league often decide the details. These may be the actual statistics of the matches. Who better knows the competition is probably more likely to be successful. In our research, we follow some selected parameters of top competitions Chamions League (CHL), Europa League (EL) and European Champions (EURO) that can help coach in next managing training process and matches (Owen et al. 2016).
Ball possession

Ball possession is the amount of time a team possesses the ball during a game of football. Possession is usually expressed as a percentage (for example, 60% for team A, 40% for team B). Historically, Dutch clubs (especially Ajax) were famous for dominating ball possession, but more recently FC Barcelona of the Liga Santander became the best in maintaining ball possession; Germany's FC Bayern Munich came out second. Lago et al. (2007) in their research, which monitored more than 170 matches Spanish league point, home teams have more possession than away teams, teams have more possession when they are losing matches than when winning or drawing, and the identity of the opponent matters - the worse the opponent, the greater the possession of the ball. Lago et al. (2010) in its other research which observed 380 matches in the Spanish league states Team possession was greater when losing than when winning (p<0.01) or drawing (p<0.01), home teams enjoyed greater possession than visiting teams (p<0.01) and playing against strong opposition was associated with a reduction in time spent in possession (p<0.01). Ball possession does not guarantee winning, but it means setting the pace and rhythm of the game and, most importantly, it forces the opponent to do lots of running. The world’s best teams distinguish themselves by nearly perfectly safeguarding and handling the ball in all game situations. They are masters at steadily building their game from the back under pressure (Schreiner and Elgert, 2013).

Time goal scoring

According to a study by Armatas et al. (2007) this is has been attributed to fatigue at the end of the match, since players certainly slow down as the game progresses. I suspect there is more to it than this – concentration, the state of the game, the intent of players as the final whistle approaches are all factors, but certainly, the final 15 minutes produces more goals. Armatas et. al. (2009) studied the impact of the first goal in the final result of the game in 240 games in the Greek Super League 2006-2007 and found that in 71.43% the team that scored the first goal of the game won. In the study headed by Armatas and Yiannakos (2010) the 64 matches of the World Cup 2006 were analyzed, the authors found that the team that scored the first goal of the game won in 73.21% of the games analyzed.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The aim of our study was to compare selected parameters monitored in matches between football teams of the elite European competitions.

2.2 Hypothesis of the study

H1: The average ball possession in the Champions League, Euro 2016 and the Europa League is not a significantly different.
H2: The average percentage of passing will be significantly better in the Champions League and the Europa League as the EURO 2016.

H3: There will be non-significant difference between the average distance covered between the CHL competitions and EURO 2016.

3 METHODS

Participants

Three elite European competitions which took place in 2015/2016 season were involved in the study. We analysed the 16 TOP clubs from CHL, 16 TOP clubs from EL 16 TOP clubs and from EURO 2016 in more than 300 matches. We watched and even Top 4 teams in the CHL (Bayern Munich, Real Madrid, Atletico Madrid, Manchester City), Top 4 teams from EL (Dortmund, Sevilla, Villareal, Liverpool) 4 TOP teams from EURO 2016 (Germany, France, Wales and Portugal).

Procedure

In our work we use the data acquisition software from the Russian manufacturer InStat 3.0, thanks to which we watched quantitative but also qualitative indicators. Software error rate is 1.2. In the software operation there are involved more than 300 people who analyze the vast amount of matches.

Statistical analysis

To determine whether the files are the independent statistical differences, we used the non-parametric method of Mann - Whitney U - test (Kampmiller et al. (2010). The results were processed by the software XLSTAT.

4 RESULTS AND DISCUSSION

Possession is often considered as one of the determining criteria in the evaluation team. Considerable ball is a sign of dominance over rival team. Of course we think is very important, as can be the dominant team in particular one half of opponent. From one perspective you high ball allows to control the game. On the other hand, averages sandpaper down the peaks and troughs. To take a fictitious example, a team having 80% of the ball during the home leg of a tie and 20% in the return would throw up an anodyne 50% average that does not reflect the reality of what happened on the pitch. A look at the figures on the team pages in this report reveals that 16 of the 32 contestants registered variations of 20% or more between their maximum and minimum possession statistics with, as it happens, Atlético posting the greatest difference – 61%. Wins for the team with greater possession is 53 % and wins for the team with less of the ball is 43 %. Only 15 of the 51 matches at UEFA EURO 2016 were won by the team that enjoyed a greater share of possession.

This trend extended right through to the final, which Portugal won with 47% of the ball. Of the 15 knockout games, only 4 were won by the team that had more of the ball. With two of the group games producing a 50-50 split, this means that possession translated into
victory in only 31% of the matches in France. After two successive EUROs in which Spain’s possession-based game had prevailed, this was a thought-provoking departure from the recent norm.

![POSSSESSION BALL](image1.png)

**Fig. 1 - Possession ball in different competitions**

When comparing the selected parameters of the ball (Fig. 1) we did not find any significantly difference between the pursuit of competition and thus we confirmed our hypothesis. This is probably due to the fact that the teams at this level are trying to achieve the best possible result and goes to the foreground and efficiency and tactics such as aesthetics. Comparing Top 4 teams among the competitions we registered a significant difference between the CHL (53.75%), EL (53.75%) and Euro 2016 (50.75%) at 5% level of significance. As additional information we watched the ball in the attacking zone (Fig. 2) in the Champions League. Where we compared the teams that progressed (20.43%) and have fallen out (19.06%). Among these files were not found a significantly differences. Conversely teams that are ranked in the top 4 achieved an average value of 24.25%, which is compared to the teams dropped out statistical significant at the 5% level.

![POSSSESSION BALL IN ATTACK AREA](image2.png)

**Fig. 2 - Possession ball in attack area**

![PASSING ACCURACY](image3.png)

**Fig. 3 – Passing accuracy in different competitions**

The success rate of passing can be a key factor for success. The best teams in the world have the best players, which are characterized by perfect technique. It is highly possible that if you want with your squad to advance further in the tournament, you have to factor in that to achieve a high percentage of success (Fig. 3). Top 4 teams among the monitored contest we have not seen significant difference. The competitions we have seen significant difference between the CHL (86%) and the EURO 2016 (82.545%) at 5% level of significance. In practice, these results may indicate that if a team is not able to pass, losing the
chance of success. In practice, these results may indicate that if a team is not able to pass, it loses the chance of success. Factors that affect the ability are for example technique of players, choice of location, conditions.

We compared the types of passing in the CHL and the EURO in 2016 (Fig. 4). We watched the long, medium and short passes. There was no difference between the monitored long pass. The difference between the CHL (309.4) and Euro (272) in the middle, the pass was significant at the 5% level. Similarly, we found significant at the difference in the endpoint short passes (CHL EURO 136 and 105.4). At a top 4 teams, this difference was even more pronounced. Overall, the average CHL fell more passes than the EURO 2016. This fact may be due, the euro that month playing tastes and aim to achieve in a short time the best result. On the contrary, the CHL is a long competition.

While watching an average distance by the player (km) during the match in the Champions League and EURO 2016, we did not detect any significant differences among the surveyed teams as well as teams from the Top 4 (Fig. 5). The average value of the top four teams in the Champions League was 10.0 km. Bangsbo (1994) reported that the average distance covered by Danish national players was 10.55 km. Later, Mohr et al. (2004) also followed the average distance covered by the Danish national team with the result of 10.33 km. Di Salvo et al. (2007) observed Spanish professional players for an average distance covered by 11.39 km. Dellal et al. (2010, 2011) followed values of the 1st Division (France, UK, Spain, Italy) at the average distance covered during the game (10.42 to 11.78 km). Our comparison with other authors differ significantly. The difference in the last year is in the balance speed sections of the matches at the top level.

In pursuing averages distance covered (Fig. 6) to the team, we did not find significant difference between competition Champions League and Euro 2016. Significant difference was found between the Top 4 teams at the 5% level of statistical significance, where teams from the Champions League Average distance covered (110 000 m).

CONCLUSION
There were not recorded significant differences in the majority of the observed parameters. The most successful clubs respectively, of the top four clubs in all competitions achieve the best results we monitor indicators. From a substantive point of view if you want to be in the tournament or competition successful, you should try to keep these key parameters at a very high level, respectively, approaching the levels of the top teams 4. Based on the results, we recommend the training process inserted positional play and small side games, because they improve the technical, tactical and physical condition, but also the psychological component of gaming performance.

References


VYBRANÉ PARAMETRE FUTBALOVÝCH DRUŽSTIEV V ELITNÝCH EURÓPSKÝCH SÚŤAŽIACH  

Pavol GREGORA  
Univerzita Komenského v Bratislave, Fakulta telesnej výchovy a športu,  
Katedra športových hier  
Školiteľ: Pavol Peráček  

ABSTRAKT  

Kľúčové slová: futbal, Liga Majstrov, Európska Liga, EURO 2016, držanie lopty
Abstract

This study examined the changes in basal cortisol concentration and acute cortisol response to weightlifting training protocol during accumulation, intensification and competitive period of elite weightlifters.

Eight elite weightlifters (international level) volunteered in present study. The salivary cortisol was measured in four testing sessions over 18 weeks during accumulation, intensification and competition period. The training protocol consisted of three specific weightlifting exercises and the saliva samples were collected before and 5 min, 15 min and 30 min after protocol, respectively.

The basal level of salivary cortisol remains unchanged during accumulation, intensification and competition period. In acute cortisol response were found decrease between pre and 5 (p ≤ 0.01), 15 (p ≤ 0.01), and 30 min (p ≤ 0.05) post testing protocol during accumulation and intensification periods. While in competition period was found significant decrease (p ≤ 0.05) only 5 min after testing protocol.

Results suggest that the monitoring of cortisol concentration may provide an effective way to monitor acute and chronic adaptive response to specific weightlifting training. More information about actual state of athlete’s organism may optimize training process over the season.

Key words: cortisol, saliva, weightlifting

1 INTRODUCTION

Cortisol is a catabolic hormone produced by the adrenal cortex. Cortisol is one of the most important stress hormone, the glucocorticoid class, mediating training adaptations, by decreases protein synthesis and increases protein breakdown (Viru and Viru 2004). Past studies in exercise science literature have used cortisol like a marker of physiological stress (Kirchbaum and Hellhammer 1994; Neary et al. 2002), cortisol was used to monitor an athlete’s response to testing, training and competition.

Previous investigations found the influence of strength training program on cortisol level in strength-trained subjects (Gotshalk et al. 1997; Kramer et al. 1997, Tremblay et al. 2004, Spiering et al. 2008). Hakkinen et al. (1988) suggest that hormonal responses of
weightlifters to strength training program are similar to the strength-trained athletes. In addition, Storey and Smith (2012) proposed that the regular evaluation of basal testosterone, cortisol and T/C ratio can provide an effective way for established the acute and chronic adaptive response to weightlifting training. Currently, the salivary analyses of biomarkers are widely used in sports science, because of non-invasive, stress-free nature of sampling procedure (Aardal, Hom, 1995). Both, salivary and serum levels of biomarkers shown high level of compliance (Kirchbaum et al., 1989, Luisi et al., 1984, Wining et al., 1983, Lac et al., 1993, Morgan 2009).

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The aim of this study was to find out changes of salivary cortisol concentration during the accumulation, intensification and competition period of elite weightlifters.

2.2 Hypothesis of the study

H 1 We hypothesized, that different basal level of salivary cortisol will be observed over the accumulation, intensification and competition period in weightlifting.

H 2 We hypothesized, that different acute response of salivary cortisol will be observed over the accumulation, intensification and competition period in weightlifting.

2.3 Tasks of the study

The task 1 was to find out and compare the level of basal salivary cortisol concentrations during the monitored period.

The task 2 was to find out and compare means values between pre testing, post testing 5, 15 and 30 min. during the monitored period, respectively.

The task 3 was to compare the relationships and differences of monitored parameters during monitored period.

3 METHODS

Participants

Eight elite weightlifters from Czech and Slovak National Team with more than 8 years weightlifting training experience volunteered for this study. The inclusion criteria for this study were sport performance expressed by Sinclair points scale (for evaluation criteria of sport performance without difference in bodyweight). Participants had to have more than 350
Sinclair points. All participants had competed in national and international weightlifting competitions before this study. General characteristics of participants, age 26.56 ± 3.43 years, weight 94.76 ± 17.60 kg at the start of this study, average height of participants was 177.00 ± 7.05 cm.

**Procedure**

Our data were collected in four testing sessions during 18 weeks of accumulation, intensification and competition period (Fig. 1).

![Fig. 1 Study time line](image)

Testing session were consisted of saliva sampling (before training protocol, 5, 15 and 30 min after training protocol), standardised warm-up and training protocol (Fig. 2).

![Fig. 2 Testing session time line](image)

The Salivette (standardized sampling vial) with a plain cotton swab were used (Sarstedt, Nurmbrecht, Germany). All samples were stored subsequently refrigerated at – 60°C for future analysis. The samples were analysed at Department of physiology, Commenius University in Bratislava. The salivary cortisol (nmol/L) concentrations were determined using commercially available ELISA kits (Salimetrics, State College, PA, USA). Centrifugation for 2 minutes at 1000 g, without repeated thawing and refreezing, were
preceded according to the recommendations (Salimetrics, State College, PA, USA). Training protocol was contained of three weightlifting exercises: muscle snatch – start at 50% 1RM with graduation to 1RM (6 sets with 1 repetition at weight), high pull with snatch grip – start at 90% with graduation to 1RM (6 sets with 1 repetition at weight) and front squat – start at 60% 1RM and ending two weights above average power maximum (7 sets with 1 repetition at weight). Rest interval was established 2 and 3 min between the sets and exercises, respectively. All of exercises were performed with maximal effort. A linear position transducer attached to the right side of the bar (Tendo weightlifting analyser; Tendosport, Trenčín, Slovakia) was used for control of maximal effort.

**Statistical analysis**

Standard descriptive statistics were calculated for all measured parameters. Because of the low sample size, nonparametric statistics were used. The Wilcoxon T-test and Friedman test were used for statistical analyses. The criterion for significance was set at \( p \leq 0.05 (*) \) and \( p \leq 0.01 (**) \).

4 RESULTS AND DISCUSSION

In this study were analyzed acute and basal changes of salivary cortisol concentrations during accumulation, intensification and competition period.

![Graph](image)

**Fig. 3** Changes of basal salivary cortisol concentrations during preparation and competition period, \( t_0 \) – entry testing session, \( t_1 \) – testing session after accumulation period, \( t_2 \) – testing session after intensification period, \( t_3 \) – testing session after competition period. Values are presented as median.
Main findings of present study were not significant differences between monitored periods in basal levels of salivary cortisol. The published data about effect of training intervention on changes of basal cortisol level remain controversial. In present study, adaptive changes of basal cortisol level were not observed during monitored period. Different changes of basal cortisol were observed in investigations that were controversial (Hakkinen, Pakkarinen, 1991, Kraemer et al., 1998, Potteiger et al., 1995). Our results are in agreement with Guilhem et al. (2015) who did not observe significant changes in cortisol level during preparation and pre-competitive period. It seems that reducing cortisol levels associate with optimizing physiological systems before maximal physical performance.

Fig. 4 Changes in acute response of Salivary Cortisol before accumulation period (A), after accumulation period (B), after intensification period (C), after competition period (D), before (Pre), 5 min. (Post 5), 15 min. (Post 15) and 30 min. (Post 30) after testing session. Values are presented as median. * Significant difference p≤0.05 and ** Significant difference p≤0.01.

Significant decrease of the acute cortisol response was observed between PRE to POST 5 and PRE to POST 15 minutes (p < 0,01) before accumulation period. Following accumulation period, significant decrease was registered between PRE to POST 5, POST 15 (p < 0,01) and POST 30 minutes (p ≤ 0,05), respectively. The same decrease was observed after intensification period between PRE to POST 5, POST 15 (p < 0,01) and POST 30
minutes ($p \leq 0.05$), respectively. After competition period, significant decrease was found between PRE and POST 15 minutes only. Our results suggest that long-term weightlifting training with different training load over the weightlifting season may affect acute cortisol response to training. In opposite, Hakkinen and Pakarinen (1993) shown that weightlifting training performing of 20 sets of 1RM, did not affect acute cortisol response to training.

McGuigan et al. (2004) investigated that the high intensity resistance exercise resulted in a significant increase of the salivary cortisol concentrations post exercise, compared to pre exercise concentration. It is obvious that application of high volume and intensive weightlifting training periods caused decrease of cortisol sensitivity during training periods.

**CONCLUSION**

Nowadays, scientific trends in elite sport training prefer the systematic, intra-individual approach to the monitoring of adaptation processes. For top level weightlifters, monitoring of changes of basal concentration and acute response to the resistance training may be useful for effective training individualisation. Also, in present study were observed high intra-individual variability of concentration of monitored hormones in all monitored periods. The results of our inter-individual monitoring indicated the number of significant changes of analyzed hormonal parameters and bring information about actual state of organism.

For the future investigation, we propose to register training volume and intensity during the training period. It seems to be helpful to understand relationship between training characteristics and hormonal changes for the optimizing of training process.

**References**


ZMENY KONCENTRÁCIÍ KORTIZOLU V SLINÁCH

POČAS AKUMULAČNÉHO, INTENZIFIKÁČNÉHO A SÚŤAŽNÉHO OBDOBIA VRCHOLOVÝCH VZPIERAČOV

Milan KOVÁČ*, Matej VAJDA**

Comenius University in Bratislava, Faculty of Physical Education and Sport, Katedra atletiky*, Katedra športovej kinatropológie**

Školiteľ: Eugen Laczo

Abstrakt

V predloženom prispevku sledujeme zmeny úrovne bazálnych koncentrácii kortizolu a zmenami a zmeny akútnej reakcie na tréningové zaťaženie počas akumulačného, intenzifikačného a súťažného obdobia vrcholových vzpieračov.

Sledovaný súbor tvorilo osem vrcholových vzpieračov (medzinárodnej úrovne). Počas 18 týždňov (akumulačné, intenzifikačné a súťažné obdobie) absolvovali štyri testové stretnutia. Testové stretnutie pozostávalo z odberov slinných vzoriek pred tréningovým protokolom a v 5., 15. a 30. minúte po tréningovom protokole. Tréningový protokol sa skladal z troch vzpieračských cvičení.

Úroveň hladiny kortizolu v bazálnom stave nezaznamenala signifikantné zmeny počas sledovaného obdobia. Úroveň hladiny kortizolu zaznamenala signifikantný pokles v 5., 15. (p ≤ 0.01) a v 30. minúte (p ≤ 0.05) po zaťažení v akumulačnom a intenzifikačnom období. Zatiaľ čo v súťažnom období bol preukázaný signifikantný pokles (p ≤ 0.05) len v 5. minúte po tréningovom protokole.

Výsledky naznačujú, že sledovanie zmien koncentrácií kortizolu môže poskytnúť informácie o akútnych a chronických adaptačných reakciách v organizme vplyvom špecifického vzpieračského tréningu. Detailnejšie poznanie aktuálneho stavu organizmu športovca môže napomôcť pri optimalizovaní tréningového procesu v priebehu športovej prípravy.

Kľúčové slová: vzpieranie, kortizol, sliny
EFFECT OF ARTISTIC GYMNASTIC TRAINING IN PREPARATORY PERIOD ON GENERAL AND SPECIFIC JUMPING ABILITIES

Jana Luptáková

Department of Sport Kinantropology, Faculty of Physical Education and Sport, Comenius University in Bratislava

Supervisor: Dušan Hamar

ABSTRACT

The aim of the study was to compare general and specific jumping abilities in elite artistic gymnasts at the beginning and end of the preparatory period. Eight artistic gymnasts (age 16.0 ± 2.7 years; body height 160.0 ± 6.9 cm; body weight 52.8 ± 8.8 kg) have participated in the study. Following tests on a jump ergometer Fitro Jumper were carried out at the beginning and at the end of the preparatory period: countermovement jump without and with arms swing, 10- and 60- second series of repeated vertical jumps, handstand jump, Salto forward and Salto backward. The height and mean power output in the concentric phase of take off (P) were used as parameters of jump capabilities. In 10- and 60- second test also fatigue index (% decrease of power in the concentric phase of take off during the test) was evaluated. A non-parametric Wilcoxon T-test was applied to prove statistical significance of the differences between measurements. Results showed significant increase (p ≤ 0.05) in height of the countermovement jump without arms swing, 10- and 60- second series of repeated vertical jumps, handstand jump and Salto forward after the preparatory period. Increase of mean power output in the concentric phase of take off only achieved statistical significance (p ≤ 0.05) only in the following tests: countermovement jump without arm swing, 10- and 60- second series of repeated vertical jumps and Salto forward. Changes of fatigue index in the 60- second series were not statistically significant. The results show that gymnastic training in the preparatory period has a positive effect on jumping abilities. The high level of this capability likely enhances the technique of complex acrobatic elements and dance leaps with a positive effect on overall gymnastic performance.

Key words: jumping abilities, explosive strength of lower and upper extremities, artistic gymnastics, preparatory period

1 INTRODUCTION

The sport performance in artistic gymnastics can be characterized by very precise execution of difficult movements under relatively stable conditions. Therefore, it can be classified as one of the technical-aesthetical sports. Contrary to other sports, the factors affecting performance in artistic gymnastics are very complex. At each apparatus gymnast has to perform a routine consisting of at least 15 to 20 different artistic elements of various
difficulty value. Execution of such gymnastics elements is evaluated by judges according to Code of Points (COP) settled by FIG in 2017. The whole spectrum of gymnastic elements on each apparatus poses a high demand on technical and aesthetical execution and of course on state of physical conditioning, coordination skills and mental state of gymnast. The description of elements by COP is very precise and literary presents an optimal or perfect technique of execution. Every deviation from prescribed technique leads to point deductions for final evaluation. To achieve such perfection, gymnasts have to possess high level of motor capabilities as for example explosive strength, speed, endurance, or joint flexibility. They are termed as limiting factors; however, they have to be applied during complex movements with a high demand on coordination. So it may be taken for granted that progress in gymnastic performance is tightly correlated with level of motor capabilities. Therefore, jumping ability may be considered one of limiting factors in structure of sport performance in artistic gymnastics. Without sufficient explosive strength upper and also lower extremities gymnasts would be not able to perform technically correct acrobatic elements and leaps in routines on gymnastic apparatus.

Explosive power, as ability to exert maximum force in the shortest possible time, is of paramount importance for dynamic acrobatic elements (Šimonek et al. 2007). The level of explosive strength may be also considered as one of relevant criteria in the selection of talented young gymnasts.

The ability to produce high level of muscular power is one of the salient characteristic of muscular action involved in gymnastic elements (Cormie et al., 2011). It is rather generally known that when a muscle is stretched prior to shortening, it produces an enhanced power output as compared to a concentric contraction in isolation (Komi, 2000). This muscular phenomenon is referred to as stretch-shortening cycle (SSC).

Plyometric ability can be evaluated in variety of ways, ranging from expensive and laboratory - based equipment, to cheaper, field - based methods. However, taking into account cost involved, the ease of use and non - invasive nature of field - based testing, plyometric ability in children and adolescent are most commonly evaluated indirectly, using special vertical jump protocol.
2  AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1  Aim of the study
The aim of study was to compare the level of general and specific jumping abilities in
elite artistic gymnasts at the beginning and the end of the preparatory period.

2.2  Hypothesis of the study
1. The group of gymnasts will achieve significant improvement in all parameters of selected
tests after preparatory period.

2.3  Tasks of the study
1. To measure parameters by means of selected tests at the beginning of preparatory period.
2. To measure parameters by means of selected tests at the end of preparatory period.
3. To evaluate the results obtained.

3  METHODS

Participants
Research group consisting of eight elite junior gymnasts (age 16 ± 2.7 years; body
height 160 ± 6.9 cm; body weight 52.8 ± 8.8 kg) participated on the study. The subjects,
members of Slovak national team represented currently the best female artistic gymnasts in
the country. They practised approximately 25 hours a week. In training process were used
special gymnastic exercises and elements for development of strength, plyometric capabilities
and flexibility.

Procedure
The experimental group was informed about the design and possible risks of the
participation in the study. All the athletes signed an informed consent. The study was
approved by an ethic committee Comenius University in Bratislava, Faculty of Physical
Education and Sport. The gymnasts underwent testing at the beginning and end of preparatory
period (January and May 2016). Tests were carried out in the premises of the Faculty of
Physical Education and Sport in Bratislava and gymnastic club KŠG Detva. Parameters
selected for the evaluation of tests applied were based on recommendation proposed by

Jump ergometer was employed to assess explosive strength of lower and upper
extremities (Hamar 1990). System consists of contact switch mattress, interface and computer
equipped with software. Height [cm] and the power in active take off phase [W.kg⁻¹] were measured in single countermovement jump with and without arm swing, in 10 and 60 second series of repeated vertical jumps and in special tests handstand jump, Salto forwards. Height was also measured during Salto backwards. In 60 second series of repeated vertical jumps also fatigue index as a percent decrease if power in active phase of take off from beginning to the end of the test calculated.

**Statistical analysis**

To evaluate statistical significance of changes after preparatory period the nonparametric Wilcoxon t-test was used. The statistical significance was determined on the 1 % and 5 % level.

4 **RESULTS AND DISCUSSION**

Fig. 1 shows the results of the height and power output in concentric phase of take off of single countermovement jump without arms in group of artistic gymnasts. The average values at the beginning were as follows 24.1 ± 3.2 cm and 11.7 ± 1.0 W.kg⁻¹, at the end 26.1 ± 2.2 cm and 12.6 ± 1.1 W.kg⁻¹. Increases 2 ± 1.9 cm and 0.8 ± 0.8 W.kg⁻¹ were statistically significant (p ≤ 0.05).

![Graph showing height and power output](image)

*Fig. 1 The height and power output in concentric phase of take off in single countermovement jump without arms swing in group of artistic gymnasts*
In the countermovement jump with arm swing (Fig. 2) the increase 1.6 ± 1.5 cm in the height of the jump between first 32.5 ± 3.6 cm and second measurements 34 ± 3.2 cm was found statistically significant (p ≤ 0.05). The difference 0.7 ± 1.1 W.kg⁻¹ in second parameter power output was not statistically significant. Comparing these values with those of elite female gymnasts reported by Marina (2003) reveals that height of single vertical jump with arm swing (45.2 cm) and without arm swing (38.2 cm) of Slovak gymnasts are substantially lower.

![Fig. 2 The height and power output in concentric phase of take off in single countermovement jump with arms swing in group of artistic gymnasts](image)

In 10- second series of repeated vertical jumps (Fig. 3) significant differences (p ≤ 0.05) between values at the beginning and end were observed in both parameters. The increases in height 2.0 ± 1.3 cm and in power output 2.9 ± 2.5 W.kg⁻¹ were obtained.

![Fig. 3 The height and power output in concentric phase of take off in 10- second series of repeated vertical jumps in group of artistic gymnasts](image)
The data of 60-second series of repeated vertical jumps performed on the jump ergometer - the height, power output in concentric phase of take off and fatigue index was compared (Fig. 4). Differences of height of the jump $2.1 \pm 1$ cm and power output $2.2 \pm 2$ W.kg$^{-1}$ between beginning and the end of preparatory period were significant ($p \leq 0.05$). The values of index fatigue were not statistically significant. This test reflects muscular endurance of lower extremities, which is considered a significant discriminator of high-versus low-level gymnasts (Sands, 2003). It is the ability to perform for extended sequences, such as long routines, without undue fatigue. Gymnasts develop this quality progressively with age and practise. Sands and colleagues have used sixty second test to select the women’s Olympic Gymnastics members during their seven month of trials leading to the Sydney Olympic Games (Sands, 2000b; Sands et al., 2001a, 2001b). The average power outputs or these trials were as follows: Female US Senior National ($n = 34$, 17.2 years): $23.7 \pm 5$ W.kg$^{-1}$; Female US Senior National Team ($n = 6$, 17.3 years): $23 \pm 4.8$ W.kg$^{-1}$; Female US Junior National Team ($n = 15$, 13.9 years): $21.6 \pm 2.8$ W.kg$^{-1}$. For comparison the elite Slovak gymnasts achieved average values of power output $35.6 \pm 2.6$ W.kg$^{-1}$.

![Fig. 4 The height, power output in concentric phase of take off and fatigue index in 60-second series of repeated vertical jumps in group of artistic gymnasts](image)

Fig. 5 shows the results of the height and power output in concentric phase of take off in specific gymnastic test a handstand jump reflecting the explosive strength of upper extremities. The statistical significance at 5% level was observed only in parameter height of the jump $0.5 \pm 0.8$ cm. The differences of power output were not significant. The high level of this ability is very important for correct performance of acrobatic elements on the floor and vault apparatus.
At the last Fig. 6 the values of specific tests Salto forward and backward were shown. The differences in height of the jump $4 \pm 3.8$ cm and power output $15.3 \pm 12.6$ W.kg$^{-1}$ in salto forward between measurements in preparatory period were observed with the level of statistical significance $p \leq 0.05$. The value in height of salto backward was not statistically significant.

The results of study show that specific gymnastic exercises in preparatory period had positive effect on the level of explosive strength of lower and upper extremities. Jumping abilities from the beginning to the end of preparatory period improved significantly due to gymnastic training.

All these jumping tests have been widely accepted and are applied in gymnastics. It has indeed been shown that the use of diagnostic system based on jumping mat is an effective assessment tool for gymnasts, which allows monitoring of training effect and may as well enhance its efficiency (Sands et al. 2004a).
CONCLUSION

Results showed that gymnastic training including special exercises in preparatory period improves the jumping abilities and may have a positive effect on sport performance in artistic gymnastics.

References


VŠEOBECNÉ A ŠPECIFICKÉ ODRAZOVÉ SCHOPNOSTI ŠPORTOVÝCH GYMNASTIEK V RÓZNYCH OBDOBIACH ROČNÉHO TRÉNINGOVÉHO CYKLU

Jana Luptáková

Univerzita Komenského v Bratislave, Fakulta telesnej výchovy a športu, Katedra športovej kinantropológie,

Školiteľ: Dušan Hamar

ABSTRAKT

Cieľom práce bolo porovnať všeobecné a špecifické odrazové schopnosti na začiatku a na konci pripravného obdobia. Štúdie sa zúčastnilo osem vrcholových gymnastiek (vek 16,0 ± 2,7 rokov; hmotnosť 160,0 ± 6,9 cm; výška 52,8 ± 8,8 kg). Vstupné aj výstupné testy boli merané na výskokovom ergometri FITRO JUMPER. Sledované boli parametre výška výskoku (h) a výkon v záverečnej fáze odrazu (P) v nasledujúcich testoch: jednorazový výskok bez a s protipohybom, 10- a 60- sekundová séria opakovaných vertikálnych výskokov, jednorazový odraz v stojke a špeciálny test salto vpred. Ďalej bola hodnotená výška výskoku v teste salto vzad a index únavy v 60- sekundovej sérii opakovaných vertikálnych výskokov. Pre porovnanie rozdielov medzi vstupnými a výstupnými meraniami v rámci skupiny bol použitý neparametrický Wilcoxonov T-test. Štatistická významnosť na 5 % hladine významnosti bola dosiahnutá vo výške výskoku v nasledujúcich testoch: jednorazový výskok bez a s protipohybom, 10- a 60- sekundová séria opakovaných vertikálnych výskokov, jednorazový odraz v stojke a v teste salto vpred. Index únavy porovnaním vstupných a výstupných hodnôt v 60- sekundovej sérii nebol štatisticky významný. Výsledky poukazujú na významné zlepšenie parametov a nárast úrovne odrazových schopností vplyvom špecifického gymnastického tréningu v pripravnom období. Vysoká úroveň odrazových schopností môže zlepšiť kvalitu a techniku prevedenia zložitých akrobatických cvičebných tvarov a tým zvýšiť celkové hodnotenie v súťaži.

Kľúčové slová: odrazové schopnosti, výbušná síla dolných a horných končatín, športová gymnastika, pripravné obdobie
THE INNOVATIVE TRAINING TOOL TO IMPROVE
GAME PERFORMANCE IN SOCCER - THE FUNCTIONAL
MOVEMENT SYSTEM

Martin MIKULIČ

Department of Sport Games, Faculty of Physical Education and Sport, Comenius University
in Bratislava

Supervisor: Pavol Peráček

ABSTRACT

Soccer players are often limited in the range of muscle groups, respectively in joints, when they try to reach the superior game performance. One of the innovative training tools to improve player’s game performance is a diagnostic system Functional Movement Screen. Through Functional Movement System can diagnose and remove defects in muscle groups of players, which obstruct their full range of motion in various joints and also limit for achieving maximum game performance. The aim of our research was to determine the effectiveness of the experimental program - Functional movement system. Players were divided into experimental and control group. Experimental group consists of 11 players and control group consists of 10 players from FC Petržalka akadémia in age category under 19 years. They are participants in Slovak second under 19 league in season 2016/2017.

Experimental group participated in twelve weeks long specific FMS training program (two times a week). It consists of a specific training program for each player by Functional Movement System philosophy, to achieve an improvement in diagnostic test Functional Movement Screen instruments. The measurements and experimental program were leading by certified trainer. Control group perform usual static stretching with his trainer. Both groups performed input and output measurement. We compared results of the experimental and control group and we were looking for statistically significant difference between the input output measurements.

For the evaluation of the intra-group results we used Wilcoxon T test. We found a significant improvement in the experimental group (p ≤ 0.01). To compare input and output measurements of both groups we used Mann-Whitney U-test. It demonstrated statistical significant difference between output measurements of both groups (p ≤ 0.01). In input measurements of both groups we found not any significant differences (n. s.). To evaluate Effect size of the experimental factor we used Cohen’s coefficient “d”. Coefficient reached the value 1.64, it means large effect of our experimental factor.

Based on our results, the Functional Movement System is a good complement of training process of young soccer players. We think it would be appropriate to add our data on the other results of the same players and then analyze their injuries and find a relationship between FMS test scores and injuries. The following researches we will try to find out, that the Functional Movement Screen is suitable for predicting the injuries in this age group in soccer.

Key words: Functional Movement Screen, soccer players, age category under 19
1 INTRODUCTION

Progressive trainer is looking for a way to develop or to improve his training program. Implementation of innovative tools in soccer is very acute. It presents in new solutions of game organizing in offensive or defense phase and specific task for every player’s role. Through this tactical solution he tries to win over his opponent (Peráček et al. 2015a, b, c, Benkovský et al. 2015, Peráček et al. 2016, ). Another trainers try to find progressive proportionality of training loads in training process (Peráček 1992), resp. they are oriented to improved game performance through game (Peráček 1995, Kačáni 2004).

It is the time to atomize every parameter that enters to training process. Vengloš said: “We have to focus on detail”. Everything is heading to game performance, which is very complicated. Individual game performance (IGP) in sport games is characterized by Peráček (2004) as individual and group performance of players in action during the match, determined by the degree of completion of the tasks. There are a huge number of determinants that determine the game performance. Peráček (2014) discusses these determinants:

- **Biomechanical factors:**
  - Operation of the musculoskeletal system
  - Fine neuromuscular coordination
  - Principles of efficient movement

- **Bioenergy factors:**
  - The type of muscle fibers
  - Biochemical security IGP
  - Ability to mobilize adequate energy system

- **Psychological factors:**
  - Cognitive processes
  - Management procedures in its monitoring
  - Anticipation and decision making, sensorial skills

- **Deformation factors:**
  - Internal disturbances
  - External disturbances
One of these are biomechanical factors, which affect the motor performance of individual sporting activities, which can be objectively observed. Details the game activities from biomechanical point of view we found in a number of scientific publications (Bloomfield et al., 1979; Elliott et al., 1980; Browder et al., 1991; Lees & Nolan, 1998; Lees & Nolan, 2002).

These activities are the product of the motor system, needs appropriate attention and mind effort (Kačáni 2005). All game skills are the result of interaction of functional muscle groups. If their function is impaired, either by shortening or weakening of specific muscles or muscle groups, occurs muscle imbalances and movement that we want to perform is not at the required level. Respectively we cannot use our potential.

From the coach becomes a manager, who manages his teammates. He gives individual tasks to colleagues in his team. Therefore, coach’s team often includes experts from the field of fitness coaching and physiotherapy. Verheijen (1998) divides the conditioning to the power, speed, endurance and also coordination and flexibility. He also says that each player must pay attention to the flexibility of their muscles, whether to permit the full range of motion of the joints and to the prevention of injuries. To find out whether are problems in different muscle groups we have to be able to diagnose. One of the innovative diagnostic tools is a Functional Movement Screen (FMS). This system is used by highest level in sports like ice hockey NHL (Rowan et al. 2015), soccer (Kiesel, Plisky & Voight 2007, Gabriš et al. 2015), NBA used by fitness coach Tim DiFrancesco (LA Lakers) and NFL Sam Ramsden (Seahawk head athletic trainer), but also in ordinary professions like firefighter (Frost et al. 2012).

FMS is professional and certificated diagnostics, which is used in high level sport and recreation sport. Its task is to identify the weakest parts in human movement and consequently offers targeted corrective strategy that is integrated into the training process. It is conducted by certified trainers who have received specific preparation. They are authorized to perform this diagnostic tool. FMS is the result of modern training philosophy known as Functional Movement Systems. The Functional movement system was developed by Gray Cook and Lee Burton in 1995. The FMS consists of seven movement patterns. That calls for balance of mobility and stability. These fundamental movement patterns are designed to provide observable performance of basic locomotor, manipulative, and stabilizing movements. The tests place the individual in extreme positions where weaknesses and imbalances become noticeable if appropriate stability and mobility is not utilized (Cook et al. 1998). The reliability of FMS was confirmed by Minick et al (2010), Schneiders at al. (2011), Teyhen & Deydre (2012), Parenteau et al. (2014).
In our research we focused on team FC Petržalka akadémia in category U19. This team is participant of second Slovak national league. Under the supervision of a certified coach we were diagnosed 21 players. They completed input and output measurements. They have been diagnosed by FMS coach a he checked and found their problematic and painful parts in movement patterns. The body is as strong as its weakest part. Therefore, we focused on these weaknesses, which we tried to remove it.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The aim of our study was to determine the effectiveness of FMS, which we implemented to training process. The intervention was conducted in duration of 12 weeks.

2.2 Hypothesis of the study

H1 We assume that the experimental group due to the experimental factor will be in the output measurements significantly better than at input measurements.
H2 We assume that the experimental group due to the experimental factor will be in the output measurements significantly better than the control group.

2.3 TASKS OF THE STUDY

1. Realize input measurements of both groups
2. Randomly divided players into two groups
3. Apply experimental program for experimental group
4. Realize output measurement of both groups
5. To evaluate data we use IBM SPSS – Statistic software

3 METHODS

Participants

Participants of this research were FC Petržalka akadémia players in count of 21, in category under 19 years in season 2016/2017. This team is participant of the second Under 19 Slovak league.
**Procedure**

The specific FMS consists of seven fundamental movement patterns (which test needs, movement is executed on both sides (left or right). Every movement patterns has score range from 0 to 3 (3 is the best score) (Cook, Burton & Hoogenboom 2006):

- 0 – during the testing proband feels pain (painful area is noted)
- 1 – proband is unable to complete the movement pattern, or is unable to assume the right position
- 2 – proband is able to complete the movement pattern but must compensate his move in some way
- 3 – proband is able to complete the movement pattern without any problems

In the end of preparatory season (t₀) we did the first measurement FMS of both group. Then we randomly divided players into two groups. In experimental group we applied FMS program one time a week for 3 months with certificated trainer, which comes on every training session. The control group train in the same time only static stretching. After three months we made second measurement (t₁).

**Statistical analysis**

To determine statistical significance of differences between both groups we used non-parametric test Mann-Whitney U-test and Wilcoxon T-test were applied to determine statistical significance of differences in group (Hendl 2004, Kampmiller et al. 2010).

To assess the power of the test’s effect (Effect size) that we made, we used Cohen’s – d (Sigmundová & Fromel, 2005).

4 RESULTS AND DISCUSSION

Our experimental program, which was controlled by certificated FMS trainer, ran over competitive season and did not occur any problem. The FMS trainer processed the FMS tests an also he performed specific training program for experimental group.
The obtained data from input measurement of both groups (CG – 12.73, EG 12.80) shown that was no significant differences, so the starting level of FMS test was the nearly same (Figure 2). In the input test, players who belonged to control group reached maximum score - 15 and also minimum score – 10.

In the second (output) measurement we found significant difference between both groups (p ≤ 0.01). Players of experimental group reached on average 15.9 FMS score and players of Control group reached on average score 12.91. This fact confirmed our second hypothesis.
Players of Control group didn’t reach any significant improvement (Fig 3). Control group optimized its performance from score 12.73 to 12.91.

![Graph showing input-output comparison with p ≤ 0.01 significance level.](image)

**Fig. 4 Experimental group: input – output**

The participants of experimental group improved their performance in FMS tests from score 12.80 to 15.9 (Fig 4). That is significant improvement (p≤0.01). This finding confirmed our hypothesis number one.

When we compared the final score of Experimental group, the players reached highest score like junior NHL players 15.2 (Rowan et al. 2015). We think it is a fact that soccer players are more athletic figure and they have greater variety of movements, such as hockey players, like jumping.

Based on statistical data that we analyzed we can conclude, average values has improved the FMS score in Experimental group of 3.1 and second Control group of 0.18. We assessed changes in average in the case of Experimental group we found a significant changes in the level of (p ≤ 0.01). In Control group was confirmed no significant changes at the 1% or 5% significance level.

In our research we tried maximizing credibility of test (effect size), we needed to decide its effect size. Cohen (1992), McCartney and Rosental (2000), Thomas & Nelson (2001) have identified for their index "d" conventional values that simplify decision when we speak of large, medium or small effect. For the experimental group was confirmed large effect size (EG = 1.64), in which we can safely say that found statistically significant differences between files. In the Control group was confirmed a small effect size (CG = 0.16), in which we can safely say, that we not detected any significant improvement.

In the Kiesel, Plisky and Voight (2007) research was assessed a score of 14 or less on the FMS was positive to predict serious injury. Experimental group reached in second
measurement on average score 15.9. Probability of injury is low. But the players from Control group were in risk of injury. Now both groups work together.

**CONCLUSION**

Based on our result, FMS is the useful training tool for removing defects in your movement and which may enable player’s to submit a superior game performance. In the next research we are going to try to analyze number of injuries during the competitive season and compare these results with FMS score to confirm the relationship between these two parameters.

**References**

BENKOVSKY, L. et al. 2015. Vytváranie voľného priestoru stredným útočníkom v útočnej fáze hry vo futbale In: Telesná výchova & šport. - Roč. 25, č. 3 (2015), s. 21-25


PERÁČEK, P. 1995. *Intenzifikácia tréningového procesu ako cesta zvyšovania výkonnosti v športových hrách*. Zborník NŠC, Bratislava, s. 209-212


PERÁČEK, P. MIKULIČ, M. & MARKO, K 2015 *Uplatnenie základného herného systému 4-3-3 proti systému 4-2-2 vo futbale 1. časť* In: Telesná výchova & šport. - Roč. 25, č. 3 (2015), s. 25-28


PERÁČEK, P. MIKULIČ, M. & MARKO, K 2015. *Uplatnenie základného herného systému 4-3-3 proti systému 4-3-3 vo futbale 3. časť* In: Telesná výchova & šport. - Roč. 26, č. 1


INOVATÍVNY TRÉNINGOVÝ PROSTRIEDOK VO FUTBALE - FUNCTIONAL MOVEMENT SYSTEM

Martin Mikulič

Univerzita Komenského v Bratislave, Fakulta telesnej výchovy a športu,
Katedra športových hier
Školiteľ: Pavol Peráček

ABSTRAKT


Na základe našich výsledkov zastávame názor, že Functional Movement Screen je vhodným doplnkom tréningového procesu mladých futbalistov. Myslím si, že by bolo dobré doplniť naše údaje o ďalšie výsledky tých istých hráčov a analyzovať aj ich zranenia. V nasledovných výskumoch sa budeme snažiť zistiť či Functional Movement Screen je vhodný na predikovanie zranenia aj v tejto vekej kategórii.

Kľúčové slová: Functional Movement Screen, futbal, kategória starší dorast
INFLUENCE OF DIFFERENTIATED STRENGTH PROTOCOL ON SPEED AND ACCURACY OF TENNIS SERVE IN FEMALE PROFESSIONAL TENNIS PLAYERS

Dávid OLASZ

Comenius University in Bratislava, Faculty of Physical Education and Sport,
Department of Track and Field

Supervisor: Marián Vanderka

ABSTRACT

Our study deals with the influence of two strength protocols on tennis serve speed and accuracy of female professional tennis players in TOP 100 in WTA Rankings. The aim of our study is to compare the influence of general and special strength training on tennis serve speed and accuracy by which we would like to contribute with our knowledge to the optimization of tennis serve of professional female tennis players in 8 weeks (2x4 weeks), 3 training units a week. The experiment starts with a four-week control period followed by a mesocycle for the development of general strength with mostly multi-joint complex exercises followed by another control period and again another mesocycle focused on special strength with plyometric exercises, medicine ball throwing and therabands. The individual exercises were re-calculated into mechanical output so that the planned training units are on a similar level from the viewpoint of mechanical output. It is a progressive intra-individual quasi-experiment. We have recorded a significant improvement in serve speed only in the period (EX1) focused on the development of strength abilities by general means, namely by 9 km.h⁻¹ (5.3 %; p<0.05) from 159±6.2 km.h⁻¹ to 168±4.2 km.h⁻¹. In the second experimental period (EX2) it was by 6 km.h⁻¹ (3.5 %; p=n.s.) from 161±5.8 km.h⁻¹ to 167±5.0 km.h⁻¹. The difference in improvements (3 km.h⁻¹), however, was not statistically significant so that we can state that the changes in serve speed in monitored periods were not significantly different.

In case of tennis serve accuracy ($\chi^2=116.3$ and $91.6; p<0.01$) we have proved a significant dependency between the changes in serve accuracy prior to and after monitored training mesocycles, however, the changes in both periods measured on the scale from 0 to 3 body, were comparable. The probands in EX2 achieved in overhead 2kg medicine ball throw (HPL) at the beginning 880±33.1 cm and at the end 908±27.2 cm which is an improvement by 28 cm (3.1 %; p= n.s.). On the contrary, in the period EX1 the improvement was by 50 cm from 810±43.5 cm to 860±31.5 cm (6.2 %; p<0.05). The difference in performance increments in HPL in these periods was 22 cm (p<0.05). Similarly to HPL, in the test evaluating the explosive strength of mainly lower extremities (height of countermovement jump – CMJ) the load content in mesocycle EX2 was insufficient for performance improvement because there were insignificant changes in jump height from 42.1±1.5 cm to 44.2±1.8 cm (by 2.1 cm; 4.9 %, p=n.s.). Load in the period EX1 was again sufficient in case of CMJ. Proband improved by 3 cm from 39.5±2.1 cm to 42.5±1.3 cm (7.5 %; p<0.05). The difference in increments was only 0.9 cm (p=n.s.). On the basis of the above results it can be stated that after applying the
mesocycle focused on the development of general strength there was not significant
disruption in serve accuracy. The load content of the mesocycle focused on the development
of special strength was not a sufficient stimulus for performance improvement in the testing
of explosive strength but it was sufficient to preserve it. It provided for the building of a
higher level of explosive abilities into specific motoric performance which was not
significantly positively manifested in tennis serve speed increase, however, the positive fact
is that it has neither decreased.

Significant dependencies in serve accuracy in the particular periods were recorded, not only
due to the influence of specific strength training as such but also mostly due to specific tennis
training. Parallel strength training was objectively not disruptive so that mainly its positive
benefit could have manifested, not only in the changes in serve speed but also in other
performance, compensation and health benefits.

**Key words:** tennis, strength abilities, tennis serve speed, tennis serve accuracy, CMJ

1  **INTRODUCTION**

The programme of strength training of a female professional tennis player should efficiently
develop limiting strength abilities: speed and strength abilities of main muscle groups. It
follows from the analysis of sports performance during which female tennis players
repeatedly perform a high number of intensive short explosive movement activities. Intensive
units of sports performance are interrupted by intervals of rest in between the games during
which the player prepares for the game beginning by serving. The rest interval duration is in
ratio 1:1 to 1:2 to load length. Moreover, the rest interval has variable length with regard to
the nature of the tennis play and the rest length between the games and sets varies from 2 to 5
minutes. It can be stated that a typical match load on female tennis players is of intermittent
movement character during which explosive strength abilities are repeatedly applied to a
significant degree.

The purpose of strength training is to develop explosive strength manifestations and
endurance in explosiveness which should create optimum conditions for stable sports
performance throughout the whole match duration. Strength training also fulfils important
roles of injury prevention and repetitive load compensation (Fernandez-Fernandez, 2013;
Raman et al., 2012; Renkawitz et al., 2007).

Similar aims of strength training can be also observed in other sports or sports games.
However, tennis is unique with its organisation conditions in which significant changes of
strength abilities must be achieved. Strength training in professional tennis should by its
effect be as similar to the specific conditions during matches as possible.

Wilson et al. (1993) divided the efficient focus of strength abilities development in
tennis into three groups. The first group consists of tools and exercises with high resistance
(over 80% of 1RM) and with a small number of repetitions. These tools are efficient in creating preconditions for the growth of strength explosiveness (increase of 1RM, activation of motoric units) but their application must be adjusted to individual needs and characteristics of a (fe)male player because movement speed in case of these strength tools is low which contradicts movement activity specialisation in tennis. The second group consists of plyometric tools for strength abilities development. The player’s own body weight resistance during jumps is used in tennis strength training, whereas various tools are used for throwing (e.g. medicine balls with various weights) creating optimum conditions for plyometric movement principle. The advantage of these exercises is significant specificity and variability and sufficient speed of movement during which the requirements are placed on the creation of strength effect (Wilson et al., 1993). The most effective and often preferred way of strength abilities development in professional tennis according to the authors is the use of dynamic ballistic strength training which is focused on the achievement of maximum strength performance during load (Wilson et al., 1993). This factor has the closest relation to the required internal structure of strength abilities development for maximum sports performance. The tools and methodology of such training represent a compromise between the first and the second group of exercises. Since strength training performed on the level of maximum strength performance represents a compromise between two contradictory components: speed of movement conducting and amount of resistance during performed exercises. Therefore it represents an optimum method which provides for efficient development of strength gradient components, i.e. ability to achieve the highest possible strength effect in the shortest possible time period. Diagnostic and monitoring equipment enables us to maintain limit strength performance with each repetition while keeping external resistance which activates more motoric units than exercises with one’s body weight resistance (Vanderka, 2013). The efficiency of the development of required strength qualities is thus increased which brings benefits for difficult time and organisation viewpoint of sports training in tennis (Wilson et al., 1993).

Fernandez-Fernandez et al. (2013) performed a study observing the impact of the development of impulsive strength abilities on the accuracy and speed of tennis players’ serve. After 18 strength training units during 6 weeks serve speed of the experimental group improved from 150.3 km.h\(^{-1}\) to 157.9 km.h\(^{-1}\) and serve accuracy from 12.5 points to 13.5 points. The training programme was performed by the subjects always before regular tennis training in the duration of 60-70 minutes. The training used exercises combining core strength exercises, strength exercises using external resistance of an elastic rubber band and
several variants of throwing a medicine ball. The control group results did not prove any statistically relevant changes in the monitored parameters of serve. The quoted study, however, lacks the evaluation of strength abilities level and their changes due to the experimental factor, and also the study lacks, prior to the period of explosive abilities development, a period which would help the subjects of the study create preconditions for efficient and safe application of explosive abilities development. A similar study to the one of Fernandez-Fernandez et al. (2013) was conducted by Kara et al. (2015) in which they examined the influence of a 6-week training focused on specific tennis exercises and their influence on the change of serve speed on the sample of 20 tennis players. Players had 3 training units per week in the duration of 45-60 minutes. A significant improvement in serve speed from 119.4 km.h\(^{-1}\) to 146.7 km.h\(^{-1}\) was observed in the experimental group. A comparison between the experimental and control group proved significantly higher increase in serve speed in the experimental group (18.1%, p<0.05). The training made use of similar exercises as the previously mentioned study, namely: throwing a medicine ball, balance and strength core exercises, strength exercises.

In our study, the period of special strength training is preceded by general strength training which creates preconditions both for more efficient development of strength abilities in a special block but also for slower loss of fitness in future periods. Different efficiency of two different load protocols during strength training on serve speed and accuracy was emphasised in the study by Behringer et al. (2013). The authors compared the efficiency of an 8-week programme of strength training on bodybuilding machines (TS) with the efficiency of the same period of plyometric strength training (TP). The average serve speed increased in PT by 3.78 % (p < 0.05), whereas in TS there was no statistically significant speed increase. Parameters of serve accuracy did not show any statistically significant changes or differences between both groups.

Barber-Westin et al. (2010) verified the effect of plyometric training programme on strength abilities and performance in the specific tests of technical player’s abilities. Experimental training programme consisted of dynamic stretching (5 exercises), several variants of bouncing exercises (13 exercises) and 18 specific variants of strength exercises using plyometrics. The programme took place three times a week during the period of 6 weeks. Due to the development of explosive strength there were statistically significant improvements in test performance: single foot cross triple jump (with both feet - p < 0.05), in the tests of forehand efficiency (p = 0.006) and backhand (p = 0.0008) from baseline and in small (p < 0.0001) and big (p = 0.02) tennis run to bases and endurance abdominal strength
Salonikidis and Zafeiridis (2008) compared the efficiency of plyometric, game and combined training in the group of beginner tennis players. All the groups improved in the start and run for 4 metres in lateral and forward direction (p < 0.05). Plyometric and combined training improved the reaction time of starting off (p < 0.05), whereas playing and combined training improved performance in running for 12 metres with/without turning (p < 0.05). A study which compared the efficiency of plyometric and strength training on the level of performance maximum in a 6-week training mesocycle of tennis players proved higher effect of strength training at performance maximum on the development of explosive strength abilities (Bastiaens et al., 2006). This statement needs to be completed and emphasised that the development of maximum strength is considered by several authors writing about tennis training as the basis for further building of strength abilities. The development of maximum strength typically leads to hypertrophy and excessive changes in the volumes of muscle groups can lead to changes in the technique of movement activity which is incredibly important for tennis performance. Use of intensive hypertrophic training units leads to the decrease in flexibility, and the response of organism to huge mechanical work is counterproductive. Delayed onset muscle soreness and nervous system fatigue decreases the training potential of soft coordination and technical abilities. To certain, optimum degree the increase of maximum strength is also permissible using hypertrophy, as it is obvious that by increasing cross-section of muscles their capacity for storing energy also increases and fatigue is thus delayed, however, the training practice prefers the development methodology described in the research of Tan and Hickson et al. (Tan, 1993; Hickson et al., 1988). Both quoted studies describe the methods of strength abilities development which resulted in maximum strength increase, however, this increase did not correlate with the increase of muscle group cross-section. This is enabled by using neuromuscular factors of adaptation to strength training, where improvement is caused by control and synchronising of activity of dominant muscle groups in movement, without significant destruction of muscles during training. However, it is confirmed that the strength readiness of a tennis player is important not only for his/her sports performance but also for injury prevention and repetitive load impact removal. Strength load not only prevents and compensates repetitive load on locomotive system but it is an excellent way to remove certain locomotive defects and treatment of tennis injuries (Sannicando et al., 2014; Raman et al., 2012; Balias et al., 2010; Renkawitz et al., 2007).

Several studies attempt to quantify the relationship between various parameters of strength and speed-strength abilities, e.g. with regard to serve speed. For example, testing in isokinetic
mode is intended to record strength and torsional movements in speeds which are specific for particular sports or sports performance. In any case, the studies of similar character are still not sufficient because they cannot sufficiently simulate/replicate actual speeds at which the individual segments are rotated when performing different variations of tennis strokes (e.g. serve etc.) (Reid – Schneiker, 2007). Literature includes a limited number of studies which attempted to find out whether different parameters (e.g. strength gradient) than torsional movement, maximum isometric or dynamic force could be more reliable with regard to the quicker movement of the racket and subsequent serve speed increase. However, with regard to previous statements we can state that a high level of strength abilities is desirable, however, without being supported by further links in the whole chain the speed of strokes will not be optimal. The optimum serve from the viewpoint of speed and accuracy is probably a result of combining strength, coordination, flexibility and technique (Pugh et al., 2003; Kovacs – Ellenbecker, 2011). Therefore we decided to perform a research to objectivise the influence of general and specific strength training on selected parameters of key playing activity, namely tennis serve.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 The aim of our project is to compare the influence of general and special strength training on tennis serve speed and accuracy by which we would like to contribute with our knowledge to the optimization of tennis serve of professional female tennis players.

2.2 Hypothesis of the study

H1: We expect that after the application of mesocycle focused on the development of general strength the players will not achieve any statistically significant changes in tennis speed and accuracy.

H2: We expect that after the application of mesocycle focused on the development of special strength there will be statistically significant differences in tennis serve speed.

H3: We expect that after the application of mesocycle focused on the development of general strength there will be statistically significant improvements in overhead medicine ball throw and in vertical countermovement jump.

H4: We expect that after the application of mesocycle focused on the development of both general and special strength the players will not achieve any statistically significant changes in tennis serve accuracy.
2.3 Tasks of the study

T1: Perform input and output testing of speed and accuracy of the first tennis serve prior to and after the first experimental period.

T2: Perform input and output testing of speed and accuracy of the first tennis serve prior to and after the second experimental period.

T3: Perform input and output testing of performance in monitored testing of strength abilities prior to and after the first experimental period.

T4: Implement differentiated training content for professional female tennis players during two mesocycles.

T5: Compare changes in the performance of tennis serve after the first and the second experimental period.

T6: Propose recommendations for practice.

3 METHODS

The influence was shown on two basic kinematic parameters of tennis serve (tennis serve speed and accuracy) of two professional female tennis players (in top 100 of WTA Ranking). The players who cooperated in our research included TP1, 21 years old, height 168 cm, weight 61 kg. The second one was TP2, 20 years old, height 176 cm, weight 63 kg. The first testing (Tvš1) was conducted before the mesocycle focused on the development by means of general strength protocol (EX1) and output measurements at the end (Tvš2). Further testing (Tšp1) of dependent variables was performed after 4-week control period (KO), and after strength protocol focused on specialised strength (EX2) we performed the last testing of parameters (Tšp2). In order to preserve internal validity we counted the amount of serves during the whole period and we registered training load in minutes to maintain approximately the same level with both players.

Strength training frequency was 3 times a week during the whole experiment. Female tennis players in the first experimental (EX1) period performed exercises in three series with 10 repetitions with the resistance at the level of 10RM which is approximately 70 % of 1RM. These were mostly multi-joint complex exercises such as press, squat, pull-up and so on. We used the system of load increase to prevent any stagnation of adaptation effect so that after the first two weeks the number of repetitions was decreased to 6-8 and external resistance was increased to 80 % of 1RM (progressive overload). The second experimental period
focused on the development of strength abilities mostly by special tools (EX2). The players used plyometric exercises, medicine ball throwing and theraband exercises.

The duration of both experimental and control periods (4 weeks) as well as the frequency of impulses were identical. Trainings were planned according to the schedules of selected top female tennis players to be able to check experimental impulses sufficiently. A common feature of both experimental factors was similarity from the viewpoint of external mechanical output. The difference was in the character of used means, general vs. special. The plan of training load was based on the following example of re-calculation of load to mechanical output: in one series of horizontal bench press (10 repetitions) with experimental factor 1, external resistance was e.g. 40 kg and speed of movement performance, as follows from our previous experience and measurement, was ca. 0.5 m.s\(^{-1}\), the calculation of mechanical output is the following:

\[
P_1 = F_1 \cdot v_1 = 400 \text{ N} \cdot 0.5 \text{ m.s}^{-1} = 200 \text{ W} \cdot 10 \text{ repetitions} = 2000 \text{ W/series}
\]

If we wanted to maintain the same mechanical output in case of experimental factor 2, whereas it is known that the external resistance while medicine ball throwing was e.g. 2 kg and the speed of the medicine ball after release can be calculated from the formula for finding speed of inclined throw:

\[
V_2 = d \cdot g \cdot \sin 2\alpha
\]

real speed was, however, a little lower because the above formula does not consider either height at the moment of release or other forces acting on the sportsman while throwing and shooting. Therefore, we mostly drew on the work of Tutevič (1969) where the above mentioned factors are taken into consideration. It follows that if the distance at the time of medicine ball throw is 12 m, then the speed of 10 m.s\(^{-1}\) can be considered.

\[
P_2 = F_2 \cdot v_2 = 20 \text{ N} \cdot 10 \text{ m.s}^{-1} = 200 \text{ W} \cdot 10 \text{ repetitions} = 2000 \text{ W/series}
\]

Based on the above calculations, after the first experimental period, each training unit focused on strength abilities development was prepared to include such exercises with individual number of repetitions in a series that the total sum of mechanical output would be comparable to the first generally developing experimental period.

Dependent variables were speed (RP) and accuracy (PP) of tennis serve. Each testing of both players was conducted 25 times by electronic system (Hawk-Eye) which monitors the trajectory and speed of the ball; whereas performance was averaged later on. The players were also tested in strength abilities by measuring vertical countermovement jump height (CMJ) and overhead medicine ball throw (HPL).
Total score was received by subjects as the average of accuracy evaluation of 25 serves into the perimeter the target zone of serve. The perimeter the target zone of serve was divided into four sectors, three “optimum” sectors of serve were awarded two points, and the “excellent” sector was awarded three points. A successful serve without hitting the perimeter was not awarded any points. The dimensions of target zones are modified in our research. The dimensions of target zones were 100x100 cm and they were divided into four sectors with the size of 50x50 cm. The target zones of serve in our research were not only located in the inner corner but also in the outer corner of the service box. Subjects performed 25 serves after each other, first into the inner and then into the outer zone of sectors. The serve was conducted from the position behind the baseline of the opposite side of the court, in the zone reserved for serve during a match. Statistical significance was evaluated by means of a parametric paired t test for dependent groups and parametric unpaired t test for independent groups. To confirm the effect size we used effect size – Cohen’s d.

Accuracy was evaluated by contingency table of the number of hits into the particular perimeter target zones prior to and after monitored periods. Statistical significance of accuracy dependency (of the occurrence of the number of hits) during the whole experiment was evaluated by chi-square ($\chi^2$).

A multi-camera kinematic system, Hawk-Eye, was used for the evaluation of serve speed; it is an analyser which is situated in the National Tennis Centre in Bratislava. The Hawk-Eye is a complicated computer system officially used in many sports such as baseball, cricket or tennis. The system enables us to visually monitor the trajectory of the ball and to display a record of its statistically most probable route. Hawk-Eye was developed by Dr. Paul Hawkins in the Great Britain. The system records the ball movement via six or seven high-speed cameras located above or beside the tennis courts which monitor the ball from various angles. The measurement error of this system does not exceed 5 mm.
It was assumed that the changes in serve accuracy of both top female tennis players would be comparable in both periods and thus that we would discover a comparably significant relationship between serve accuracy and beginning or end of both experimental periods focused on the development of general (EX1) and special (EX2) strength.

4 RESULTS AND DISCUSSION

Tennis serve accuracy as one of the efficiency criteria was in both periods similarly variable (Fig. 2). The players had approximately the same proportionality of the individual degrees of serve accuracy both prior to the beginning and at the end of training mesocycles. The values of chi-square ($\chi^2=116.3$ and $91.6; p<0.01$) proved a significant dependency between the changes in serve accuracy prior to and after the monitored training mesocycles, however, the changes in both periods measured on the scale 0 to 3 points were comparable. Certain deviations in the occurrence of individual degrees of accuracy in favour of the period focused special strength (EX2) can be observed, however, they were not significant enough. We admit the possibility that in exceptional cases, it could be the case. Nevertheless, it is to be reminded that we have monitored only two parameters of a single playing activity and as a result it is only a certain assumption because victory is decided by other factors in general. Apart from other things, for example the number of unforced errors in other playing activities of the individual the efficiency of which is unlike the serve always in a certain way limited not only by the sport performance of a particular player and his/her abilities and momentary state of mind but also by his/her opponent’s activity.
Fig 2. Number of ball hits during tennis serve into individual perimeter target zones awarded points

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>prior</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>14</td>
<td>116.3</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>after</td>
<td>11</td>
<td>14</td>
<td>12</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EX2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>prior</td>
<td>15</td>
<td>11</td>
<td>16</td>
<td>8</td>
<td>91.6</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>after</td>
<td>8</td>
<td>17</td>
<td>13</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3 Tennis serve speed during the whole experiment

In serve speed (Fig. 2) a significant improvement was only recorded in the period (EX1) focused on strength abilities development by general tools, namely by 9 km.h$^{-1}$ (5.3 %; p<0.05) from 159±6.2 km.h$^{-1}$ to 168±4.2 km.h$^{-1}$. In the special (EX1) period it was by 6 km.h$^{-1}$ (3.5 %; p=n.s.) from 161±5.8 km.h$^{-1}$ to 167±5.0 km.h$^{-1}$. However, the difference in improvement (3 km.h$^{-1}$) was not statistically significant so that we are able to state that the changes in serve speed during monitored periods were not significantly different.

The load content in the mesocycle focused on special strength was not a sufficient stimulus for increased performance in explosive strength tests but it was sufficient to preserve it.

The performance in overhead 2kg medicine ball throw (HPL; Fig. 2) achieved by probands in EX2 was at the beginning 880 ± 33.1 cm and at the end 908 ± 27.2 cm which is an improvement by 28 cm (3.1 %; p= n.s.). On the other hand, in the period EX1 the
improvement was by 50 cm from $810 \pm 43.5$ cm to $860 \pm 31.5$ cm (6.2 %; $p<0.05$). The difference in performance improvement in HPL in these periods was 22 cm ($p<0.05$). The general strength development has probably provided for the building of a higher level of explosive skills into specific motoric performance which has manifested significantly positively, as mentioned above, also in tennis serve speed increase. The fact which can be considered as positive is that despite insignificant changes in HPL as well as serve speed in the period ŠPEC, no decrease was recorded.

![Fig. 4 HPL – achieved performance in testing of two arm overhand medicine ball throw](image)

Similarly to HPL also in the test evaluating explosive strength of mainly lower extremities (height of countermovement jump – CMJ; Fig. 3 the load content in mesocycle EX2 was not sufficient for performance increase, therefore there were insignificant changes in jump height from $42.1 \pm 1.5$ cm to $44.2 \pm 1.8$ cm (by 2.1 cm; 4.9 %, $p=n.s.$). Load in the period EX1 was in case of CMJ efficient again. Probands improved by 3 cm from $39.5 \pm 2.1$ cm to $42.5 \pm 1.3$ cm (7.5 %; $p<0.05$). The difference in increments was only 0.9 cm ($p=n.s.$).
The same problem (influence of strength abilities on tennis serve speed and accuracy), but with a different methodological approach was pursued by Fernandez-Fernandez et al. (2013) and Behringer et al. (2013). Fernandez-Fernandez et al. conducted a study monitoring the influence of explosive strength development on the players’ serve accuracy and speed. The training programme was undertaken by subjects always before the regular tennis training in the duration of 60-70 minutes. Training made use of exercises combining core strength exercises, strength exercises using the external resistance of an elastic rubber tape and different variants of medicine ball throwing. After 18 training units during 6 weeks focused on the development of explosive strength the serve speed in the experimental group improved from 150.3 to 157.9 km.h\(^{-1}\) and serve accuracy from 12.5 to 13.5 points (7.4%). Control group did not show any statistically significant change in monitored parameters. It also corresponds with our results where our players improved in the period EX1 by 9 km.h\(^{-1}\) and in EX2 by 6 km.h\(^{-1}\) in serve speed. Serve accuracy in the sum of the points for all the serves in EX1 increased from 37 to 40 points (7.5 %) and in the period ŠPEC from 34 to 40 points (15 %). This implies that the period EX2 was not sufficiently efficient in significantly increasing speed but more efficient in accuracy improvement. However, input values must be also taken into consideration which were not comparable and the output accuracy values was
identical in marking. Therefore, it cannot be definitely confirmed that the period focused on the development of special strength was more efficient from this viewpoint.

Behringer et al. compared training efficiency during 8 weeks on bodybuilding machines (TS) and plyometric strength training (TP). The average serve speed increased in TP by 3.78% (p<0.05), whereas in TS there was no statistically significant serve speed increase. There were no statistically significant changes in the parameters of serve accuracy in neither of the groups. Compared to our results it can be stated that despite the fact that in our case these were experienced female professional tennis players their improvement in serve speed was 5.3% after EX1 and 3.5% after EX2 period. We see the explanation in adaptation reserves which our players dispose of. Probable causes may also include genetic predispositions of probands to improvement (sensitivity to training impulses), but also a deficit in fitness but mostly strength training in previous periods.

Also Kara et al. (2015) investigated the influence of a 6-week training focused on specific tennis exercises on changes in serve speed on the sample of 20 male tennis players. Players had 3 training units a week in the duration of 45-60 minutes. The experimental group showed a significant improvement in serve speed from 119.4 km.h⁻¹ to 146.7 km.h⁻¹. Comparison between experimental and control group showed higher increments in service speed in experimental group (18.1%, p<0.05). Training made use of similar exercises as in the previous study, namely: medicine ball throwing, balance and core strength exercises and strength exercises. In this case a noticeable improvement by means of specific tennis exercises could have been expected because it was a group of beginners and performance players, not professional tennis players.

**CONCLUSION**

In summary it can be stated that according to our expectations after the application of the mesocycle focused on the development of general strength (EX1) there was statistically significant performance improvement in monitored testing of explosive strength but at the same time there was no significant disruption in serve accuracy.

Load content during mesocycle focused on the development of special force (EX2) was not a sufficient stimulus for the growth of performance in the testing of explosive strength but it was sufficient to preserve it. It provided for the building of the higher level of explosive skills into specific motoric performance which was not significantly positively manifested in tennis serve speed increase but it can be considered as a very positive fact that it has neither decreased.
Significant dependencies in serving accuracy in the particular periods was recorded not only due to the influence of the specific strength training as such but also mostly due to the specific tennis training. Parallel strength training was objectively not disruptive so that mainly its positive benefit could have manifested, not only in the changes in serve speed but also in other performance, compensation and health benefits.

References


VPLYV DIFERENCOVANÉHO SILOVÉHO PROTOKOLU NA RÝCHLOSŤ A PRESNOSŤ TENISOVÉHO PODANIA VRCHOLOVÝCH TENISTIEK

Dávid OLASZ

*Univerzity Komenského v Bratislave, Fakulta telesnej výchovy a športu, Katedra atletiky*

Školiteľ: Marián Vanderka

**ABSTRAKT**

V našej štúdií sa zaoberáme vplyvom dvoch silových protokolov na rýchlosť a presnosť tenisového podania u vrcholových hráčiek z TOP 100 tenisového rebríčka WTA. Cieľom našej práce je porovnať vplyv všeobecného a špeciálneho silového tréningu na rýchlosť a presnosť tenisového podania, čím chceme prispiť našimi poznatками k optimalizácii tenisového podania vrcholových tenistiek za 8 týždňov (2x4 týždne), 3 tréningové jednotky týždenné. Experiment začína štvrťtýždňovým kontrolným obdobím po ktorom zaradíme mezocyklus na rozvoj všeobecné sily, kde sme aplikovali prevážne viackĺbové komplexné cvičenia, opät zaradíme kontrolné obdobie po ktorom bude implikovať mezocyklus zameraný na špeciálnu sílu, kde sme zaradili plyometrické cvičenia, odhody medacinbalov a terabandy. Jednotlivé cvičenia sme prepočítali na mechanicky výkon a tréningové
jednotky boli naplánované tak, aby boli z hľadiska mechanického výkonu na podobnej úrovni. Ide o časovo postupný intraindividuálny kvázi experiment. V rýchlosti podania sme zaznamenali významné zlepšenie iba v období (EX1) zameranom na rozvoj silových schopností všeobecnými prostriedkami, a to o 9 km.h⁻¹ (5,3 %; p<0,05) z 159±6,2 km.h⁻¹ na 168±4,2 km.h⁻¹. V druhom experimentálnom období (EX2) to bolo o 6 km.h⁻¹ (3,5 %; p=n.s.) z 161±5,8 km.h⁻¹ na 167±5,0 km.h⁻¹. Rozdiel v zlepšeniach (3 km.h⁻¹) však nebol štatisticky významný, takže môžeme konštatovať, že zmeny rýchlosti podania v sledovaných obdobiach neboli významne rozdielne. Pri presnosti tenisového podania (χ²= 116,3 a 91,6; p<0,01) sme preukázali významnú závislosť medzi zmenami v presnosti podania pred a po sledovaných kondičných mezocykloch, avšak v oboch obdobiach boli zmeny, merané škálou od 0 po 3 body, porovnateľné. V hode plnou loptou 2kg sponad hlavy (HPL) dosiahli probandky v EX2 na začiatku výkon 880±33,1 cm a na konci 908±27,2 cm čo je zlepšenie o 28 cm (3,1 %; p= n.s.). Naopak v období EX1 to bolo zlepšenie o 50 cm z 810±43,5 cm na 860±31,5 cm (6,2 %; p<0,05). Rozdiel v prírastkoch výkonu v HPL v týchto obdobiach bol 22 cm (p<0,05). Podobne ako pri HPL aj v teste hodnotiacom výbušnú sílu prevažne dolných končatín (výška výskoku z miesta s protipohybom – CMJ) nebol obsah zaťaženia v mezocykle EX2 dostatočný na nárast výkonu, pretože došlo k nevýznamným zmenám výšky výskoku z 42,1±1,5 cm na 44,2±1,8 cm (o 2,1 cm; 4,9 %, p=n.s.). Zaťaženie v období EX1 bolo v prípade CMJ opäť účinné. Probandky sa zlepšili o 3 cm z 39,5±2,1 cm na 42,5±1,3 cm (7,5 %; p<0,05). Rozdiel v prírastkoch bol iba 0,9 cm (p=n.s.). Na základe výsledkov možno konštatovať, že po aplikácii mezocyklu zameraného na rozvoj všeobecnej sily nedošlo k významnému narušeniu presnosti podania. Obsah zaťaženia počas mezocyklu zameraného na rozvoj špeciálnej sily nebol dostatočným stimulom na rast výkonov v testoch výbušnej sily, no stačil na ich udržanie. Zabezpečil zabudovanie vyššej úrovne výbušných schopností do špecifického motorického výkonu, čo sa významne pozitívne neprejavilo v zvýšení rýchlosti tenisového podania, ale pozitívne je, že nedošlo k jej poklesu. Významné závislosti v presnosti podania v jednotlivých obdobiach sme zaznamenali nielen vplyvom samotného špecifického silového tréningu, ale samozrejme najmä špecifický tenisovým tréningom. Súbežný silový tréning objektívne nepôsobil rušivo, takže sa mohol prejaviť najmä jeho kladný prínos, a to nielen v zmene rýchlosti podania, ale aj ostánych výkonových, kompenzačných a zdravotných benefitech. **Kľúčové slová:** tenis, silové schopnosti, rýchlost tenisového podania, presnosť tenisového podania, CMJ
EFFECT OF PLYOMETRIC TRAINING DURING EXCERCISE DROP JUMP-JUMP ON RATE OF FORCE DEVELOPMENT OF ELITE WOMEN’S VOLLEYBALL PLAYERS
Róbert Ollé
Comenius University in Bratislava, Faculty of Physical Education and Sport,
Department of Track and Field
Supervisor: Miroslav Vavák

ABSTRACT
The purpose of this study was to find the effects of plyometric training with the gradation of drop jump height during exercise drop jump - jump, on the changes in rate of force development of elite women's volleyball players. In this study participated 18 volleyball players of Slávia EU Bratislava and they underwent a 6-weeks plyometric training and 6-weeks without plyometric training. Plyometric training program was applied to the subjects twice per week. The FiTRO force-plate was used to evaluate the mean rate of force development (RFD). The results revealed that between the experimental period and the control period was significant differences in pre testing, post testing and control testing in RFD50 ms (p = 0.000) and RFD200 ms (p = 0.000). Experimental period (6 weeks) with plyometric training significantly improve RFD 50 ms and 200 ms. Control period (6 weeks) without plyometric training showed a significant decrease in RFD 50 ms and 200 ms. In this present study, the results demonstrated that, by using plyometric training we have increased the RFD.

Key words: plyometric training, women volleyball, rate of force development

1 INTRODUCTION
In volleyball, the players react to the ball, opponent, or teammate in short interval with high-intensity. During the match, the well developed physical ability is needed for the players to perform spike, block, serve and defense. Volleyball is a sports game, in which is the good coordination and cleverness as important as the good anticipation and cooperation of the players. Important is excellent level of explosive strength which also could be defined as the meanRFD which represent the slope of the force-time curve during muscle contraction (Aagaard, Simonsen, Andersen, Magnusson and Dyhre-Poulsen, 2002). A literature revealed that the plyometric exercises are used as a complementary strength training program to improve the maximal strength performance and jumping ability (Markovic, 2007; Potteiger, et al., 1999). The benefits of plyometric training are resulting from the storage of elastic energy...
during muscle stretch (eccentric and concentric), the stretch-shortening cycle (SSC) (Makaruk, and Sacewicz, 2010; Komi and Nicol, 2011). Thorstensson et al. (1976) in a range of sports involving explosive movements (e.g. sprint running, karate, jumping), the time allowed to exert force is typically very limited (50–250 ms). In contrast, longer time is needed to reach the maximum muscular force (>300 ms). Developing of the RFD is particularly important at foot contact with the floor at the time 0.08 - 0.2 s, whereby achieving maximum value of force is at the time 0.6 to 1 s (Moravec 2007). In this respect, it appears plyometric training as the best means to develop the RFD. Therefore, the aim of this study was to investigate the effects of plyometric training on RFD in women's volleyball.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 The aim of the study

The purpose of this study was to compare the effects of plyometric training with the gradation of drop jump height during exercise drop jump - jump, on the changes in rate of force development in elite women's volleyball players.

2.2 Hypothesis of the study

We expect that, after the application of plyometric training with the gradation of drop jump height occurs significant improvement in RFD 50 ms.

We expect that, after the application of plyometric training with the gradation of drop jump height occurs significant improvement in RFD 200 ms.

2.3 Tasks of the study

Determine the significance of differences in mean values in RFD test (50 ms and 200 ms) before and after applications of plyometric training with the gradation of drop jump height.

3 METHODS

Participants
A total of 18 women volleyball players (EXP), 16 to 33 years of age (20.71 ± 3.75 years), from the Slávia EU Bratislava women volleyball team that plays in the slovak women's volleyball extraleague volunteered to participate in the study. Anthropometrics characteristics of volleyball players are presented in table 1. (mean ± SD). In the season 2015/2016 the team finished in first place in the slovakwomen's volleyball extraleague. All participants and their parents were informed of the purpose, benefits, and potential risks of the participation. Written consent was obtained from all participants, and parents gave written consent for the participants younger than 18 years old.

Table 1. Descriptive data for anthropometric features of players

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal age (years)</td>
<td>20.71 ± 3.75</td>
</tr>
<tr>
<td>Training age (years)</td>
<td>9.47 ± 4.33</td>
</tr>
<tr>
<td>Body height [cm]</td>
<td>179.76 ± 5.29</td>
</tr>
<tr>
<td>Body weight [kg]</td>
<td>68.29 ± 6.17</td>
</tr>
</tbody>
</table>

Procedure

The subjects were subjected to two periods: experimental period (EXP) and control period (CONP).

In EXP subjects trained 2 times per week for 6 weeks of plyometric training (PT). PT was realized with the gradation of drop jump height during exercise drop jump - jump, with a frequency of 6 series and 6 reps. The gradation of drop jump height was increased by 10% every 2 weeks, so in 6th week we ended up at 30%. The drop jump height during exercise drop jump - jump was determined for each subject individually based on the maximum countermovement jump (CMJ) height, that was recorded by the Myotest device. The Myotest device has been shown to be valid and reliable to measure CMJ (ICC = 0.95) (Nuzzo et al. 2011).

CONP is the period of decline acquired parameters, of at 6 weeks without applying plyometric training, followed immediately after the (EXP).
Model of research situation

<table>
<thead>
<tr>
<th>PRE-TESTING</th>
<th>6 WEEKS</th>
<th>POST-TESTING</th>
<th>6 WEEKS</th>
<th>CONTROL TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPERIMENTAL PERIOD</td>
<td>WITH PLYOMETRIC TRAINING</td>
<td>CONTROL PERIOD</td>
<td>WITHOUT PLYOMETRIC TRAINING</td>
<td></td>
</tr>
</tbody>
</table>

**Measurement of rate of force development**

To assess rate of force development, a modified smith-machine was used with subjects standing on a dynamometric FiTRO Force Plate (FiTRONiC Diagnostic and Training Systems LTD, Bratislava, Slovakia). The system consists of a strain gauge force plate connected to a PC via a 12-bit AD convertor and uses customized software to calculate vertical forces acting on the force platform (sampling frequency was 1000 Hz). The force plate was calibrated and zeroed before each measurement. The barbell was placed on the racks and was individually adjusted so that the subject’s knee angle was 90 degrees during the half squat. Each subject was instructed to push “as hard and as fast as possible” and was alerted to the correct execution of the test. Subjects performed 3 trials over duration of 5 seconds. A rest interval of 3 min was given between each trials. Into account we took the best performance of the 3 trials. The evaluated parameter was the mean RFD (N.ms\(^{-1}\)) over time intervals of 0-50ms (RFD\(_{50}\)), 0-200ms (RFD\(_{200}\)). The dynamometric FiTRO Force Plate has been shown to be valid and reliable to measure RFD (ICC = 0.94) (Hart al. 2012).

**Statistical analysis**

Standard methods were used to determine means and standard deviations. The collected data was analysed using a non-parametric Friedman test of differences among repeated measures of pre, post and control testing. Post-hoc analysis with Wilcoxon signed-rank test was conducted. Effect size were calculated and interpreted as 0.1 is a small, 0.3 is a medium, 0.5 is a large and 0.7 is a very large effect (Ellis, P.D. 2009). All descriptive statistics and statistical methods were performed using IBM SPSS 20. Alpha was set at ≤ 0.05.
4 RESULTS AND DISCUSSION

From the study is clearly that the Friedman’s test showing a significant difference among pre testing, post testing and control testing in \( \text{RFD}_{50} \), \( \chi^2(2) = 26.333, p = 0.000 \). Post-hoc analysis with Wilcoxon signed-rank test was conducted. The mean \( \text{RFD}_{50} \) (±SD) was 2.62 N.ms\(^{-1}\) (0.82) at pre testing, 3.51 N.ms\(^{-1}\) (0.64) at post testing and 2.84 N.ms\(^{-1}\) (0.60) at control testing. A significant increase was seen between pre and post testing (\(Z = 3.73, p = 0.000, 25.35 \%, \text{ES} = 0.88\)). A significant decrease was seen between post testing and control testing (\(Z = -3.403, p = 0.001, -19.08 \%, \text{ES} = 0.80\)). The changes in \( \text{RFD}_{50} \) are presented in figure 1.

![Figure 1](image1.png)

**Fig. 1** Changes (mean ±SD) in rate of force development 0 – 50 ms in the pre testing, post testing and control testing during the 12-week study period. **p< 0.01. PRE = pre testing, POST = post testing and CONTROL = control testing.

In \( \text{RFD}_{200} \) was significant difference \( \chi^2(2) = 29.6, p = 0.000 \) among pre testing, post testing and control testing. The mean \( \text{RFD}_{200} \) (±SD) was 2.54 N.ms\(^{-1}\) (0.69) at pre testing 3.18 N.ms\(^{-1}\) (0.51) at post testing and 2.68 N.ms\(^{-1}\) (0.5) at control testing A significant increase was seen between pre and post testing (\(Z = 3.731, p = 0.000, 20.12 \%, \text{ES} = 0.88\)). Between post testing and control testing was a significant decrease (\(Z = -3.732, p = 0.000, -15.72 \%, \text{ES} = 0.88\)). The changes in \( \text{RFD}_{200} \) are presented in figure 2.
Fig. 2 Changes (mean ±SD) in rate of force development 0 – 200 ms in the pre testing, post testing and control testing during the 12-week study period. ** p< 0.01. PRE = pre testing, POST = post testing and CONTROL = control testing.

The main findings of this study were that 6 weeks of EXP and 6 weeks of CONP led to improvements in parameters, namely: 1) significant difference in RFD$_{50}$ among pre, post and control testing, significant increase was seen between post and pre testing and between control and post testing; 2) significant difference in RFD$_{200}$ among pre, post and control testing, significant increase was seen between post and pre testing and between control and post testing. Previous studies have reported that the plyometric exercises are used as a complementary strength training program to improve the maximal strength performance and jumping ability (Markovic 2007; Potteiger, et al. 1999). Important is the excellent level of explosive strength which also could be defined as the mean RFD which represent the slope of the force-time curve during muscle contraction (Aagaard, Simonsen, Andersen, Magnusson, and Dyhre-Poulsen 2002). Interestingly, percentage improvements in RFD was about 17.29%, $p = 0.001$ among pre and post testing (6 weeks) in a study by LIN, Kuo-Chuan, et al.(2016). The main difference between the study of LIN, Kuo-Chuan, et al.(2016) and the present study is the drop jump height. It may be that use of the gradation of drop jump height has greater efficacy to improve RFD than the jump with 90% height used in a study by LIN, Kuo-Chuan, et al.(2016). With similar issues as we dealt also Burgess E. et al. (2007) and they increased the RFD by 18.9 % after 6 weeks plyometric training. In our study we increased the training volume with the gradation of drop jump height and Burgess E. et al. (2007) increased the training volume with sets and repetitions. Bogdanis G. C. et al. (2016) increased the RFD
between pre-testing and post-testing (6 weeks of plyometric training, 2 – 3 series of 10 repetitions plus knee extension) by 24.4 %, \( p = 0.023 \). It is possible that less series and more repetitions have greater efficacy to improve performance in RFD.

**CONCLUSION**

Six weeks of experimental period with plyometric training resulted in a significant improvement between pre testing and post testing (\( Z = 3.73, p = 0.000, 25.35 \% , \text{ES} = 0.88 \)) in the RFD 50 ms and between pre testing and post testing (\( Z = 3.731, p = 0.000, 20.12 \% , \text{ES} = 0.88 \)) in the RFD 200 ms. Control period (6 weeks) without plyometric training resulted in a significant decrease between post testing and control testing (\( Z = -3.403, p = 0.001, -19.08 \% , \text{ES} = 0.80 \)) in the RFD 50 ms and between post testing and control testing (\( Z = -3.732, p = 0.000, -15.72 \% , \text{ES} = 0.88 \)) in the RFD 200 ms. The control period revealed us that plyometric training can increase the RFD in 50 ms and 200 ms. The influence of plyometric training is shorter foot contact with the floor and therefore could be generate a greater amount of force, which was reflected in the values of RFD. Further research is needed to see whether different plyometric training have an positive effect on rate of force development in women's volleyball.

**References**


MAKARUK, Hubert; SACEWICZ, Tomasz. Effects of plyometric training on maximal power output and jumping ability. *Lateral*, 2010, 3: 4


ABSTRAKT

Cieľom našej práce bolo zistiť účinky plyometrického tréningu s gradáciou výšky zoskoku pri cvičení zoskok – výskok na zmény silového gradientu vrcholových volejbalistiek. Práce sa zúčastnilo 18 volejbalistiek Slávie EU Bratislava, na ktorých sme aplikovali 6 týždňový plyometrický program a vzápätí 6 týždňový kontrolný program bez plyometrického tréningu. Plyometrický tréningový program sme aplikovali na našom súbore dva krát v týždni. Na vyhodnotenie priemerných hodnôt silového gradientu (RFD) sme použili FiTRO force-plate. Výsledky preukázali signifikantné zmeny medzi experimentálnym a kontrolným obdobím v pre – testovaní, post – testovaní a control – testovaní v RFD50 ms (p = 0.000) a RFD200 ms (p = 0.000). Experimentálne obdobie signifikantne zvýšilo RFD v 50 ms a 200 ms. Kontrolné obdobie preukázalo významné zníženie RFD v 50 ms a 200 ms. Výsledky našej práce preukázali zvýšenie RFD po aplikácii nášho plyometrického tréningového programu.

Kľúčové slová: plyometrický tréning, ženský volejbal, silový gradient
INFLUENCE OF TABATA AND MINI TRAMPOLINE WORKOUT ON BIOCHEMICAL PARAMETERS OF WOMEN

Katarína PÉLIOVÁ

Comenius University in Bratislava, Faculty of Physical Education and Sport, Department of Gymnastics

Supervisor: Ol'ga Kyselovičová

ABSTRACT

There is no doubt, that sport became attractive for many people nowadays. They are willing to spend hours and hours in a gym, in the swimming pools, in the rings, on the courts as they are searching for a time to relax. Moreover free time sport activities are beneficial for their health and body. In our study, we set as a goal to observe biochemical parameters of women, who were involved in Tabata or mini trampoline workout known like Jumping. We split our experimental sample of the women in two separate groups. They were required to choose whether they want to do Tabata or Jumping within their preferences. Both observed groups were attending courses twice a week. They were mainly college students, who are not professionals in any of sports. We measured women’s basic somatometric characteristics: body height, body weight, body fat percentage and we calculated body mass index (BMI). We also provided biochemical analysis of blood that was necessary for the examination of the values of cholesterol, lactate and glucose. The measurements were realized in October and December 2016 at the Faculty of Physical Education and Sport. The results of blood analysis were processed at Comenius University Science Park. In the processing and evaluation of results we used basic statistical characteristic. We carried out comparative analysis using statistical methods the Wilcoxon T-test and Mann Whitney U-test. We made also relational analysis using Spearman’s correlation test. According to a statistical significance we decided to compare the results with a table of critical values. There were shown statistically significant changes in some parameters. We accept H1.1, H1.6 and H2.2. The women, who were involved in Tabata had hypoglycemia and hypercholesterolemia after training intervention. In conclusion we note that, mini trampoline workout is better for women who want to start exercising, because of influence of exercise on biochemical parameters.

Key words: biochemical parameters, Tabata, mini trampoline workout – Jumping, cholesterolemia, glycemia, lactate
1 INTRODUCTION

For birth of high-intensity interval training (HIIT) stand two Japanese representatives: Irisawa Koichi, he is a national coach of Japanese speed skaters. Second one is Izumi Tabata, professor at the College of Sport & Health Science Ritsumeikan University in Japan.

Tabata is one of the most effective, most difficult and demanding high-intensity interval training methods at this time. It is named by founder Izumi Tabata. The exercises Tabata was at first published in 1997 in journal Medicine and Science in Sports and Exercise. This article has named „Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO2max.” (Tabata et al. 1997).

The aim of the study Talaniana et al. (2007) was examined effect of HIIT after two weeks intervention. It was focused on changes in skeletal muscles, mitochondrial enzyme activity, transport of fatty acids, maximum oxygen consumption and influence of exercises on metabolic, hormonal and cardiovascular functions. Experimental group contained 8 women (22.1 ± 0.5 years), the average body weight 65.0 ± 2.2 kg. They did 7 exercises of HIIT every day for two weeks. The program included 4-minutes periods at 90% VO2max with two minute interval of rest. During the exercise, the oxidation of fat in the body has increased by 36 % (from 15.0 ± 2.4 to 20.4 ± 2.5 g). The results show that HIIT after two weeks induced in women, who were doing exercises regularly significant increase in fatty acid oxidation.

Gibala and McGee (2008) they add, that HIIT is very effective and it causes many metabolic changes in human organism.

Jumping is also known as mini trampoline workout. The study of Cunha et al. (2016) showed that a exercise program on a mini-trampoline can be used for reducing blood glucose levels. In the study were 24 adult normoglycemic participants. In the experimental group were only half of them. The experimental group was doing a 50-minute session of moderate-to-high intensity (70 to 85% HRmax) exercise on a mini-trampoline. The control group did not perform any exercise. In the study was measured capillary blood glucose before and also every 15 minutes during the exercise. There were statistically significant changes in experimental group compared to the control group. The experimental group showed a decrease in blood glucose levels from baseline (108.7 mg/dl): 26.1% reduction (15 min; P<lt; 0.001), 24.2% (30 min; P<lt; 0.001), and 15.7% (45 min; P<lt; 0.001). Compared to the control group, blood glucose levels in the experimental group were reduced by 18.8% (15 min; P<lt; 0.001), 14.3% (30 min; P<lt; 0.001) and 6.9% (45 min; P=0.025). The study
results provide good evidence that a imposed exercise program on a mini-trampoline can be used for reducing blood glucose levels and thus can potentially control blood glucose.

The results of the study Gülşah, Demir, Aydın (2016) have shown that trampoline training is a more effective training method than traditional running training to increase maximal oxygen consumption and reducing fat %. In addition, trampoline training had a significant effect on vertical jumping distance for young healthy men.

**Cholesterol** is an organic molecule. It is a type of lipid molecule, and is biosynthesized by all animal cells, because it is an essential structural component of all animal cell membranes; Physiological cholesterol levels in blood = 4.5 – 5.2 mmol/l. The body uses cholesterol to help build cells and produce hormones. Too much cholesterol in the blood can build up inside arteries, forming what is known as plaque. Large amounts of plaque increase your chances of having a heart attack or stroke (Pickering 1952; Dustan, Roccella, Garrison 1996).

**Glucose** is very important for human body and also for athletes. It represent immediate source of energy. It is permanent part of our blood. It is representative of monocarbohydrates. Physiological glucose levels in blood is 4.5 to 5.5 mmol/l. Hyperglycemia (high blood sugar) also increases the risk of cardiovascular disease (Sarwar et. al 2007). The cumulative incidence of cardiovascular disease and myocardial infarction increased with number of previous events and presence of hyperglycemia and hypertension and decreased with pharmacological treatment of diabetes. A higher number of previous stroke events increased the cumulative incidence of stroke but no protective effect of pharmacological treatment was observed (Janson, Svärdsudd, Andersson 2007).

**Lactate** is a conjugate base of lactic acid. It arises from anaerobic glycolisis conversion of pyruvate by lactate dehydrogenase. The level of lactate in the blood is given by the ratio between its creation and its degradation (glukoneogenesis) in liver. Physiological lactate levels in blood is 0.6 to 2.1 mmol/l (Schneiderka, 2004).

The blood lactate response to exercise has interested physiologists for over fifty years, but has more recently become as routine a variable to measure in many exercise laboratories as is heart rate. The lactate response to exercise is reproducible under standardised conditions it can be influenced by the site of blood sampling, ambient temperature, changes in the bodys’s acid-base balance prior to exercise, prior exercise, dietary manipulations, or pharmacological interpretation (Jacobs, 1986).
2 AIM, HYPOTHESES AND TASKS OF THE STUDY

2.1 Aim of the study
Determine influence of Tabata and mini trampoline workout on biochemical parameters of women.

2.2 Hypotheses of the study
H1: We are assuming significant differences in biochemical parameters in blood which are influenced by 8 weeks intervention of two different training programs.

H1.1 Cholesterol in Tabata
H1.2 Glucose in Tabata
H1.3 Lactate in Tabata
H1.4 Cholesterol in Jumping
H1.5 Glucose in Jumping
H1.6 Lactate in Jumping

H2: We are assuming statistically significant differences between Tabata and Jumping workout in biochemical parameters in blood.

H2.1 Cholesterol
H2.2 Glucose
H2.3 Lactate

2.3 Tasks of the study
T1: Make measurements of women in day zero. Somatometric parameters - body height, body weight, body fat percentage and calculate body mass index. Biochemical parameters – venous blood sampling.

T2: Make output measurements of women, who are involved in Tabata or Jumping workout after 8 weeks training intervention in day 56. Biochemical parameters – venous blood sampling.

T3: Analyze and evaluate statistic differences in watched parameters.

T4: Formulate conclusions for science and sport practice.
3 METHODS

Participants

We analyzed two groups. The first group contained 8 women, who involved in Tabata training twice a week. The average age of this group was $25.5 \pm 4.75$ years. The average body weight was $63.14 \pm 7.96$ kg and the body height reached $167 \pm 6.32$ cm. BMI was $22.59 \pm 2.44 \, [\text{kg/m}^2]$ and body fat percentage $31.8 \pm 4.71\%$. The second group contained 11 women, who involved in Jumping workout twice a week. The average age $25.00 \pm 3.46$ years, body weight reached $60.75 \pm 9.46$ kg and the average body height was $167.64 \pm 7.97$ cm. BMI was $21.55 \pm 2.19 \, [\text{kg/m}^2]$ and body fat percentage $29.47 \pm 5.18\%$. They were mainly students at university, who are not doing professional sport.

Procedure

At first we made the entrance measurements. We measured basic somatometric characteristics of women: body height, body weight, body fat percentage and we calculated body mass index (BMI) as weight divided by height squared [kg/m²]. We did venous blood sampling under professional supervision in partnership with Faculty of Pharmacy. All participants were informed about participation in biomedical screening. We have signed and archived informed consent according to the Health Care Act NR SR. 576/2004. We repeated this process after eight weeks training intervention. The results of blood analysis were processed at Comenius University Science Park. We examined the value of cholesterol, lactate and glucose in blood. We used equipment Accutrend® Plus system. The measurements were realized in October and December 2016 at Faculty of Physical Education and Sport. We cooperated with Faculty of Pharmacy and Faculty of Medicine in Bratislava. Both exercises were 60 minutes long and the structure of the lesson was the same. We started with warming up which lasted about 10 minutes. Then followed by a main part of training and final part with 10 minutes lasting. Only difference was in the main part of the training. Tabata is a high intensity interval workout in contrast to Jumping which has a more aerobic character. Tabata consists of the 7 series: interval of workout was $20$ s, interval of rest was $10$ s, 8 repetitions. The whole workout ended with 2 minutes rest. In Jumping were 3 series: interval of workout was 10 minutes, interval of active rest was 3 minutes. Intensity of load was 60%-90% max HR. Active rest with Intensity of load 40%-50% max HR.
Statistical analysis

In the processing and evaluation of results we used basic statistical characteristic: arithmetic mean, minimum, maximum, median, variance, standard deviation. We carried out comparative analysis using statistical methods the Wilcoxon T-test for nonparametric comparison of two dependent files and Mann Whitney U-test for nonparametric comparison of two independent files. We also did a relational analysis using Spearman’s correlation test. In the case of statistical significance, we decided for a comparison of the results with a table of critical values (p≤0.05).

4 RESULTS AND DISCUSSION

Tab 1: Average levels of cholesterol, glucose and lactate in blood day 0 and day 56

<table>
<thead>
<tr>
<th>BLOOD</th>
<th>cholesterol [mmol/l]</th>
<th>glucose [mmol/l]</th>
<th>lactate [mmol/l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABATA</td>
<td>4.75 -&gt; 5.64 ↑*</td>
<td>4.79 -&gt; 4.20 ↓</td>
<td>4.18 -&gt; 2.80 ↓</td>
</tr>
<tr>
<td>R</td>
<td>0.39</td>
<td>0.29</td>
<td>-0.36</td>
</tr>
<tr>
<td>JUMPING</td>
<td>4.96 -&gt; 4.86 ↓</td>
<td>4.81 -&gt; 5.57 ↑</td>
<td>4.09 -&gt; 2.25 ↓*</td>
</tr>
<tr>
<td>R</td>
<td>-0.06</td>
<td>-0.71</td>
<td>0.05</td>
</tr>
</tbody>
</table>

(↑= higher, ↓=lower, *=significant changes day 0 vs. day 56; p≤0.05; Wilcoxon T-test, R=Spearman’s correlation test)

We used Wilcoxon T-test for nonparametric comparison of two dependent files. After 8 weeks period there were shown statistically significant changes in cholesterol level in Tabata group. The average level of cholesterol was considerably higher on average by 0.89 mmol/l. Compare to jumping group where showed up meaningly changes in lactate level. The average level of lactate was statistically significantly lower on average by 1.84 mmol/l. We accept hypotheses H1.1 and H1.6.

Tab 2: Average levels of cholesterol, glucose and lactate in blood day 0 and day 56

<table>
<thead>
<tr>
<th>BLOOD</th>
<th>cholesterol [mmol/l]</th>
<th>glucose [mmol/l]</th>
<th>lactate [mmol/l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABATA</td>
<td>4.57 -&gt; 5.64</td>
<td>4.79 -&gt; 4.20</td>
<td>4.18 -&gt; 2.80</td>
</tr>
<tr>
<td>JUMPING</td>
<td>4.96 -&gt; 4.86</td>
<td>4.81 -&gt; 5.57</td>
<td>4.09 -&gt; 2.25</td>
</tr>
</tbody>
</table>

(#=significant changes day 0 vs. day 56; p≤0.05; Mann Whitney U-test)
We used Mann Whitney U-test for nonparametric comparison of two independent files. We observed statistically significant changes in glucose level in comparison between Tabata and Jumping workout. Output measures showed statistically significant changes in average level of glucose. As a corollary of this we may see considerable differences between Tabata and Jumping on average by 1.37 mmol/l. We accept hypothesis H2.2.

**Tab 2: Clinical results of cholesterol, glucose and lactate in blood after 8 weeks intervention**

<table>
<thead>
<tr>
<th></th>
<th>BLOOD</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cholesterol [mmol/l]</td>
<td>glucose [mmol/l]</td>
<td>lactate [mmol/l]</td>
</tr>
<tr>
<td>TABATA</td>
<td>HYPER</td>
<td>HYPO</td>
<td>NORM</td>
</tr>
<tr>
<td>JUMPING</td>
<td>HYPO</td>
<td>NORM</td>
<td>NORM</td>
</tr>
</tbody>
</table>

We identified important changes in physiological parameters. The women who were involved in Tabata had hypercholesterolemia and hypoglycemia after 8 weeks training period. On the other hand women who were involved in Jumping training had hypocholesterolemie and normal value of glucose level in blood. Therefore Tabata training may not be the best choice for those who want to start exercising as it showed bad influence on biochemical parameters of blood. It is too hard for unready body to start up adaptation processes.

Gibala and McGee (2008) added, that HIIT is very effective and it causes many metabolic changes in human organism. We can say, that Tabata or high-intensity interval training had bad influence for women in our study. There were shown very important facts. The results of women’s cholesterol changed from normal value of cholesterol to hypercholesterolemia and also from normal value of glycemia to hypoglycemia. We have the same opinion like Gülşah et al. (2016), that trampoline workout is a very effective training method. It is suitable for women, who want to start with exercise.

For better vision we present our results in following graphs. In Fig 1 there are shown average levels of cholesterol in day 0 and day 56 and also statistically significant changes between entry and exit measurement and also between Tabata and Jumping. In Fig 2 we display results from glucose and in Fig 3 from lactate.
**Fig 1: Average of cholesterol levels day 0 and day 56 in Tabata and Jumping**

( * = Wilcoxonov T-test, # = Mann Whitney U-test)

Physiological cholesterol levels in blood = 4.5 – 5.2 mmol/l.

**Fig 2: Average of glucose levels day 0 and day 56 in Tabata and Jumping**

( * = Wilcoxonov T-test, # = Mann Whitney U-test)

Physiological glucose levels in blood 4.5 to 5.5 mmol/l.
Fig 3: Average of lactate levels day 0 and day 56 in Tabata and Jumping

(* = Wilcoxon T-test, # = Mann Whitney U-test)

Physiological lactate levels in blood 0.6 to 2.1 mmol/l.

CONCLUSION

The women, who were involved in Tabata had hypoglycemia and hypercholesterolemia after training intervention. To conclude, we could say that mini trampoline workout is better for women who want to start exercising. It is very important to find out physiological characteristic of athletes and determine influence of different training program on biochemical parameters. Early diagnosis can improve the quality of life.

REFERENCES


VPLYV CVIČENIA NA MINI TRAMPOLÍNACH A TABATY NA BIOCHEMICKÉ PARAMETRE ŽIEN

Katarína PÉLIOVÁ

Univerzita Komenského v Bratislave, Fakulta telesnej výchovy a športu,
Katedra gymnastíky

Školiteľ: Oľga Kyselovičová

ABSTRAKT


Kľúčové slová: biochemické parametre, Tabata, cvičenie na mini trampolínach – Jumping, cholesterolémia, glykémia, laktát
MUSCLE POWER AND VELOCITY DURING TRUNK ROTATIONS AFTER 6 WEEKS OF TRAINING IN CANOEISTS

Oliver POÓR

Comenius University in Bratislava, Faculty of Physical Education and Sport, Department of Sport Kinantropology

Supervisor: Erika ZEMKOVÁ

ABSTRACT

The study evaluates muscle power and velocity during trunk rotations in canoeists after six weeks of training in preparation period. A group of 14 canoeists performed 2 trunk rotations to each direction in a standing position with barbell of 6, 10, 12, 16, 20, 22, and 26 kg placed on the shoulders. Basic biomechanical parameters during the movement were monitored using the FiTRO Torso Dyne system. Results showed that mean velocity of trunk rotation significantly increased after 6 weeks of the training at all weights, i.e. 6 kg (p=0.023), 10 kg (p=0.000), 12 kg (p=0.000), 16 kg (p=0.000), 20 kg (p=0.000), 22 kg (p=0.000) and 26 kg (p=0.000). Similarly, the mean power significantly increased with all weights, i.e. 10 kg (p=0.000), 12 kg (p=0.004), 16 kg (p=0.000), 20 kg (p=0.000), 22 kg (p=0.002), and 26 kg (p=0.001) except the lowest weight of 6 kg (p=0.166). These findings reflect specificity of the training in preparation period and the fact, that all canoeists were at the beginning of the preparation period following one to two months of regeneration period without systematical power training.

Key words: preparation period, rotational power, trunk muscles

1 INTRODUCTION

Core spinal muscles are related to trunk stability and assume the main role of stabilizing the spine during daily activities. Primary the core-strengthening was an important part of rehabilitation and muscle injury prevention. Therefore is no surprise that core-strengthening exercises have also become a part of amateur and professional sportsmen training. Core exercises are also used as an important part in long term conditioning, to gain maximal performance in most sports.

Traditionally used power measurements incorporating the lower limbs are often linear in nature. There is less known about the involvement of the upper extremities and the trunk musculature. Since the core is central to almost all sports activities, control of core strength, balance and motion should optimize upper and lower extremity function. However, most core assessments are focused on isometric muscular endurance with long tension times and low
loads. Given that most athletic upper body power generation involves high levels of neuromuscular activation of a rotational nature, it is important to assess athletic ability that replicates as closely as possible the rotational activity of an athlete (Talukdar et al. 2015). Effective execution of movement requires also strength and power of trunk muscles. These muscles (erector spinae, abdominal oblique, and rectus abdominis) are particularly active during the acceleration phase of trunk rotations.

Most of the testing methods evaluating the efficiency of training programs for improving core stability are insufficient. Rather, they are based on the biomechanical analysis of technique, the experience of conditioning specialists or cross-sectional training evidence. In addition, low reliability and sensitivity of current diagnostic methods evaluating the strength of lower back muscles limits their practical application. In order to provide testing conditions specific to demands imposed by most sports, one can use a system that allows monitoring of basic biomechanical parameters during rotational movement of the trunk. Presumably, the test adapted from the wood chop exercise may provide conditions similar to those imposed in many sports involving trunk rotation such as baseball, golf, karate, and so forth (Zemková 2015). The study of Andre et al. (2012) determined the test-retest reliability of the kinetic rotational characteristics of the pulley trainer when performing a rotational exercise of the axial skeleton in the transverse plane. The authors found that a pulley system and an external dynamometer can be used together as a reliable research tool to assess rotational power. However, this does not guarantee that power measured during a standing cable wood chop exercise will provide similar reliability. Power in the acceleration phase can be used as a parameter of functional assessment of trunk muscles (Zemková et al. 2014) in athletes of different specializations as well as its changes during the training.

There was alternative to use inertial dynamometer allowing assessment of muscle power during trunk rotations. Using such a system it was distinguished that mean power and among group of athletes such as karate, ice-hockey, tennis, golf, ballroom dancing, rock & roll dancing, judo, wrestling, canoeing, rowing, weightlifting, and bodybuilding (Zemková et al. 2013, 2014). Though the system was found to be sensitive in discrimination of groups of athletes of various sport specializations, it is not known whether it can reveal slight changes in muscle power and velocity during trunk rotations in preparation and/or competition period in well-trained athletes. Therefore the aim of the study was to evaluate the effect of 6-week training of canoeists in preparation period on muscle power and velocity during trunk rotations with different weights.

2 AIM, HYPOTHESIS, TASKS OF THE STUDY
2.1  **Aim of the study**

To evaluate the effect of 6-week training of canoeists in preparation period on muscle power and velocity during trunk rotations with different weights.

3  **METHODS**

**Participants**

Fourteen canoeists (21 ± 1.9 years, height 181.1 ± 5.5 cm, weight 78.8 ± 13.6 kg) competing in Slovak Cup participated in this study. They were at good health and free of any injuries 6 months before and during the study.

**Procedure**

Canoeists were tested in the preparation period prior to and after 6 weeks of training. All tests were performed indoor, in InPulse Fitness Gym. Before the testing, all participants completed an individual warm-up consisting mostly of cycling and dynamic stretching.

Each participant performed 2 trunk rotations to each direction (either from right to left or from left to right) in a standing position with barbell of 6, 10, 12, 16, 20, 22, and 26 kg placed on the shoulders (Fig. 1). Participants were instructed to perform trunk rotations with maximal effort during the acceleration phase of movement.

**Fig. 1. Assessment of power and velocity of the trunk rotation in a standing position with barbell placed on the shoulders**

The FiTRO Torso Dyne (Fig. 2) was used to monitor basic biomechanical parameters of the movement. The system consists of an inertial measurement unit in a small box with an
integrated USB interface and software. While inserted on the barbell axis, the sensor unit registers instant angular of rotation movement. Calculations of force and power are based on the Newton’s second law of mechanics. Force produced to accelerate and decelerate a rotation movement is obtained as a product of barbell mass and acceleration of its center of gravity (CoG). Angular acceleration is obtained by derivation of angular velocity. For the transformation of angular velocity and acceleration into their real values, a rotation radius (distance between rotation axis and barbell mass CoG) is used. Power is calculated as a product of force and velocity.

*Figure 2. FiTRO Torso Dyne sensor unit placed on the barbell axis*

**Statistical analysis**

All statistical procedures were conducted using IBM SPSS Statistics 22.0. Wilcoxon t-test was used to determine significance in mean power and velocity before and after the training. P-value < .05 was defined as a statistically significant.

**4 RESULTS AND DISCUSSION**

Mean velocity in acceleration phase of trunk rotation significantly increased after 6 weeks of the training at weights of 6 kg (p=0.023), 10 kg (p=0.000), 12 kg (p=0.000), 16 kg (p=0.000), 20 kg (p=0.000), 22 kg (p=0.000) and 26 kg (p=0.000) (Fig. 3).
Fig. 3. Mean velocity in the acceleration phase of trunk rotation before and after 6-week training in canoeists

Mean power during the trunk rotation significantly increased after 6 weeks of the training at weights of 10 kg (p=0.000), 12 kg (p=0.004), 16 kg (p=0.000), 20 kg (p=0.000), 22 kg (p=0.002), 26 kg (p=0.001) but not at the lowest weight of 6 kg (p=0.166) (Fig. 4).

Fig. 4. Mean power in the acceleration phase of trunk rotation before and after 6 weeks of the training in canoeists
Velocity of trunk rotations increased significantly after six weeks of the training with all used weights. Power during trunk rotations also increased significantly with all weights used except the 6 kg. This may be due to the fact, that all canoeist had at least one month regeneration period without systematical power training before the start of the preparation period. The purpose of this period is to gain high capacity in condition what is essencial for every paddle shot. Exercises during preparation period are mostly performed with higher weights to gain higher muscle strength, but still with focus on the speed of the movement. This may explain the improvement of muscle power and velocity during trunk rotations in the preparation period.

On the other hand, in the competiton period coaches are focused on „water“ preparation and on improving the technique. For this reason the condition capacity is usually slowly decreasing with ongoing season. Our previous study showed that mean velocity significantly increased after 6 weeks of training at 6 kg and 12 kg, whereas its values did not changed significantly during rotations with higher weights (16, 20, 22 and 26 kg) (Poór, Glevaňák & Zemková 2017). However, there were no significant changes in mean power of trunk rotation after six weeks of training in competition period of ice-hockey players. These findings reflect specificity of the training in competition period.

CONCLUSION

Mean velocity in the acceleration phase of trunk rotations increased significantly after six weeks of the training in canoeists with all weights used. Mean power in the acceleration phase of trunk rotations also increased significantly with all weights used except the lowest weight of 6 kg. These findings reflect specificity of the training in preparation period and the fact, that all canoeists were at the beginning of the preparation period following one to two months of regeneration period without systematical power training.

ACKNOWLEDGEMENTS

This work was supported by the Slovak Research and Development Agency under the contract No. APW-15-0704.
REFERENCES


111
SVALOVÁ SILA RÝCHLOSŤ ROTAČNÉHO POHYBU TRUPU PO 6 TÝŽDŇOCH TRÉNINGU U KANOISTOV

Oliver POÓR

Univerzita Komenského v Bratislave, Fakulta telesnej výchovy a športu,
Katedra športovej kinantropológie

Školiteľ: Erika Zemková

ABSTRAKT

Štúdia porovnáva svalovú silu a rýchlosť rotačného pohybu trupu kanoistov po šiestich týždňoch tréningu v pripravnom období. Súbor 14 kanoistov vykonal v stoji po dve rotácie trupu do každej strany s 6, 10, 12, 16, 20, 22 a 26 kg činkou na pleciach. Základné biomechanické parametre rotačného pohybu sme zaznamenávali pomocou zariadenia FiTRO Torso Dyne. Výsledky ukázali, že priemerná rýchlosť rotačného pohybu trupu sa po 6 týždňoch tréningu významne zvýšila so všetkými testovanými hmotnosťami činky, 6 kg (p=0,023), 10 kg (p=0,000), 12 kg (p=0,000), 16 kg (p=0,000), 20 kg (p=0,000), 22 kg (p=0,000) a 26 kg (p=0,000). Významne sa zvýšil aj priemerný výkon rotačného pohybu trupu s hmotnosťami 10 kg (p=0,000), 12 kg (p=0,004), 16 kg (p=0,000), 20 kg (p=0,000), 22 kg (p=0,002), a 26 kg (p=0,001). Zmeny priemerného výkonu s najnižšou, 6 kg (p=0,166) činkou, významne neboli. Tieto zistenia reflektujú špecificitu tréningu a skutočnosť, že všetci kanoisti boli na začiatku pripravného obdobia po predchádzajúcej 2- mesačnej rekondičnej prestávke bez systematického silového tréningu.

KĽÚČOVÉ SLOVÁ: pripravné obdobie, výkon rotačného pohybu trupu, svaly trupu
THE CHANGES IN THE LEVEL OF MAXIMAL IZOMETRIC FORCE AFTER MODEL LOAD IN ELITE KARATEKAS, JUDOKAS, WRESTLERS

Tomáš PUPKAY

Department of Track and Field, Faculty of Physical Education and Sport, Comenius University in Bratislava

Supervisor: Marián Vanderka

ABSTRACT

In the study we occupy with a decrease in the level of motor performance after model loads in combat sports, so we want to point the differentiated impact of fatigue in karate, judo and wrestling. The goal was to determine and compare the performance of an immediate change in the level of maximum isometric force of the back muscles after model load specifications, and thus contribute to the clarification of potentially differentiated types of fatigue in sports practice karate, wrestling and judo. In our work, we assumed different drop maximum isometric force at a different karatekas decrease in wrestlers and judokas. Our set comprised 22 subjects (Nk = 7, Nw = 8, Nj = 7) who were tested after model load on isometric force. The results were evaluated by non-parametric methods Wilcoxon T-test for dependent files and we also used the Cohen d (effect size) is considered good in practice whit presenting empirical research findings in many fields. The file karatekas we have seen a significant decline in performance between the input measurement model and the third model load (p = 0.03, -15.57 kg, -8.63 %, d = 0.82). The file judokas nonsignificant decline in performance, but the effect size was recorded at a high level after the second model load d = 0.92. In a group of wrestlers we have seen a significant increase in strenght between the input and the second model load (p = 0.05, 13.93 kg, 9.36 %, d = 0.81). Karatekas is recommended to set the training units pay more attention to the maximal strenght of the back muscles as a prevention against injury. In the group of wrestlers and judokas we recommend to the ability to continue to operate as a prevention against injury because their sports is limited mainly strength back muscles.

Key words: model load, karate, judo, wrestling, decrease in motoric performance

1 INTRODUCTION

Our work session with the decrease in the maximum isometric force back muscles in combat sports. The maximum isometric force is such an integral part of sports industry mainly as a prevention against injuries during explosive dynamic exercises. In the scientific literature, it is difficult to form objective information about how influences in competition practice (combat sports) routine, repetitive load on this parameter. Such load undoubtedly cause
fatigue and the associated decline in the level of condition not only skills. The term muscular fatigue is used to describe a temporary reduction in ability to perform physical activity (Kirkendal 2000). Under high intensity load fatigue starts after 6 - 8 s. Fatigue but not in all sports and athletes the same (Kirkendal 2000). For example, when running marathon will be different from fatigue at 10 repetitions squat jump. Intense stress - inducing load training or competitive nature temporarily impair sport performance. When fatigue in any sport picked up the recuperation process by which we can distinguish three types (acute recovery, short-term recovery, training recovery) (Bishop et al. 2008). Our research deals with the right short-term recovery between the two model matches. According Finsterer (2012) recovery is defined as a return of muscle function in the basal state at the time, on starting fatigue. Mohr et al. (2010) investigated the effect of matches burden on high-speed-strength abilities of Spanish professional football players. Before and after the game, subjects performed repeatedly squat jump for 15 s and 3 x 30 m sprint with IR 25 s between sets. Football players results were repeated sprint 3 x 30 m by 2.6 % and inferior in squat jump test with 15 s of 8.2 % by comparison with the worse before the game (p < 0.05). Morin Drouin (2000) based on video analysis investigated the impact of fatigue on the biomechanics of skating's top hockey players. They found that the effects of fatigue decreases speed skating, reflections frequency and length slip. The support layer on one leg in order not worn during the slip represented 83.5 % and the effect of fatigue was reduced to 78 %, on the other hand, the share of two legs support phase from 16.5 % to 21 % during the skating fatigue. The authors argue that fatigue causes deterioration of skating technique, but also point to the departure of matches load. Dominguez (2010) who tested 11 judokas for maximum performance squatting - jump and investigated the relationship between maximal strenght and lactate response. Judoka had 4 model matches and were tested before and after the model match and compared the values before and after the model load. The author states that the results were statistically nonsignificant. For sport practice it is very important to know the response of the organism to a competitive model matches in different kinds of sports specialization in order to guide the training program precisely those abilities that limit sports performance. Explanation decline in performance at different motor tests helps us in the training process to apply such means and methods that allow us as much as possible to help prevent high decline in performance. Each training action must be directed and controlled so that athletes were able to offer the best performance in the competition directly, which is why it is important to know what the response model is available in karate, judo and wrestling.
2 AIM, HYPOTHESIS, TASKS OF THE STUDY

2.1 Aim of the study

The goal was to determine and compare the performance of an immediate change in the level of maximum isometric force of the back muscles after model load specifications, and thus contribute to the clarification of potentially differentiated types of fatigue in sports practice karate, wrestling and judo.

2.2 Hypothesis of the study

H1: We expect that after the model loads not report a decrease in the maximum isometric force back muscles at karatekas.

H2: We expect that after the model load recorded a decrease in the maximum isometric force back muscles at wrestlers.

H3: We expect that after the model load recorded a decrease in the maximum isometric force back muscles at judokas.

2.3 Tasks of the study

T1: Realize testing and evaluate the maximum isometric force of the back muscles before and after model load at karatekas.

T2: Realize testing and evaluate the maximum isometric force of the back muscles before and after model load at wrestlers.

T3: Realize testing and evaluate the maximum isometric force of the back muscles before and after model load at judokas.

3 METHODS

Participants

In research, we have included 22 subjects (men) who are performance athletes as well as representatives of the Slovak Republic in the senior category.

In a group of seven karatekas, the mean age of 23.7 (± 3.3) years, mean age 16 sports (± 2.2) years, the average height of 180.7 cm (± 3.8), and an average weight of 80.4 kg (± 7.9).
In a group of eight wrestlers the mean age was 23.8 (± 2.8) years, mean age 17 sports (± 1.5) years, the average height of 178.6 cm (± 5.1), and an average weight of 81.7 kg (± 9.5).

In a group of seven judokas the mean age was 22.2 (± 1.8) years, mean age 15 sports (± 2.1) years, the average height of 179.2 cm (± 6.4), and an average weight of 78.1 kg (± 7.4).

Brief characteristics of subjects: All participants, subjects are taking parts in events such as senior. EC, WC is successful representative of Slovakia. Each of the subjects has a good location for top events.

Procedure

Back muscles dynamometers (Šimonek 2012)

Tested feet will stand on the dynamometer base, arms are running freely next to the body and grip dynamometer grip. Adjust the length of the chain so that the angle at the knees clutching 100 degrees

ICC – 0.95 (Měkota a Blahuš 1983)

Model research situation

<table>
<thead>
<tr>
<th>Breaks:</th>
<th>Breaks:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vk- 15min.</td>
<td>Vk-10min.</td>
</tr>
<tr>
<td>Vj-10min.</td>
<td>Vj -10min.</td>
</tr>
<tr>
<td>Vw- 15min.</td>
<td>Vw-15min.</td>
</tr>
</tbody>
</table>

Statistical analysis

When mathematical and statistical processing of collected empirical data we used basic statistical characteristics (minimum value, maximum value, the arithmetic mean). To evaluate the significance of differences in mean values we used Wilcoxon T-test for dependent files and Cohen's d for factual justification. The level of statistical significance, we
determined the 5 % and 1 % level of significance. When evaluating and interpreting the results, we used the logical interpretation file comparison, reasoning, analysis and synthesis.

4 \hspace{1em} RESULTS AND DISCUSSION

![Graph showing effect of competitive model of load to the maximum isometric muscle force in the back karatekas.](image)

*Fig.1. Effect of competitive model of load to the maximum isometric muscle force in the back karatekas.*

In this test we have demonstrated a significant loss of performance at the 5 % level of significance between the input measurement and third model load. From our own experience we can say that the maximum isometric force of the back muscles in karate is not a factor that affects the performance of the match, because tactile contact with an opponent not in such amount, such as judo and wrestling. Karates by this ability, according to our data should be collected and thus be put into the training process as it will influence the matches load capacity decreases and this ability is at a lower level of factor. The maximum isometric force in the investigated group is particularly important in terms of prevention. Similar work that measured the maximum isometric strength of the back muscles, we find that we can not compare with our data acquisition.
In the test, although we did not show statistical significance but have eternal significance to the middle and large effect which is reflected throughout the match in judo, where competitors are in constant contact, blocking and attacking mostly arms and engage in the largely back muscles. It depends on the case and the weight of each opponent with whom the opponent, the more difficult because the team needs to do more to entrained in the match. It should here be noted also that the judokas had a rest interval between ends 10 minute which managed to draw enough energy for the next model match and testing. We can not compare the data obtained from any author since we did not find similar work with similar problem.

Fig. 2. Effect of competitive model of load to the maximum isometric muscle force in the back judokas.

Fig. 3. Effect of competitive model of load to the maximum isometric muscle force in the back wrestlers.
In a group of wrestlers we have not recorded a significant drop, but we recorded a decrease to the substantive significance of $d = 0.85$. This decline can be attributed to static warm-up before the first model load. Current standards in the warm-up is considered to be particularly dynamic use of methods that are more favorable acute effect in terms of activation energy systems, cardiovascular system, associated and elevated body core temperature of the body and neuromuscular activation (Faigenbaum, 2012; Dawes – Roozen, 2012). It is therefore not surprising that after second model match had a significant increase in observed skills. We can say that after the first modeled matches were best prepared for feed performance in their specialization.

**CONCLUSION**

The file karatekas we have seen a significant worsening in the back dynamometers between input measurement and the third model load $p = 0.027$. We have also seen a high level of material significance ($d = 2.51$) difference was in kilograms, strenght reduction of 15.57 kg in the percentage level represents a decrease of 8.63 %. Therefore, we recommend that file and work on the skills that can serve as a prevention against injury.

In a group of wrestlers we have not seen a significant drop in performance in the back dinamometers, but the performance improvement between the input measurement and the second model load $p = 0.049$ kilograms which is an improvement of 13.93 kilograms and as a percentage is an improvement of 9.36 %. Worsening of the material significance at a high level was recorded between the input measurement and the first model load ($d = 0.85$) the significant worsening in kilograms kg of -13.75 and -10.07 % percentages. The wrestler is recommended to work on the skills in terms of prevention against injury and also for better performance because their technique are mostly limited by strenght of back muscles.

In a group of judokas we have found a significant decrease in the back dinamometers. Materially significant decrease at a high level was recorded between the input measurement and the second model load ($d = 0.92$) the significant worsening in kilograms -19.25 kg and as a percentages is a worsening of -10.44 %. Judokas is recommended to work on this skill for the same reasons as mentioned in the file wrestlers.
References


ZMENY ÚROVNE MAXIMÁLNEJ IZOMETRICKEJ SILY PO ABSOLVOVANÍ OPAKOVAŇCH MODELOVÝCH ZAŤAŽENÍ U ELITNÝCH KARATISTOV, DŽUDISTOV A ZÁPASNÍKOV

Tomáš PUPKAY

Univerzita Komenského v Bratislave, Fakulta telesnej výchovy a športu,
Katedra atletiky
Supervisor: Marián Vanderka

ABSTRAKT

V našej práci sa zaoberáme poklesom úrovne motorickej výkonnosti v úpolových športoch, a tak chceme poukázať na diferencovaný vplyv únavy po modelových zaťaženiach. Cieľom práce bolo zistiť a porovnať okamžitú zmenu úrovne maximálnej izometrickej sily chrbtového svalstva po absolvovaní opakovaných modelových súťažných zaťažení, a tým prispieť k objasnenu vzniku potenciálne diferencovaných typov únavy v športovej praxi v karate, zápasení a v džude. V našej práci sme predpokladali rozdielný pokles maximálnej izometrickej síly u karatistov, džudistov a zápasníkov po absolvovaní opakovaných súťažných zaťažení. Nám súbor obsahoval 22 probandov (nk = 7, nz = 8, nj = 7), ktorý bol testovaný chrbtovým dynamometrom po modelových zaťaženiach v jednotlivých typoch športov. Výsledky sme vyhodnocovali neparametrickou metódou Wilcoxonovho T-testu pre závislé súbory a použili sme tiež Cohen d pre vecné zdôvodnenie. V súbore karatistov sme zaznamenali významný pokles medzi vstupným meraním a tretím modelovým zápasom (p = 0,03, -15,57 kg, -8,63 %, d = 0,82). v súbore džudistov sme nezaznamenali významný pokles výkonu, ale vecná významnosť bola zistená na vysokej hladine po druhom modelovom zápase d = 0,92. V súbore zápasníkov sme zaznamenali významný nárast výkonu medzi vstupným meraním a druhým modelovým zápasom (p = 0,05, 13,93 kg, 9,36 %, d = 0,81). Pre karatistov odporúčame pracovať v tréningových jednotkách v treningových jednotkách na sledovanom parametre z hľadiska prevencie voči zraneniam. Pre súbore zápasníkov a džudistov odporúčame pracovať naďalej na tejto schopnosti z hľadiska prevencie, a aj z hľadiska ich športového výkonu, a ich technické činnosti sú limitované vo veľkej miere aj silou chrbtového svalstva.

Kľúčové slová: modelové zaťaženie, karate, džudo, zápasenie, pokles motorických výkonov
THE HISTORY OF NORDIC WALKING AND HEALTH BENEFITS OF NORDIC WALKING

Michal BÁBEŁA

Department of Sport Educology and Sport Humanities, Faculty of Physical Education and Sports, Comenius University in Bratislava

Supervisor: Josef Oborný

ABSTRACT

There are only few physical activities, that can be done when facing health problems, physical restrictions and in this way to improve health, physical fitness, mental strength and enjoy physical activity in the nature and develop relationship to the nature at the same time.

The aim of the poster is to present a physical activity – The nordic walking. The poster has two main sections. The first section focuses on the formation and evolution of the nordic walking. The second section focuses on the nordic walking and its main health benefits for the human body, which are clearly based on results, findings of the serious scientific research.

For writing section The history of nordic walking I have decided for research method Historiography. First of all I focused on collecting material about nordic walking. I have been searching for two kinds of sources: primary and secondary sources. Primary sources are materials produced in the time period under study. Common examples include diaries, newspaper, speeches, historical data, electronic data. Secondary sources are materials produced after the time period under study. Works of scholarship (researches) are the most common secondary sources. I evaluated collected material. I have validated relevance and objectivity of individual information by answering following questions:

- Where was the source located?
- What type of source is it? (for example, sources from Wikipedia are not acceptable)
- Who is the author and what are the qualifications of the author in regard to the topic?
- When was the information published?
I have made categorization of facts and studied their relations on the bases of comparative method. Based on analyzed information data i have created logic, chronologic (corresponding to section The history of nordic walking) and systematic complex work reasoning and confirming main argument of the poster.

For writing section The health benefits of nordic walking i have decided for the same methodological approach as in the previous section (The history of nordic walking). I have focused on searching for scientific papers and solid researches related to the issue of the health benefits of nordic walking. Regarding the extension of scientific papers and researches i have stated only abstracts and conclusions in the text, which justify the health benefit of nordic walking. Poster contains many pictures and infographic corresponding with the topic.

Nordic walking is a useful physical activity to keep adequate level of health, to improve health and to keep or improve fitness aimed on quality of the life. Nordic walking is an adequate physical activity for people facing health problems such as: vascular diseasess, diabetes mellitus, hypertension, arthrosis, osteoporosis, beckache. Nordic walking is a relatively technically simple and efficient physical activity for all age categories, all genders and can be done almost in every wheather and in different natural terrain. Nordic walking has a high potential to become a non-medicamentous tool (resource) for current sedentary society facing implications of industrial revolution and for elderly generation of people with degenerative malfunctions. Nordic walking has a high potential to encourage bio-psycho-social balance of an individual. In addition to health benefits (from the perspective of physiology) has nordic walking a demonstrable positive effects to the human psyche, what could be next reasearch subject of nordic walking.

**Key words:** nordic walking, walking, history, physical activity, health benefits
DEVELOPMENT OF STRENGTH-SPEED ABILITIES USING CLUSTER SETS WITH MAXIMUM POWER OUTPUT

Matej HALAJ

Comenius University in Bratislava, Faculty of Physical Education and Sport,
Department of Track and Field

Supervisor: Tomáš Kampmiller

ABSTRACT

The purpose of the study is to investigate relationship between traditional sets (TS) and cluster sets (CS) in 8-week training program. Thirty strength trained men, will perform twelve sets of his optimal number of repetitions in calf-raise squat at two different external loads. First 4 weeks at the load of lower limit of zone +90 % of maximal power output. Than second 4 weeks at the load of maximal power output (Pmax). The groups will use two different training protocols; TS - with continuous repetitions and CS - with 20 s intra-set rest interval after every 2 repetitions. Inter set rest interval will be two minutes in both protocols. There will be at least three days of rest between protocols (72 hours). All repetitions will be executed with maximum effort measuring with power and speed analyzer FiTRODyne. Optimal load will be provided by progressive loading test to measure Pmax. Optimal number of repetitions will be provided by testing one „work set“ on the load of Pmax for measure number of effective repetitions - repetitions more than 90 % of Pmax. Parametrical unpaired t-test was used in order to evaluate the statistic difference.

Expected results: Compared TS, CS should be resulted in greater average maximal power output and velocity made in the training protocol. The results should have us show that with the development of cluster sets can intensify training load and perform more repetitions of the desired intensity as in the traditional sets. Therefore adaptability for the strength-speed abilities should be in higher level of significance in group which will use cluster sets.

Key words: calf-raise squat, strength-speed abilities, power output, cluster sets, traditional sets
STRENGTH TRAINING AS A SUPPLEMENTAL THERAPY OF ANDROGEN DEFICIENCY OF THE AGING MALE

Michal KRÁLIK

Department of Sport Kinanthropology, Faculty of Physical Education and Sport, Comenius University in Bratislava

Supervisor: Milan Sedliak

ABSTRACT

Androgen deficiency of the aging male (ADAM) is a syndrome resulting from the low production of androgens. Symptoms include decrease in muscle mass and strength, adiposity, cognitive function, libido and erectile dysfunction. Untreated chronic lower than normal testosterone level dramatically increases the risks of cardiovascular and metabolic diseases, Alzheimer's disease and prostate cancer later in the life. Standard treatment of ADAM is testosterone replacement therapy (TRT) life-long, as it helps to prevent most of the adverse health effects. But, this therapy doesn’t fully prevent loss in muscles, doesn’t reverse visceral obesity and metabolic health. Beneficial effects of strength training on the most of these parameters and quality of life have been clearly shown in the past. The aim of the study is to examine the effects of 12-week strength training in patients with and without TRT on muscle size and muscle strength, physical function and the quality of life. The main hypothesis of this study is that evidence-based strength training will change various parameters related to quality of life and health aspects in patients with ADAM. More specifically, we suggest that strength training will have positive effect on muscle strength, function, body composition, selected biochemical markers of metabolic health and quality of life in patients with ADAM. 36 participants in age from 45 to 60 years old will perform supervised strength training sessions 2 times per week for 12 weeks. Each session will take 60 minutes and consist of 6 exercises for major muscle groups with intensity 60-80% of one-repetition maximum (1RM). We expect, that body composition and muscle mass (measured by dual-energy x-ray absorptiometry), muscle strength (measured by dynamometry and 1RM tests) cardio-respiratory fitness (VO_{2max}) and quality of life (measured by questionnaires) will improve in all experiment groups. Muscle cellular outcomes from muscle biopsy should be increase in all experimental groups of muscle fiber size, regulators of muscle fiber size and regulators of muscle fiber function.

Key words: strength training, physical activity, testosterone, male hypogonadism.
STUDENT RESEARCH CONFERENCE 2017
BRATISLAVA, APRIL 6, 2017
Proceedings

Publisher: Comenius University in Bratislava
Year of issue: 2017
Issue: 1
Pages: 125
Technical Editor: Lukáš Chovanec

ISBN 978-80-223-4351-0