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*"Child is growing in dream".*
*(Dalmatian traditional)*

*Dear reader,*
*Here, for the eighth time already (Vol. 4, Issue 2) we are addressing you in this way by offering a wide range of fine papers from around the world, from different environments in which our authors operate (USA, Italy, Turkey, Iran, Bosnia and Herzegovina, Croatia, Serbia, Montenegro, Macedonia, ...). In total, there are exactly 50 different authors in 18 articles actively in this issue. So, slowly and seemingly imperceptible, we reached the end of a four-year cycle, a time that in sports means closed Olympic circle and the time usually available to the recapitulation and to set new result goals. But it is also a time which typically produce changes that are not always sure that they were visible on a daily basis or that we are generally carried out. Sometimes it seems that everything went like a dream, as well as the proverb says, "our baby was growing in a dream" and has grown so we just ask: When did this happen? In addition to all other life commitments, continued efforts to get children to build and strengthen, everything did to us that years are flying and suddenly we look - one full cycle is completed and passed. And with him, our eight concerns, eight hurries, eight joys, eight annoyed, eight common hopes and pleasures. Time flows in the world of science, as well as any other aspect of life, and it is hard to say what we all can expect tomorrow, but it is certain that this journal has many of you as friends and acquaintances that wishes much good, and successful future. Thank you all from our hearts. We will be, as before, coordinators standing here for your service. Where our and your scientific paths meet, we will build common bridges, interchanges and scientific research especially as a common place for young scientists, where they can show what they can. The journal was launched for this purpose - with the same aim will be continued. Now it starts a new cycle, new hopes and new concerns, but we are confident - new joy and fulfillment too. After all, it seems that, to "child" or to us, this "dream" does not intend to finish. Well, if that is so, then we will not "run away" in a dream, but we will live it in reality.*

*Editor-in-Chief*
*Assist.Prof.Dobromir Bonacin, PhD*

*"U snu dite reste".*
*(Dalmatinska narodna)*

*Dragi čitatelju,*
*Evo, već po osmi put (Vol. 4, broj 2.) vam se na ovaj način obraćamo nudeći široku lepezu lijepih članaka iz cijeloga svijeta, iz raznih sredina u kojima djeluju naši autori (USA, Italija, Turska, Iran, Bosna i Hercegovina, Hrvatska, Srbija, Crna Gora, Makedonija,…). Ukupno je točno 50 različitih autora u 18 članaka aktivno u ovom broju časopisa. Tako, polako i naizgled neosjetno, došli smo do konca jednog četverogodišnjeg ciklusa, ciklusa koji u sportu znači zatvoren Olimpijski krug i vrijeme obično raspoloživo, kako za rekapitulacije, tako i za postavljanje novih rezultatskih ciljeva. No to je i vrijeme u kojemu se obično dogode promjene za koje nije uvijek sigurno da su bile svakodnevno vidljive ili da smo ih uočavali. Ponekad se učini da je sve prošlo kao u snu, a kao što poslovica lijepo kaže, "naše dijete je raslo u snu" i naraslo da se naprosto zapitamo: Kad se to dogodilo? Uz sve ostale životne obveze, stalni napori da se to dijete izgradi i ojača, činili su da nam godine uz njega prolete i gle – jedan cijeli ciklus je prošao i završio. A s njim i naših osam briga, osam žurbi, osam radosti, osam nerviranja, osam nadanja i osam zajedničkih zadovoljstava. Vrijeme teče, a u svijetu znanosti, kao i u bilo kojem drugom segmentu života teško je reći što nas sve sutra čeka, ali je sigurno da ovom časopisu mnogi od vas prijatelja i poznanika želite mnogo dobra i daljnju uspješnu budućnost. Svima vama od srca hvala, a mi ćemo kao i do sada biti koordinatori i svima vama na usluzi. Tamo gdje se naši i vaši znanstveni putovi susretnu gradit ćemo zajedničke mostove, znanstvena čvorišta i posebno znanstvena svratišta, s ciljem da i dalje, naročito mladi znanstvenici imaju gdje stati i pokazati što mogu. S tom svrhom je časopis pokrenut – s tom svrhom će postojati i dalje. Počinje novi ciklus, nova nadanja i nove brige, ali smo isto tako sigurni - i nove radosti i ispunjenja. Po svemu izgleda da ni "djetetu" ni nama, ovaj "san" nema namjeru završiti. Pa kad je već tako, tada nećemo "bježati" u san, već ga živjeti na javi.*

*Glavni urednik*
*Doc.dr.Dobromir Bonacin*

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## Sadržaj (nastavak):

# THE ENERGY REQUIREMENT OF WALKING WITH RESTRICTED BLOOD FLOW

**Jeremy P. Loenneke[1], Austin D. Thrower[2], Abhishek Balapur[3], Jeremy T. Barnes[3] and Thomas J. Pujol[3]**

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*Original scientific paper*

***Abstract***
*Previous research has demonstrated favorable outcomes with restricted blood flow walking. The purpose of this study was to investigate if using elastic knee wraps as a mode of blood flow restriction (BFR) could increase oxygen consumption (VO2), energy expenditure (EE) and heart rate (HR) over control (CON) during low intensity walking. Ten healthy men and women performed two trials of treadmill walking with (BFR) and without (CON) restricted blood flow. Elastic knee wraps (76 mm wide) were placed around the upper thigh of both legs during BFR. Exercise consisted of five 2-min bouts of walking at 75 m/min with, 1-min rest between each bout. VO2, EE, and HR were measured following each exercise bout. VO2 and EE was significantly higher with BFR for bouts 2-5, but was not different after the first bout, or 3 minutes post exercise. HR was significantly elevated over control with BFR at every time point except baseline. In conclusion, there are differences for VO2, EE, and HR between BFR and CON, despite both walking at the same absolute workload. It remains unknown if subtle differences in EE between exercise conditions results in favorable physiologic change over time.*

***Key words****: blood flow restriction, heart rate, energy expenditure*

## Introduction

In 2009, the American College of Sports Medicine (ACSM) updated their position stand titled Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults (Donnelly et al., 2009). The position stand reports that 66% of adults are affected by overweight and obesity, which puts them at increased risk for numerous chronic diseases. The new recommendations conclude that moderate intensity physical aerobic activity (3-5.9 METS) of at least 150min/week is needed to prevent weight gain and reduce chronic disease risk factors. A dose effect of physical activity likely exists, with greater weight loss and enhanced prevention with doses of moderately intense aerobic physical activity of approximately 250-300 min/week (~2000 kcal/week) (Donnelly, et al., 2009). Despite the moderate intensity recommendation, some populations such as those in post-operative rehabilitation or elderly might be unable to withstand longer duration at a moderate intensity level. Thus, any mode of exercise that could increase the intensity of exercise while maintaining the same external workload could possibly be advantageous to such populations. One such alternative is blood flow restriction training, which involves decreasing blood flow to a working muscle, by application of a wrapping device, such as a blood pressure cuff(for reviews please see (Loenneke & Pujol, 2009, 2010; Loenneke, Wilson, & Wilson, 2010; Manini & Clark, 2009; Wernbom, Augustsson, & Raastad, 2008). Evidence indicates that this style of training can provide a unique, beneficial mode of exercise in clinical settings, as it produces positive training adaptations equivalent to the physical activity of daily life (10-30% of maximal work capacity) (Abe, Kearns, & Sato, 2006). Treadmill walking with moderately restricted blood flow has previously demonstrated an increase in maximal oxygen consumption (VO2MAX) (Park et al., 2010) and increases in both skeletal muscle hypertrophy and strength (Abe, et al., 2006; Ozaki, Miyachi, Nakajima, & Abe, 2011). In addition, Ozaki et al. (2011) found that 10 weeks of blood flow restricted treadmill walking in the elderly (~66 years) at 45% heart rate reserve produced not only increases in muscular size and strength but also increased carotid arterial compliance. It is hypothesized that blood flow restriction training induces skeletal muscle hypertrophy through a variety of mechanisms (for a review please see (Loenneke, Wilson, et al., 2010)), however the mechanisms are still under investigation. Low intensity walking is a mode of exercise that is commonly prescribed to increase physical activity. This coupled with the aforementioned walking studies provides the rationale for the current investigation to determine if VO2 could also be elevated with a practical means to restrict blood flow. Additionally energy expenditure (EE) was investigated to see if restricting blood flow increases the caloric cost of low intensity aerobic exercise. The blood flow restriction stimulus often used in the research is applied by a KAATSU Master Apparatus, which limits the practical application in that very few individuals can gain access to such equipment or they lack the skill to correctly operate the device. Elastic knee wraps have previously been investigated as a blood flow restriction stimulus with resistance training (Loenneke, Balapur, Thrower, Barnes, & Pujol, 2010; Loenneke, Kearney, Thrower, Collins, & Pujol, 2010); however the effects with aerobic exercise are currently unknown.

## Material and methods

Elastic knee wraps (76 mm wide) were used to test the hypothesis that restricting blood flow to the proximal portion of the legs would result in changes in VO2, EE, and heart rate (HR). Elastic knee wraps were used because they are easy to obtain, inexpensive, and practical. Tension was purposely not measured, as there is a need to observe how a stimulus would work in a field setting.

*Participants*
Ten healthy men and women (age=21.4 (1.42) years, height= 170.14 (9.95) cm, body mass= 77.26 (17.86) kg) participated in a randomized crossover study consisting of 2 trials separated by at least 6 days and no more than 8 days, thus no dramatic changes in their metabolism could be expected during the ~1 week time period of the study. Participants had no known symptoms of impaired endothelial function or known risk factors for cardiovascular or metabolic disease. Participants were permitted to train their leg musculature as usual up to 48 hours before each testing trial. Participants were asked to abstain from alcohol consumption for 24 hours before each test, abstain from caffeine for 12 hours prior, and participants were also required to fast four hours prior to testing. Although not controlled for, participants were advised to maintain their habitual dietary practices throughout the week. Participants were informed about the procedures and potential risks of the tests before their informed consent was obtained. The universities institutional review board approved this protocol, which was written in accordance with standards set by the Declaration of Helsinki.

*Exercise Testing*
Participants attended the human performance laboratory on 2 separate occasions. The first meeting consisted of randomization to either the blood flow restricted (BFR) or control (CON) group. The second meeting consisted of completion of the opposite trial. In addition, testing was performed at the same time of day under both conditions to control for any possible diurnal variation. Exercise consisted of five 2-min bouts of walking at 75 m/min on a treadmill with a one minute rest period following each exercise bout. This protocol was chosen because it has been previously used in the literature (Abe, et al., 2006). BFR and CON trials were conducted in exactly the same manner with the only difference being the application of elastic knee wraps (Harbinger Red-Line, 76 mm wide) to the upper thighs, as described and depicted by Loenneke and Pujol (2009). Knee wraps were applied by the same investigator to maximize intra-rater reliability. The BFR stimulus was applied immediately before exercise, remained on throughout the rest periods, and was removed following the final bout of exercise. VO2 was determined with the Vista Mini-CPX model 17670 using Turbofit v. 4.0 software (VacuMed, Ventura, CA), which was calibrated using manufacturer guidelines prior to each testing session. Energy expenditure (EE) was calculated using the caloric equivalents for the non-protein respiratory exchange ratio (RER) values for each liter of oxygen used. Heart rate (HR) was measured using a T31 Transmitter to a FS1 wrist attachment manufactured by Polar Electro (Polar Electro USA, Lake Success, NY). Following proper fitting of the correct sized face mask, participants were asked to stand on the treadmill for 10 minutes to allow for acclimation to breathing with the gas collection mask on. This was done to ensure that subjects gas values represented resting conditions. All subjects' gas values reached steady state by 4 minutes. Once a steady state breathing pattern was observed, baseline VO2, EE, and HR 30 second average values were recorded and subsequently recorded upon completion of each 2 minute exercise bout, prior to the rest period.

*Statistical analysis*
Data were analyzed using PASW Statistics 18 with all variability represented using notation that is in accordance with the Scientific Style and Format for standard deviation (SD) (Council of Science Editors. Style Manual Committee., 2006). Baseline measurements from both days were used to determine the intra-class correlations (ICC) of VO2, EE, and HR, which was used in the calculation of the standard error of the measurement (SEM) (SEM= SD?1-ICC). The minimal differences (MD) for VO2, EE, and HR needed to be considered a real change was calculated from the SEM (MD= SEM x 1.96 ?2). VO2, EE, and HR levels were analyzed using repeated measures analysis of variance (ANOVA) to determine significant differences between BFR and CON at an alpha level of 0.05. When significance was found, paired sample t-tests were used to determine pair-wise differences with a Bonferroni corrected alpha of 0.007 to control the family-wise error rate. The effect size for each pairwise comparison was calculated using Cohen's d (d= [(BFRmean-CONmean)/SD]).

## Results

Table 1 presents mean VO2, EE, and HR values following each individual bout of exercise for both BFR and CON. VO2 was significantly higher with BFR over CON (p=0.001). Post hoc analysis found differences with exercise bouts 2-5 but no significant differences at baseline, after the first bout, or 3 minutes post exercise. The significant differences found with VO2 exceeded the MD following all exercise bouts (>0.1 l/min) and Cohen's d test found that the BFR had a large effect for all bouts of exercise compared to CON (range of 0.90-2.00). EE was significantly increased with BFR over CON (p=0.001). Post hoc analysis found differences for exercise bouts 2-5 but no significant differences at baseline, after the first bout, or 3 minutes post exercise. The MD to be considered real was exceeded (>0.5 kcal/min) for all exercise bouts and Cohen's d test found that the BFR had a large effect for all bouts of exercise compared to CON (range of 0.98-2.05).

HR was significantly elevated with OCC compared to CON (p=0.001) and exceeded the MD to be considered real with every time point except baseline (>11 bpm). Cohen's d test also found a large effect of BFR at every time point except baseline (range of 1.11-1.53).

Table 1. Mean Values of oxygen consumption (V02), energy expenditure (EE), and heart rate (HR) following low intensity walking with blood flow restriction (BFR) and without (CON). *indicates a significant difference between BFR and CON (p ?0.007). † indicates exceeding the minimal differences to be considered real. All values are expressed as means ± SD.

| | VO2 (l/min) | | | | |
|---|---|---|---|---|---|
| | BFR | CON | Mean Dif. | p value | Cohens d |
| Pre | 0.3 (0.1) | 0.3 (0.1) | 0 | 0.591 | -0.2 |
| 1st | 1.0 (0.2) | 0.9 (0.2) | 0.1† | 0.02 | 0.9 |
| 2nd | 1.1 (0.2) | 0.9 (0.2) | 0.2† | .001* | 2 |
| 3rd | 1.1 (0.2) | 0.9 (0.1) | 0.2† | .001* | 1.5 |
| 4th | 1.1 (0.2) | 0.9 (0.2) | 0.2† | .001* | 1.76 |
| 5th | 1.1 (0.2) | 0.9 (0.1) | 0.2† | .002* | 1.33 |
| Rec | 0.3 (0.1) | 0.3 (0.1) | 0 | 0.508 | -0.16 |

| | EE (kcal/min) | | | | |
|---|---|---|---|---|---|
| | BFR | CON | Mean Dif. | p value | Cohens d |
| Pre | 1.4 (0.4) | 1.5 (0.4) | -0.1 | 0.626 | -0.14 |
| 1st | 5.0 (1.3) | 4.5 (1.1) | 0.5† | 0.013 | 0.98 |
| 2nd | 5.4 (1.3) | 4.4 (0.8) | 1.1† | .001* | 2.05 |
| 3rd | 5.7 (1.2) | 4.4 (0.8) | 1.3† | .001* | 1.57 |
| 4th | 5.6 (1.3) | 4.5 (1.0) | 1.1† | .001* | 1.83 |
| 5th | 5.3 (1.3) | 4.3 (0.4) | 1.0† | .001* | 1.43 |
| Rec | 1.6 (0.4) | 1.6 (0.6) | 0 | 0.862 | -0.05 |

| | HR (bpm) | | | | |
|---|---|---|---|---|---|
| | BFR | CON | Mean Dif. | p value | Cohens d |
| Pre | 73 (9) | 72 (9) | 1 | 0.638 | 0.15 |
| 1st | 118 (16) | 98 (13) | 20† | .007* | 1.19 |
| 2nd | 118 (14) | 96 (10) | 22† | .001* | 1.53 |
| 3rd | 123 (17) | 98 (12) | 25† | .004* | 1.2 |
| 4th | 128 (21) | 98 (11) | 30† | .005* | 1.15 |
| 5th | 128 (25) | 98 (11) | 30† | .006* | 1.11 |
| Rec | 112 (19) | 92 (12) | 20† | .005* | 1.16 |

## Discussion

The current study was the first to investigate the effects of knee wraps as a mode of restricting blood flow with an activity of daily living such as walking. This study demonstrated that knee wraps produce significant increases in VO2, EE, and HR over exercise without elastic knee wraps at the same absolute workload. Although significance was seen between groups, the physiologic relevance of such a small change is unknown. Nevertheless, subjects were able to tolerate blood flow restricted walking with elastic knee wraps, thus providing a foundation for future research.

The current findings are in agreement with Abe et al. (2006) who found a significant increase in VO2 and HR with low intensity blood flow restricted walking. The exercise protocol used in this study was similar to Abe et al. (2006) (five 2-min bouts) except for the treadmill speed and blood flow restriction stimulus used. This investigation used a speed 75 m/min whereas 50 m/min had been previously used. In addition, the blood flow restriction stimulus used in this study was via knee wraps as opposed to the KAATSU Master Apparatus used in the Abe study. Despite difference in speed between studies, the overall intensity of exercise was still maintained at a relatively low level. This elevated oxygen requirement for exercise may be related to the increased electromyographic (EMG) activity of the leg muscles seen with blood flow restricted exercise (Moore et al., 2004; Takarada, Nakamura, et al., 2000; Takarada, Takazawa, et al., 2000). This increased recruitment likely occurs from the reduction in oxygen and subsequent metabolic accumulation, during blood flow resistance restricted exercise. Both reduced oxygen and metabolic accumulation can increase fiber recruitment, mechanistically speaking, through the stimulation of group III and IV afferents which may cause inhibition of the alpha motorneuron, resulting in an increased fiber recruitment to maintain force and protect against conduction failure (Yasuda et al., 2010). This is the first investigation with blood flow restriction of any kind, to quantify EE from an exercise bout and demonstrates that the EE is elevated over CON when knee wraps are applied to the proximal portion of the legs prior to an activity of daily living such as walking. This indicates that utilizing knee wraps requires more energy to complete exercise of a given workload, than exercise with no blood flow restriction. Although the overall increase in caloric expenditure was small, it was considered a real increase based on the reliability of our measurements. Additionally, the increases in HR with blood flow restriction are consistent with previous research, attributed to the decreased venous return (Sumide, Sakuraba, Sawaki, Ohmura, & Tamura, 2009). Although increases in muscle hypertrophy, strength, and endurance capacity have been observed with blood flow restricted walking, the application of this type of training is limited by the high cost and technical skills needed to operate pneumatic tourniquets. Thus, a need exists for a more practical way to restrict blood flow (e.g. elastic knee wraps). Future research should focus on both the acute and chronic effects of knee wraps as a mode of practical blood flow restriction for aerobic exercise. Seven out of ten participants in this study self-reported being aerobically trained (mean 125 min/wk, range of 120-300 min/wk), so it is plausible that the current aerobic status of our participants buffered a response that might be more evident with a less active population. In addition, the effects of continuous walking, rather than the five 2 minute intermittent bouts used in this study should be investigated. Furthermore, although it has been thought that the increased oxygen requirement is due to elevated EMG activity; this study did not

measure EMG activity so the degree of muscle activity with practical blood flow restriction is unknown. Previous research with elastic knee wraps has shown elevated perceptual responses (RPE and Pain) with blood flow restricted resistance training (Loenneke, Balapur, et al., 2010; Loenneke, Kearney, et al., 2010). Perceptual responses were not measured with the current study, but future investigations should quantify that response, because previous reports have shown a relationship between perceptual responses and stress hormones levels (Adler, 2000; Borg, 1998).

It remains unknown if this relationship exists with practical blood flow restricted aerobic exercise, and further examine what, if any limitations this may present in its application. Investigations should also be completed with the elderly to determine if this is in fact a beneficial mode of exercise for that population. In conclusion, this is the first study to investigate the effects of practical blood flow restricted aerobic exercise finding significant increases in VO2, EE, and HR with blood flow restriction compared to CON, despite both walking at the same absolute workload. These results provide proof of concept that restricting blood flow provides a mode of increasing the intensity of both aerobic and resistance training, however caution should be applied until long term studies are conducted to determine if subtle changes in metabolism result in significant physiologic adaptation. The need for an affordable, effective means to receive the benefits of blood flow restriction training exists, thus the need for further research in the field of practical blood flow restricted exercise.

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## ENERGETSKA POTREBA U HODANJU S OGRANIČENJEM OPTOKA KRVI


### Sažetak

*Prethodno istraživanje je pokazalo povoljan rezultat pri hodanju s ograničenjem optoka krvi. Svrha ovog istraživanja je utvrđivanje može li korištenje elastičnog zavoja za koljeno kao oblika restrikcije optoka krvi (BFR) povećati potrošnju kisika (VO2), potrošnju energije (EE) i frekevnciju srca (HR) uz controlu (CON) za vrijeme hodanja niskog intenziteta. Deset zdravih muškaraca i žena provelo je dva pokusa na pokretnom sagu sa (BFR) i bez (CON) ograničenja optoka krvi. Elastični zavoji (širine 76 mm) su postavljeni oko gornjeg bedra obiju nogu za vrijeme BFR. Vježba se sastojala od pet dvo-minutnih djelovanja hodanjem pri 75 m/min, uz 1 minutu odmora između svakog djelovanja. VO2, EE i HR su mjereni za vrijeme svake vježbe. VO2 i EE su bili značajno viši uz BFR za djelovanje 2-5, ali nije bilo razlika u prvoj seriji, kao ni 3 minute nakon vježbe. HR je bio značajno podignut sa BFR u svakom trenutku osim na samom startu. Zaključno, postoje razlike za VO2, EE i HR između BFR i CON, bez obzira što su oba hodanja bila na istom apsolutnom random opterećenju. Ostaje nepoznato bi li fine razlike u EE između uvjeta vježbanja rezultirale povoljnim fiziološkim promjenama kroz dulje vrijeme.*


***Ključne riječi**: restrikcija optoka krvi, frekvencija srce, potrošnja energije*

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# MOTOR COORDINATION IN THE ITALIAN PRIMARY SCHOOL: TEACHING RELEVANCE AND AVAILABILITY OF ANOCHIN'S THEORETICAL MODEL

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*Review paper*

***Abstract***
*The 2007 National Guidelines for the curriculum of the Italian primary school require the achievement of the motor abilities and motor coordination to be one of the main goals for the development of the skills at the end of the primary school. Anochin's theoretical model provides an overview of the motor coordination, based on 5 analyzers which can identify a teaching method centered on the development of both gross motor and up-motor skills. Anochin's remarks are rich of possible teaching ideas which are consistent with the Italian school system. They might also be a topical theoretical support to choose and use the motor evaluation tests in the Italian primary school, in order to evaluate the coordination and its constituent elements.*

***Key words****: teaching, programs, primary school, motor evaluation tools, coordination, tests*

## Introduction

In 2009, the American College of Sports Medicine (ACSM) updated their position stand titled Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults (Donnelly et al., 2009). The position stand reports that 66% of adults are affected by overweight and obesity, which puts them at increased risk for numerous chronic diseases. The new recommendations conclude that moderate intensity physical aerobic activity (3-5.9 METS) of at least 150min/week is needed to prevent weight gain and reduce chronic disease risk factors. A dose effect of physical activity likely exists, with greater weight loss and enhanced prevention with doses of moderately intense aerobic physical activity of approximately 250-300 min/week (~2000 kcal/week) (Donnelly, et al., 2009). Despite the recommendation of moderate intensity, some populations such as those in post-operative rehabilitation or elderly might be unable to withstand longer duration at a moderate intensity level. Thus, any mode of exercise that could increase the intensity of exercise while maintaining the same external workload could possibly be advantageous to such populations. One such alternative is blood flow restriction training, which involves decreasing blood flow to a working muscle, by application of a wrapping device, such as a blood pressure cuff(for reviews please see (Loenneke & Pujol, 2009, 2010; Loenneke, Wilson, & Wilson, 2010; Manini & Clark, 2009; Wernbom, Augustsson, & Raastad, 2008). Evidence indicates that this style of training can provide a unique, beneficial mode of exercise in clinical settings, as it produces positive training adaptations equivalent to the physical activity of daily life (10-30% of maximal work capacity) (Abe, Kearns, & Sato, 2006). Treadmill walking with moderately restricted blood flow has previously demonstrated an increase in maximal oxygen consumption (VO2MAX) (Park et al., 2010) and increases in both skeletal muscle hypertrophy and strength (Abe, et al., 2006; Ozaki, Miyachi, Nakajima, & Abe, 2011). In addition, Ozaki et al. (2011) found that 10 weeks of blood flow restricted treadmill walking in the elderly (~66 years) at 45% heart rate reserve produced not only increases in muscular size and strength but also increased carotid arterial compliance. It is hypothesized that blood flow restriction training induces skeletal muscle hypertrophy through a variety of mechanisms (for a review please see (Loenneke, Wilson, et al., 2010)), however the mechanisms are still under investigation. Low intensity walking is a mode of exercise that is commonly prescribed to increase physical activity. This coupled with the aforementioned walking studies provides the rationale for the current investigation to determine if VO2 could also be elevated with a practical means to restrict blood flow. Additionally energy expenditure (EE) was investigated to see if restricting blood flow increases the caloric cost of low intensity aerobic exercise. The blood flow restriction stimulus often used in the research is applied by a KAATSU Master Apparatus, which limits the practical application in that very few individuals can gain access to such equipment or they lack the skill to correctly operate the device. Elastic knee wraps have previously been investigated as a blood flow restriction stimulus with resistance training (Loenneke et al., 2010; Loenneke, Kearney, Thrower, Collins, & Pujol, 2010); however the effects with aerobic exercise are currently unknown.

## Material and methods

Elastic knee wraps (76 mm wide) were used to test the hypothesis that restricting blood flow to the proximal portion of the legs would result in changes in VO2, EE, and heart rate (HR). Elastic knee wraps were used because they are easy to obtain, inexpensive, and practical.

Tension was purposely not measured, as there is a need to observe how a stimulus would work in a field setting.

*Participants*
Ten healthy men and women (age=21.4 (1.42) years, height= 170.14 (9.95) cm, body mass= 77.26 (17.86) kg) participated in a randomized crossover study consisting of 2 trials separated by at least 6 days and no more than 8 days, thus no dramatic changes in their metabolism could be expected during the ~1 week time period of the study. Participants had no known symptoms of impaired endothelial function or known risk factors for cardiovascular or metabolic disease. Participants were permitted to train their leg musculature as usual up to 48 hours before each testing trial. Participants were asked to abstain from alcohol consumption for 24 hours before each test, abstain from caffeine for 12 hours prior, and participants were also required to fast four hours prior to testing. Although not controlled for, participants were advised to maintain their habitual dietary practices throughout the week. Participants were informed about the procedures and potential risks of the tests before their informed consent was obtained. The universities institutional review board approved this protocol, which was written in accordance with standards set by the Declaration of Helsinki.

*Exercise Testing*
Participants attended the human performance laboratory on 2 separate occasions. The first meeting consisted of randomization to either the blood flow restricted (BFR) or control (CON) group. The second meeting consisted of completion of the opposite trial. In addition, testing was performed at the same time of day under both conditions to control for any possible diurnal variation. Exercise consisted of five 2-min bouts of walking at 75 m/min on a treadmill with a one minute rest period following each exercise bout. This protocol was chosen because it has been previously used in the literature (Abe, et al., 2006). BFR and CON trials were conducted in exactly the same manner with the only difference being the application of elastic knee wraps (Harbinger Red-Line, 76 mm wide) to the upper thighs, as described and depicted by Loenneke and Pujol (2009). Knee wraps were applied by the same investigator to maximize intra-rater reliability. The BFR stimulus was applied immediately before exercise, remained on throughout the rest periods, and was removed following the final bout of exercise. VO2 was determined with the Vista Mini-CPX model 17670 using Turbofit v. 4.0 software (VacuMed, Ventura, CA), which was calibrated using manufacturer guidelines prior to each testing session. Energy expenditure (EE) was calculated using the caloric equivalents for the non-protein respiratory exchange ratio (RER) values for each liter of oxygen used. Heart rate (HR) was measured using a T31 Transmitter to a FS1 wrist attachment manufactured by Polar Electro (Polar Electro USA, Lake Success, NY).

Following proper fitting of the correct sized face mask, participants were asked to stand on the treadmill for 10 minutes to allow for acclimation to breathing with the gas collection mask on. This was done to ensure that subjects gas values represented resting conditions. All subjects' gas values reached steady state by 4 minutes. Once a steady state breathing pattern was observed, baseline VO2, EE, and HR 30 second average values were recorded and subsequently recorded upon completion of each 2 minute exercise bout, prior to the rest period.

*Statistical analysis*
Data were analyzed using PASW Statistics 18 with all variability represented using notation that is in accordance with the Scientific Style and Format for standard deviation (SD) (Council of Science Editors. Style Manual Committee., 2006). Baseline measurements from both days were used to determine the intra-class correlations (ICC) of VO2, EE, and HR, which was used in the calculation of the standard error of the measurement (SEM) (SEM= SD?1-ICC). The minimal differences (MD) for VO2, EE, and HR needed to be considered a real change was calculated from the SEM (MD= SEM x 1.96 ?2). VO2, EE, and HR levels were analyzed using repeated measures analysis of variance (ANOVA) to determine significant differences between BFR and CON at an alpha level of 0.05. When significance was found, paired sample t-tests were used to determine pair-wise differences with a Bonferroni corrected alpha of 0.007 to control the family-wise error rate. The effect size for each pairwise comparison was calculated using Cohen's d (d= [(BFRmean-CONmean)/SD]).

**Results**

Table 1 presents mean VO2, EE, and HR values following each individual bout of exercise for both BFR and CON. VO2 was significantly higher with BFR over CON (p=0.001). Post hoc analysis found differences with exercise bouts 2-5 but no significant differences at baseline, after the first bout, or 3 minutes post exercise. The significant differences found with VO2 exceeded the MD following all exercise bouts (>0.1 l/min) and Cohen's d test found that the BFR had a large effect for all bouts of exercise compared to CON (range of 0.90-2.00). EE was significantly increased with BFR over CON (p=0.001).

Post hoc analysis found differences for exercise bouts 2-5 but no significant differences at baseline, after the first bout, or 3 minutes post exercise. The MD to be considered real was exceeded (>0.5 kcal/min) for all exercise bouts and Cohen's d test found that the BFR had a large effect for all bouts of exercise compared to CON (range of 0.98-2.05). HR was significantly elevated with OCC compared to CON (p=0.001) and exceeded the MD to be considered real with every time point except baseline (>11 bpm). Cohen's d test also found a large effect of BFR at every time point except baseline (range of 1.11-1.53).

Table 1. Mean Values of oxygen consumption (V02), energy expenditure (EE), and heart rate (HR) following low intensity walking with blood flow restriction (BFR) and without (CON). *indicates a significant difference between BFR and CON (p = 0.007)

| | VO2 (l/min) | | | | |
|---|---|---|---|---|---|
| | BFR | CON | Mean Dif. | p value | Cohens d |
| Pre | 0.3 (0.1) | 0.3 (0.1) | 0 | 0.591 | -0.2 |
| 1st | 1.0 (0.2) | 0.9 (0.2) | 0.1† | 0.02 | 0.9 |
| 2nd | 1.1 (0.2) | 0.9 (0.2) | 0.2† | .001* | 2 |
| 3rd | 1.1 (0.2) | 0.9 (0.1) | 0.2† | .001* | 1.5 |
| 4th | 1.1 (0.2) | 0.9 (0.2) | 0.2† | .001* | 1.76 |
| 5th | 1.1 (0.2) | 0.9 (0.1) | 0.2† | .002* | 1.33 |
| Rec | 0.3 (0.1) | 0.3 (0.1) | 0 | 0.508 | -0.16 |

| EE (kcal/min) | | | | | |
|---|---|---|---|---|---|
| | BFR | CON | Mean Dif. | p value | Cohens d |
| Pre | 1.4 (0.4) | 1.5 (0.4) | -0.1 | 0.626 | -0.14 |
| 1st | 5.0 (1.3) | 4.5 (1.1) | 0.5† | 0.013 | 0.98 |
| 2nd | 5.4 (1.3) | 4.4 (0.8) | 1.1† | .001* | 2.05 |
| 3rd | 5.7 (1.2) | 4.4 (0.8) | 1.3† | .001* | 1.57 |
| 4th | 5.6 (1.3) | 4.5 (1.0) | 1.1† | .001* | 1.83 |
| 5th | 5.3 (1.3) | 4.3 (0.4) | 1.0† | .001* | 1.43 |
| Rec | 1.6 (0.4) | 1.6 (0.6) | 0 | 0.862 | -0.05 |

| HR (bpm) | | | | | |
|---|---|---|---|---|---|
| | BFR | CON | Mean Dif. | p value | Cohens d |
| Pre | 73 (9) | 72 (9) | 1 | 0.638 | 0.15 |
| 1st | 118 (16) | 98 (13) | 20† | .007* | 1.19 |
| 2nd | 118 (14) | 96 (10) | 22† | .001* | 1.53 |
| 3rd | 123 (17) | 98 (12) | 25† | .004* | 1.2 |
| 4th | 128 (21) | 98 (11) | 30† | .005* | 1.15 |
| 5th | 128 (25) | 98 (11) | 30† | .006* | 1.11 |
| Rec | 112 (19) | 92 (12) | 20† | .005* | 1.16 |

† indicates exceeding the minimal differences to be considered real. All values are expressed as means ± SD

## Discussion

The current study was the first to investigate the effects of knee wraps as a mode of restricting blood flow with an activity of daily living such as walking. This study demonstrated that knee wraps produce significant increases in VO2, EE, and HR over exercise without elastic knee wraps at the same absolute workload. Although significance was seen between groups, the physiologic relevance of such a small change is unknown. Nevertheless, subjects were able to tolerate blood flow restricted walking with elastic knee wraps, thus providing a foundation for future research. The current findings are in agreement with Abe et al. (2006) who found a significant increase in VO2 and HR with low intensity blood flow restricted walking.

The exercise protocol used in this study was similar to Abe et al. (2006) (five 2-min bouts) except for the treadmill speed and blood flow restriction stimulus used. This investigation used a speed 75 m/min whereas 50 m/min had been previously used. In addition, the blood flow restriction stimulus used in this study was via knee wraps as opposed to the KAATSU Master Apparatus used in the Abe study. Despite difference in speed between studies, the overall intensity of exercise was still maintained at a relatively low level. This elevated oxygen requirement for exercise may be related to the increased electromyographic (EMG) activity of the leg muscles seen with blood flow restricted exercise (Moore et al., 2004; Takarada, Nakamura, et al., 2000; Takarada, Takazawa, et al., 2000). This increased recruitment likely occurs from the reduction in oxygen and subsequent metabolic accumulation, during blood flow resistance restricted exercise. Both reduced oxygen and metabolic accumulation can increase fiber recruitment, mechanistically speaking, through the stimulation of group III and IV afferents which may cause inhibition of the alpha motorneuron, resulting in an increased fiber recruitment to maintain force and protect against conduction failure (Yasuda et al., 2010). This is the first investigation with blood flow restriction of any kind, to quantify EE from an exercise bout and demonstrates that the EE is elevated over CON when knee wraps are applied to the proximal portion of the legs prior to an activity of daily living such as walking. This indicates that utilizing knee wraps requires more energy to complete exercise of a given workload, than exercise with no blood flow restriction. Although the overall increase in caloric expenditure was small, it was considered a real increase based on the reliability of our measurements. Additionally, the increases in HR with blood flow restriction are consistent with previous research, attributed to the decreased venous return (Sumide, Sakuraba, Sawaki, Ohmura, & Tamura, 2009). Although increases in muscle hypertrophy, strength, and endurance capacity have been observed with blood flow restricted walking, the application of this type of training is limited by the high cost and technical skills needed to operate pneumatic tourniquets. Thus, a need exists for a more practical way to restrict blood flow (e.g. elastic knee wraps). Future research should focus on both the acute and chronic effects of knee wraps as a mode of practical blood flow restriction for aerobic exercise. Seven out of ten participants in this study self-reported being aerobically trained (mean 125 min/wk, range of 120-300 min/wk), so it is plausible that the current aerobic status of our participants buffered a response that might be more evident with a less active population. In addition, the effects of continuous walking, rather than the five 2 minute intermittent bouts used in this study should be investigated. Furthermore, although it has been thought that the increased oxygen requirement is due to elevated EMG activity; this study did not measure EMG activity so the degree of muscle activity with practical blood flow restriction is unknown.

Previous research with elastic knee wraps has shown elevated perceptual responses (RPE and Pain) with blood flow restricted resistance training (Loenneke, Balapur, et al., 2010; Loenneke, Kearney, et al., 2010). Perceptual responses were not measured with the current study, but future investigations should quantify that response, because previous reports have shown a relationship between perceptual responses and stress hormones levels (Adler, 2000; Borg, 1998). It remains unknown if this relationship exists with practical blood flow restricted aerobic exercise, and further examine what, if any limitations this may present in its application. Investigations should also be completed with the elderly to determine if this is in fact a beneficial mode of exercise for that population.

In conclusion, this is the first study to investigate the effects of practical blood flow restricted aerobic exercise finding significant increases in VO2, EE, and HR with blood flow restriction compared to CON, despite both walking at the same absolute workload. These results provide proof of concept that restricting blood flow provides a mode of increasing the intensity of both aerobic and resistance training, however caution should be applied until long term studies are conducted to determine if subtle changes in metabolism result in significant physiologic adaptation. The need for an affordable, effective means to receive the benefits of blood flow restriction training exists, thus the need for further research in the field of practical blood flow restricted exercise.

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## MOTORIČKA KOORDINACIJA U TALIJANSKOJ OSNOVNOJ ŠKOLI: ZNAČAJ NASTAVE I UPOTREBLJIVOST ANOHINOVOG TEORIJSKOG MODELA


### Sažetak

*U 2007. Nacioalni Vodič za kurikulum talijanske osnovne škole zahtijevao je postizanje motoričkih sposobnosti i motoričke koordinacije kao glavnih ciljeva razvoja vještina na kraju osnovne škole. Anohinov teorijski model omogućava pregled motoričke koordinacije, temeljen na 5 analizatora koji mogu identificirati nastavnu metodu centriranu na obje – veće motoričke a i nad-motoričke vještine. Anohinova zapažanja su bogata mogućim nastavnim zamislima koje su sukladne talijanskom školskom sustavu. Oni također mogu biti tematska teorijska potpora za izbor i korištenje testova motoričke evaluacije u talijanskoj osnovnoj školi, u skladu s evaluacijom koordinacije i njenih konstitutivnih elemenata.*


***Ključne riječi**: nastava, program, osnovna škola, evaluacija motorike, koordinacija, testovi*

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# TEACHERS' PHYSICAL ACTIVITY LEVELS WITH RESPECT TO SEVERAL VARIABLES (A STUDY FROM TURKEY)

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*Original scientific paper*

***Abstract***
*The purpose of this study is to estimate the physical activity level of the teachers in Turkey, examining and generalizing the results of the study conducted in Konya, which is one of the biggest cities of Turkey. This study was carried out with 319 teachers with different specialties who were employed in schools located in the city center of Konya. The International Physical Activity Questionnaire-Long Form (IPAQ) was used in the study to assess teachers' physical activity levels. In conclusion, it was determined, according to the total metabolic expenditure units (MET) values of the participant teachers that 11% were inactive, 43% had low physical activity level, and 46% had adequate physical activity level. In MET values regarding the time spent with moderate physical activity, on the other hand, a statistically significant difference was found in the favor of female teachers.*

***Keywords:*** *teacher, physical activity, MET*

## Introduction

Physical activity can most simply be defined as the motion of the body to consume energy (Bates, 2006). Regular physical activity reduces the risk of catching chronic diseases like cancer, diabetes and cardiovascular illnesses (Lee, et al., 2007). Even the light physical activities performed only 30 minutes at least 5 days a week reduces cardiovascular problems (Aydın, 2006).

Regular physical activity contributes to young individuals' bone and muscle developments as well as helping them feel better psychologically. Moreover, it reduces the obesity risk among the youth (Lee, et al., 2007). With the technological advancements, physical activities have diminished and the activities that are considered to be physical activity have undergone changes. The decline in the physical activity level began to be observed frequently in all age and professional groups. As a result of inactiveness, important health problems emerge such as obesity, increase in body fats, decrease in the muscle mass, problems with respect to appearance, muscle bone problems, sleeping disorder, immune system impairment and stress.

For a healthy society and healthy generations, it is of great importance to determine the physical activity levels of and to promote physical activity among individuals from different age and professional groups (Şanlı, 2008). It is important to contribute to the body of knowledge on teachers' physical activity levels and to interpret it. In this study, through the application of questionnaire that is one of the methods of determining physical activity levels, it is targeted to evaluate teachers' physical activity levels with respect to several variables.

## Material and methods

*Subjects*
This study was carried out with 319 teachers (208 male, 111 female) with different specialties who were employed in 14 schools (8 elementary and 6 high schools) located in the city center of Konya. Teacher participant are presented in Table 1.

Table 1. Descriptive statistics

| Variables | | n | Weight (kg) | | Height (cm) | |
|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD |
| Gender | Female | 111 | 63.97 | 10.89 | 164 | 6.54 |
| | Male | 208 | 77.43 | 11.12 | 173 | 6.89 |
| Age(year) | 20-30 years | 39 | 64.48 | 12.07 | 166 | 8.42 |
| | 31-40 years | 148 | 71.79 | 12.68 | 170 | 8.07 |
| | 41-50 years | 95 | 75.30 | 11.69 | 171 | 8.13 |
| | 51 year and above | 37 | 78.70 | 11.80 | 171 | 5.59 |
| Marital Status | Married | 295 | 72.85 | 12.85 | 170 | 7.87 |
| | Single | 24 | 71.42 | 12.47 | 167 | 9.14 |
| Type of School | Primary | 170 | 71.67 | 13.48 | 169 | 8.47 |
| | Secondary | 149 | 73.97 | 11.80 | 171 | 7.30 |
| Branch | Science Teachers (Math, Physics etc.) | 90 | 73.50 | 12.89 | 171 | 8.66 |
| | Social Sciences Teachers (History etc.) | 142 | 71.95 | 12.35 | 169 | 7.60 |
| | Classroom Teachers | 47 | 77.34 | 12.15 | 170 | 6.19 |
| | Visual Arts, Technology-Design and Music Teachers (VATDMT) | 24 | 61.54 | 10.10 | 166 | 8.79 |
| | PE Teachers | 16 | 78.86 | 10.19 | 177 | 5.34 |

*Data Collection*
The International Physical Activity Questionnaire (IPAQ) was used in order to determine teachers' physical activity levels. The IPAQ was developed by an international group of physical activity assessment experts between 1997 and 1998 in short and long forms.

The IPAQ was designed in a way to determine adults' physical activity and inactivity conditions. The determination of individuals' physical activity levels is based on recalling the activities performed in the most recent seven days. The short form is administered to collect data via phone interviews. The validity and reliability studies of the IPAQ were carried out in 12 countries and 14 centres. The criteria validity was found to be r=0.33 for its long form and to be r=0.30 for the short form (Craig et al., 2003). The validity and reliability studies of this questionnaire in Turkey were conducted by Öztürk (2005) with the participation of 1097 (721 female and 376 male) voluntary university students between the ages of 18 and 32. The construct validity, concurrent validity, criteria validity and test-retest reliability of the long and short forms of the IPAQ were assessed. The IPAQ's short and long forms provide repeatable (r=0.69 for the short form, r=0.64 for the long form) and comparable data (r=0.66). Criteria validity was found to be r=0.30 in the short form and to be r=0.29 in the long form. IPAQ's Turkish versions are valid and reliable in determining physical activity level (Öztürk, 2005). In this study, the long form that was designed for face-to-face interviews was used. The questionnaire provides information about the time spent in sitting, walking, moderate and vigorous activities. In the evaluation of all physical activities, the criterion is that each activity must be done at least for 10 minutes each time (Craig et al., 2003). Individuals' MET min/week (kcal/kg/week), kcal/week, MET/hour scores can be calculated by using the IPAQ. Variables of frequency, duration and intensity are used in the calculation of these data. Frequency is the number of days a week the activity is done, duration is the time spent for each activity each time (hours or minutes) and intensity is the MET value spent to the activity per hour. MET is a measure regarding the amount of oxygen consumed per kilogram within a unit of time. One MET is equivalent to the amount of oxygen consumed during rest (around 3.5 ml/kg/minute) (Craig et al., 2003). The following formula is used in the calculation of MET min/week values: MET/week: Frequency of the activity x Duration of the activity x Intensity of the activity (Karaca and Turnagöl, 2007). MET values regarding the physical activity levels obtained are grouped under three categories: 1.High physical activity level >3000 MET-min/week, 2.Low physical activity level >600 – 3000 MET-min/week, 3.Inactivity <600 MET-min/week (Craig et al., 2003).

*Statistical Analysis*

The SPSS 16.0 statistical software was employed in the analysis of the data. The data were summarized by presenting mean and standard deviation values. Whether the data exhibit normal distribution or not was tested through One-Sample Kolmogorov-Smirnov test and the independent groups t-test and ANOVA were performed for those data that fit normal distribution. For the data that do not fit normal distribution, on the other hand, Mann Whitney U and Kruskal Wallis H tests were performed.

In order to determine the group that creates the difference, the Tukey test among multiple comparison tests was selected. Error performance in this study is $p < 0.05$.

## Results

Table 2. Normality test of BMI and MET values.

| Variables | n | Mean | SD | Z | P |
|---|---|---|---|---|---|
| BMI | 319 | 25.14 | 3.713 | 1.107 | 0.172 |
| Total (MET-min/week) | 319 | 4784.99 | 3815.345 | 2.721 | 0.000* |
| Vigorous (MET-min/week) | 319 | 1139.14 | 1984.439 | 5.054 | 0.000* |
| Moderate (MET-min/week) | 319 | 1185.45 | 1661.135 | 4.246 | 0.000* |
| Walking (MET-min/week) | 319 | 1353.00 | 1385.259 | 2.935 | 0.000* |
| Sitting (MET-min/week) | 319 | 714.39 | 359.562 | 2.236 | 0.000* |

*P<0.05

As Table 2 demonstrates, the BMI values of 319 participants fit normal distribution (P>0.05), however, the data regarding MET values do not exhibit normal distribution (P<0.05). Therefore, parametric tests were used for the data that fit normal distribution whereas nonparametric tests were used that do not.

Table 3. Percentage (%) and frequency distribution related to the participants' physical activity levels with respect to their total MET values.

| Physical Activity Levels | Female (n=111) | Male (n=208) | Total (n=319) | % |
|---|---|---|---|---|
| Inactive | 11 | 25 | 36 | 11 |
| Low | 47 | 90 | 137 | 43 |
| Adequate | 53 | 93 | 146 | 46 |

The total MET values of the participants presented in Table 3 suggest that 11% of them are inactive, 43% have low physical activity levels and 46% have adequate physical activity levels.

Table 4. The comparison of the participants' BMI and MET values with respect to their genders.

| | Gender | n | Mean | SD | t | P |
|---|---|---|---|---|---|---|
| BMI | Male | 208 | 25.87 | 3.48 | 5.027 | 0.000* |
| | Female | 111 | 23.76 | 3.75 | | |
| Total (MET-min/week) | Male | 208 | 4748.52 | 4147.01 | -0.233 | 0.816 |
| | Female | 111 | 4853.33 | 3116.48 | | |
| Vigorous (MET-min/week) | Male | 208 | 1217.43 | 2077.78 | 0.964 | 0.336 |
| | Female | 111 | 992.43 | 1796.37 | | |
| Moderate (MET-min/week) | Male | 208 | 872.34 | 1484.86 | -4.763 | 0.000* |
| | Female | 111 | 1772.17 | 1815.30 | | |
| Walking (MET-min/week) | Male | 208 | 1405.83 | 1529.91 | 0.932 | 0.352 |
| | Female | 111 | 1254.00 | 1061.94 | | |
| Sitting (MET-min/week) | Male | 208 | 739.86 | 367.21 | 1.737 | 0.083 |
| | Female | 111 | 666.68 | 341.28 | | |

*P<0.05

As Table 4 shows, there do not exist any significant differences between the participant female and male teachers' total MET values, their MET values regarding the time spent doing vigorous physical activity, their MET values regarding the time spent walking, and their MET values regarding the time spent sitting (P>0.05).

On the other hand, it is observed that male teachers' BMI values are significantly higher than those of female teachers. In the MET values regarding the time spent doing moderate physical activity, a statistically significant difference was found in the favour of female teachers (P<0.05).

Table 5. Comparison of the participants' BMI and MET values with respect to their ages

| BMI and MET values | | Sum of Squares | df | Mean Square | F | P |
|---|---|---|---|---|---|---|
| BMI | Between the groups | 302.16 | 3 | 100.72 | 7.774 | 0.000* |
| Total (MET-min/week) | Between the groups | 9715918.32 | 3 | 3238639.44 | 0.221 | 0.882 |
| Vigorous (MET-min/week) | Between the groups | 7413597.66 | 3 | 2471199.22 | 0.625 | 0.599 |
| Moderate (MET-min/week) | Between the groups | 1.344E7 | 3 | 4478857.90 | 1.633 | 0.182 |
| Walking (MET-min/week) | Between the groups | 1.386E7 | 3 | 4618683.08 | 2.440 | 0.064 |
| Sitting (MET-min/week) | Between the groups | 595364.15 | 3 | 198454.72 | 1.543 | 0.203 |

*P<0.05

Table 6. Multiple comparison of the participants' BMI values with respect to their ages

| (I) Age | (J) Age | Means (I-J) difference | SD | P |
|---|---|---|---|---|
| 20–30 years | 31–40 years | -1.714 | 0.648 | 0.009* |
| | 41–50 years | -2.681 | 0.685 | 0.000* |
| | 51 years and above | -3.560 | 0.826 | 0.000* |
| 31–40 years | 41–50 years | -0.966 | 0.473 | 0.042* |
| | 51 years and above | -1.846 | 0.662 | 0.006* |
| 41–50 years | 51 years and above | -0.880 | 0.698 | 0.208 |

*P<0.05

Table 5 suggests that there is not any statistically significant difference between the participants' MET values with respect to their ages (P>0.05). However, a statistically significant difference exists between the groups' BMI values with respect to their ages (P<0.05). As Table 6 demonstrates, the BMI values of participants aged between 20-30 years were found to be significantly lower than those of participants at other age groups. In addition, the BMI values of the participants aged between 31-40 years are significantly lower than those of the participants aged between 41-50 years and 51 years and above. The BMI values of participants aged between 41-50 years were found to be significantly higher than the BMI values of the participants aged between 20-30 years and 31-40 years. As the above Table 7 suggests, there do not exist any significant differences between the participant teachers' total MET values, their MET values regarding the time spent doing vigorous physical activity, their MET values regarding the time spent doing moderate physical activity, their MET values regarding the time spent walking, and their MET values regarding the time spent sitting with respect to their specialties (P>0.05).

Table 7. Comparison of the participants' MET values with respect to their specialties.

| | Branch | n | Mean | Chi-square | P |
|---|---|---|---|---|---|
| Total (MET-min/week) | Science Teachers (Math, Physics etc.) | 90 | 154.83 | 2.818 | 0.589 |
| | Social Sciences Teachers (History etc.) | 142 | 159.60 | | |
| | Classroom Teachers | 47 | 156.39 | | |
| | Visual Arts, Technology-Design and Music Teachers (VATDMT) | 24 | 189.52 | | |
| | PE Teachers | 16 | 159.00 | | |
| Vigorous (MET-min/week) | Science Teachers (Math, Physics etc.) | 90 | 152.13 | 3.109 | 0.540 |
| | Social Sciences Teachers (History etc.) | 142 | 157.45 | | |
| | Classroom Teachers | 47 | 170.64 | | |
| | (VATDMT) | 24 | 182.77 | | |
| | PE Teachers | 16 | 161.44 | | |
| Moderate (MET-min/week) | Science Teachers (Math, Physics etc.) | 90 | 150.26 | 6.115 | 0.191 |
| | Social Sciences Teachers (History etc.) | 142 | 166.65 | | |
| | Classroom Teachers | 47 | 150.78 | | |
| | (VATDMT) | 24 | 191.27 | | |
| | PE Teachers | 16 | 135.94 | | |
| Walking (MET-min/week) | Science Teachers (Math, Physics etc.) | 90 | 156.28 | 1.434 | 0.838 |
| | Social Sciences Teachers (History etc.) | 142 | 158.16 | | |
| | Classroom Teachers | 47 | 174.45 | | |
| | (VATDMT) | 24 | 155.15 | | |
| | PE Teachers | 16 | 162.06 | | |
| Sitting (MET-min/week) | Science Teachers (Math, Physics etc.) | 90 | 167.27 | 4.730 | 0.316 |
| | Social Sciences Teachers (History etc.) | 142 | 154.72 | | |
| | Classroom Teachers | 47 | 145.55 | | |
| | (VATDMT) | 24 | 189.83 | | |
| | PE Teachers | 16 | 163.69 | | |

*P<0.05

Table 8. Multiple comparison of the participants' BMI values with respect to their specialties

| (I) Branch | (J) Branch | Means difference (I-J) | Std. dev. | P |
|---|---|---|---|---|
| Science Teachers (Math, Physics etc.) | Social Sciences Teachers (History etc.) | -.125 | .486 | 0.797 |
| | Classroom Teachers | -1.648 | .649 | 0.012* |
| | (VATDMT) | 2.727 | .828 | 0.001* |
| | PE Teachers | -.153 | .978 | 0.876 |
| Social Sciences Teachers (History etc.) | Classroom Teachers | -1.522 | .606 | 0.013* |
| | (VATDMT) | 2.852 | .795 | 0.000* |
| | PE Teachers | -.028 | .950 | 0.977 |
| Classroom Teachers | (VATDMT) | 4.375 | .904 | 0.000* |
| | PE Teachers | 1.495 | 1.043 | 0.153 |
| (VATDMT) | PE Teachers | -2.880 | 1.163 | 0.014* |

*P<0.05

It is seen in Table 8 that the BMI values of visual arts, technology design and music teachers are significantly lower than the BMI values of teachers of quantitative courses, teachers of verbal courses, classroom teachers and physical education teachers. It is also seen that the BMI values of classroom teachers are significantly higher than those of teachers with other specialties.

**Discussion and conclusion**

In this study which was carried out to assess the physical activity levels of teachers employed in elementary and high schools located in the city center of Konya, it was concluded according to teachers' MET values that 11% of them are inactive and 43% of them have low physical activity levels. These two values suggest that teachers' physical activity levels are not adequate for a healthy daily life. This finding is in parallel with the findings of the study carried out by Gürel et al. with elementary school teachers in 15 different cities.

Gürel et al. (2004) found the percentage of teachers with inadequate physical activity levels to be 77.9%. Şanlı (2008), in the study carried out with 286 teachers with different specialties, concluded that the physical activity levels of only 19% were adequate to maintain good health. Arabacı and Çankaya (2007), in their study on 250 physical education teachers, found the mean physical activity duration to be 1380.16 min/week and underlined the inadequacy of physical education teachers' physical activity levels. They also concluded that inactivity was common among physical education teachers. Arslan et al. (2003), in their study conducted with 232 professors aged between 26 and 64 in order to investigate the relationship between university professors' physical activity levels and their health problems, determined that the professors' rates of participating physical activities were very low and their physical activity habits were inadequate.

As indicated above, the findings of this study are in parallel with the findings of studies carried out with educators in Turkey. Similarly, the findings of the current study are supported by the findings obtained from studies conducted to determine the physical activity levels of individuals' employed in other sectors as well as those of students attending elementary and high schools. For example, Karataş et al. (2002), in their study conducted with 367 participants employed in banks in the city center of Malatya, determined that 42.5% (156 individuals) of the participants had not participated in any physical activity within the last month. In the study conducted by Vaizoğlu et al. (2004) with the aim of determining first-grade high school students' physical activity levels, on the other hand, the mean weekly MET value that students consume by doing physical activity was found to be 47.32 ± 6.808.

The same research suggested that 35.7% of girls and 16.2% of boys are sedentary and underlined the inadequacy of the participants' physical activity levels. These findings present examples from different sections of the Turkish society. Observing the inadequacy of physical activity levels of teachers, who constitute one of the most enlightened segments of the society, among other professional groups and among students is upsetting but unsurprising.

On the other hand, Sokolowski, et al. (2010), in their study carried out using the IPAQ's short form with randomly selected 100 female students enrolled in the Physical Education Department of Eugeniusz Piasecki University in Poland, obtained high levels of MET values in most of the participant students. They concluded that the participants' physical activity levels are high and adequate. The findings of the study do not point to a statistically significant difference between the teachers' MET values ($P>0.05$). Karaca et al. (2009), in the study they conducted with 1027 volunteered university students to determine physical activity levels, determined that females concentrate on walking whereas males allocate more time to vigorous physical activities than females do. It was concluded in this study that the BMI values of the participant male teachers were significantly higher than those of female teachers ($P<0.05$). However, the MET values related to the time spent by female teachers by doing moderate physical activity were found to be significantly higher than the values regarding the males ($P<0.05$).

It could be thought that the above finding arises from the fact that female teachers are occupied with doing domestic work that require moderate physical activity such as sweeping the ground, wiping windows and washing dishes. Akandere et al. (2008), in their study aimed at determining the physical activity levels of Kick-Box trainers, found that the time spent at home and at work differs with respect to gender and that females spend less time at the workplace. In a similar fashion, Karaca et al. (2009) determined that women spend more time than men do in doing housework and without sitting. No significant difference was found between the participant teachers' MET values with respect to their ages ($P>0.05$). However, it was observed that the BMI values of the participants aged between 20-30 years are significantly lower than those of participants aged 30 and above. These data might suggest that BMI values rise and physical activity declines as the age increases. Yasunaga et al. (2008), in their study conducted with 41 male and 54 female participants aged between 65-83 years in order to determine the interactions between the physical activity habits of Japanese people with respect to the variables of age, gender and season, used pedometer. Whereas they found that physical activity and number of steps of women are inversely proportional to age <3 MET, physical activity and number of steps were found in males to be directly proportional to age >3 MET. This finding supports the findings of this study related to females, while it contrasts with the findings of this study with respect to males. In the comparison in terms of the types of institutions where the teachers are employed, it was observed that the MET values regarding the vigorous physical activity levels of elementary school teachers are significantly higher than the MET values regarding the vigorous physical activity levels of high school teachers.

In addition, the MET values related to the time spent by elementary school teachers while sitting were found to be significantly lower than those related to the time spent by high school teachers while sitting. It is thought that this situation might have arisen from the difference in the education of different age groups in the types of schools where the teachers were employed. It was observed in the study that the BMI values of visual arts, technology design and music teachers are significantly lower than those of teachers with other specialties, and that the BMI values of classroom teachers are significantly higher than those of teachers with other specialties.

In conclusion, as it could be understood from the findings of the current study as well as from the findings of similar studies carried out earlier, the physical activity levels of teachers in Turkey are inadequate. Especially classroom teachers employed in elementary schools display a highly negative situation in terms of their MET and BMI values. It is of importance for teachers, who raise future generations, to understand the importance of physical activity in terms not only of their personal health and their own professional performance but also of their capability as role models to raise the awareness of their students about physical activity.

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## RAZINE TJELESNE AKTIVNOSTI UČITELJA UZ UVAŽAVANJE VIŠE VARIJABLI (ISTRAŽIVANJE IZ TURSKE)


### Sažetak

*Svrha ovog istraživanja je bila procjena tjelesne aktivnosti učitelja u Turskoj, uz istraživanje i generalizaciju rezultata provedenog u Konya-i koji je jedan od najvećih gradova u Turskoj. Istraživanje je provedeno na uzorku od 319 učitelja različitih specijalnosti zaposlenih u školama u centru grada Konya. Korišten je međunarodni upitnik o tjelesnoj aktivnosti (dugi oblik) (IPAQ) za procjenu razine tjelesne aktivnosti učitelja. Zaključno je utvrđeno, sukladno ukupnoj vrijednosti jedinica metaboličke potrošnje (MET) da je 11 % učitelja neaktivno, 43 % ima nisku razinu tjelesne aktivnosti a 46 % ima odgovarajuću razinu. S druge strane, uvažavajući vrijeme provedeno u umjerenim tjelesnim aktivnostima, u MET vrijednostima je pronađena statistički značajna razlika u korist učitelja ženskog spola.*


***Ključne riječi:*** *učitelj, tjelesna aktivnost, metaboličke jedinice*

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# MORPHOLOGICAL CHARACTERISTICS AND PHYSIOLOGICAL PROFILE OF THE CROATIAN MALE TENNIS PLAYERS

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*Original scientific paper*

***Abstract***

*The sample of twenty adult (senior) male tennis players (ten ranked on the ATP ranking list and ten ranked among the first 25 players on Croatian national ranking list), where measured by 23 morphology anthropometric measures and 11 measures assessing work capacities (functional abilities) of the tennis players. The collected data were processed by the software package SPSS for Windows, ver 18.0. Body height of the subjects ranged between 173.60 and 199.50 cm with the average of 184.42±7.14 cm, whereas their body mass ranged between 64.90 and 89.00 kg, with the average of 77.60±7.26 kg. The percentage of fat tissue varied between 6.65 and 21.77 % with the average value of 9.20±3.91%. In comparison with results of top-level tennis players (top 100 ATP), who are tall on average 183.5 cm and heavy 80.5 kilograms on average, reveals that the current study subjects are, on average, somewhat taller, but also a little bit lighter than the top professional players. In the research observed tennis players had a somewhat lower values of aerobic capacity in comparison to the professional tennis players. For the desired transition into a higher rank of competition the better physical condition is recommended since it would enable a higher rate of more quality regeneration between points, matches and tournaments, resulting in higher performance consistency in professional tennis.*

***Key words:*** *morphology, physiology, tennis, profile*

## Introduction

Attractiveness and popularity of tennis, as well as numerous changes in the rules of the game and the way in which the game is played have made the game interesting for sports science and cognate scientific disciplines. It can be said that tennis has been well supported by ever more quality and informative scientific research studies over the last decade. Advances in tennis equipment technology and in sports preparation technology of tennis players have caused certain changes in tennis techniques, strength, power and accuracy of shot performance. It further has caused better utilization of space-time component of the game. Numerous research studies (Morante, 2006; Kovacs, 2006; Fernandez, 2006; Weber, 2007) have well documented acceleration of tennis play (the higher force generation the higher speed of the tennis ball flight; the higher spin generation on the ball the quicker bounce off of the ball).

That play acceleration has caused changes over the years in physical demands of top-level tennis. For example, huge advances in tennis serve, in performance of which players generate nowadays considerably greater force than ever before. A more powerful, controlling start of a point relay (and a higher percentage of aces and winners) enables the server to enhance his/her space-time pressure upon his/her opponent and facilitates winning the point from the second or third shot. Further, a good start of a point relay can significantly facilitate winning the serve games. It also has a strong influence on self-assurance of the server in play.

Although the increased speed of the serve can be attributed to technology advances and to improvements in ever more detailed yet comprehensive sports preparation programming and implementation, a longitudinal research of Schönborn (2001) indicates there is another possible cause of speed enhancement: the constant trend of average body height increment in the top 100 players of the ATP ranking lists (Association of Tennis Professionals) – the association promotes men (senior, adult-age) professional tennis and organizes tennis tournaments for the profesional players at the world class level.). Therefore, it can be said that anthropometric dimensions of tennis players have also a kind of influence on the development and dynamics of the game.

Anthropological characteristics and physiological profile, that is, general physical condition should be monitored from the very beginning of engagement in sport because particular play styles of individual players are usually determined on the basis of their anthropometric, functional and psychological characteristics (Tiley, 2005; Filipčič, Filipčič & Leskošek, 2004; Schönborn, 2001). Constant monitoring of those parameters allows quality monitoring and prediction of physical and physiological development of a child, allowing further adequate training programming, directed to the desired style of play. In that way the development of play style can be developed in harmony with the anthropological and physiological capacities of the player in question.

Such an early specialization of players can contribute to higher play quality and to the acquisition of game-specific segments of play, due to which probabilities for successful performance at the high ranked tournaments become much higher. The aim of the paper was to determine morphological characteristics and work capacities (physiological profile) of the best Croatian male tennis players.

**Methods**

The sample of subjects included twenty adult (senior) male tennis players; ten ranked on the ATP ranking list and ten ranked among the first 25 players on the ranking list of the Croatian Tennis Association. The latter are active contestants in the Croatian Tennis First League, suggesting that they pertain to the similar quality level of tennis play. The number of domestic and international tennis tournaments played is the only crucial difference among them, which eventually determines their standings on the international ATP list, that is, on the ranking list of the Croatian Tennis Association. Chronological age and tennis playing experience of the subjects were determined first. The sample of variables consisted of 23 morphology anthropometric measures and 11 measures assessing work capacities (functional abilities) of the tennis players. Anthropometric variables were measured in line with the IBP (International Biological Program) procedures, and the variables assessing work capacities were obtained from the progressive load continuous all-out test on the treadmill with the constant inclination conducted in the Sports diagnostic Centre of the University of Zagreb, Faculty of Kinesiology, Croatia. The collected data were processed by the software package SPSS for Windows, ver 18.0. For each variable the central and dispersion parameters were computed: arithmetic mean (Mean), standard deviation (SD), minimum (Min) and maximum (Max) values.

**Results**

Table 1. Descriptive statistic parameters on age and playing experience of the tennis players

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Age | 21.45 | 3.45 | 18 | 30 |
| Experience | 13.85 | 4.14 | 8 | 24 |

Average age of the tennis players was 21.45±3.45 years and their average tennis playing experience was 13.85±4.14 years. It can be concluded that these players started their sports career early in their childhood. Body height of the subjects ranged between 173.60 and 199.50 cm with the average of 184.42±7.14 cm, whereas their body mass ranged between 64.90 and 89.00 kg, with the average of 77.60±7.26 kg. The percentage of fat tissue varied between 6.65 and 21.77 % with the average value of 9.20±3.91%. Forced vital capacity in the examined tennis players ranged from 4.88 to 7.13 L, with the average of 5.93±0.62 L.

By means of testing the dynamic forced expiration volume in the first second of expiration the Tiffennaou's index was computed (84.14±4.28%), which was satisfactory for all the subjects on average. The subjects achieved maximal speeds from 15 to 20 km/h in progressive test, with the average maximal speed of 17.7±1.19 km/h.

Table 2. Descriptive statistical parameters of morphological characteristics of the examined tennis players

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Body height | 184.42 | 7.15 | 173.60 | 199.50 |
| Body mass | 77.60 | 7.26 | 64.90 | 89.00 |
| % fat | 9.90 | 3.37 | 6.65 | 21.77 |
| Elbow diameter L | 7.07 | 0.48 | 6.00 | 8.00 |
| Elbow diameter R | 7.20 | 0.48 | 5.80 | 7.80 |
| Knee diameter L | 9.73 | 0.53 | 8.30 | 10.60 |
| Knee diameter R | 9.80 | 0.49 | 8.80 | 10.50 |
| Upper arm circumference L | 29.11 | 2.16 | 26.00 | 34.00 |
| Upper arm circumference R | 30.08 | 2.33 | 27.00 | 36.00 |
| Flexed upper arm circ. L | 31.40 | 2.40 | 28.00 | 36.30 |
| Flexed upper arm circ. R | 32.69 | 2.33 | 29.20 | 37.80 |
| Forearm circumference L | 26.56 | 1.15 | 25.20 | 29.00 |
| Forearm circumference R | 28.45 | 1.56 | 25.50 | 31.50 |
| Thigh circumference L | 57.75 | 2.70 | 52.70 | 62.00 |
| Thigh circumference R | 57.60 | 2.79 | 52.90 | 61.90 |
| Calf circumference L | 37.47 | 2.09 | 33.30 | 42.70 |
| Calf circumference R | 37.63 | 1.99 | 33.90 | 42.80 |
| Triceps skinfold | 9.68 | 3.09 | 5.10 | 17.80 |
| Subscapular skinfold | 9.77 | 3.18 | 7.50 | 22.60 |
| Chest skinfold | 7.39 | 3.31 | 4.60 | 18.00 |
| Abdominal skinfold | 12.27 | 5.76 | 7.40 | 30.40 |
| Calf skinfold | 7.40 | 2.85 | 3.70 | 14.60 |
| Biceps skinfold | 4.60 | 1.46 | 3.20 | 9.60 |

Table 3. Descriptive statistical parameters of working capacities of the investigated tennis players (arithmetic mean – Mean, standard deviation – SD, minimum and maximum values)

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| FVC (L) | 5.93 | 0.62 | 4.88 | 7.13 |
| TIFF (%) | 84.14 | 4.28 | 74.50 | 93.30 |
| V_MAX (km/h) | 17.70 | 1.19 | 15 | 20 |
| V_ANT (km/h) | 13.20 | 1.13 | 10 | 15 |
| $VO_2$max (l/min) | 4.17 | 0.51 | 3.25 | 5.02 |
| $VO_2$max rel (ml/kg/min) | 53.66 | 5.74 | 40.20 | 63.80 |
| rel$VO_2$ANT (ml/kg/min) | 46.55 | 4.85 | 35.15 | 54.21 |
| HRmax (bpm) | 192.95 | 7.30 | 180 | 208 |
| $HR_{ANT}$ (bpm) | 173.85 | 9.21 | 151 | 189 |
| %VO2max at ANT | 86.87 | 4.34 | 79.74 | 97.19 |
| %HRmax at ANT | 90.09 | 3.21 | 83.42 | 96.41 |

VC – vital capacity; Tiff – Tiffeneaou's index; V_MAX – maximum speed of the tread mill; V_ANT – speed of the tread mill at the anaerobic threshold; $VO_{2max}$ – maximum oxygen uptake; $VO_{2max}$ rel – relative maximum oxygen uptake; rel$VO_2$ANP – relative oxygen uptake at the anaerobic threshold; HRmax – maximum heart rate; $HR_{ANT}$ – heart rate at the anaerobic threshold; %$VO_{2max}$ at ANT – oxygen uptake at the anaerobic threshold expressed as the percentage of the maximum oxygen uptake; %HRmax at ANP – heart rate at the anaerobic threshold expressed as the percentage of the maximum heart rate.

Maximum oxygen uptake varied across the sample of subjects from 3.25 to 5.02 L/min, with the average of 4.17 L/min, whereas the obtained parameters for relative maximum oxygen uptake ranged between 40.20-63.80 ml/kg/min, with the average of 53.66±5.74 ml/kg/min. The subjects were crossing the anaerobic threshold within the range of 79.74 do 97.19 %, that is, on average at 86.87±4.34 % of the maximum oxygen uptake, which indicated the aerobic character of their physical fitness.

**Discussion**

The obtained parameters of morphological characteristics indicate certain specificities in the morphology status of the top Croatian male players. The average body height of the subjects was 184.42±7.14 cm, average body mass 77.60±7.26 kg, whereas the values of skin-folds were low as well as according to them assessed the average percentage of fat tissue (9.90±3.37%). When the results obtained in the current research are compared to the scores of the subjects from the non-selected adult male population, then the following becomes obvious: the tennis players are higher and heavier (Mišigoj-Duraković et al., 1995), whereas they have smaller amount of fatty tissue than the non-selected counterparts. Such a result was expected due to active involvement of the tennis players in regular strenuous physical activity, thus indicating that the greater body mass was related to the greater muscular mass. On the other hand, the comparison of the obtained results with the scores of the world top-level tennis players (top 100 ATP), who are tall on average 183.5 cm and heavy 80.5 kilograms on average (www.atptennis.com, October 22, 2007), reveals that the current study subjects are, on average, somewhat taller, but also a little bit lighter than the top professional players. Pronounced body height may be advantageous in tennis, therefore, it is considered as being one of the important morphological characteristics (Filipčič, Filipčič & Leskošek, 2004), especially when playing on fast-paced court surfaces. Previous studies indicated significant contribution of body height above 180 cm to powerful serves, faster than 200 km/h (Zmajić, 2003). The mentioned was also confirmed by the research by Schönborn (2001) where the author mentioned that one of the important factors of serve acceleration was a constant increment of average body height in the players ranked first 100 on the ATP list over the last decade. Pronounced longitudinal dimensionality of tennis players allows higher impact point (impact point between the racket and the ball) when serving, resulting in positive influence on not only speed of the ball served, but also on accuracy and more beneficial performance angle of the starting shot (Schönborn, 2001; Filipčič, Filipčič & Leskošek, 2004). It also facilitates performance of forehand, backhand, volley i smash shots at a higher impact point and provides a player with the better reach possibilities to catch remote balls (Filipčič, Filipčič & Leskošek, 2004), being especially beneficial when covering space during the on net play.

The mentioned contributes very often to the aggressive style of play accompanied usually with frequent approaches to the net. As opposed to the tall players, the players with the less pronounced body height move faster across the court, their agility is better (due to the lower centre of gravity), and because they approach the net less frequently then the tall players, they have a wider repertoire of the base line shots. Due to their style of play (either the offensive, defensive, or versatile style of play at the base line), they usually have better aerobic condition, their endurance is higher, and therefore, they do not get tired easily during longer point relays. The obtained elbow and knee diameter and circumference values of the tennis players are higher than the same average values in the non-selected population (Mišigoj-Duraković et al., 1995). If their lower percentage of fatty tissue is taken into account, then all indicates they have bigger muscular mass. Muscular mass in tennis players is highly developed. However, the obtained differences between the dominant and non-dominant body sides in elbow diameter values and in circumference values of the upper arm, both extended and flexed, and forearm circumference values indicate specific nature of lawn tennis in which the upper extremity of the dominant body side is more developed. The dominant arm in tennis players may have up to 20% bigger circumference values than the non-dominant arm (Kannus et al., 1994). The mentioned suggests that long-lasting tennis training stimuli have a considerable influence on the increments in circumference and diameter values of the dominant upper extremity (Köning et al., 2001), but it also accentuates importance of compensation exercises for body muscular balance attainment and maintenance. Namely, muscular balance is of outmost importance to injury prevention, but also to the continuity in competition appearances and to the prolongation of sports career (Lees, 2003). Tennis training and competition position players in specific space-time relations (conditions), determined by the rules of the game (for example: length, shape and weigth of the racket, court length, quality and size of the tennis ball, the game rules related to the court surface, etc.), which characterize the tennis game.

Tennis is usually regarded as an anaerobic sport, with the prevailing glycolytic or glycogenolytic metabolic processes providing energy during a point relay. Previous analyses of loadings during a tennis match agree that average work intensity ranges between 60 and 70% of the maximum oxygen uptake. If time parameters of play are observed, it becomes obvious that players do not have enough time to recover completely between points. This lack of recovery time is even more detrimental to physical condition of players on the wider scale of the annual compact competition calendar of singles' tournaments and matches. Therefore, although the bioenergetic basis of tennis play is anareobic, good aerobic capacity is also indispensable to provide tennis players with high cardio-respiratory endurance, thus contributing to their consistent perforamnce and sport success.

Most research papers indicate tennis players have well developed aerobic capacity, which in professional players can range from 55 to 65 ml/kg/min (Kovacs, 2006). The subjects in the current research had somewhat lower average values (the result range 40.2-63.8 ml/kg/min), probably due to the part of the sample not being on the ATP ranking list; that finding undoubtedly indicates their lower quality despite their high ranking on the national list of players. A quality indicator of cardio-respiratory endurance is also a level at which the anaerobic threshold occurrs. In the observed sample this level was on average at 86.87±4.34 % of the maximum oxygen uptake, indicating their still good physical condition. The finding is extremely important because it suggests their quality ability to resist fatigue and quite an acceptable rate of regeneration processes in their metabolisms, allowing the players for good performance in professional tennis.

**Conclusion**

The developmental level of particular morphological characteristics (body height, muscular mass of the upper extremity of the dominant body side and muscular mass of the lower extremities) can contribute to a more powerful shot performance in a game, to a fewer number of relays in a point and to its shorter duration. Although many authors (Filipčič, Filipčič & Leskošek, 2004; Schönborn, 2001; Zmajić, 2003, Tiley, 2005) have stated that body height and weight and other morphological characteristics (except fatty tissue, perhaps) do not limit performance, they still have influence on style of play, players' attitude towards sports training, tactics selection and strategy of individual play.

Based on the already mentioned, one can conclude that the observed subjects should pertain, according to their measured morphological characteristics, to the population of tennis players whose style of play is characterized by powerful serves and by the tendency to play more aggressively. In the research observed tennis players had a somewhat lower values of aerobic capacity in comparison to the professional tennis players.

In spite of that a bit poorer result, a still enough quality parameter of cardio-respiratory endurance of the measured players was obtained; it was the level of oxygen uptake at the anaerobic threshold. In the sample of the measured subjects the level was on average 86.87±4.34 % of the maximum oxygen uptake. Based on the obtained results it can be said that the physiological profiles (functional abilities) of the observed tennis players resemble physiological profiles obtained in previous research with tennis players of similar age, ranking and playing experience (Bergeron et al., 1991; Cristmass et al.,1993; Smekal et al., 2003; Reilly & Palmer, 1993; Girard & Millet, 2003; Kovacs, 2006; Fernandez, 2006; Weber, 2007). The already mentioned confirms adequate physical condition of the examined tennis players, that is, transformational effects induced by the perennial engagement in tennis training and competition. However, for the desired transition into a higher rank of competition the better physical condition is recommended since it would enable a higher rate of more quality regeneration between points, matches and tournaments, resulting in higher performance consistency in professional tennis.

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## MORFOLOŠKE ZNAČAJKE I FIZIOLOŠKI PROFIL HRVATSKIH MUŠKIH TENISAČA

### Sažetak

*Uzorak ispitanika sastavljen od dvadeset tenisača seniorskog uzrasta (deset rangiranih na ATP ljestvici i deset rangiranih do 25 mjesta na listi Hrvatskog teniskog saveza), izmjeren je s 23 morfološke antropometrijske mjere te 11 varijabli za procjenu funkcionalnih sposobnosti. Obrada podataka je obavljena programskim paketom SPSS for Windows, ver 18,0. Rezultati prikazuju kako se tjelesna visina izmjerenih ispitanika kreće između 173,60 i 199,50 cm s prosjekom od 184,42± 7,14 cm, dok se tjelesna masa kretala između 64,90 i 89,00 kg, a prosječno iznosi 77,60± 7,26 kg. Postotak masnog tkiva varira između 6,65 i 21,77 % uz prosječnu vrijednost od 9,20± 3,91%. Usporede li se dobiveni rezultati s rezultatima vrhunskih svjetskih tenisača (top 100 ATP) koji su u prosjeku visoki 183,5 cm, te prosječne mase 80,5 kilograma, može se zamijetiti kako su ispitanici ove studije u prosjeku nešto viši te nešto manje tjelesne mase u odnosu na vrhunske tenisače. Istraživanjem je također utvrđeno kako naši tenisači bilježe nešto niže vrijednosti aerobnog kapaciteta u odnosu na profesionalne igrače. Za prijelazak u nešto bolji rang natjecanja, preporuča se svakako bolja funkcionalna spremnost tenisača, budući ista omogućava kvalitetniju mogućnost regeneracijskih procesa između poena, mečeva i turnira, što svakako može doprinijeti većoj konzistentnosti i uspjehu u profesionalnom tenisu.*

***Ključne riječi:*** *morfologija, fiziologija, tenis, profil*

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# SITUATIONAL SUCCESS IN 100-M BACKSTROKE EVENT AT THE 2004 AND 2008 EUROPEAN SWIMMING CHAMPIONSHIPS

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*Original scientific paper*

***Abstract***
*Research involved 9 female swimmers who competed at the 2004 and 2008 European Swimming Championships in the 100m backstroke event. Situational success of female swimmers was measured through overall swim-time, start time (15 m), lap times per 25 meter sections, swimming speed, turn times (7.5 m), stroke frequency, stroke length and finish phase (5 m) were also calculated. The results show statistically significant progress in overall time which was mostly accomplished based on shorter start and turn times. Also, progress in the anaerobic capabilities of four years older female swimmers is notable, indicated by smaller variations in swimming speed in the second half of the section, whereas said differences are not statistically significant for the given model. It is to be assumed that an important role in such start and turn results were played by the new swimsuits that have proven to be most efficient while sliding through water.*

***Key words****: swimming, situational success, backstroke, European Championship*

## Introduction

The goal of top swimmers at European Championships (EC), World Championships (WC), and the Olympic Games (OG) is to attain the highest possible placement or result The time required to swim an individual section consists of many segments that add up to a result itself. By analyzing the race through spatial and temporal parameters, one is able to obtain a complete insight into the swimmer's tactics, swimming technique and certain physiological parameters of the swimmer.

Based on relevant data, the coach obtains an analysis of the race itself, whereby in the next race or during the following period he strives to bring the swimmer closer to the operational technique model as much as possible (Volčanšek, 2002). The dynamics of these characteristics during competitive swimming was the subject of numerous investigations (Haljand, 2004; Lipsky & Abramov, 1988; Wakayoshi, Nomura, takahashi, Mutoh, & Miyashito, 1992; Wirtz, Wilkie, & Zimmermann, 1992; Arellano, Brown, Cappaert, & Nelson, 1994; Pyne & Trewin, 2001).

At all swimming contests organized by FINA (International Swimming Federation) and LEN (European Swimming League), swimming races are being recorded by cameras since 1991, with individual parameters being analyzed. Said program was implemented by Rein Haljand, Ph.D., professor of Kinesiology and a member of LEN, all with a view of discovering when, why and how some swimmers are faster than others. Naturally, when comparing all the parameters, swimmer's anthropometric characteristics, race tactics and a certain period during multiannual preparations of a swimmer play a significant role. The official results were provided by Omega measurement equipment.

## Problem and aim

In order to determine differences of situational success in an individual swimming race, it is necessary to analyze the same swimmers on the same section during approximately the same period of annual preparations. It would be desirable for those swimmers to have almost the same level of quality and be of age at which the intense growth and development has finished. Furthermore, it would be recommendable for the time period between the monitored contests to be long enough for differences to be determinable. In such a situation potential changes in racing results will be recorded, as well as differences of individual race parameters. This paper will analyze race results of women's 100 meters backstroke at the 2004 EC in Madrid and the 2008 EC in Eindhoven. Those contests hosted 9 same swimmers in semifinal and final races. The EC's were held during Olympic years which guaranteed a maximum level of preparedness in swimmers. The goal of this paper is to determine the difference in situational success indicators influencing the final race result in 100m backstroke, between the European Championship held in 2004 and the one held in 2008.

## Materials and Methods

The subject sample consisted of nine equivalent top swimmers who appeared in the semifinals and finals of the European Championships in a 50 meter pool, i.e. in 2004 in Madrid and in 2008 in Eindhoven, in 100 m backstroke. At those two temporal milestones (EC 2004 and 2008), 17 variables were measured in 100 m backstroke for women in a 50 meter pool. Result in 100 m backstroke: the time, in seconds, that the swimmers required to swim 100 m from the sound starting signal until touching the touch pad electronically recording the result; Start time 15 m:

time, in seconds, from the sound starting signal until the swimmer's head passed through the 15m markup; Lap time 25 m: time, in seconds, from the sound starting signal up to the 25 m distance; Lap time 75 m: time, in seconds, from the sound starting signal up to the 75 m distance, including the flip turn the swimmers perform after swimming a 50 meter length; Swim speed first 25 m: swimming speed during the initial 25 meters in meters per second; Swim speed second 25 m: swimming speed during the second 25 meters, i.e. speed between 25 m and 50 m, in meters per second; Swim speed third 25 m: swimming speed during the third 25 meters, i.e. speed between 50 m and 75 m, in meters per second; Swim speed last 25 m: swimming speed during the last 25 meters, i.e. speed between 75 m and the finish line, in meters per second; Frequency first 50 m: stroke frequency during the initial 50 m, in the number of strokes per minute; Frequency second 50 m: stroke frequency during the second 50 m, i.e. stroke frequency between 50 m and 100 m, in the number of strokes per minute; Stroke length first 50 m: stroke length during the initial 50 meters in meters; Stroke length second 50 m: stroke length during the second 50 meters in meters; Turn time 15 m: turn time in seconds which is calculated 7,5 m before a turn, i.e. prior to the time swimmer's feet touch the pool wall, and 7,5 m after the turn, i.e. after the swimmer pushes against the pool wall with one's feet and dives or swims for 7,5 m; Finishing time last 5 m: time, in seconds, the swimmers required to swim the final 5 m. Finish time was defined as the time that it took for the swimmer's head to pass under the flags (5m from the wall) until the swimmer's hands touched the wall at the end of the race; Average swimming speed: average swimming speed at 100 m backstroke, in meters per second; Average frequency: average stroke frequency at 100 m backstroke, i.e. the number of strokes per minute;Average stroke length: average stroke length at 100 m backstroke, in meters. In order to process and analyze data, a statistical program SPSS for Windows was used. All data was obtained in a form of an official record of the EC. Data recorded under water were processed by Rein Hallyand, a professor of Kinesiology from Estonia.

## Results

Basic descriptive parameters were calculated and thereafter a t-test for dependent samples was used, with a level of significance of $p<0.05$. By comparing the results in 100 meters backstroke of the equivalent 9 female swimmers at the 2004 and 2008 EC's, one is able to determine that a statistically significant ($p<0.05$) progress in results arose, for 1.55 seconds (Table 1). By analyzing individual parameters, statistically significant differences appear in start times, lap times at 25 and 75 meters, as well as in turn times. Swim speed in 2008 is the same or faster per 25 meter sections, but does not show statistically significant differences ($p<0.05$) for the observed sample.

The difference is highest at the third 25 meter distance when, in 2004, a decrease in swimming speed occurred in relation to the second 25 meter distance (0.06 m/s), while in 2008 speed almost remained constant. By comparing average swimming speeds, stroke frequencies and stroke lengths, we are able to determine that no statistically significant difference exists ($p<0.05$). A relatively large difference in overall time is based on differences in start times and turn times.

Table 1 Arithmetic means, standard deviations and t-test significance in comparing results at individual variables in 2004 and 2008

| Variable | AS ± | t- test |
|---|---|---|
| Result 04 | 62.90 ± | |
| Result 08 | 61.35 ± | **.001** |
| Start time 15m 04 | 8.30 ± | |
| Start time 15m 08 | 7.72 ± | **.001** |
| Lap time 25 m 04 | 14.42 ± | |
| Lap time 25 m 08 | 13.89 ± | **.004** |
| Lap time 75 m 04 | 46.03 ± | |
| Lap time 75 m 08 | 44.81 ± | **.003** |
| Swim speed first 25 m 04 | 1.63 ± | |
| Swim speed first 25 m 08 | 1.62 ± | .261 |
| Swim speed second 25 m 04 | 1.57 ± | |
| Swim speed second 25 m 08 | 1.57 ± | .637 |
| Swim speed third 25 m 04 | 1.50 ± | |
| Swim speed third 25 m 08 | 1.56 ± | .011 |
| Swim speed last 25 m 04 | 1.46 ± | |
| Swim speed last 25 m 08 | 1.48 ± | .069 |
| Frequency first 50 m 04 | 47.33 ± | |
| Frequency first 50 m 08 | 47.66 ± | .831 |
| Frequency second 50 m 04 | 45.44 ± | |
| Frequency second 50 m 08 | 45.77 ± | .674 |
| Stroke length first 50 m 04 | 2.01 ± | |
| Stroke length first 50 m 08 | 1.99 ± | .738 |
| Stroke length second 50 m 04 | 1.94 ± | |
| Stroke length second 50 m 08 | 1.96 ± | .744 |
| Turn time 15m 04 | 8.95 ± | |
| Turn time 15m 08 | 8.62 ± | **.004** |
| Finishing time last 5m 04 | 3.17 ± | |
| Finishing time last 5m 08 | 3.11 ± | .198 |
| Av. Swimming speed 04 | 1.54 ± | |
| Av. Swimming speed 08 | 1.56 ± | .018 |
| Av. Frequency 04 | 46.11 ± | |
| Av. Frequency 08 | 46.55 ± | .673 |
| Av. Stroke length 04 | 1.98 ± | |
| Av. Stroke length 08 | 1.97 ± | .917 |

## Discussion

An evident improvement of results achieved at the European Championship by the same group of swimmers at 100 m backstroke can primarily be attributed to an overall longer training process, a training process adapted to a senior category in which, amongst other things, attention is devoted to strength and development of anaerobic capabilities, as well as the advanced technology of swimsuit manufacturing.

From the observed 9 swimmers who appeared at the 2004 EC, 6 were aged between 17 and 19. For those swimmers, 2004 was the year they entered senior competitions. In 2008, the swimmers increased their swim speed in the initial 15 meters, which requires great concentration and experience, as well as performance technique and speed, being largely correlated with strength. According to Seifert et al. (2006), swimming up to 15 meters implies start reaction time, airborne and water entry time, water glide time – underwater swimming and swim start time. Start time (15m) is a part of overall time, taking up a share of 0.8% up to 26.1%, depending upon the event and course (Cossor & Mason, 2001). Based on the backstroke start analysis, it is to be concluded that the overall start time consists of several segments, such as reaction time to the sound signal, take-off time, airborne time, water entry and glide time, underwater leg movement time and exit and swim start time. Analysis used does not provide temporal parameters for each of these segments, thereby making it difficult to say whether such an advantage was realized in 2008 based on only some of them. Race analysis has shown convincingly that times spent in the turning and starting phases of swimming races are strongly related to swimming performance (Arellano et al., 1994; Mason & Cossor, 2000). Backstroke turn performance was significantly faster in 2008 as compared to 2004. The next most highly correlated variable with race performance was the turn time, which was significant in 92% of all events (Mason & Cossor, 2000). The same observation pertains to the backstroke flip turn. The most pronounced resistance decrease is noticeable in moments when swimmers are endeavoring to maintain an ideal body position in the glide phase during start and flip turns (Benjanuvatra, Dawson, & Blanksby, 2002; Tiozzo, Leko, & Ružić, 2009). Directly prior to the 2008 Eindhoven EC, manufacturers of Arena and Speedo swimsuits produced new models of Powerskin R-evolution and LZR Racer in which the majority of female swimmers competed. Stroke frequency and length, and thereby the backstroke swimming technique itself, did not change significantly. We suppose that the swimmers perfected their technique when they were juniors. According to Mason and Cossor (2000), it is a common perception of people within swimming circles that the single most important factor in a successful race is stroke length.

It is thought that a swimmer with a longer stroke length than another competitor is more likely to be successful in the event. However, the analysis of the 1999 Pan Pacific Swimming competition analysis indicated that this perception is incorrect with respect to top level international swimmers. One of the consequences were also better lap times at 25 m and 75 m. Although swimming speed on individual sections in 2004 and 2008 does not show a statistically significant difference ($p<0.05$), a different tactic is noticeable in swimming a 100 meter course.

Swimmers who were four years older swam the initial, as well as the second 25 meters at almost identical speed as in 2004, but did not allow for the swim speed to drop in the other half of the course as they did in 2004. It is evident that the swimmers were more prepared in the anaerobic sense, realizing most of the resulting difference during start and flip turns. It is to be supposed that they improved on all those elements during the four year period, i.e. between 2004 and 2008, but also that the new swimsuits have had an important impact on those time differences. According to Mason and Cossor (2000), the second half of the race was more strongly related to race performance than the first half of the distance races.

**Conclusion**

More experience at large swimming competitions, probably better anaerobic capabilities and improved swimsuit technology have contributed to the advancement of swimming results of the same group of swimmers at a 100 meters backstroke in 2008, compared to 2004. Better times at 100 meters backstroke in 2008 are mostly a result of better start and turn times. The reason why these segments have improved may be attributed to a refinement of the technique in which starts and turns are executed, said actions including underwater gliding and underwater leg movements where, according to some authors (Benjanuvatra et al., 2002; Tiozzo et al., 2009), new swimsuits contribute the most to improved results. Stroke frequency, stroke length and swimming speed have not significantly changed in 2008, compared to 2004. Fluctuations were recorded in swimming speed over the final 50m in 2008, but said differences do not show statistical significance at a level of $p<0.05$.

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## SITUACIJSKI USPJEH U DISCIPLINI 100-M LEĐNO NA EUROPSKIM PLIVAČKIM PRVENSTVIMA 2004 I 2008

### Sažetak

*Istraživanje je provedeno na 9 plivačica koje su nastupile na Europskim plivačkim prvenstvima 2004. i 2008. godine u disciplini 100 metara leđnom tehnikom. Situacijska uspješnost plivačica se mjerila kroz ukupno vrijeme plivanja, vrijeme starta (15 m), prolazna vremena po dionicama od 25 metara, brzini plivanja, vremenima okreta (7.5 m), frekvenciji zaveslaja, dužini zaveslaja i finišu (5 m). Rezultati ukazuju da postoji statistički značajni napredak u ukupnom vremenu koje je u najvećoj mjeri ostvareno na osnovu kraćeg vremena starta i okreta. Također, može se primijetiti napredak u anaerobnim sposobnostima četiri godine starijih plivačica koje se očituje manjim oscilacijama u brzini plivanja u drugoj polovici dionice, ali te razlike ne pokazuju statističku značajnost za promatrani uzorak. Pretpostavlja se da su veliku ulogu u takvim rezultatima starta i okreta imala nova plivačka odijela Speedo i Arena koja su se pokazala najefikasnija tijekom klizanja kroz vodu.*

***Ključne riječi:*** *plivanje, situacijska uspješnost, leđno, Europsko prvenstvo*

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# EFFECTS OF STRENGTH TRAINING ON AEROBIC AND ANAEROBIC POWER IN FEMALE SOCCER PLAYERS

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*Original scientific paper*

***Abstract***
*The purpose of this study was to determine the effects of a 12-week strength training programme on aerobic and anaerobic power in female soccer players. Twenty-four female soccer players (U-20) volunteered to participate in the study. The participants were tested with strength tests as well in aerobic and anaerobic power. 1RM bench press (BP), squat (SQ), leg extension (right leg – LER and left leg – LEL) and leg flexion (right leg curl – LCR and left leg curl – LCL) measured strength, while $VO_{2max}$ and 300y shuttle run test assessed aerobic and anaerobic power. A two-way ANOVA with repeated measures was used to determine pair wise effect. In addition post hoc procedure located difference between the means. Positive effects of strength training were determined in all tests. The largest effect was determined for the variable right leg curl (LCR) where the improvement was 10.7% as well as in the variable squat – 9.7%. After 12 weeks of strength training aerobic power of female soccer players has improved by 4.3% and anaerobic power by 2.8%. The data suggest that our 12-week strength training improved both the aerobic and the anaerobic power in female soccer players.*

***Key words****: female soccer players, aerobic power, anaerobic power*

## Introduction

The length of high intensity running during a soccer game in elite female players (0.71 – 1.71 km) is significantly different from that of male players (1.9 – 2.4 km) (Krustrup et al., 2001; Krustrup et al., 2005). On top of it all, gender differences can be seen in running performance or aerobic capacity ($VO_{2max}$). Female soccer players have lower $VO_{2max}$ (43.4 – 56.8 ml/kg/min) than male players (55 – 67 ml/kg/min). It is important to emphasize that male soccer players tend to have a better ratio of lean body mass and body fat than female players (25), which eventually affects the endurance of female players. Strength, power and endurance have proven to be of importance in soccer. Maximal strength is one of the basic qualities that influence power performance. The increase in maximal strength is usually connected with improvement in relative strength, and therefore, with the improvement of power abilities (Hoff et al., 2004). Female soccer players must not postpone strength training because it not only offers injury prevention (Yap et al., 2002), but it also improves aerobic endurance performance by means of improved work economy (Siegler et al., 2003; Hoff et al., 2002; Johnston et al., 1997). Moreover, it is reported that neuromuscular training reduces gender-related differences in force absorption, active joint stabilization, muscle imbalances and functional biomechanics (Myer et al., 2005; Gettman et al., 1981; Holloszy et al., 1976). Strength training, involving intermittent exercise of short duration using high resistance, results in muscle hypertrophy and increased strength (Komi et al., 1979; MacDougall et al., 1979) with little or no changes in $VO_{2max}$ (Hickson et al., 1980; Hirley et al., 1984).

Circuit weight training using lighter resistance, a higher number of repetitions per set, and shorter rest periods results in increases in $VO_{2max}$ of approximately 5 to 10 percent, and improvement in strength of 7 to 32 percent (Gettman et al., 1981). Hickson's (1980) research results showed that combined strength and endurance training compromised strength gains compared with strength training alone. It is apparent that endurance training may limit the ability to produce force (Dudley et al., 1985; Hickson, 1980) and explosive movement (Ono et al., 1981). Since metabolic and neuromuscular demands placed on skeletal muscle by endurance and strength training result in specific biochemical adaptation, it might be expected that both strength and endurance would be compromised by a combined training, especially in elite athletes. However, Hickson et al. (1988) showed that the addition of heavy resistance training to the training routines of well-trained cyclists and runners improved endurance performance. The studies (Dudley et al., 1985; Hickson, 1980) suggested that the compromise of the ability to produce force during high velocity movement is due to differences in the pattern or efficiency of motor unit recruitment during strength or endurance training. Strength training places a large amount of tension on muscle fibres. Endurance training does not result in higher tension development but stimulates oxidative metabolism to a greater extent. Therefore, these two types of training may activate to different degrees various anabolic or catabolic processes which are modulated by endocrine responses to exercise and training.

Past research indicates that muscular strength and anaerobic power may be important for increased running performance through neurological and muscular changes (Abernethy, 1994; Sale, 1988). These positive muscular adaptations may include increased anaerobic enzyme activity, increased force production, increased intramuscular glycogen, or shifts within major fibre type groups. Neural adaptations may include improved motor unit recruitment and synchronization, improved force development rate, and improvements in the stretch-shortening cycle. But, little is known about the influence of strength training on aerobic and anaerobic power particularly in female athletes. The purpose of this study was to determine the effects of strength training on aerobic and anaerobic power in female soccer players.

## Methods

*Experimental Approach to the Problem*

Female players underrun a twelve-week strength training programme. We hypothesized that, due to the nature of strength training and the interval type of sport such as soccer, both the aerobic and the anaerobic power performance in female soccer players would improve. The study was done done during pre-season. Start was in January (in Croatia there are two competition periods during the season, and the study was done during the second preparation period because it lasts from November to March). During the preparation period the subjects had 6 practice sessions per week, and each session lasted from 90 to 105 minutes. A friendly game was also played and during this game each player has played only one half, i.e. 45 minutes). Strength training was conducted in a gym three times a week, each practice lasting 90 minutes (a 30-minute warm up was followed by 40 minutes of strength training and the practice ended with 20 minutes of stretching exercises). Technical and tactical practice was done twice a week during the second preparation period, and intensity was set at 75% of $VO_{2max}$. The intensity of the technical and tactical practice was monitored using polar heart rate monitors (Polar S-610; Polar Electro, Kempele, Finland).

Table 1. Conditioning programme – the overview for pre-season training (a 12-week strength intervention)

| | Morning session (from 9-11 am) | Afternoon session (from 18-20 p.m.) |
|---|---|---|
| Monday | | strength-training |
| Thursday | technical-tactical training | |
| Wednesday | | strength-training |
| Thursdays | technical-tactical training | |
| Friday | | strength-training |
| Saturday | | friendly game |
| Sunday | day off rest | |

Table 2. Strength training distribution during 14 weeks

| Weeks | Number of sets | Number of repetitions | Intensity % |
|---|---|---|---|
| 1 | testing | | |
| 2 | 3 | 8 | 70 |
| 3 | 3 | 8 | 70 |
| 4 | 3 | 8 | 70 |
| 5 | 3 | 8 | 70 |
| 6 | 4 | 10 | 75 |
| 7 | 4 | 10 | 75 |
| 8 | 4 | 10 | 75 |
| 9 | 4 | 10 | 75 |
| 10 | 5 | 12 | 80 |
| 11 | 5 | 12 | 80 |
| 12 | 5 | 12 | 80 |
| 13 | 5 | 12 | 80 |
| 14 | testing | | |

All workouts were supervised both by a team coach and by a conditioning coach. The subjects were first tested in the 1RM bench press, squat, leg extension and leg flexion. After strength testing aerobic and anaerobic power was measured. The volume and the intensity of the training sessions were adjusted according to the training plan which was designed by applying the progressive overload principle. The main part of each training session consisted of strength exercises in the following order: sit-ups with legs up and with plate back extensions on the fit ball, bench press, squat, dead lift (Romanian), lat pull-down and shoulder press. The rest period between sets lasted 1 minute and between exercises 2 minutes. During the break the players performed technical drills. The intensity of training was determined as the percentage of one repetition maximum (1RM) for bench press (BP), squat (SQ), leg extension (LE) and leg curl (LC). Sit-ups and leg extensions were done in 60 seconds.

*Subjects*

Twenty-four elite female soccer players, members of a first league team, volunteered to participate in the study. Twelve subjects were also members of the Croatian national team. All participants have signed a written consent after they were fully informed about all experimental procedures. The protocol of the study was approved by the Ethical Committee of the Faculty of Kinesiology, University of Zagreb, according to the revised Declaration of Helsinki. The sample comprised 5 defenders, 12 midfield players, 4 forwards and 3 goalkeepers. All players had more than 3 years of playing experience in the First Croatian League (Table 3).

*Procedures*

The initial testing took place in January, one week before the beginning of the experimental strength programme, while the final testing was done after 12 weeks of strength training programme intervention. To prevent unnecessary fatigue accumulation, the players and coaches were instructed to avoid intense exercise for a 24-hour period before each testing session. Also, before each testing the subjects performed a standard 25-minute warm-up. During the testing procedure air temperature ranged from 22°C to 25°C. The testing always began at 10 a.m. and finished by 1 p.m. All tests were performed indoors. Before the 1RM test, all participants followed a standard warm-up routine composed of one set of 10 repetitions with

Table 3. Descriptive statistical parameters of female soccer players

| | Mean±SD (n=24) | Goalkeepers (n=3) | Attackers (n=4) | Midfielders (n=12) | Defenders (n=5) |
|---|---|---|---|---|---|
| Age (years) | 18.3±0.6 | 19.1±0.5 | 17.4±0.4 | 18.3±0.7 | 18.5±0.6 |
| Experience (years) | 10.1±2.3 | 11.2±1.3 | 10.2±1.6 | 9.8±1.1 | 10.5±1.3 |
| Body weight (kg) | 58.3±4.6 | 64.4±4.2 | 63.6±4.1 | 56.0±4.8 | 56.3±4.9 |
| Body height (cm) | 165.6±4.2 | 172.5±4.6 | 165.0±4.2 | 164.0±4.3 | 165.8±3.9 |
| Percentage of body fat (%) | 21.3±1.5 | 20.7±1.2 | 20.3±1.7 | 21.6±1.8 | 21.8±0.9 |

Table 4. Mean ± standard deviation of strength and endurance tests

| | Initial testing | Final testing | Absolute | Percentage |
|---|---|---|---|---|
| BP(kg) | 35.75 ± 5.31 | 37.66 ± 4.74 **#** | 1.91 | 5.3% |
| SQ (kg) | 55.97 ± 12.26 | 61.13 ± 12.48 **#** | 5.16 | 9.2% |
| LER (kg) | 42.75 ± 8.60 | 44.70 ± 8.41 **#** | 1.95 | 4.5% |
| LEL (kg) | 40.20 ± 8.13 | 42.33 ± 8.27 **#** | 2.13 | 5.2% |
| LCR (kg) | 26.04 ± 5.51 | 28.83 ± 5.32 **#** | 2.79 | 10.7% |
| LCL (kg) | 24.79 ± 5.61 | 26.41 ± 5.02 **#** | 1.62 | 6.5% |
| $VO_{2max}$ (ml/kg) | 47.21±4.33 | 49.24±4.32**#** | 2.03 | 4.3% |
| 300y (s) | 68.42 ± 4.42 | 66.53 ± 4.17 **#** | 1.89 | 2.7% |

*# statistically significant differences between the initial and the final testing (p<0.05)*
*Legend: bench press (BP); squat (SQ), leg extension (LE; right leg extension – LER; left leg extension – LEL) in the sitting position and leg curl (LC; right leg curl – LCR; left leg curl – LCL) from the lying position. Aerobic power ($VO_{2max}$) Anaerobic power was evaluated using the 300y test (300y).*

approximately 50% of the anticipated 1RM load, followed by 3–5 repetitions with approximately 75% of the 1RM. After the warm-up protocol, the subjects performed their first 1RM attempt with a load slightly lower than their anticipated maximum weight. Trained research assistants supervised the testing and dictated the resistance of each 1RM attempt. A minimum rest interval of 5 minutes was strictly enforced between 1RM attempts. Most subjects achieved their true 1RM weight within three to five attempts. 1RM was measured for bench press (BP); squat (SQ), leg extension (LE; right leg extension – LER; left leg extension – LEL) in the sitting position and leg curl (LC; right leg curl – LCR; left leg curl – LCL) from the lying position. The leg extension and the leg curl tests were performed both with the left and with the right leg. The bench press and the squat were performed with free weights. Aerobic power was determined by incremental test. It was performed on a motor-driven treadmill (Run race, Technogym, Italy), with a 1.5% inclination. Quark b2 "breath-by-breath" gas analysis system (Cosmed, Italy) was used for respiratory gas exchange monitoring. Heart rate was monitored using a Polar Vantage NV (Polar ElectroOi, Finland) heart rate monitor. The maximal exercise test was interrupted when the plateau of oxygen consumption was observed or when the subject perceived volitional fatigue. VT was assessed by a nonlinear increase in carbon dioxide to oxygen consumption ratio (V-slope method). Anaerobic power was evaluated using the 300y test (300y) (Ivanjko et al., 2005). Skin-fold thickness was obtained using a Lange skin-fold calliper at the calf, chest, thigh, triceps and sub scapular regions. Three trials were performed and the median value was used in further analysis. The skin-folds recorded at the chest, thigh and sub scapular regions were also used for the estimation of body density (Jackson et al., 1978).

*Statistical Analyses*

Data analysis was performed using the Statistical Package for Social Sciences (v13.0, SPSS Inc., Chicago, IL). Descriptive statistics were calculated for all experimental data. In addition, to test the normality of distribution, the Kolmogorov-Smirnov test was conducted on all data before the analysis. Statistical power was calculated using the G-power software. T-test for dependant samples was used to determine differences between initial and final measurement. The correlation between all tested variables was determined using the Pearson product-moment correlation coefficient. Statistical significance was set at $p<0.05$.

## Results

The Kolmogorov-Smirnov test showed that the data were normally distributed. The statistical power was 0.95. ICCRs for all variables ranged from 0.78 to 0.88. Positive effects were determined among all tests (Table 4). Negative correlation was determined between body fat percentage and $VO_{2max}$ (r=-0.43) and 300y (r=-0.55). Positive correlation was determined between the variables *bench press* and *squat* (r=0.44). Also, a positive correlation was determined between squat strength and leg extension and leg flexion strength with right and left leg (ranging from 0.46 to 0.64), and between the variables *squat* and *$VO_{2max}$* (r=0.44).

The improvement in strength ranged from 2.7 to 10.7% in the variables. The largest effect was determined for the variable LCR where the improvement was 10.7 % as well as for the variable *squat* (9.7%). After 12 weeks of strength training aerobic power has improved by 4.3% and anaerobic power by 2.8%.

**Discussion**

The purpose of this study was to investigate the effects of strength training on aerobic and anaerobic power in female soccer players. Three to five sets of 8-12 repetition were performed for all exercises. The major findings of this study were the improvement of muscular strength as well as the improvement of aerobic and anaerobic power after 12 weeks of strength training in female soccer players. The shortcoming of this study is the lack of the control group, due to the coaches' disagreement with suggested. But, to the authors' knowledge, this is one of the rare studies which deal with aerobic and anaerobic power improvement after a strength training programme in female athletes. In most studies the authors were interested in how strength training would improve subject's strength parameters (Hennessy, 1994; Hoff et al., 2004; Stølen et al., 2005). However, for soccer and other team sports it is very important to realize how the development of one's ability – in this particular case strength – may influence the other ability, e.g. aerobic and anaerobic power. In soccer one usually talks about endurance, strength, agility, flexibility, etc. The question is, however, how all these abilities can be improved when the training programmes for the development of each of them take place simultaneously. Further, how can the development of one's ability influence all other abilities? When analysing the training process we must always keep in mind that athletes participate in every training session with all their abilities, so that it is very difficult for coaches to know how the development of one's ability can influence the development of other abilities of an athlete and in what percentage this can be done. The second problem is that fewer researches into female soccer players were done in comparison to the number of researches done into their male colleagues. After 12 weeks of strength training, bench press strength improved by 5.3% and squat strength improved by 9.2%. The improvement in bench press strength was different from the improvement observed by Brazell-Roberts (Brazell-Roberts et al., 1989) who reported the improvement in bench press strength by 12.4% after 12 weeks of strength training. Herrick & Stone (1996) reported the improvement of upper body strength of 31.9% after 15 weeks of strength training. Stone & Coulter (1994) reported the 18.9% improvement in upper body strength, which was similar to Boyer (1990) who reported the 15.3% improvement in upper body strength. The only study that reported a lower improvement in bench press strength was the one performed by Marx et al. (2001) who reported the 2.1% improvement in bench press strength. Similar results to ours were detected for squat strength improvement. Brazell-Roberts et al. (1989) reported the improvement in squat strength by 33.0% after 12 weeks of strength training. Herrick & Stone (1996) reported the 53.5% improvement in lower body strength after 15 weeks of strength training. Stone & Coulter (1994) reported the 33.0% improvement, whereas Boyer (1990) reported the improvement in squat strength similar to that obtained in our study (9.2 percent), namely, 11.2%. It is difficult to compare Boyer's (1990) study to our study because the resistance in Boyer's study was used by the nautilus machine, and in all other researches free weights were used. The right and left leg extension strength improvement was 4.5% and 5.2%, respectively. This improvement was expected because extensor exercise and squat exercise were highly correlated (r=0.64), and the muscles responsible for good exercise results were the same, i.e. the quadriceps.

In comparison to leg extension strength improvement, leg flexion strength improvement was different as regards the comparison in strength increase between the left and the right leg. LCR increased by 10.7 percent while LCL increased by only 6.5 percent. The right leg proved to be the dominant leg in the female players who participated in this analysis. Therefore, the inter-muscular coordination can be said to have been better in the right than in the left leg, so that the female soccer players were able to activate a large number of motor neurons and were able to produce greater force. The improvement in leg flexor strength (hamstring muscles) could be said to have been in correlation with the influence of the dead lift exercise. However, the influence of this exercise on leg flexor strength was smaller than the influence of squat exercise on leg extension strength – the correlation of squat and leg extensor was 0.64, and for the leg flexion and squat it was 0.46. The sample in our study was comprised of well trained female athletes, whereas the subjects in the cited studies were mostly college women or untrained population with large age variance. It is well known that the top-level athletes who have reached their top-level performance improved their abilities, and in particular strength and endurance, more difficult and to a smaller extent than the untrained population. When we consider the correlation between the variables *bench press* and *squat* (r=0.44), the conclusion could be drawn that in female athletes the strength of upper extremities is related to the strength of lower extremities. One of the most interesting correlations is the correlation between the squat and the $VO_{2max}$. Since soccer itself is a stop-go sport with quick changes of direction, leg strength is important both for successful play and for a satisfactory level of aerobic power.

To achieve a good level of aerobic power in female soccer players a good level of basic leg strength and upper body strength (r=0.44) is necessary. The results of our study have shown that 12 weeks of strength training may improve aerobic power by 4.6 percent. These results are similar to the results of Getteman & Pollock (1981) who reported the improvement in $VO_{2max}$ of approximately 5 to 10 percent. Similar results were also reported by Hickson (1980) and Hurley et al. (1984). This information is vital for coaches since strength training can have positive effects on aerobic power in female soccer players.

The data in our research suggest that our training programme caused improvement in muscular endurance. However, it is important to acknowledge that not all subjects in the present study had at least a moderate level of resistance training experience before the intervention, so that the exercise learning effect may have contributed to the increased performance in addition to the increase in muscle function. The lowest improvement was detected in anaerobic power – namely, the results in the 300y test improved by 2.7 percent. This was expected since the type of training used in this study influences muscle strength but mostly muscle endurance and to be successful in the 300y, the muscles should be more trained for power (Ivanjko et al., 2005). It is known that anaerobic power is one of the abilities which is the most difficult to develop. Tolerance to high blood lactate concentration is also closely correlated with motivation. In the authors' opinion, it is possible that the subjects did not give their best. This is one of the problems when analysing the training effects, i.e. it is impossible to have the similar conditions both in the initial and in the final testing. Additionally, the player's motivation is very rarely measured. Also, it is very difficult to control the subject's activities after practice. The question that needs to be addressed regardless if we have detected changes in number of kilogram that players could lift or in seconds in which they run faster is: are there any changes – significant changes occurring in the players ability, because the question is rightfully raised whether the improvement of 5.3 percent in the bench press or the 1.91 kilogram improvement in bench press means that it is strength that has improved, or that the improvement in both aerobic and anaerobic power has occurred. This is generally a methodological problem of quantitative studies, namely that they cannot detect changes in abilities. To do so, we need more qualitative analyses to see if the changes in motor abilities can be noticed. The most important finding of this study is that the 12-week strength training could improve the aerobic and anaerobic power in female soccer players.

## Conclusion

Strength training has positive effects on aerobic and anaerobic power. After 12 weeks of strength training, the aerobic power of female soccer players has improved by 4.3% and the anaerobic power by 2.8%. These data suggest that our training programme has caused the improvement in muscular endurance and that strength training of the 12-week duration improved both the aerobic and anaerobic power in female soccer players. These observations may point to potential changes so the coaches are encouraged to use more strength training with female soccer players.

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## UČINCI TRENINGA SNAGE NA AEROBNI I ANAEROBNI RAD NOGOMETAŠICA

### Sažetak

*Svrha ovog istraživanja bila je utvrđivanje učinaka 12-tjednog programa treninga snage na aerobni i anaerobni rad kod nogometašica. Dvadeset i četiri nogometašice (selekcija U-20) dragovoljno su sudjelovale u istraživanju. Ispitanice su testirane testovima snage kao i aerobnog i anaerobnog rada. Testovi: 1RM bench press 8Bp), squat (SQ), ekstenzija noge (desna noga LER i lijeva noga LEL) i fleksija noge (desna noga curl – LCR i lijeva LCL) mjerili su snagu, dok su $VO_{2max}$ i 300y shuttle run mjerili aerobni odnosno anaerobni rad. Dvosmjerna ANOVA s ponovljenim mjerenjima je korištena za utvrđivanje dvostrukih učinaka. Nadalje, post hoc postupak je primjenjen za otkrivanje razlika aritmetičkih sredina. Pozitivni učinci treninga snage su utvrđeni u svim testovima. Najveći učinak je utvrđen za varijablu desna noga curl (LCR) gdje je napredak bio 10.7 % kao i u varijabli squat – 9.7 %. Nakon 12 tjedana treninga snage aerobni rad nogometašica je poboljšan za 4.3 % a anaerobni za 2.8 %. Podaci sugeriraju da 12-tjedni trening snage poboljšava i aerobni i anaerobni rad kod nogometašica.*

***Ključne riječi**: nogometašice, aerobni rad, anaerobni rad*

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# THE EFFECTS OF A 6-WEEK OF PLYOMETRIC TRAINING ON ELECTROMYOGRAPHY CHANGES AND PERFORMANCE

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*Original scientific paper*

***Abstract***
*The purpose of this study was to compare the effects of depth jump (DJ) and countermovement jump (CMJ) training on sand on electromyography (EMG) changes and performance in healthy subjects. Twenty-seven male collegiate students participated in this study and randomly divided into three groups: DJ, CMJ and control group (CG). Subjects in the DJ and CMJ groups performed 5 sets of 20 repetition jumps from a 45-cm box onto a 20-cm dry sand two days a week for 6 weeks. The EMG activities in the vastus medialis (VM), rectus femoris (RF) and vastus lateralis (VL) muscles, vertical jump (VJ) and 20-m sprint time were assessed pre and post training. The results showed significant increases in the EMG activities (IEMG) for the VM and RF following DJ and CMJ training on sand and compared with control group ($P < 0.05$). The DJ and CMJ groups showed significant improvement than control group in the VL muscle activities, and no statistically significant differences were found among groups ($P > 0.05$). The DJ and CMJ training on sand led to significant improvement in VJ and decreases in 20-m sprint time ($P < 0.05$). In conclusion, the DJ and CMJ training on sand improved EMG activities, power, and sprint performance and it is recommended that, coaches design plyometrics on sand for athletes or individuals, because these types of training on sand can be effective for increasing performance.*

***Key words****: stretch shortening cycle, intense plyometric, motor unit, performance*

## Introduction

Plyometrics are training techniques used by athletes in all types of sports to increase strength and explosiveness (Chu, 1998). Plyometrics consists of a rapid stretching of a muscle (eccentric action) immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle & Earle, 2000). Success in many sports depends heavily upon the athlete's explosive leg power and muscular strength. In jumping, throwing, track and field events and other activities, the athlete must be able to use strength as quickly and forcefully as possible. This display comes in the form of speed-strength or power (Yessia & Haltfield, 1986). Researchers have shown that plyometric training can improve muscular power (Gehri et al., 1998; McClenton et al., 2008; Saez Saez de Villarreal et al., 2008).

Muscle power depends on the amount of nerve stimulation and the number of active motor units. To evaluate the power production mechanism, muscle activities will be studied and compared through direct measurement techniques. Inner-muscular neural adaptations consist of using motor units, the amount of stimulation and intermuscular harmony. A qualitative procedure that can be used with the existing methods and can make needed quantitative measurements is the electromyography (EMG) (Rezaimanesh et al., 2011). It appears that plyometric taining on land improved muscle activation and motor unite recruitment during depth jump and maximum voluntary isometric contraction (MVIC) (Chimera et al., 2004; Ebben et al., 2008; Pietrosimone et al., 2009).

Others have recommended that these exercises (e.g., plyometric exercise) be done on sand surface. Plyometric training on sand may increase motor unite recruitment because of the absorptive qualities of sand are likely to increase contraction time and allow the leg extensor muscles to build up active state and force prior to shortening. This can enable subjects to produce more work and force development on sand, than on the land (Bishop, 2003). Unfortunately, no study examined the effects of intense plyometric training on sand on MVIC and muscle power, and the effects of plyometric training especially depth jump and countermovement jump on MVIC, vertical jump and sprint performance are unknown. Therefore, the purpose of this study was to examine the effects of 6 weeks DJ and CMJ training on sand on MVIC (vastus medialis, rectus femoris and vastus lateralis), vertical jump and sprint performance in healthy subjects.

## Methods

*Subjects*: Twenty-seven male collegiate students volunteered to participate in this study and randomly assigned to two treatment groups that performed 2 times per week: depth jump and countermovement jump. A control group of 9 subjects did not train and were tested before and after a 6-week period to assess the reliability of the observations. The subjects were healthy, free of lower body injuries and they had no medical or orthopedic problems. Subjects were carefully informed about the experiment procedures and possible risk and benefits associated with participation in the study and signed an informed consent document before the investigation.

The Institutional Review Board of the University approved the research protocol. Subjects' characteristics are displayed in Table 1.

**Table 1**. Subjects' characteristics (means ± SD)

| | DJ (n = 9) | CMJ (n = 9) | CG (n = 9) |
|---|---|---|---|
| Age (y) | 20.5±0.7 | 20.6±0.7 | 20.0±0.3 |
| Body mass (kg) | 70.6±5.0 | 69.5±7.8 | 69.0±5.2 |
| Height (cm) | 180.6±7.0 | 176.5±4.2 | 174.8±3.0 |

DJ = depth jump; CMJ = countermovement jump; CG = control group

*Plyometric training on sand*: The plyometric training programs included 2 days a week for 6 weeks (Thomas et al., 2009). Each training session lasted 35 minutes, including 10 minutes warm-up (e.g., jogging, stretching and ballistic exercises), 20 minutes training (DJ or CMJ), and 5 minutes cool-down (e.g., jogging and stretching exercises). Subjects performed 5 sets of 20 repetitions (Miyama & Nosaka, 2004) of DJ or CMJ with an 8-second interval between jumps. A 2-minute and 72-hour rest period was given between sets and training sessions, respectively. Subjects performed DJ or CMJ onto a 0.2-m-deep dry sand surface from the height of a 45-cm box (Impellzzeri et al., 2008). Subjects in plyometric groups (DJ and CMJ) were instructed to perform exercises in each training session with maximal effort. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise. During the intervention of 6 weeks; DJ, CMJ and CG continued their normal daily activities, and were not allowed to perform any other training (such as: resistance training and or plyometric training) that would impact the results. *DJ procedure*: Participants began by standing on a 45-cm box and were instructed to lead with one foot as they stopped down from the box and land with two feet on the sand. After sand contact, subjects were instructed to explode off the sand by jumping as quickly and as high as possible (Chu, 1998; Thomas et al., 2009). *CMJ procedure*: Participants in the CMJ group stopped from the 45-cm box and were instructed to drop on the sand with two feet.

After sand contact, subjects were instructed to flex their knees (countermovement) and then rebound upward in a maximal vertical jump (Chu, 1998; Thomas et al., 2009). *EMG measurement*: Subjects performed a five-minute warm up on a stationary bicycle at a self-selected pace, and some regular stretching of lower-extremity muscles before the skin was prepared for the application of surface electromyography electrodes. After setting up the instrumentation, a MVIC of vastus medialis (VM), rectus femoris (RF) and vastus lateralis (VL) were measured for subjects' right legs in sitting position. During the MVIC, their right legs were fixed at 90˚ of knee flexion and subjects were verbally encouraged to extend their knees as hard as possible for a five-second bout. The better of two maximal effort isometric contractions per muscle were used for statistical analyses. There was a one-minute rest period between trials (Peng et al., 2010).

The EMG signals were acquired using 8-channel electromyography equipment (Muscle Tester ME 3000P8, Mega Electronic Ltd, Finland), consisting of signal conditioner with a band pass filter with cut-off frequencies at 20-500Hz, and amplifier gain of 2000x, and a common mode rejection ratio > 120dB. Pre amplified bipolar superficial electrodes of Ag/AgCl (Skintact®) with an interelectrode (center to center) distance of 20 mm were used. The EMG signal was full wave rectified and integrated (IEMG in μV). In order to achieve an optimal EMG signal and low impedance (< 5 kΩ), two 4 $cm^2$ areas of skin were shaved, abraded and cleaned (Chimera et al., 2004; Ebben et al., 2008). The electrodes of VM were located 20% of distance from the anterior superior iliac spine to the midpoint of the medical joint line. The RF electrodes were placed halfway between the greater trochanter and medial epicondyle of the femur. The VL electrodes were placed one quarter of the distance from the midpoint of the lateral line of the knee joint to the anterior superior iliac spine. A common reference electrode was placed over the proximal tibia (Chimera et al., 2004; Ebben et al., 2008; Peng et al., 2010; Fauth et al., 2010). *Vertical jump test*: This test involves measuring the difference between a person's standing reach and the height recorded from a jump and reach. The difference between the standing height and the jump height is the vertical jump value. Subjects were instructed to perform two-foot vertical jump and peak vertical jump value was recorded in cm (McClenton et al., 2008). *20-m sprint*: The 20-m sprint test was performed on a hard even surface on an indoor track. The subjects had standing start position on the start line, and on command they ran a 20-m sprint as fast as possible over the distance. When they crossed the finish line, the time was stopped on the handheld stopwatch (Joerex, ST4610-2) (Rimmer & Slevert, 2000). *Statistical analyses*: All data are presented as mean ± SD. A one-way analysis of variance (ANOVA) was used to determine significant differences among groups. In the event of a significant *F* ratio, *Tukey* post hoc tests were used for pairwise comparisons. Paired *t*-test was used to identify any significant differences between the groups at the pre and post tests for the dependent variables. A criterion α level of $P \leq 0.05$ was used to determine statistical significance. All statistical analyses were performed through the use of a statistical software package (SPSS®, Version 16.0, SPSS., Chicago, IL).

## Results

There were significant increases in the EMG activities (IEMG) for the VM and RF following DJ and CMJ training on sand and compared with control group ($P < 0.05$) (Figure 1. A, B). The DJ and CMJ groups only showed significant improvement than control group in the VL muscle activities, and no statistically significant differences were found among groups ($P > 0.05$) (Figure 1. C). The DJ and CMJ training on sand led to significant improvement in VJ and decreases in 20-m sprint time ($P < 0.05$) (Figure 2 and 3).

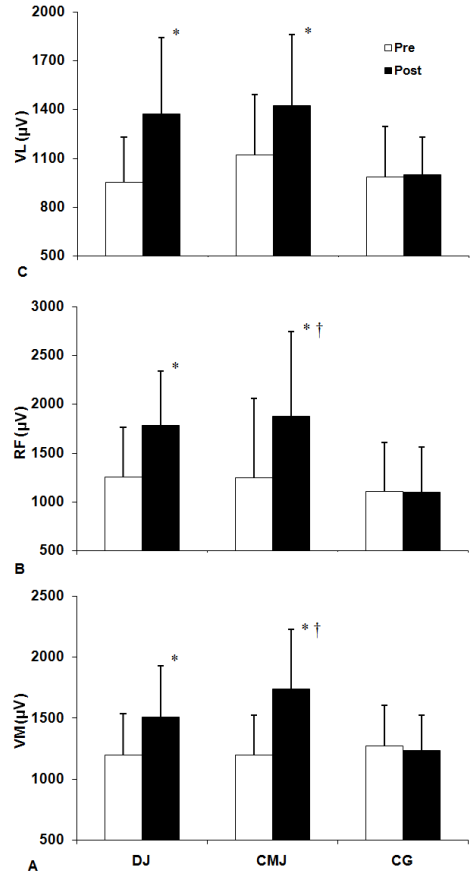


Figure 1. EMG changes in VM, RF and VL at pre and post training. Values are mean ± SD (DJ: Depth jump; CMJ: Countermovement jump; CG: Control group.
* Significantly different ($P \leq 0.05$) from the corresponding pre training value. † Significantly different ($P \leq 0.05$) from the corresponding CG value)

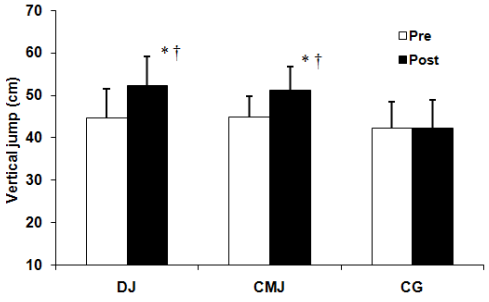


Figure 2. Changes in vertical jump at pre and post training. Values are mean ± SD (DJ: Depth jump; CMJ: Countermovement jump; CG: Control group.
* Significantly different ($P \leq 0.05$) from the corresponding pre training value. † Significantly different ($P \leq 0.05$) from the corresponding CG value)

## Discussion

The novel approach of this study was to investigate the effects of DJ and CMJ training on sand on EMG activities, VJ and 20-m sprint time. The finding of the present study showed that 6 weeks of DJ and CMJ training increased motor unite recruitment during MVIC in the VM, RF and VL muscles. Also, CMJ training showed significant differences in the VM and RF compared to CG. These findings are not in line with Mehdipour et al`s (2008) study.

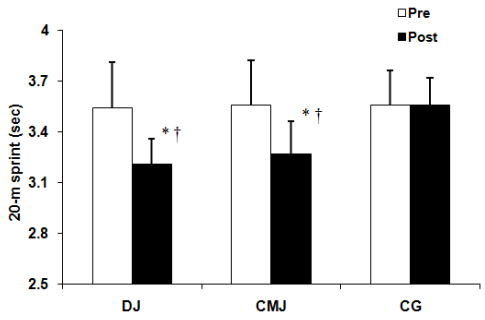


Figure 3. Changes in 20-m sprint time at pre and post training. Values are mean ± SD (DJ: Depth jump; CMJ: Countermovement jump; CG: Control group.
* Significantly different ($P \leq 0.05$) from the corresponding pre training value. † Significantly different ($P \leq 0.05$) from the corresponding CG value)

They examined the effects of 6 weeks plyometric training on RF muscle activity and did not find significant difference. Some of the reasons for such a variety of results may be noted as the difference in type and intensity of exercise. These findings are in line with Rezaimanesh et al., (2011) and Hakkinen et al., (1986) who reported significant changes in the motor unit recruitment and rate of force development for the lower body muscle. It appears that plyometric exercises add much force and tension to muscle cords. Performing such activities or tolerating extreme force and tension may lead to needed physiological or biological changes in muscle cords and other parts of the contraction system and can also cause muscle EMG changes to rise (Rezaimanesh et al., 2011).

The results indicated that plyometric training on sand increased EMG activities. The absorptive qualities of sand are also likely to increase contraction time, thus allowing the leg extensor muscles to build up an active state and force prior to shortening (Bishop, 2003). As sand, is mobile and uneven in nature it may be important to consider the role of postural muscles in relation to the co-ordination required for jumping (Impellzzeri et al., 2008). The compliance of sand surface made it hard for the ankle to push along the vertical axis of the movement of the body and as a result it slipped behind in an attempt to maximize population. As a result, the body tries to balance and equalize this movement and move the hip to larger extension (Giatsis et al., 2004). Perhaps above mechanisms of sand plyometric become effective on the contraction elements and the muscle physiology changes. Also, changes in the IEMG following plyometric training on sand can be increases in firing rate and motor unite recruitment. The CMJ training indicated significant changes than CG. The reason of this result can be mechanical characteristic of exercise. Knee flexion during DJ was lesser than CMJ (30 ° vs. 90 °), and maybe muscle fiber and motor unit did not use properly (Gehri et al., 1998). Overall, plyometric training (DJ and CMJ) on sand can lead to enhance in the rate of force development and motor unite recruitment, and consequently, leg extensor muscle activity increased using IEMG.

The current study indicated that 6 weeks of DJ and CMJ training on sand induced positive effects on VJ, but no significant differences between two modalities of training. These results are in agreement with Thomas et al., (2009) who reported gains in jumping ability after a 6-week of DJ or CMJ training on firm surface in youth soccer players. They also didn't find any significant differences between DJ and CMJ. Gehri et al., (1998) examined the effects of 12 weeks of DJ and CMJ training on jumping and energy production. They found significant increases in VJ for both training groups. None of the training methods improved utilization of elastic energy. It appears that high intensity plyometrics (e. g., DJ and CMJ) can improve jumping ability in men and women (McClenton et al., 2008; Seaz Saez de Villarreal et al., 2008, 2009). Previous studies recommended that plyometric training drills should be performed on the firm surface, because compliance of surface like sand may reduce elastic energy following plyometric training such as DJ or CMJ (Impellzzeri et al., 2008; Miyama & Nosaka, 2004). In this study, we not only found significant improvements in jumping abilities but also found 15 % increases in VJ for DJ and 13.5 % for CMJ training after 6 weeks of training on sand. A possible explanation for the jump enhancement in the present study could be the rate of force development, stiffness and power enhancement (Kotzamanidis, 2006). Improved muscle performance (VJ) due to a plyometric training program like DJ and CMJ may be in part to increased motor unit functioning (McClenton et al., 2008). It has been suggested that DJ and CMJ training are more effective in improving jump performance in stretch shortening cycle jumps because it enhances the ability of individuals to use the elastic and neural benefits of the stretch shortening cycle (Saez-Saez De Villarreal et al., 2009). Another finding of the present study was that DJ and CMJ training improved the results of the 20-m sprint time after 6 weeks of training on sand. These findings are in line with Kotzamanidis (2006) who found significant improvement in sprint (30-m) following 20 sessions (10 weeks × 2 sessions per week) of plyometric training. In contrast of our results, Markovic et al., (2007) examined the effects of 10 weeks plyometric training (e. g., DJ and hurdle jumps) on 20-m sprint time and found no significant changes. Recently, Thomas et al., (2009) compared the effects of DJ and CMJ training on 5, 10, 15 and 20-m sprints, and found no statistically significant improvements. It seems that, the differences in intensity of training, training volume and sample size could be the reason of the discrepancy in results (Markovic et al., 2007). Several studies have suggested that plyometric training may enhance sprint ability because the use of stretch-shortening cycles during DJ and CMJ performance has been shown to have a significant relationship to sprint (Nesser et al., 1996; Saez-Saez De Villarreal et al., 2008). The greatest improvements in sprinting will occur at the velocity of muscle action that most closely approximates the velocity of muscle action of the plyometric exercises employed in training (Rimmer & Sleveret, 2000). Other mechanisms that improved sprint performance could be changes in stride length and stride frequency following plyometric training (Rimmer & Sleveret, 2000; Schmidtbleicher et al., 1988). In conclusion, the results of this study are very encouraging the benefits of DJ and CMJ plyometric training on sand for improving EMG activities, power, and sprint. It is recommended that, coaches design plyometrics on sand for athletes or individuals, because these types of training on sand can be effective for improving performance.

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## UČINCI 6-TJEDNOG PLIOMETRIJSKOG TRENINGA NA ELEKTROMIOGRAFSKE PROMJENE I REZULTAT

### Sažetak

*Svrha ovog istraživanja bila je usporedba učinaka treninga skoka u dubinu (DJ) i povratnog skoka (CMJ) u pijesku na elektromiografske (EMG) promjene i rezultat kod zdravih subjekata. U istraživanju je sudjelovalo dvadeset i sedam muških studenata koledža slučajno podijeljenih u tri grupe: DJ, CMJ i kontrolnu (CG). Ispitanici u DJ i CMJ grupama izvodili su 5 serija po 20 ponavljanja skokova s kutije od 45-cm na 20-cm suhog pijeska dva dana u tjednu kroz 6 tjedana. Praćene su EMG aktivnosti vastusa medialisa (VM), rectusa femorisa (RF) i vastusa lateralisa (VL), vertikalni skok (VJ) i vrijeme za 20-m sprinta prije i nakon trenažnog procesa. Rezultati su pokazali značajno povećanje EMG aktivnosti (IEMG) za VM i RF nakon DJ i CMJ treninga u pijesku i u usporedbi s kontrolnom grupom ($P < 0.05$). DJ i CMJ grupe u odnosu na kontrolnu pokazale su značajan napredak u aktivnosti VL a između njih nije bilo značajnih razlika ($P > 0.05$). DJ i CMJ trening u pijesku vodi prema značajnom poboljšanju VJ i smanjuje vrijeme kod 20-m sprinta ($P < 0.05$). Zaključno, DJ i CMJ trening na pijesku poboljšava EMG aktivnosti, snagu i sprintersku izvedbu pa se preporuča da treneri dizajniraju pliometrijski trening na pijesku za sportaše ili pojedince jer ova vrsta treninga može biti učinkovita za povećanje rezultata.*

***Ključne riječi**: istezanje skraćenog ciklusa, intenzivna pliometrija, motoričke jedinice, izvedba*

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# CASCADE REGULATION OF TRANSFORMATION PROCESSES

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*Review paper*

***Abstract***
*Managing any sort of processes is often a difficult task that requires a lot of responsibility most of the time. Due to the growing complexity of existing systems (from local all the way up to global), ordinary regulation procedures that should "maintain" the systems within normal parameters are having more and more difficulties when meeting new demands. This is applicable in all areas of human activity, even in technical, particularly in so called social and especially, in a broader sense, anthropological areas. The article puts forward the implementation of the rules for cascade regulation into the management of transformation processes in kinesiology, medicine, pedagogy and other anthropological disciplines with possible application based on two in part convergent ways: 1. Embedded, and 2. Temporal cascade regulation. Both cases demand good understanding of mathematical tools. It seems that the awareness of transformational achievement goals would be raised to a whole new level and errors caused by unknown factors would be reduced to a minimum.*

***Key words****: processes, cascades, embedment, temporal*

## Introduction

A growing number of anthropological disciplines (kinesiology, medicine, pedagogical sciences…) are, among other things, immanently dealing with transformation processes (except selection, preparation, prevention…) (Bonacin, 2006; Bonacin et al., 2008), regardless of whether they are about training, treatment or education etc. (Vukasović, 1976; Grmek et al., 1996; Bonacin, 2006; Gyton & Hall, 2006). All such processes contain some universal phenomena: 1. Subjects (athlete, patient, student…), 2. Diagnostics (condition), 2. Goals (achievement, recuperation, knowledge…), 4. Procedures (training operators, treatment elements, educational tasks…), 5. Facilitator (trainer, doctor, teacher…) and 6. Evaluation (achieved result or degree of achieved goals). This is presented in figure 1. This simple but complete illustration shows that in the aforementioned areas of human activity there are potential deviations from the achieved results and the targeted results. This discrepancy is caused by numerous reasons, mainly due to insufficient knowledge of initial state parameters and processes, unpredictable interferences etc. (Bonacin, 2008). Because of that, evaluation is introduced to every serious model. This evaluation needs to, in an objective manner, provide the degree of goal – achievement concordance that, alongside other inevitable findings, represents most frequently one sort of objective mathematical tool (Bonacin, 2004; Lozovina et al., 2011). However, all these described processes often show exceptional complexity in their application. This makes them variable in final results. The issue focused on in this paper relates to temporal dynamics of local i.e. partial achievements that cumulatively lead to the desired results within a time domain. Such dynamics are caused by temporary impact of certain stimuli that have different effects on the subject. This takes place with respect to numerous conditions to which the subject had been exposed in its own individual "history". This, of course, is possible because of: a) diversity among subjects, and b) subject adaptation to certain stimuli, i.e. to requested temporary tasks, while the time scope of the effects of such tasks is often completely unknown. This logic is illustrated in figure 2. In every situation, no matter how brief, latency always exists (when it appears as though nothing is happening), and afterwards certain effects can be expected (Bonacin et al., 2008). Under normal circumstances there is always a whole spectrum of effects that can be viewed as the three named here (short-term, mid-term, and long-term), while the definition of an optimal deadline of anticipated effects depends on the goals, current state of subject, and applied procedures for the transformations, as well as other acceptable and not necessarily acceptable effects. Furthermore, there are of course always all three effects, even though they do not necessarily have to be of the same intensity, nor need they be easily and quickly identifiable (Bonacin i sur., 2008).

## Biological, technical and mixed systems

As already mentioned, biological systems have the possibility of adaptation to applied stimuli, regardless of their source (targeted, stochastic environmental, natural…). However, technical systems (designed by man) do not have such freedom of functioning, because the purpose of their functions is usually completely predetermined, therefore unpredictable variations of their functioning would represent a definite breakdown and endangerment of their purpose with all possible (often very serious) consequences that arise from that. Consequently, biological (Bonacin, 2008) and technical system management is significantly different, and is shown in figure 3.

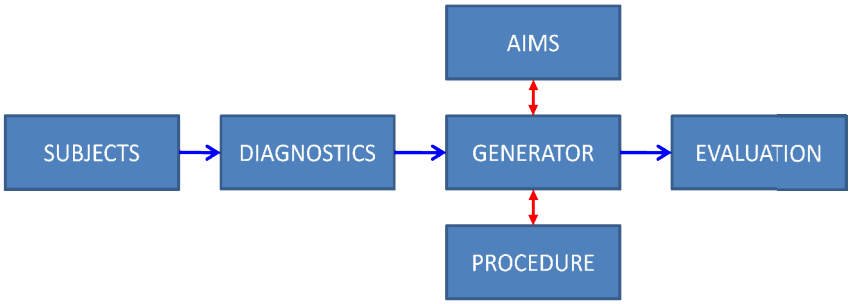


Figure 1. Universal phenomena in transformations
(Source: Bonacin)

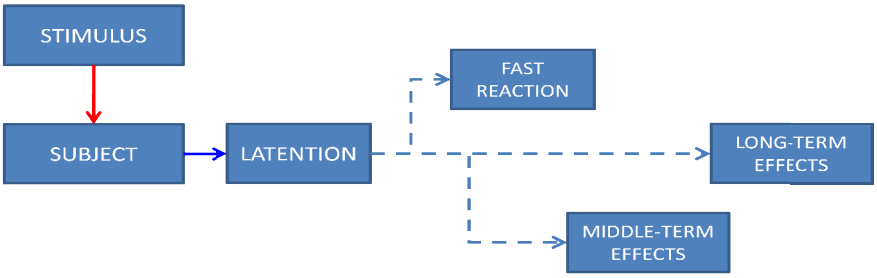


Figure 2. Possible typical effects of stimuli aplication through time
(Source: Bonacin)

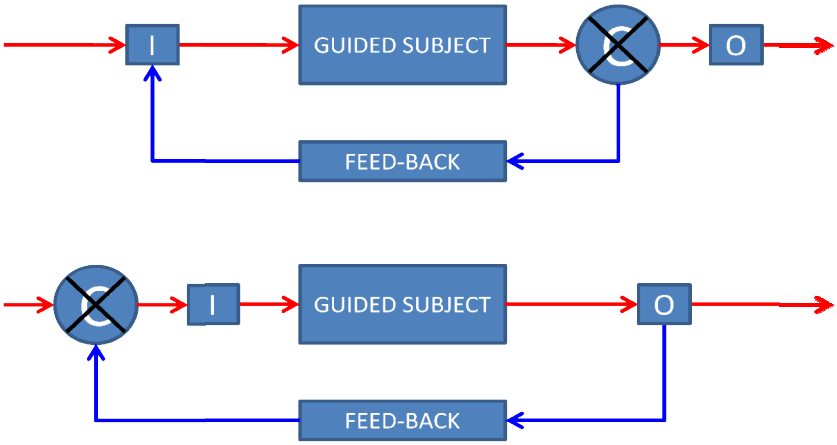


Figure 3. Feed-back mechanism in biological (up) and technical (down) systems
(I = input, O = output, C = comparator)
(Source: Bonacin)

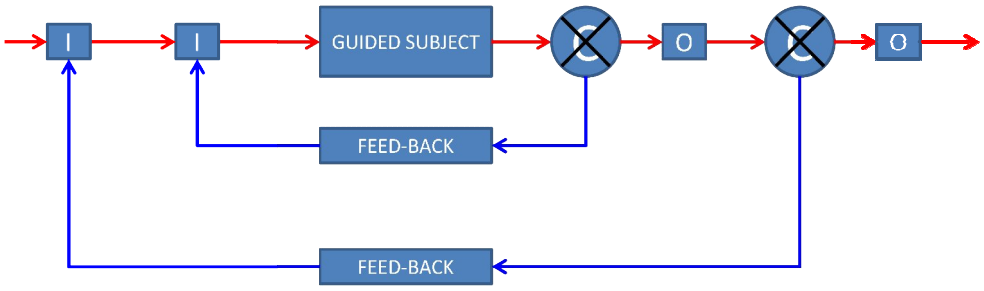


Figure 4. Embedded cascade regulation
(U = input, I = output, C = comparator)
(Source: Bonacin)

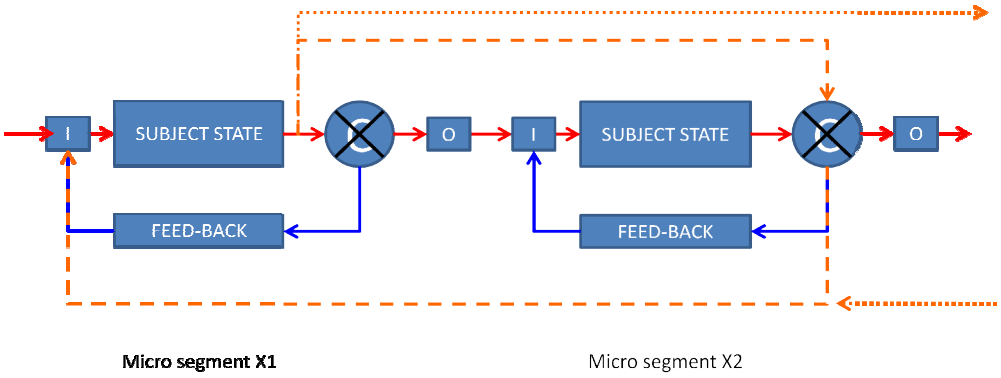


Figure 5. Time depended cascade regulation
(I = input, O = output, C = comparator, X1, X2 = individual cascade or regulation microcycles)
(Source: Bonacin)

Figure 3 clearly shows that technical control systems must satisfy the condition that their behavior is known beforehand, otherwise the system will not get any input values because the comparator will reject them as unacceptable, hence there will not be any comparison in the output. Consequently, when driving a car it is not viable that the car will accelerate and "then we will see what happened" it has to be known in advance that turning the steering wheel will turn the car in the desired direction. The output is, of course, still compared to the input goal for the purpose of correcting the goals. However, biological systems' responses cannot be predetermined due to adaptation, but the output values depend on many factors, and this certainly means that the output will be examined and if it does not meet the requirements, a new set of input values will be defined and introduced as a new set of inputs through a feed-back mechanism. As long as the comparison does not meet the requirements, there will not be any new effects in that segment. A typical example are of course faculty examinations or athlete's conditions which require e.g. initial values of the strength of some topological segment in order to train any further; in other words, in medicine there are no further actions if a patient does not respond to applied therapy as expected, some other therapy should be applied within the known set of solutions. In mixed systems, these two models of feed-back mechanisms are applied in combination.

**Mid-term and long-term effects**

As clearly seen from the above, and in accordance with figure 2 and 3, the technical control systems can relatively easily respond to requests for quick responses or short-term effects, which is sometimes measured in centiseconds or even faster. This is all possible thanks to findings in areas of electrical engineering, mechanical engineering, informatics… especially in the last 50 years. Billions of sensors are installed in technical systems and continuously inform the controllers of certain mechanisms about required impulse levels, and possible related actions respectively reactions that are previously anticipated and stored adequately, whereby the boundaries of Automatic regulation is completely defined (Božičević, 1988; Šurina, 1996), although some of these systems can show features of rudimentary learning, without human intervention they do not have enough variations and choice so that they can be proclaimed autonomous in the same way as in biological systems. However, mid-term and especially long-term effects in technical systems have much larger uncertainties, because such systems are often designed for shorter purposes, with regulation of quick responses, therefore findings on long-term effects are often lacking, with serious consequences for such systems and mankind in general.

Examples are pollution, nuclear waste, oxidation of iron in structures, fatigue of materials in mechanical mechanisms, etc. Of course, sometimes there is not much difference in biological disciplines, and it manifests itself through the loss of some functions such as low immunity, cumulative concentrations of toxic elements in tissues, weak effect of antibiotics, in education as boredom or tedious professors, outdated programs, and in sports as micro-traumas, overtraining or speed barriers etc. Years-long functioning of certain stimuli with unknown (or at least insufficiently known) effects is typical for all these situations. Although it is right to question the application of stimuli whose long-term effects we do not know, it is equally right to question if there is a reason to delay application of some knowledge while the acute effects (such as health segments, learning results, recent sport results etc.) are practically immediately attainable. Answers to these questions are, of course, related to findings which science is yet to make, and in the meantime universal solutions to identify any kind of processes that occur in certain situations should be found if possible, preferably in relation to the mid-term and long-term effects. One of the possible solutions, at least for mid-term effects of applied processes is identification of particular phases where the effects of stimuli application can be expected. In that sense, one of such solutions are cascade processes.

**Embedded and temporal cascade regulation**

In technical systems, management and regulation of cascade processes is a known fact. In this manner Bolf (2010) claims that deviations can be continuous in slow processes because the beginning of correctional operation takes more time after the occurrence of the disturbance. In addition, waiting for the results of the operation takes more time as well. As a result, cascade regulation uses a so-called "intermediate size" which is regulated whereas correctional operation is executed much earlier due to disturbances. The basic idea is to place one control circuit into another (Bonacin and Bonacin Da., 2007) and to find an intermediate size that will be controlled in the inner circuit. Cascade regulation shows its true value when dynamic delay in process is very long, i.e. when regulating very slow processes (Figure 4). A typical example is regulation of room temperature.

In the classical sense (e.g. heating), some sensor measures the temperature of the room, and, for instance, if the temperature of the room falls below the setting due to opening doors, then the air heater turns on, but only after the sensor registers the change, which may occur after several minutes. However, the cascade regulation involves the measurement of air temperature at the door entrance (inner control circuit), hence if the temperature of incoming air is lower, then, without any delay, heating turns on in accordance with the temperature of the air that comes through the door, and in accordance with the setting of the main regulator (outer control circuit). In this way, it is regulated in advance, without waiting longer. As a result, the problem is solved with two regulators, where the outer or the main regulator (in the room) is primary, whereas the inner or the auxiliary regulator (at the door) is secondary. The secondary responds much faster, it needs to absorb as many disturbances as possible and must be able to respond quickly (Bolf, 2010). It is clear that, even in this simple case, there are numerous situations that may lead to totally unacceptable solutions. For instance, if the door is constantly being opened and the temperature of incoming air is just a bit below the setting, the secondary regulator will constantly activate the primary regulator which may eventually lead to irrational operation and even overheating. Slow processes mostly include almost all medical treatments, training processes in kinesiology, as well as pedagogical processes. In all of these processes, it is often not possible to know in advance when large effects will take place, therefore in such situations controlled processes and regulations are always the case. In order to achieve wanted goals, it is necessary to ensure constant surveillance, regulation and size changes that are needed for process monitoring or control. In this matter it is obviously the case of continuous, slighter or larger redesign of the transformation process (Bonacin, Da. and Bonacin, 2007). One of the ways to solve these problems is applied cascade regulations described in technical systems.

Especially when changes are turbulent, and dynamic delay is long at the same time, which is, for instance, regularly the case in kinesiology and sport, therefore time parameters for occurrences of desired effects are unknown. However, there is also another way for cascade regulation, whose logic is derived from the term cascade itself. "Cascade" means a series of interconnected components in which information or resources "cascade" from one segment to another, as in the regulated river flows in cities, where in a series of small waterfalls (e.g. half meter) river between them flows relatively symmetrically and calmly. This way of practical chain-link enables regulation of some occurrence within a cascade with a series of effects that can be measured in any cascade. However, the long-term effects that are possible to set up in accordance with goals are essential. Figure 5 clearly shows that there is regulation within a cascade, (e.g. a seven-day or shorter training micro cycle), as well as a series of direct cascade effects (- - ->) but also the possibility of taking into account long-term effects (.....>) that last several weeks, months and even years. Such a transformation process management model is certainly very complex and it requires good understanding of informatics, cybernetics, regulations, management, identification and modelling skills, apart from "field knowledge in the narrow sense", and finally it requires thorough knowledge of mathematics.

Without such an approach it will be difficult for transformation processes to be placed in a position of acceptable accuracy, i.e. into the scientific scope. Transformation process management is objectified in the two ways mentioned above in the fields of kinesiology, medicine, pedagogy, as well as in sociological processes, management and economy, market regulation and elsewhere.

**Conclusion**

Managing any sort of processes is often a difficult task that requires a lot of responsibility most of the time. Due to the growing complexity of existing systems (from local all the way up to global), ordinary regulation procedures that should "maintain" the systems within normal parameters are having more and more difficulties when meeting new demands. This is applicable in all areas of human activity, even in technical, particularly in so called social and especially, in a broader sense, anthropological areas.

The article puts forward the implementation of the rules for cascade regulation into the management of transformation processes in kinesiology, medicine, pedagogy and other anthropological disciplines with possible application based on two in part convergent ways: 1. Embedded, and 2. Temporal cascade regulation. Both cases demand good understanding of mathematical tools. It seems that the awareness of transformational achievement goals would be raised to a whole new level and errors caused by unknown factors would be reduced to a minimum.

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## KASKADNA REGULACIJA TRANSFORMACIJSKIH PROCESA

### Sažetak

*Upravljanje procesima bilo koje vrste, nerijetko je teška, a prečesto i jako odgovorna zadaća. Zbog sve veće složenosti sustava koji danas egzistiraju (od lokalnih pa sve do globalnih na razini cijele Zemlje), uobičajeni regulacijski postupci koji bi trebali „održavati" sustave unutar željenih granica sve teže zadovoljavaju nove zahtjeve. To vrijedi u svim područjima ljudskog djelovanja, pa čak i tehničkim, a napose u tzv. društvenim i, pogotovo nešto šire, antropološkim područjima. U članku je predloženo da se u upravljanje transformacijskim procesima u kineziologji, medicini, pedagogiji i drugim antropološkim disciplinama uvedu zakonitosti kaskadne regulacije uz moguće aplikacije na dva temeljna, međusobno u dijelu konvergentna načina: 1. Ugniježđena, i 2. Vremenska kaskadna regulacija. U oba slučaja traži se dobro poznavanje matematičkih alata. Čini se da bi poznatost ostvarenja ciljeva transformacija tada bila podignuta na sasvim novu razinu a pogreške uvjetovane nepoznatim faktorima svedene na minimum.*

*Ključne riječi: procesi, kaskade, gniježđenje, vremenski*

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# THE DIFFERENCES IN BODY PHYSIQUE BETWEEN TWO GENERATIONS OF ELITE WATER POLO PLAYERS (1995-2008)

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*Original scientific paper*

***Abstract***
*The physique of elite players in a team sport game (Olympic sport water polo) of two generations is study and compared. In both generations, in the years 1995 (N =95) and 2008 (N=87) the same measurement procedures and variables were used. The analysis of variance and discriminative analysis showed statistically significant differences in most of the 23 anthropometric variables. The main univariate differences were in variables of girths and skinfolds, both increased in GP2008. The latent variables, obtained by factor analysis, are representing: by girths and, subcutaneous adipose tissue on trunk, appendicle skeleton linear growth and limb skinfolds. No significant differences in linear growth, and, trunk subcutaneous fat factors, but, statistically significant positive differences in body muscle mass pertained in girths and decrease in limb skin folds, were observed. The problem of the differences between two generations of athletes is identified as a complex system topic combining two different processes: that of population changes and sport selection (morphological optimization) on the one hand, and the changes in sport itself on the other. The simplified model of such complex change is also provided for possible future refinements and uses.*

***Key words****: water polo, body physique, generations*

## Introduction

Of all human characteristics, the physique probably has the slowest time dynamic, both over human life time span, and as an effect of population change dynamic, between generations. In this study we are interested in identifying the main factors contributing to change the physiques of elite water polo sportsmen between generations. Those factors in general, we infer, should be structured in two mutually dependent main causes: the population changes and the changes of team sports game.

The scientific topic of elite sportsman physique changes analysis has recently been battered by approaches adopting new developments and achievements in the fields of developmental biology, body patterning modeling, and genetics. By that we amend the dominating, somewhat simplified interpretation of Physique by functional anatomy and/or biomechanical approaches. In particular, in the analyses of changes in athlete physique between generations, it allows new scientific perspectives and findings. Human body patterning, growth and development from embryo through early childhood and later maturation are the resultant of genetically coded body plan (bauplan) realization. Detailed genetic mechanisms controlling the shape and growth of individual bones are still poorly understood. This is an unfolding process driven by genes in the complex and not yet fully understood process of genetic signaling and transcription in the earliest embryonic phase of growth, and subsequent processes by which cartilage is formed from mesenchyme cell tissue, and gradually replaced in bone formation by endochondral ossification process of the long bone growth plates.

Skeletal patterning in the vertebrate limb, i.e. the spatiotemporal regulation of cartilage differentiation (chondrogenesis) during embryogenesis and regeneration, is one of the best studied examples of developmental processes (Wolpert, 1994; Tickle, 2003; Endo et al., 2004; Brockes & Kumar, 2005; Newman & Müller, 2005). Limb morphogenesis involves subcellular, cellular and supracellular components that interact in a reliable fashion to produce functional skeletal structures. Since these components and interactions are also typical of other embryonic processes, understanding this phenomenon is providing insights into a variety of morphogenetic events in early development. This process is appropriately accompanied by other muscle, skin, blood vessels and nerves tissue growth and development. These processes continue throughout childhood to puberty and adulthood. Elite sportsmen are marked by a long-period exposure to the sports training process. The physique of sportsmen participating in elite sports competitions is therefore the resultant of a long-term complex process. Although it is not easy to comprehensively study and analyze this process, we found that a number of scientifically interesting conclusions may be drawn from the contemporary comparative analysis of anthropometric measures of distinct generations. The athlete population, due to its selection, and because of its submission to prolonged training process strains, is a complex topic. The population itself is changing. The secular growth trend is noted in many scientific studies over a period of about 100 years. But, the athlete population, aside from such population changes, is also changing due to new sports achievements. Such athletes, better selected and superiorly trained, are also in turn changing the sports activity itself.

In water polo game playing, for example, there has been substantial change in the course of the last several decades. It is, we may say, in many ways a different game, and it is almost unthinkable to compare players of two generations in the same imaginary match (Lozovina, 2009). Accordingly, today's athletes physique characteristics are the result of a complex interplay between player physique changes and changes in game. The anthropometric secular changes, or, a more rapid growth and development, demonstrated as higher mean stature and body mass, have been noticeable already for more than a century. A positive secular trend of increasing body size and faster growth rate has been observed in a number of countries since the middle of the 19th century: Tanner (1966), Ljung, Bergsten-Brucefors, & Lindgren (1974). This positive secular trend has been attributed to the environmental causes and the composite and complex influence of improving living conditions, nutrition, and control of infections: Van Wieringen (1978), Tanner (1986), Hauspie et al. (1997). The secular trend of increased stature, observed during the last century, amounted to 1.3 cm per decade by the end of childhood, 1.9 cm in mid-adolescence, and 0.6 cm at young adult age: Meredith (1976). Coefficients of increase in the stature per decade (cm/decade) differ among European countries, from 0.3 in Norway and Sweden to 1.9 in Slovenia: Hauspie et al. (1996). The relationship between various types of sports activities and sports training with growth and development have also been investigated and summarized in a number of publications and textbooks: Malina (1991), Malina at al. (1991), Borms & Hebbelinck (1984). On the other hand, the athlete's anthropometric dimensions, reflecting body shape, proportionality, and composition play a significant role as a component determining success in a given sport: Carter (1970; 1984), Battinelli (1990). In our previous paper we showed that anthropometric characteristics of elite water polo players have changed over the 15 years period (from year 1980 to year 1995).

Body shape changed in terms of greater height and more elongated limbs, with thinner waist and broader shoulders, but, body mass remained unchanged. Muscle-to-fat mass ratio increased. The observed changes are concluded to be both a consequence of population secular trend, and, a consequence of sport morphological optimization (Lozovina & Pavičić, 2004). In the elite sport talent identification process, skill level and physical fitness is largely the dominant factor. However, given the lesser possibilities of influence on anthropometric characteristics, due to genetic limitations, body shape and composition are of paramount importance. It is obvious that anthropometric characteristics for the athlete selection and success in sports performance might be decisive. Today distinctive top athlete anthropometric characteristics are the result of the selection of successful athletes from a number of successive generations. This is in particular obvious in top level athletes.

This phenomenon as identified as sport morphological optimization Norton & Olds (2001), Lozovina & Lozovina (2008). In this paper we analyze the differences in the physique of two distinct generations of elite water polo sportsmen. The first GP was measured 1995 and second GP in 2008. About 20% of the players in each sample were Olympic medalist level. In both measurements the same anthropometric set of 23 body measures based on IBP measurement procedure was used. The measurement set comprised measures of appendicular body skeleton lengths and breadths, muscle and fat mass, represented by girths and skin fold measures respectively. The analyses were made on direct measurements, and also on derived variables, obtained as factor scores. The analysis of the differences between generations is interpreted and discussed using statistical analyses of variance and discriminate analysis. Also, we identified and suggested a simple model of change aimed for better understanding, interpretation and discussion of this topic with a complex system background.

## Methods

*Subjects*

The sample in total consisted of 152 elite male water polo players drawn from the top National division (Croatian) clubs. Anthropometric measures of 65 players (approx. 50% of the target population) were taken in 1995 (GP1995) and of 87 players (approx. 70% of the target population) in 2008 (GP2008). In the GP1995, the players' age ranged from 19 to 29 years (mean ± standard deviation, 21.8± 3.9 years), whereas in the GP2008 the range was 19-34 years (23.8 ± 3.8). All participants were clinically healthy without morphological aberrations. The only inclusion criterion was participation in at least one official game as a member of the national division level team in the year of measurement. There are no overlaps between the two groups. About 20% of respective generation was members of the national Olympic team, and Olympic medallists in each respective competition. All players were subject to the training process for at least five years before measurement took place. Most players, however, had training and playing history even longer and up to about 20 years. Training frequency, intensity and volume, in the preparing period was distributed over training sessions accordingly, lasting between 1.5 to 2.5 hours, each day in the morning and in afternoon/evening sessions.

The sessions consisted of basic special strength and conditioning exercises in and out of water, technique exercises drills, and game playing in simulated official games. In each day, distribution was, approximately, 50, 15, and 35% of time devoted to basic, technique and playing exercises respectively. Each year in competitions each player played 22 official in national competition, and members of national team played at least one international official tournament.

*Measurements*
Qualified and trained investigators performed measurements; using standardized procedures recommended by the International Biological Program (Weiner & Lourie, 1969) (measurements are also compatible to ISAK Criterion standards). A medical balance was used with a precision of 0.1 kg, Martin anthropometer with a precision of 1 mm, pelvimeter with a precision of 1 mm, skin fold calliper (John Bull) with a compression of 10 g/mm$^2$ with accuracy of 0.1 mm, small sliding calliper with accuracy of 1 mm$^2$, and synthetic length measuring tape with accuracy of 1 mm. Anthropometric status of subjects was determined on the basis of 23 anthropometric measures. Katch & McArdle formulae were used to estimate the body fat percentage index on the basis of direct performed measurements: Katch & McArdle (1973).

*Statistical Analysis*
Data for each sample were represented with mean and standard deviation statistics. Analysis of variance between independent groups, and discriminative analysis was used in the analyses of differences. Factor analysis under component model with oblique rotated factors solution (Direct Oblimin) was used for the identification of common derived body components. Statistical test and analyses of differences between two generations was utilized on the manifest, measured variables and on the factor scores on derived variables. SPPS statistical software (*SPSS Inc., Chicago, IL, USA*), was used for all statistical calculations and analyses.

## Results

In Table 1 anthropometric measures and indexes basic statistics by groups are presented accompanied by the statistical test of significance (F-test) of differences, and the structure of the discriminative function. Statistically, two groups differ significantly in almost all anthropometric measures. In discriminative function structure (Canonical Correlation 0.*875*, Wilks' Lambda 0.*235*, Chi-square =*199.83*, p≤0.001), the largest correlation showed measures of body girths and breadths accompanied with body linear measure along skeleton proximodistal (PD) axis. The foot length measure is significantly decreased (diff=-4.8mm). Two other decreased measures are those of calf skinfold and body density. The body girths measures on trunk and appendicular skeleton measures are all significantly increased in 2008 generation. The measures of breadths, measured on limbs articulatios, are also increased, and with notable contributions to discrimination function. With the exception of triceps, all skin folds are significantly increased. The differences in body weight and BMI, and percent of body fat are also statistically significant and increased in generation 2008. The factor analysis solution is not as parsimonious as one would expect (Table 2.). The four factors, explaining 75% of variance, are significant according to the Guttman-Kaiser criterion.

Table 1. Statistics by generations 1995 and 2008, means differences and discriminative function structure

| | 1995 | 2008 | | |
|---|---|---|---|---|
| Measure | Mean± | Mean± | M | S |
| WEIGHT | 85.91±6.88 | 94.76±11.16 | 8.85** | .26 |
| HEIGHT | 189.59±5.02 | 192.47±6.38 | 2.89** | .14 |
| LEG LENGTH | 107.33±3.84 | 108.54±4.82 | 1.21 | .08 |
| TOTAL ARM LENGTH | 83.15±3.45 | 85.67±3.59 | 2.52 | .20 |
| HAND LENGTH | 18.62±0.81 | 19.19±0.83 | 0.57 | .19 |
| FOOT LENGTH | 28.03±1.06 | 27.55±1.41 | -0.48* | -.10 |
| HAND BREADTH | 8.41±0.41 | 8.89±0.36 | 0.48** | .35 |
| WRIST BREADTH | 5.81±0.26 | 6.13±0.30 | 0.32** | .32 |
| FOOT BREADTH | 10.13±0.53 | 10.29±0.52 | 0.16 | .08 |
| BIACROMIAL BREADTH | 43.73±1.33 | 44.00±1.97 | 0.27 | .04 |
| BIILIOCRISTAL BREADTH | 28.52±1.58 | 29.53±1.96 | 1.01** | .15 |
| BIEPYCONDILAR FEMUR | 9.65±0.45 | 10.03±0.46 | 0.37** | .22 |
| BIEPYCONDILAR HUMERUS | 6.57±0.58 | 7.42±0.37 | 0.85** | .49 |
| CHEST GIRTH | 103.94±5.11 | 109.28±6.63 | 5.34** | .25 |
| ARM GIRTH | 32.49±1.73 | 34.79±2.19 | 2.30** | .32 |
| FOREARM GIRTH | 27.34±1.23 | 29.50±1.35 | 2.16** | .46 |
| THIGH GIRTH | 56.50±2.62 | 61.83±4.17 | 5.32** | .409 |
| CALF GIRTH | 37.57±1.42 | 39.24±2.35 | 1.67** | .23 |
| TRICEPS SKINFOLD | 8.15±2.71 | 8.17±2.62 | 0.02 | .00 |
| SUBSCAPULAR SKINFOLD | 8.95±2.28 | 10.90±3.55 | 1.95** | .18 |
| AXILAR SKINFOLD | 7.28±2.77 | 9.21±4.49 | 1.93** | .14 |
| CALF SKINFOLD | 10.57±3.13 | 8.69±3.57 | -1.88** | -.15 |
| ABDOMINAL SKINFOLD | 10.56±4.47 | 14.30±6.45 | 3.74** | .18 |
| BODY MASS INDEX | 23.88±1.43 | 25.52±2.08 | 1.64** | .25 |
| BODY DENSITY | 1.08±0.00 | 1.07±0.21 | -0.01** | -.13 |
| PERCENT BODY FAT | 9.44±2.38 | 10.79±3.05 | 1.35** | .13 |

**p ≤0.001, *p ≤0.01
M = Mean diff-2008-1995, S = Disc.Struct. Function

Table 2. Factor oblique rotated solutions (Direct Oblimin) pattern matrix and communalities

| | | | | | $h^2$ |
|---|---|---|---|---|---|
| Measure | 1 | 2 | 3 | 4 | |
| WEIGHT | .54 | -.31 | .39 | -.21 | .93 |
| HEIGHT | .08 | -.05 | .89 | -.07 | .88 |
| LEG LENGTH | -.11 | -.04 | .95 | -.08 | .83 |
| TOTAL ARM LENGTH | .09 | -.04 | .84 | -.08 | .80 |
| HAND LENGTH | .33 | .05 | .58 | .21 | .62 |
| FOOT LENGTH | -.11 | .06 | .85 | .13 | .67 |
| HAND BREADTH | .80 | .18 | .08 | -.02 | .63 |
| WRIST BREADTH | .74 | .08 | .15 | .07 | .62 |
| FOOT BREADTH | .46 | .19 | .42 | .22 | .54 |
| BIACROMIAL BREADTH | .01 | -.11 | .45 | -.39 | .38 |
| BIILIOCRISTAL BREADTH | .40 | -.34 | .28 | .01 | .57 |
| BIEPYCONDILAR FEMUR | .73 | -.05 | .10 | .29 | .65 |
| BIEPYCONDILAR HUMERUS | .78 | .04 | -.07 | -.02 | .56 |
| CHEST GIRTH | .43 | -.36 | .17 | -.45 | .81 |
| ARM GIRTH | .68 | -.35 | -.10 | -.29 | .84 |
| FOREARM GIRTH | .84 | -.07 | -.01 | -.24 | .87 |
| THIGH GIRTH | .68 | -.35 | -.01 | -.18 | .81 |
| CALF GIRTH | .80 | -.07 | -.01 | .13 | .66 |
| TRICEPS SKINFOLD | -.01 | -.72 | .04 | .57 | .81 |
| SUBSCAPULAR SKINFOLD | .10 | -.87 | -.01 | -.12 | .85 |
| AXILAR SKINFOLD | -.03 | -.88 | .02 | -.20 | .81 |
| CALF SKINFOLD | -.14 | -.62 | .05 | .57 | .67 |
| ABDOMINAL SKINFOLD | .09 | -.86 | .02 | -.17 | .86 |
| BODY MASS INDEX | .70 | -.38 | -.14 | -.23 | .86 |
| BODY DENSITY | -.07 | .96 | -.02 | -.12 | .97 |
| PERCENT BODY FAT | .07 | -.96 | .02 | .11 | .97 |
| EIGENVALUE | 11.5 | 4.2 | 2.5 | 1.3 | |
| % OF VARIANCE EXPLAINED | 44.4 | 16.1 | 9. 6 | 4.8 | |
| FACTOR MATRIX | | -.34 | .43 | -.16 | |
| | | | -.13 | .05 | |
| | | | | .03 | |

The most prominent groups of loadings on the first factor have measurements of girths on limbs, indicating the limb muscle tissue component, and three diameters, measuring two body articulatios on limbs, and also with high projections of hand and wrist breaths (anterior-posterior axis AP). All skeletal measures along PD growth axis, longitudinal dimensionality, are confined to the third factor, indicating linear growth factor, possibly generated by underlining genetic body patterning mechanism. The second and fourth factors are explaining respectively 16.1% and 4.8% of total variance. Both are dominantly specified by, topologically scattered, subcutaneous adipose tissue defined by skinfold measures. Bipolar second factor reflects the percentage of body fat index and skinfold measure on trunk, and, on the other side the body density index. On a somewhat lower level are added two limb skinfolds, on the upper and lower leg segments. It is obviously the factor of body fat tissue which is of lower density and which by that partial contribution is lowering total body density. The last, fourth factor is sparsely loaded.

Here are prominent two skinfold measures loadings on limbs, already present on the second factor, negatively contributing to body density there, and moderately higher loadings of circumference and breadth on the trunk with the negative sign. This is also the bipolar factor, distinguishing specific, topologically confined, skin fold measures on limbs, and, on the other pole, trunk spatial measures. The factor intercorrelation matrix (Table 2.) indicates a positive relation between (1.) girths and (2.) subcutaneous adiposity (under skin fat factors), and even to a greater extent, with the third linear skeletal growth factor (3.). There are no significant mutual relations between the topologically defined subcutaneous adiposity on the trunk (2.) and on the limbs (4.). A weak negative relation of the fourth factor with the first one indicates the interesting nature of its partial contribution to whole girths. Other factor intercorrelations have low and statistically insignificant values. In the discriminant analysis applied on factor scores (Table 3.) variables (regression model) we found statistically significant discrimination between two generations (Canonical Correlation 0.67, Wilks' Lambda 0.56, Chi-square =86.86, $p \leq 0.001$) based primarily on 1st factor – girths and 4th factor representing skin tissue on limbs component. The longitudinal dimensionality, on 3rd, and subcutaneous fat tissue, on 2nd factor, do not contribute significantly to the discrimination between two given groups on latent variables. A statistically significant increase is noted in girths (mean z value from -0.72 to 0.54) in the first factor, and a decrease in limb skin tissue factor (mean z-score value from 0.32 to -0.24) in the fourth one. Unexpectedly, in this weakly parsimonious solution, however, still five measures are not very well defined (as much as 25% of variance remains unexplained by this solution). Having low communalities and/or factor loadings, these variables are almost evenly distributed over all four factors.

Table 3 Factor scores group statistics, difference of group means and discriminative function structure

| | 1995 N=65 | 2008 N=87 | | |
|---|---|---|---|---|
| | Mean± Std. Dev. | Mean± Std. Dev. | Mean difference-08-95 | Disc. Function Structure |
| Body volumi-nossity | -0.722±.649 | 0.539±.868 | 1.261** | .899 |
| Sub-cotaneus fat tissue | 0.211±.761 | -0.158±1.125 | -0.369 | -.208 |
| Bone component (PD axis) | -0.145±.866 | 0.108±1.082 | 0.253 | .142 |
| Limb Skinfold | .320±1.046 | -0.239±.898 | -0.559** | -.324 |

These measures are both indicators of measures of the trunk upper and lower girdle. Interestingly, the measure of weight or total body mass measure is also present in this group. In spite of having high communality, body mass measure has practically equal loadings on all factors. All that is implying that some, possibly important, sources of variations in player's physique have remained undefined by this solution.

**Discussion**

On the most abstract level, we can see that the water polo sportsman physique can be defined by four factors. The first factor (1) is of general type and is constituted of most measures of circular (girth) and transversal (breadth) body measurements. The third factor (3) is determined by body liner growth measures. The remaining two (2, 4) are defined by body skinfolds. In relation to body growth dynamic, the first factor is dominated by loadings comprising measurements of body parts with prolonged development and growth. Besides that, it is also, to greatest extent of all physique components, open to changes later in the lifespan, and in particular, when the body is exposed to programmed and extensive exercise over a long time period (Woo et al., 1981; Frost, 1990; Currey, 2002). On the other hand, the linear body component factor (3.), defined by long appendicular skeleton bones, is genetically most fixed in growth and development variations, and is also least dependent on external influences. For that reason, it is of all physique characteristics, most defined by primary sports selection. The second under skin fat factor (2), which did not change significantly, is pointing to the, water sports-specific, "fatness". It is important to note that it is confined only to the trunk (containing cardio-pulmonary organs and digestive tube) skinfolds, and limb skinfold measures do not have notable loadings. It seems that the fourth factor (4) is defined by the limbs skin component (skinfolds measures) which is not representing the body fat tissue. Thus, here the fat free limbs skin tissue component may be recognized. Besides, loadings of the girths and breadths to the same fourth factor hint an underlying relation that a bigger trunk is accompanied by smaller limb skin folds.

The discriminate analysis results imply there is no change in game playing that would imply change in under skin fat body component and linear skeletal dimensionality, but there are enforcing changes in increased body voluminosity (mean z value from -0.72 to 0.54) and a decrease in limb skin tissue component, which also statistically significantly differs (mean from 0.32 to -0.24). Motivated by the ambition to cut the long story short, we here suggest a very simplified model devised only for better enumeration and explanation of the possible sources of the differences in elite sportsman physique between two generations. The model designed, therefore, only for the aims of clarification and more versatile discussion on the topic of acquiring secular changes in sports. The list of basic influencing factors in such a hypothetical simple model can be enumerated as: environmental impacts (E), body anthropometry – body patterning, and growth and development (A), selection for the elite sports achievements (S), sports training process strains impacts (T), and changes of game in rules or/and playing discipline, and changes in playing tactic and technique (G), sport morphological optimization effect on selection for sport (O) and resulting elite sportsmen physique (P). A simplified model devised for depicting different complex system dynamic relationships subject to change between generations we then define by simple schemata (figure 1). Within one generation we have two principal kernels of influences, that is, general environmental effect filtrated (E) by morphologically optimized selection (O), and second, specialized sports activity effects (S). In the effects, participation in (sport) activities, we may identify two main different influencing component parts, that is, prolonged and intensive training strains effects (T) and game playing effects (G). The influencing factors A, E, T and G are all subject to change in a given time.

It is obviously a complex system dynamic problem defined on several mutually dependent layers of different complexities, which is here only elaborated from the perspective of the possible consequences it produces in sportsman physique.

## Conclusion

All data considered, we identified two main manifestations of elite water polo players' physique changes between generations; the muscle mass and fat tissues indicating soft body masses, on the one hand, and linear appendicular skeleton together with skin tissue components on the other. This distinction indicates the possible cause of changes is in different latent body growth and development mechanisms having different genetic background. We can extrapolate that both, sport playing and training strains and selection effects are in the background of the relations found. In regard to training, we know that elite water polo players are subjects of severe training strains over a long period, with a characteristic distribution of different types of loads in the course of the calendar year and the Olympic four-year cycles.

This process is causing changes in expected players' body physique. Together with the changes in game playing (tactic, technique) this causes changes of ideal player anthropometric characteristics. We may conclude that elite water polo player physique is changing between generations. The underlying causes of changes allowing for clarification and interpretation of changes are of great complexity. Clarification and explication of one part of this process, as it is here in domain of anthropometry measures, is contributing to better general human biological anthropology topics understanding and possibly improved sports practice.

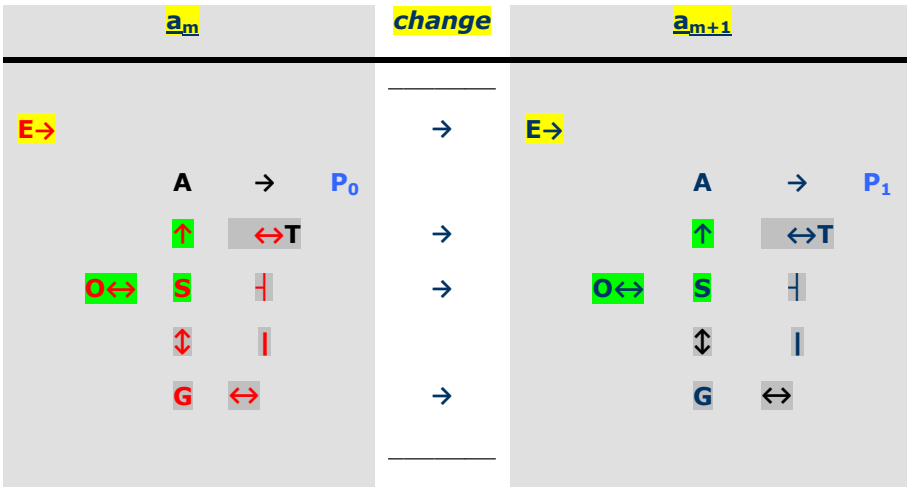


Figure 1. Schemata describing generations

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## RAZLIKE U TJELESNOJ GRAĐI IZMEĐU DVIJU GENERACIJA ELITNIH VATERPOLISTA (1995-2008)


### Sažetak

*Tjelesna građa elitnih igrača u kolektivnom sportu vaterpolo (Olimpijski sport vaterpolo) proučavana je i komparirana. Za obje generacije /GP 1995 (N=95) i 2008 (N=87)/ primijenjene su iste mjerne procedure na istim varijablama. Analiza varijance i diskriminativna analiza pokazale su statistički značajne razlike u većini od 23 mjerene antropometrijske varijable. Najveće razlike uočene su na opsezima i mjerama potkožnog masnog tkiva, u oba slučaja u smislu povećanja kod GP 2008. Latentne varijable, dobivene faktorskom analizom, reprezentirane su: opsezima i potkožnim masnim tkivom na trupu, apendikularnom linearnom rastu skeleta i potkožnim masnim tkivom na ekstremitetima. Nema signifikantnih razlika u linearnom rastu skeleta i u potkožnom masnom tkivu na trupu, ali, statistički signifikantne promjene, u smislu povećanih vrijednosti, uočene su na mišićnoj masi odnosno opsezima kao i padajuće vrijednosti na potkožnom masnom tkivu ekstremiteta. Problem razlika između dviju generacija vaterpolista objasnili smo kao kompleksan sustav kombiniran iz dva različita procesa, a to su: promjene nastale u populaciji u vremenskoj distanci i sportska selekcija (morfološka optimizacija), s jedne strane, te promjene u samom sportu (promjene pravila igre i promjene u trenažnoj operatici), s druge strane. U tom smislu kreirali smo jednostavan model ovih kompleksnih promjena koji daje mogućnost za neka buduća usavršavanja i upotrebu.*


***Ključne riječi**: vaterpolo, tjelesna građa, generacije*

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# DIFFERENCES IN AGILITY PERFORMANCE BETWEEN FUTSAL AND SOCCER PLAYERS

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*Original scientific paper*

***Abstract***
*The purpose of this study was to determine differences in agility performance between futsal and soccer players. The research was conducted on a sample of 82 subjects divided in two groups: 40 futsal players (body mass 70.39 ± 5.33 kg; body height 176.26 ± 6.85 cm) and 42 soccer players (body mass 70.86 ± 5.65 kg; body height 175.42 ± 5.95 cm). The subjects were tested in the following variables: Slalom test (SL); Slalom test with ball (SLB); Sprint with 90° turns (S90°); Sprint with 90° turns with ball (SB90°); Sprint 9-3-6-3-9 m with 180° turns (S180°); Sprint 9-3-6-3-9 m with backward and forward running (SBF). The values for the Slalom test with and without the ball are very similar for soccer and futsal players and without statistically significant difference (slalom test p = 0674; slalom test with ball p = 0830). The same results are in the sprint test 9-3-6-3-9 whether it was done by turning for 180° or with running back and forth. For the agility performance of players, in the tests SL and SLB there was no statistically significant difference between futsal and soccer players. The futsal and soccer players differ in the intensity exertion during the game, but not in the motor activities such as agility. Agility is a very important component of both, futsal and soccer and it represents a common characteristic. Based on that fact we can conclude that the players in these two sports are very similar in agility performance.*

***Key words:*** *field test, futsal, comparison, team sport*

## Introduction

Despite the fact that soccer is one of the most popular sports today, interest in futsal slowly starts to grow (Roxburg, 2008) and therefore its popularity too. Compared to soccer, futsal has very similar game structure. Nevertheless, it has been much less the object of scientific research. Up to date, much more researches have been conducted in soccer than in futsal. It is particularly interesting that only a few studies exist which deals with the comparison of players in soccer and futsal, despite the fact that they are very related.

What the soccer and futsal have in common is that they represent an intermittent high-intensity activity which is based not only of aerobic but also of anaerobic capacity of players (Barbero-Alvarez et al., 2008; Bangsbo et al., 1991; Ben Abdelkrim et al., 2007). However, the intensity during the futsal match was almost 90% of the maximum Heart rate (Barbaro-Alvarez et al., 2008) compared to match intensity in soccer that was lower and ranged from 80 to 90% of maximum Heart rate (Reilly, 1994). In futsal the total distance covered during the match consists of 13.7% high intensity running and 8.9% sprinting (Barbaro-Alvarez et al., 2008). In soccer, those high intensity activities account about 11% (Baron et al., 2007, Reilly et al., 2000). In addition, Dragomaci & Watsford (2006) has pointed out that futsal players spend 26% of time during the match in high intensity level, which is direct consequence of futsal rules that allow players more frequent changes than in soccer.

The technical proficiency of futsal players is influenced by the smaller ball, which forces the players to technically more quickly and accurately respond in control and keeping the ball (Burns, 2003; Goncalves, 1998). Besides this, the reduced size of the field will cause a constant pressure from the opposite players, so the futsal players are found under constant markings and in situations 1vs1 (Vaeyens et al., 2007). Such reduced pitch dimensions and the frequent turnovers during futsal match requires from players fast decision-making and high sprint capabilities under pressure during attacking and defending phases of the game (Vaeyens et al., 2007). The question is whether they need better agility performance in order to help them to come to a better position to receive the ball and threaten the opponent's goal.

The ability of athletes to make a quick movement of the entire body with a change of direction and speed of movement, known as agility (Sheppard and Young, 2006) may represent a basic component in team sports such as futsal and football. During a soccer match and the player frequently performs activities that require rapid development of force, such as sprinting or changing direction quickly (Bangsbo, 1996). High-speed actions in soccer and futsal can be categorized into actions requiring acceleration, maximal speed, or agility (Gambetta, 1996). Concerning that fact, SAQ (speed, agility and quickness) method has become dominant in training (Pearson, 2001).

Based on the determination model of agility, Young & Farrow (2006) emphasize the ability of perception and decision-making as a key skill of agility athletes in team sports, to which futsal and soccer belong too. As it is already mentioned above, there are few studies related to futsal with the objectives mostly based on physiological response of players (Castagna et al., 2007; Barbero-Alvarez et al., 2008) or aerobic fitness (Barbero-Alvarez et al., 2009). Also, to our knowledge, there are no studies that compare men's futsal and soccer players in agility performance. Although agility is one of the motor skills that are still unexplored in Futsal, still it represents a very important component regard to the amount of high intensity movements during the match. Knowing all that, the purpose of this study was to determine the differences in agility performance between futsal and soccer players.

## Methods

*Subjects*

The research was conducted on a sample of 82 subjects divided in two groups: 40 futsal players (body mass = 70.39 ± 5.33 kg; body height = 176.26 ± 6.85 cm) and 42 soccer players (body mass = 70.86 ± 5.65 kg; body height = 175.42 ± 5.95 cm). Soccer and futsal players in this research were taken from the first Croatian football and futsal league. All players were fully informed and they signed a consent form. The study protocol was held for every subject. Beside the results, the basic anthropometric parameters (body height and body weight) were registered in the study protocol. The tests were performed on the same day in the morning for all the subjects. The study was approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb. Subjects were admitted in the study if they had a minimum training age of 3yr, engaged in strenuous training at least 10 h per week and were currently active in competition. The characteristics of the sample are presented in Table 1.

Table 1. Descriptive statistics parameters

| | Futsal | Soccer |
|---|---|---|
| | N=40 (Mean±SD) | N=42 (Mean±SD) |
| Body height (cm) | 176.26±6.85 | 175.42±5.95 |
| Body mass (kg) | 70.39±5.33 | 70.86±5.65 |
| S180° (s) | 7.49±0.45 | 7.48±0.37 |
| SBF (s) | 7.93±0.45 | 7.73±0.44 |
| SL (s) | 3.66±0.81 | 3.74±0.73 |
| SLB (s) | 7.96±0.94 | 7.91±1.12 |
| SB90° (s) | 9.91±0.63 | 9.71±0.67 |
| S90° (s) | 7.75±0.61 | 7.45±0.69 |

SL-Slalom Test; SLB-Slalom Test with ball; S90°-Sprint With 90° Turns; SB90°-Sprint With 90° Turns with ball; S180°-Sprint 9-3-6-3-9 m with 180° Turns; SBF-Sprint 9-3-6-3-9 m with Backward and Forward Running.

*Procedure*

Body height and body weight were measured according to the instructions of the International Biological Program–IBP (Weiner & Lourie, 1969). The body height was measured with a GPM anthropometer (Siber & Hegner, Zurich, Switzerland) to the nearest 0.1 cm. Body weight was obtained by Tanita BC 540 (Tanita Corp., Arlington Heights, IL) to the nearest 0.1 kg. Tests: 1) *Slalom Test (SL):* They all started with both feet behind starting point. Six cones were set up 2 m apart, the first cone 1 m away from the starting line. Every player stood still facing the starting line, with his feet apart and the cone between his legs. He started after the signal and ran from point to point. The player at second point had to be passed on his right-hand side. The player continued to run as fast as possible constantly changing the direction from right to left, until he reached the player standing at last point. After last point, the player made an 180° turn and went on running the slalom to the starting line. 2) *Slalom Test with ball (SLB):* The test is by the structure the same to the SL test, but it differs only in that sense that it was performed with the ball. 3) *Sprint With 90° Turns (S90°):* The players began with both of their feet behind starting point. They started from first point after the signal, ran as fast as possible to second point, and made a 90° turn to the right. After reaching second point, they continued to run to third point where they made a 90° turn to the left. At fourth point, they made another 90° turn to the left and ran on to point five, where they made a 90° to the right. Point six had the same direction and turning angle (90° turn to the right). At point seven, they made a turn to the left and ran on to the finish line-point. The track was 15 m long, the distance between the start line and the first flag was 3 m, the second and the third 2 m, the third and the fourth 2 m, the fourth and the fifth 5 m, the fifth and the sixth 3 m, the sixth and the seventh 3 m, the seventh and the eight 2 m, and nine 2 m. 4) *Sprint With 90° Turns with ball (SB90°):* The test is by the structure the same to the S90° test, but it differs only in that sense that it was performed with the ball. 5) *Sprint 9-3-6-3-9 m with 180° Turns (S180°):* The players started after the signal and ran 9 m from starting line A to line B (the lines were white, 3 m long and 5 cm wide). Having touched line B with one foot, they made either a 180° left or right turn. All the following turns had to be made in the same direction. The players then ran 3 m to line C, made another 180° turn, and ran 6 m forward. Then, they made another 180° turn (line D) and ran another 3 m forward (line E), before making the final turn and running the final 9 m to the finish line (line F). 6) *Sprint 9-3-6-3-9 m with Backward and Forward Running (SBF):* The distance that the players had to cover was the same as in the previous test (S180°). The only difference was that instead of making a turn, the players shifted from forward to backward running. After the starting signal, they ran 9 m from starting line A to line B (the lines were white, 3 m long and 5 cm wide).

Having touched line B with one foot, the players shifted from running forward to running backward. Then, they ran 3 m to line C and changed from backward running to forward running. After 6 m, the players made another change (line D) and ran another 3 m backward (line E) and then made the final change and ran the final 9 m forward to the finish line (line F). All tests used in this study were reliable and had good metric characteristics (Sporis et al., 2010). The tests were performed from a standing start and measured by means of infrared photocells (RS Sport, Zagreb, Croatia).

*Data analysis*

The statistical Package for Social Sciences SPSS (v18.0, SPSS Inc., Chicago, IL) was used for the statistical analysis. Descriptive statistics were calculated for all experimental data. Kolmogorov-Smirnov test was used to test if data were normally distributed. Statistical power was calculated using G-power software. The significance of differences between soccer and futsal players was determined by the Independent-Samples T test. We used the Bonferrony correction for the level of significance, so the level was $p < 0.0083$.

## Results

The Kolmogorov-Smirnov test showed that data was normally distributed. Statistical power was 0.95 and effect size was from r = 0.024 to r = 0.45. The greatest effect size was found in the tests $S90^0$ (r = 0.46) and SBF (r = 0.45) and the lowest for the test $S180^0$ r = 0.02. Basic statistical parameters has shown that players have similar values of body height and body mass (Table 1). The average body height of soccer players was 175.42 ± 5.95 cm and of futsal players 176.26 ± 6.85 cm. The average body mass among soccer players was 70.86 ± 5.65 kg, while among futsal players 70.39 ± 5.33 kg. Other descriptive parameters have shown that the soccer players achieved better results in all tested variables for agility except for the slalom test, where the average values for futsal player was 3.66 ± 0.81 seconds and for soccer players 3.74 ± 0.73 sec.

Table 2. Differences - futsal and soccer players

| | t | df | Sig. (2-tailed) |
|---|---|---|---|
| S180° | 0.12 | 80 | .903 |
| SBF | 1.99 | 80 | .051 |
| SL | -0.42 | 80 | .674 |
| SLB | 0.22 | 80 | .830 |
| SB90° | 1.34 | 80 | .183 |
| S90° | 2.06 | 80 | .043 |

SL-Slalom Test; SLB-Slalom Test with ball; S90°-Sprint With 90° Turns; SB90°-Sprint With 90° Turns with ball; S180°-Sprint 9-3-6-3-9 m with 180° Turns; SBF-Sprint 9-3-6-3-9 m with Backward and Forward Running.

The values for the Slalom test with and without the ball are very similar for soccer and futsal players and without statistically significant difference (slalom test p = 0674; slalom test with ball p = 0830).

Thus, the same results are in sprint test 9-3-6-3-9 whether it was done by turning for 180 ° or with running back and forth. For the agility performance of players, in the test change of direction for 90 ° there was no statistically significant difference between futsal and soccer players (p = 0.043). In addition, no statistically significant difference has been found to the one (SB90°) done with the ball (p = 0,183).

## Discussion

Average values of players' body height and body mass are similar or slightly higher than the values of the national team players' of Singapore and the first League players' of Iceland and Hong Kong (Arnason et al., 2004; Aziz & Chin, 2000; Chin et al., 1994). Body height of futsal players is similar to the one found in the study conducted among Spanish professional futsal players. The study has also shown that Spanish players were slightly heavier (76.9 kg) (Esteban et al., 2009). It is interesting that specific agility tests have shown no significant difference between futsal and soccer players, despite the fact that the size of the ball used in futsal significantly differs to one used in soccer (Burns, 2003; Goncalves, 1998). This leads us to the conclusion that in both, the elite soccer and futsal, it is necessary to have very skilful players. That was indicated by STB test of dribbling the ball with the inside of the foot as well as by SB90° test in which all the leading skills of controlling the ball have been examined (dribbling the ball with inner and outer side of the foot and etc.).

There was no statistically significant difference in the test $S90^0$ in which the change of direction for the 90° dominated. The soccer players have shown better results than the futsal players in that test, but it was not statistically significant. The explanation could be found in the fact that this type of turn (0-90°) during the match is the most common structure which makes 85% of all the turns during the match (Bloomfield et al., 2007). Bloomfield et al. (2007) stated that during the soccer match each player performs approximately 305 turns of 0-90° to the right side and 303 turns of 0-90° to the left side. Since the test S90° includes change of direction at angle greater than 90° in practical terms, there was no difference between futsal and soccer players. On the other hand, the difference is obvious because during the soccer match there are 45 turns on the right and 49 turns on the left side when the angle for the change of direction is 0-180°, which represents about 10% of all turns. The research results demonstrate that both futsal and soccer players have quite a similar motor characteristics of agility type. The results obtained by this research could be explained by the fact that in Croatia does not exist a school of futsal that would start from the beginning with the futsal practice. The majority of futsal players at first goes through the soccer schools and after that they are exposed to the to the futsal training.

The second explanation could be found in the fact that in the modern soccer practice the small-sided games, which represent one sort of futsal, are often used. Such activities are all performed on the shortened space where the ratio of players is 4 vs 4, 5 vs 5, 5 vs 4, which insist on the strict surrounding of players. With this type of training soccer and futsal players are approaching the movement structure, so that the results obtained in this study could substantiate that fact. On the other side SAQ method (Pearson, 2001) become very familiar for both, futsal and soccer players, and more often represented in training methodology. The players have become familiar with the movement in which is present not only the acceleration but also the deceleration in combination with the quick change of direction and body control (Pearson, 2001). The statement is enclosed by the research which implies that better athletes have quicker and more precise reactions due to their ability to choose anticipated information (Abernethy, Wann & Parks, 1998) which extremely important in the course of the agility test performance. The possession of good agility performance reduces the injury risk, enhance sports performance and neutralizes the opponent or avoids the opponent by using the body feints (Foran, 2001), that are very frequent in futsal and soccer. Specifically, it plays an important role in dribbling in a position where players are in a situation 1vs1. Agility also contributes to the ability of successful manipulation of the external object such as the ball (Foran, 2001).

**Conclusion**

Based on our results, we can conclude that the futsal and soccer players differ in the intensity exertion during the game, but not in motor activities such as agility. Agility is a very important component of futsal and soccer and it represents a common characteristic. Based on that fact it can be said that the players in this two sports are very similar in agility performance.

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## RAZLIKE U IZVEDBI AGILNOSTI IZMEĐU IGRAČA FUTSALA I NOGOMETAŠA

### Sažetak

*Svrha ovog istraživanja bila je utvrđivanje razlika u sposobnosti agilnosti između igrača futsala i nogometa. Istraživanje je provedeno na uzorku od 82 ispitanika podijeljenih u dvije grupe: 40 futsal igrača (tjelesne mase 70.39 ± 5.33 kg; visine 176.26 ± 6.85 cm) i 42 nogometaša (tjelesne mase 70.86 ± 5.65 kg; visine 175.42 ± 5.95 cm). Ispitanici su mjereni u slijedećim varijablama: Slalom test (SL), slalom test s loptom (SLB), Sprint sa 90° promjene pravca (S90°), Sprint sa 90° promjene pravca s loptom (SB90°); Sprint 9-3-6-3-9 m sa 180° promjene pravca (S180°), Sprint 9-3-6-3-9 m s trčanjem naprijed i natrag (SBF). Vrijednosti SL i SLB bile su jako slične kod oba uzorka i bez statistički značajne razlike (p > 0.05). Isti rezultati su bili i u testovima SBF. Za iskazivanje agilnosti također nije bilo razlika. Igrači futsala i nogometa razlikuju se u intenzitetu opterećenja za vrijeme utakmice, ali ne i u motoričkoj aktivnosti kao što je agilnost. Agilnost je jako važna za obje vrste sporta i predstavlja zajedničko svojstvo. Temeljeno na toj činjenici može se zaključiti kako su igrači ovih dvaju sportova vrlo slični u iskazivanju agilnosti.*

***Ključne riječi:*** *terenski test, futsal, usporedba, momčadski sport*

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# SWIMMING SIMILARITIES AND DIFFERENCES FROM MILITARY ACADEMY CADETS

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*Original scientific paper*

***Abstract***

*The swimming speed is characterized by short sections of the explosive and endurance swimming. It is a feature of compliance of the cardiovascular and muscular systems. Diving is a separate discipline that depends on both the cardiovascular and functional abilities. The case studies were functional ability in swimming of Military Academy cadets.The problem of the study was swimming correlations and differences of the functional abilities. The goal is to establish correlations and differences in functional capabilities of the Military Academy cadets in swimming. A sample (Table 1) was 526 cadets of the Military Academy, aged 20 (± 1 year), 430 men and 96 women, divided into first, second and third year of study. Variables are divided on the dependent variable summary: swimming 50 meters (S50m), swimming at 10 minutes (S10min), and diving (DIVE) and the individual classes, egg. S50m1 swim 50 meters. The significance of the research is to improve the process of evaluation and improvement of functional ability. It is interesting to note that diving is closer to the results of swimming for 10 minutes, which can only be explained by the vital lung capacity and moderate cost-effective strokes, not speed or uncontrolled moving under water. The obtained result of the survey measured the statistical significance p> 0.05.*

***Key words**: swim, ability, military, academy, cadet*

## Introduction

Making trough water on its surface and below followed by time and length parameters, opens the possibility to monitor, check and improve swimming and diving capabilities. Swimming speed is characterized by short sections of the explosive and endurance swimming. It is a feature of compliance with cardiovascular and muscular systems. Diving is a separate discipline which depends on cardiovascular and functional abilities. In this study we deal with different disciplines and try to determine their differences and correlations.

## Previous studies

Trappe, Costill & Thomas (2001) research effects of swim taper on whole muscle and single muscle fibre contractile properties. They examine the changes in whole muscle function and single cell contractile properties of Type I and II muscle fibbers from the deltoid muscle of highly trained swimmers before and after a 21-d reduction in training volume on six college male swimmers (age, 20 ± 1 yr; height, 187 ± 2 cm, weight, 79 ± 3 kg, fat, 7 ± 1%) who had been, on average, swimming 6200 $m \cdot d^{-1}$ for 5 months before the taper participated in this investigation. Conclusions suggest that tapering induces alterations in the contractile properties of single muscle fibbers. Type IIa fibers are more affected than the Type I fibers by the taper. The increased size, strength, velocity, and power of the IIa fibers may be responsible for the improvements in whole muscle strength and power after the taper. Girold et al. (2006) research assisted and resisted sprint training in swimming. This study was undertaken to determine whether the resisted-sprint in overstrength (OSt) or the assisted-sprint in overspeed (OSp) could be efficient training methods to increase 100-m front crawl performance. Thirty-seven (16 men, 21 women) competition-level swimmers were randomly divided into 3 groups: OSt, OSp, and control (C). All swimmers trained 6 days per week for 3 weeks, including 3 resisted or assisted training sessions per week for the groups OSt and OSp respectively. Elastic tubes were used to generate swimming overstrength and overspeed. Three 100-m events were performed before, during, and after the training period. Before each 100-m event, strength of the elbow flexors and extensors was measured with an isokinetic dynamometer. Stroke rate and stroke length were evaluated using the video-recorded 100-m events. In the OSt group, elbow extensor strength, swimming velocity, and stroke rate significantly increased ($p$ _ 0.05), while stroke length remained unchanged after the 3-week training period. In the OSp group, stroke rate significantly increased ($p$ _ 0.05) and stroke length significantly decreased ($p$ _ 0.05) without changes in swimming velocity. No significant variations in the C group were observed. Both OSt and OSp proved to be more efficient than the traditional training program. However, the OSt training program had a larger impact on muscle strength, swimming performance, and stroke technique than the OSp program. Tuuri, Loftin & Oescher (2002) research relations of swim distance and age with body composition in adult female swimmers. The purpose of this investigation was to examine the relationship between average weekly swimming distance and age with body composition in adult female endurance swimmers. Thirty-five women, aged 21-73 yr. Results: swimming distance had shared variances as follows: 23% with percent body fat, 26% with waist circumference, 20% with

abdominal sagittal diameter, and 20%, 24%, and 22% with subscapular, suprailiac, and triceps skinfolds, respectively. Abdominal sagittal diameter was the only adiposity measure demonstrating a stronger relationship with age ($R^2$ = 0.29, *P* = 0.00) than with swimming distance ($R^2$ = 0.20, *P* = 0.03). Bone mineral content was linearly related to swimming distance and age having a negative association with age ($r^2$ = 0.18, *P* = 0.01) and a positive one with swimming distance ($r^2$ = 0.12, *P* = 0.05). In addition, there was a negative linear association observed between swimmer age and bone mineral density ($r^2$ = 0.12, *P* = 0.05). Conclusion: In these female adults, endurance swimming was mildly associated with body adiposity. Age was not associated with body fat mass independently from swimming activity except with that measure reflecting abdominal visceral fat deposits. These data suggest that greater fat mass in female swimmers is more strongly related to lower levels of exercise than to age but that there is an additional influence of age on fat accumulation in the intra-abdominal area of the body. Juli et al. research respiratory muscle training improves swimming endurance in divers. The purpose was to determine if two different respiratory muscle training protocols enhance respiratory function and swimming performance in divers. Thirty male subjects (23.4 ± 4.3 years) participated. They were randomized to a placebo (PRMT), endurance (ERMT), or resistance respiratory muscle training (RRMT) protocol. Training sessions were 30 min/day, 5 days/week, for 4 weeks. PRMT consisted of 10-s breath-holds once/minute, ERMT consisted of isocapnic hyperpnea, and RRMT consisted of a vital capacity maneuver against 50 cm H2O resistance every 30 s. The PRMT group had no significant changes in any measured variable. Underwater and surface endurance swim time to exhaustion significantly increased after RRMT (66%, P < 0.001; 33%, P = 0.003) and ERMT (26%, P = 0.038; 38%, P < 0.001). Breathing frequency (f b) during the underwater endurance swim decreased in RRMT (23%, P = 0.034) and tidal volume (V T) increased in both the RRMT (12%, P = 0.004) and ERMT (7%, P = 0.027) groups. Respiratory endurance increased in ERMT (216.7%) and RRMT (30.7%). Maximal inspiratory and expiratory pressures increased following RRMT (12%, P = 0.015, and 15%, P = 0.011, respectively). Results from this study indicate that respiratory muscle fatigue is a limiting factor for underwater swimming performance, and that targeted respiratory muscle training (RRMT > ERMT) improves respiratory muscle and underwater swimming performance. Zhi & Hong-hui (2006) have a comparative research on body shape structure of swimming athletes in different train stage. They divided each training stage of swimming athlete, and studying the characteristic of body shape in each training stage. Then comparing the different appearance on swimming athlete of different train the stage. The result indicated that 13-15 years old is the particularly-item raises stage of swimming the female athlete. The best tournament stage is 16-22 years old. They keep contesting stage as 23-26 years old. Each stage of man is later 1-2 years than that of woman. Moreover, the main characteristic of body shape of swimming athlete is long arm, higher height, "inverted triangle" type of figure and higher quantity of muscles. The body shape characteristic of different training stage of swimming athlete is as follows. In spite of men and women, at particularly-item raises stage, some index signs of body shape have certain growth and potential but opposite the best tournament and tournament keep stage, They don't have advantage on the particularly body shape. On the best tournament stage, each appearance index sign is mature, but the possibility further perfect is not big.

**Problem, aim and research importance**

The study object is swimming functional ability of Military Academy cadets. The research problem is correlations and differences of functional ability in swimming of Military Academy cadets. The goal is to establish functional ability of correlations and differences in swimming. The importance of research was based on the fact that conditionally be divided into narrow significance that is related to the fact that this research can directly address the strengthening of monitoring the process of evaluation and improvement of functional abilities. The wider significance of research lies in the fact that this is a multi-year project aimed at three stages. This study represents the first basic stage. The findings of enrolment of the Military Academy were until the end of the first year. The second stage of the educational upbringing makes a training program that will valorise the data from the swimming of the cadets in the second year of studies and the third stage refers to revolutionize research in the form of prediction, taking into account the last two years of studies.

**Methods**

Sample (Table 1) was approximately 526 cadets of the Military Academy aged 20 (± 1 year), 430 men and 96 women, divided into first, second and third year of study with the same title class. The total number of first class was 224 subjects (179 men and 45 women), 167 second-class subjects (137 men and 30 women) and 135 third-class subjects (114 men and 21 women).

Table 1. Cross-tabulation

| | | | CLASS | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| SEX | 1 | 179 | 137 | 114 | 430 |
| | 2 | 45 | 30 | 21 | 96 |
| Total | | 224 | 167 | 135 | 526 |

(1 Man, 2 Women)

Variables are divided on the dependent variable summary: swimming 50 meters (S50m), swimming for 10 (S10min) minutes, diving (DIVE) and the individual variable in classes, egg. S50m1 swimes 50 meters in a class.

All three tests were standardized in the teaching of physical education at the Military Academy. Independent variables: name, age, class and sex were used to obtain comprehensive statistics connotation. Experimental treatment dates from 2008 to 2011. year. Specifically, the data are taken into account were the class of data after the first year of study. All three groups are mutually and simultaneously controled and experimented. The data is analyzed in the statistical program SPSS 11.5. Obtained data were analyzed in the measurement of the descriptive statistics (mean – AS, standard deviation - SD), the determination of correlation was performed by variate correlation analysis (Pearson correlation analysis) and determining the difference between groups by the univariate analysis of variance (ANOVA).

**Results and discussion**

Descriptive statistics (Table 2) are valid for all 526 results for processing. The value of variable swimming 50 meters (S50m) shows that 526 respondents mean value (AS) 52.57 seconds, a standard deviation (SD) 15.98, which indicates normal distributive results. The range of variables in the 50m swimming (S50m) ranges from 27.4 seconds to 105 seconds. The value of variable swimming for 10 minutes (S10min) shows us that the value of the mean (AS) 322.74, and standard deviation (SD) 83.94. Results shows the normal distribution. A minimum stock of swimming for 10 minutes was riding approximately 100 meters and maximum of 700 meters. The mean value of variable diving (AS) was 19.54, and standard deviation (SD) are 9.25, which indicates that is a number of fuzzy results. Minimum score of diving was 7 meters and maximum was 75 meters.

Table 2. Descriptive statistics

| | | S50m | S10min | DIVE |
|---|---|---|---|---|
| N | Valid | 526 | 526 | 526 |
| | Missing | 0 | 0 | 0 |
| Mean | | 52.58 | 322.74 | 19.55 |
| Std. Error of Mean | | .70 | 3.66 | .40 |
| Std. Deviation | | 15.98 | 83.94 | 9.25 |
| Variance | | 255.43 | 7045.97 | 85.62 |
| Skewness | | 1.15 | .21 | 1.05 |
| Std. Error of Skewness | | .11 | .11 | .11 |
| Kurtosis | | .82 | .21 | 2.17 |
| Std. Error of Kurtosis | | .21 | .21 | .21 |
| Range | | 77.60 | 600.00 | 68.00 |
| Minimum | | 27.40 | 100.00 | 7.00 |
| Maximum | | 105.00 | 700.00 | 75.00 |

Looking for information on the significance results (Table 3) we came to the information that has significance within the group of pieces by gender. The only significance in variables by sex within the group was in swimming for 10 minutes in a class (S10MIN1) .717.

Summarized data by sex (Table 4) we can see the significance of differences between groups in all three variables (S50M, S10MIN and DIVE) for the .000 level of significance.

Table 3. Significant differences by gender within groups (df=1)

| | Sum of Sq | Mean Sq | F | Sig. |
|---|---|---|---|---|
| S50M1 | 1590.90 | 1590.90 | 8.689 | .004 |
| S50M2 | 10792.07 | 10792.07 | 54.467 | .000 |
| S50M3 | 17205.55 | 17205.55 | 81.256 | .000 |
| S10MIN1 | 830.78 | 830.78 | .132 | .717 |
| S10MIN2 | 63133.71 | 63133.71 | 8.046 | .005 |
| S10MIN3 | 117512.33 | 117512.34 | 19.467 | .000 |
| DIVE1 | 709.05 | 709.05 | 13.577 | .000 |
| DIVE2 | 2273.99 | 2273.99 | 26.718 | .000 |
| DIVE3 | 2781.11 | 2781.11 | 34.256 | .000 |

Table 4. Differences by gender overall (df=1)

| | Sum of Sq | Mean Sq | F | Sig. |
|---|---|---|---|---|
| S50M | 27618.55 | 27618.56 | 135.91 | .000 |
| S10MIN | 142929.77 | 142929.77 | 21.06 | .000 |
| DIVE | 5546.24 | 5546.24 | 73.75 | .000 |

Analyzing the data by determining the significance of differences in classes (Table 5) found a statistically significant variables of swimming for 10 minutes (S10MIN) .046, while the variables of swimming at 50 meters (S50M) .407 and diving (DIVE) .364, did not find statistically significant results.

Table 5. Significant differences by class (df=2)

| | Sum of Sq | Mean Sq | F | Sig. |
|---|---|---|---|---|
| S50M | 460.18 | 230.09 | .90 | .407 |
| S10MIN | 43375.53 | 21687.77 | 3.10 | .046 |
| DIVE | 173.48 | 86.74 | 1.01 | .364 |

Analizing correlation between groups, variable sex show us high correlation with variable swimming with 50 meters (S50M) .454 (**), and negative correlation with swimming for 10 minutes (S10MIN) -. 197 (**) and diving (DIVE) -0.351 (**). Correlation for each class does not show any significance in all variables. Variable swimming 50 meters (S50M) is in high negative correlation with variable swimming for 10 minutes (S10MIN) -. 669 (**) and variables diving (DIVE) -. 579 (**). Variable swimming for 10 minutes (S10MIN) was in high correlation with variable diving (DIVE) .603 (**).

Table 6. Correlations

| | | sex | class | s50m | s10min | dive |
|---|---|---|---|---|---|---|
| sex | Pears Correl | 1 | .047 | .454** | -.197** | -.351** |
| | Sig. | . | .280 | .000 | .000 | .000 |
| | N | 526 | 526 | 526 | 526 | 526 |
| class | Pears Correl | .047 | 1 | .013 | .094* | .059 |
| | Sig. | .280 | . | .764 | .031 | .175 |
| | N | 526 | 526 | 526 | 526 | 526 |
| s50m | Pears Correl | .454** | .013 | 1 | -.669** | -.579** |
| | Sig. | .000 | .764 | . | .000 | .000 |
| | N | 526 | 526 | 526 | 526 | 526 |
| s10min | Pears Correl | -.197** | .094* | -.669** | 1 | .603** |
| | Sig. | .000 | .031 | .000 | . | .000 |
| | N | 526 | 526 | 526 | 526 | 526 |
| dive | Pears Correl | -.351** | .059 | -.579** | .603** | 1 |
| | Sig. | .000 | .175 | .000 | .000 | . |
| | N | 526 | 526 | 526 | 526 | 526 |

## Conclusion

Following primarily descriptive statistics first properly strikes us to the range of 50 meters (S50M) from 27.4 seconds to 105 seconds. Bearing in mind that there are active athletes at the Military Academy who were engaged in swimming or water polo professionally, it comes to really good results. Also, there are cadets who enrolled in the study as non-swimmers, and learned to swim in the first school year. This shows that it is fully justified that as a beginner they have to have bad results. Following a variable swimming for 10 minutes (S10MIN) we can identify the universal conclusion that shows span from beginner to athlete furthest. In terms of endurance, swimming has an important role in regular physical exercise, healthy lifestyle what will be explained better in the comparison. Diving (DIVE) varies from 7 meters to 75 meters. The reason for this range is due to swimming skills and functional abilities. In commenting on the difference of dependent variables within the group by gender we have come to data that have statistical significance (Table 3). This can be explained by the fact that the female body muscle and functionally is weaker, so the differences were expected. The only significance in variables by sex within the group was in swimming for 10 minutes in a class (S10MIN1) .717, which can be explained by the high number of good swimmers in the group that "raise" the result and change the whole study. The variables of swimming at 50 meters (S50M) and diving (DIVE) primarily expressed by speed-endurance and excplosive strength, and vital lung capacity, where the dominant male present difference between groups within the first classes by gender. The differences by gender within each class level summarized data by sex (Table 4) shows that there are significant differences between groups in all three variables (S50M, S10MIN and DIVE) for significance level .000. Analyzing the data by determining the significance of differences in classes (Table 5) found a statistically significant variables in swimming for 10 minutes (S10MIN) .046, while the variables of swimming at 50 meters (S50M) .407 and diving 0.364, were found statistically insignificant. This can be explained by the fact that the continuous training of a discipline within the physical education class can give more pronounced results concerning the swimming endurance. Swimming for 10 minutes, to get the continual improvement of functional capacity of the cardiovascular system and muscle skills which will be reflected in improved results for several tens of meters. It is difficult to statistically explain explosive swimming because these improvements are expressed in hundreds and tens of seconds. The same is in diving. Analizing correlation between groups, we came to data that the gender of the swimmer is highly correlated with the 50 meters swim (S50M) .454 (**) which can be explained by the fact above that the number of respondents with evidentially good results in swimming at 50 meters were given that the average value of 52.57 meters of all respondents in the survey. The negative correlation was found in-between the sex and swimming for 10 minutes (S10MIN) -. 197 (**) or diving (DIVE) -.351 (**). This fact can be explained by the number of fuzzy results, the extremely good and extremely bad results. Correlation for each class does not show any significance in all variables. It is evident that the training program of swimming at the Military Academy is standardized, so this information was expected. Variable swimming 50 meters (S50M) is in the high negative correlation with variable swimming for 10 minutes (S10MIN) -0.669 (**) and variable diving (DIVE) -0.579 (**). As previously stated it is the difference between muscular endurance and speed endurance swimming in debt. There is a definite difference in the way of energy production, aerobic and anaerobic, as well as compatibility with the functioning of the cardiovascular system of the two styles of swimming. Variable swimming for 10 minutes (S10MIN) in a very high correlation with the variable diving (DIVE) .603 (**). It is interesting to note that diving is closer to the results of swimming for 10 minutes, which can only be explained by vital lung capacity and moderate cost-effective strokes, not speed or uncontrolled moving under water.

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# PLIVAČKE SLIČNOSTI I RAZLIKE KOD KADETA VOJNE AKADEMIJE


## Sažetak

*Plivačka brzina se odlikuje kratkim eksplozivnim dionicama, a plivačka izdržljivost je direktno ovisna o usaglašavanju kardiovaskularnog i mišićnog sustava, dok je ronjenje posebna disciplina koja ovisi kako od funkcionalnih tako i od kardiovaskularnih sposobnosti organizma. Predmet istraživanja su funkcionalne sposobnosti u plivanju kadeta Vojne akademije. Problem istraživanja predstavljaju korelacije i razlike funkcionalnih sposobnosti u plivanju kadeta Vojne akademije. Cilj istraživanja je utvrđivanje korelacija i razlike funkcionalnih sposobnosti kadeta Vojne akademije u plivanju. Uzorak ispitanika je činilo 526 kadeta Vojne akademije uzrasta 20 (±1 godina), 430 muškaraca i 96 žena, podijeljenih na prvu, drugu i treću godinu studija. Varijable su podijeljene na zavisne zbirne varijable: plivanje na 50 metara (S50m), plivanje za 10 (S10min) minuta, ronjenje (DIVE) i pojedinačne po klasama npr. S50m1 plivanje na 50 metara. Značaj istraživanja je u poboljšanju funkcionalnih sposobnosti i praćenju procesa evaluacije. Rezultat istraživanja je da je ronjenje u korelaciji sa plivanjem za 10 minuta što se jedino može objasniti vitalnim kapacitetom pluća i umjerenim ekonomičnim, a ne brzinskim kretanjem pod vodom. Dobiveni rezultat istraživanja mjeren je statističkom značajnošću p<0.05.*


***Ključne riječi**: plivanje, sposobnost, vojska, akademija, kadet*

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# INTERACTION OF MOTOR AND COGNITIVE ABILITIES OF ELITE HANDBALL PLAYERS

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*Original scientific paper*

***Abstract***
*In order to identify statistically significant interactions between the motor latent variables (structure of motion, tonus regulation and synergy regulation, regulation of intensity of excitation and regulation of duration of excitation) and latent variables of cognitive abilities (IT – 1 - the efficiency of perceptive processor, S – 1 - the efficiency of parallel processor and AL – 4 - the efficiency of serial processor) a system of 15 variables was applied (12 motor and 3 cognitive) to the sample of 180 handball players who belong to I and II Serbian handball league. Data were analyzed using regression analysis of the statistical package IBM SPSS Statistics 19. The results confirm the general assumption that the cognitive mechanisms are in a statistically significant interaction with the motor mechanisms of top players. Cognitive test IT–1 - the efficiency of perceptive processor is in the interacton with latent motor variables for assessment of regulation of intensity of excitation, structure of motion and regulation of duration of excitation. The manifest predictor motor variable has the biggest single and statistically significant influence 20R - 20m run from the standing start (β=.000*), SLJ - standing long jump (β=.050*), FHB - feet and hands banging (β=.026*) and ISH - indurance of seated hang (β=.045*). Test S–1 - the efficiency of parallel processor is in interaction with latent motor variables for assessment of structure of motion and regulation of intensity of excitation, and the biggest single and statistically significant influence has the manifest predictor motor variable FHB - feet and hands banging (β=.001*) and SLJ - standing long jump (β=.030*). Cognitive test AL–4 - the efficiency of serial processor – symbolic reasoning is in interaction with latent motor variables for assessment of structure of motion, tonus regulation and synergy regulation, regulation of intensity of excitation and regulation of duration of excitation, and the biggest single and statistically significant influence have manifest predictor motor variables COS - coordination with the stick (.006*), DPB - deep pull-up hang on the bench (.010*), AHT - aiming at the horizontal target (.038*), MTL - medicineball throw from supine lying (.012*) and ISH - indurance of seated hang (.024*).*

***Key words****: handball players, motor abilities, cognitive abilities, interaction, regression analysis*

## Introduction

The ability of people to be able to notice, understand, adopt and reproduce some complex motion structures primarily depends on their cognitive abilities. The impact of cognitive regulatory mechanisms on success in some sporting activity is of different intensity, depending on the types of mechanisms and types of sports, as well as of other planned and /or unplanned endogenous or exogenous situations and circumstances in order to make sports achievement optimal regarding cognitive skills, sports knowledge, motion structure and athletes' form (Kirkendall & Gruber, 1970; Blažević & Malacko, 2007; Malacko, 2010). It is considered that there is no sport, no matter how simple it is where cognitive skills do not participate in the equation specification of the sport. In this regard, it was found that even among elite athletes there are few with average intelligence moreover the intelligence is in most cases above average, especially when it comes to sports of high and various complexity (Malacko & Popović, 2001; Malacko & Rađo, 2004). Handball is considered a game which requires athlete to have such motor ability, which is interrupted by shorter and longer breaks, with the participation of sudden and rapid changes of intensity, direction of movement and position of a player, with permanent jumps during the game, as well as alternate investment of intense anaerobic effort and aerobic work. Bearing in mind that the handball player has to resolve number of problem situations on the court, which require assessment, forecasting and responding to ever-changing situation, it is assumed that the analysis of interactions between cognitive and motor skills may be an important indicator of their anthropological status and mutual functioning (Stankovic & Malacko, 2008).

## The aim of the research

The aim of the research is to determine statistically significant interactions (relation and effects) between the system of motor and cognitive variables on the sample of top handball players, in order to form rational procedures for optimal sport orientation and selection, planning and programming of training content, as well as monitoring and controlling the transformation process of relevant anthropological characteristics.

Table 1: The basic statistical parameters and their discrimination

| Variables | M | min | max | S | Sk | Ku |
|---|---|---|---|---|---|---|
| Cognitive variables | | | | | | |
| IT – 1 - the efficiency of perceptive processor | 24.722 | 8.00 | 39.00 | 6.522 | .033* | -.466 |
| S – 1 - the efficiency of parallel processor | 34.883 | 22.00 | 40.00 | 4.422 | -1.220 | .944 |
| AL – 4 - the efficiency of serial processor | 24.377 | 5.00 | 30.00 | 4.974 | -1.518 | 2.800 |
| Motor variables | | | | | | |
| COS - coordination with the stick | 89.100 | 48.00 | 250.00 | 30.434 | 1.825 | 5.631 |
| FHB - feet and hands banging | 9.916 | 3.00 | 16.00 | 2.810 | .202* | .334 |
| HTA - hand tapping | 35.644 | 22.00 | 52.00 | 5.060 | .325* | .928 |
| DPB - deep pull-up hang on the bench | 46.322 | 6.00 | 62.00 | 7.359 | -1.169 | 4.263 |
| SOL - standing on one leg | 33.572 | 10.00 | 87.00 | 13.846 | 1.064 | 1.404 |
| AHT - aiming at the horizontal target | 21.105 | 3.00 | 80.00 | 9.556 | 2.037 | 9.776 |
| SLJ - standing long jump | 231.161 | 180.00 | 285.00 | 21.907 | .097* | .011 |
| 20R - 20m run from the standing start | 125.794 | 40.00 | 180.00 | 31.361 | -.974* | .289 |
| MTL - medicineball throw from supine lying | 36.811 | 28.00 | 51.00 | 3.788 | .105* | .165 |
| MSU - sit-ups | 5.761 | .00 | 17.00 | 3.718 | .628* | -.255 |
| UCU - undergrip chin-ups | 16.216 | .00 | 90.00 | 19.006 | 1.812 | 3.008 |
| ISH - indurance of seated hang | 51.972 | 34.00 | 80.00 | 7.976 | .050* | .342 |

M – arithmetic mean, min – minimal value, max - maximum value, S - standard deviation, Sk - skewness, Ku – curtosis, *normality of distribution

Table 2: Interkorrelations of manifest variables

| Var. | FHB | HTA | DPD | SOL | AHT | SLJ | 20R | MTL | MSU | UCU | ISH | IT–1 | S–1 | AL–4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COS | .16* | .08 | -.09 | -.14* | -.05 | -.25** | .02 | .38** | -.07 | -.03 | -.20** | -.07 | .03 | -.32** |
| FHB | H | -.05 | -.24 | -.08 | -.07 | -.06 | -.14 | .08 | .13 | 5 | -.00 | .23** | .21** | -.07 |
| HTA | | | .18 | -.10 | .19** | .28** | .31** | -.04 | -.31** | .30** | -.05 | -.06 | .04 | -.00 |
| DPD | | | | .15* | .30** | .21** | .36** | -.21** | -.02 | .01 | -.02 | -.15* | .14 | .30** |
| SOL | | | | | -.00 | .09 | .01 | -05 | -.11 | .09 | -.12 | -.09 | .10 | .12 |
| AHT | | | | | | .10 | .38** | .02 | .00 | -.04 | .07 | -.12 | .15* | .25** |
| SLJ | | | | | | | .53** | -.59** | .25** | .21** | .22** | .07 | .18* | .18* |
| 20R | | | | | | | | -.35** | .16* | .06 | .26** | -.21** | .16* | .25** |
| MTL | | | | | | | | | -.30** | .03 | -.22** | -.02 | -.01 | -.33** |
| MSU | | | | | | | | | | -.06 | .43** | .22** | .11 | .07 |
| UCU | | | | | | | | | | | .01 | .06 | .01 | -.09 |
| ISH | | | | | | | | | | | | .18* | .12 | .23** |
| IT–1 | | | | | | | | | | | | | .13 | .05 |
| S–1 | | | | | | | | | | | | | | .24** |

Table 3: Impact of predictor motor variables on the individual criterion cognitive variables

| Variables | IT–1 | | | S–1 | | | AL–4 | | |
|---|---|---|---|---|---|---|---|---|---|
| | β | t | p | β | t | p | β | t | p |
| COS - coordination with the stick | -.03 | -.33 | .74 | .50 | .59 | .56 | -.22 | -2.77 | .01* |
| FHB - feet and hands banging | .17 | 2.24 | .03* | .26 | 3.45 | .00* | .07 | 1.03 | .31 |
| HTA - hand tapping | .06 | .67 | .51 | -.00 | -.04 | .97 | -.05 | -.60 | .55 |
| DPB - deep pull-up hang on the bench | -.01 | -.08 | .94 | .15 | 1.82 | .07 | .20 | 2.61 | .01* |
| SOL - standing on one leg | -.05 | -.67 | .51 | .13 | 1.68 | .10 | .07 | 1.03 | .31 |
| AHT - aiming at the horizontal target | -.02 | -.30 | .77 | .09 | 1.11 | .27 | .16 | 2.09 | .04* |
| SLJ - standing long jump | .20 | 1.97 | .05* | 2.3 | 2.20 | .03* | -.11 | -1.16 | .25 |
| 20R - 20m run from the standing start | -.36 | -3.64 | .00* | .00 | .04 | .97 | .11 | 1.14 | .26 |
| MTL - medicineball throw from lying | .05 | .49 | .62 | .15 | 1.55 | .12 | -23 | -2.55 | .01* |
| MSU - sit-ups | .17 | 1.86 | .07 | .03 | .38 | .71 | -.10 | -1.17 | .24 |
| UCU - undergrip chin-ups | .02 | .31 | .76 | -.06 | -.74 | .46 | -.08 | -1.04 | .30 |
| ISH - indurance of seated hang | .16 | 2.02 | .05* | .12 | 1.41 | .16 | .18 | 2.28 | .02* |
| $R_0^2$ | .21 | | | .17 | | | .30 | | |
| $R_0$ | .45 | | | .41 | | | .55 | | |
| F | 3.60 | | | 2.77 | | | 5.90 | | |
| Q | .000* | | | .002* | | | .000* | | |

Univariate parameters: β – individual impact of each standardized predictor, t – testing of the individual significance, p – the set level of statistical significance. Multivariate parameters: $R_o^2$ – multiple correlation squared; $R_o$ – multiple; F – testing of significance; Q – the set of statistical significance of the impact of the whole system

## Methods

*Entities*

A system of 15 variables (12 motor and 3 cognitive) was applied to the sample of 180 handball players who belong to I and II Serbian handball league.

*Variables*

To assess cognitive and motor skills the following latent and manifest variables were applied: a) Cognitive variables - from baterry KOG 3 (Wolf, Momirović, Džamonja, 1992), 1) for efficiency of perceptive processor IT-1, 2) for efficiency of parallel processor S-1, 3) for efficiency of serial processor AL-4; b) Motor variables - from the model of motor

structure (Gredelj, Hošek, Metikoš, Momirović, 1975): 1) for structuring of motion /COS - coordination with the stick; FHB - feet and hands banging; HTA - hand tapping/, 2) for regulation and synergy regulation /DPB - deep pull-up hang on the bench; SOL - standing on one leg; AHT - aiming at the horizontal target/, 3) for regulation of intensity of excitation /SLJ - standing long jump; 20R - 20m run from the standing start; MTL - medicineball throw from supine lying/, 4) for regulation of duration of excitation /MSU - sit-ups; UCU - undergrip chin-ups; ISH - indurance of seated hand/.

*Data processing*

The following central and dispersion parameters were determined for each variable: mean (M), minimal value (min), maximal value (max) and standard deviation (S). The normality of distribution was tested by skewness (Sk) and kurtosis (Ku). Calculation of the impact of the system of motor variables (as a system of predictor variables) on a single criterion variable of cognitive abilities was done by the use of regression analysis. In this procedure, the following univariate statistical parameters were applied: the influence of each standardized predictive variable on the criterion variable (β), testing of the significance of each predictive variable's influence on the criterion variable (t), and statistical significance of each predictive variable's influence on the criterion variable at p= .05- .00. Multivariate values were drawn based on the following parameters: multiple correlation squared ($R_o^2$), multiple correlation between the entire system of predictive variables and criterion variable, testing of significance by F-test (F), and statistical significance of the influence of the entire system of predictive variables on the criterion variable at p=.05-.00. Data were analyzed using the statistical package SPSS Statistics 19.

## Results

Table 1 presents the results of dispersion and central statistical parameters of motor and cognitive variables, as well as their discrimination. When analyzing skewness (Sk), an asterisk (*) indicates variables that have normal (symmetrical) distribution, according to the criterion that the result goes from 0:00 to 1:00 standard deviations, while those variables whose distribution is not normal (asymmetric), positive or negative asymmetry is interpreted on the basis of their signs (+ or -). Testing the normality of distribution of cognitive variables one can see that the results of the S-1 (efficiency of parallel processor) and AL-4 (efficiency of serial processor) significantly deviate from normal distribution in favor of higher values (negative asymmetry). Out of 12 motor variables it is clearly observed that the distributions are normal in 7 variables (symmetric), since they do not exceed the value of 1.00 of standard deviation, while 5 variables have abnormal distribution, and its asymmetry is expressed in the negative direction (-1169) in 1 variable (DPB - deep pull hang-up on the bench), which means that a number of respondents had significantly higher values, in 2 variables (COS - coordination with the stick and SOL - standing on one leg), values are expressed in seconds, where the lower value is actually a better value, which means that the majority of respondents in these variables had better values. In 2 variables (AHT - aiming at the target and the horizontal UCU - undergrip chin-ups), with a positive sign, slightly lower values were achieved. From table 2, which shows inter-correlations between manifest motor and cognitive variables, it can be clearly seen that out of the total of 106 only 39 correlations are statistically significant at the .01 level (p =.01) or .05 (p =.05). With cognitive variable IT-1 - efficiency of perceptive processor statistically significant correlation have motor variables FHB - banging feet and hands (.23 **), DPB - deep pull-up hang on the bench (-.15 *), 20R - 20m run from the standing start (-.21 **), MSU - sit-ups (.22 **) and ISH - indurance of seated hang (.18 *). Cognitive variable S-1 - efficiency of parallel processor is statistically significantly associated with motor variables FHB - feet and hands banging (.21 **), AHT - aiming at the horizontal target (.15 *), SLJ - standing long jump (.18 *) and 20R - 20m run from the standing start (.16 *), and AL-4 variable – efficiency of serial processor with COS - coordination with the stick (-.32 **), DPB - deep pull-up hang on the bench (.30 **), AHT - aiming at the horizontal target (.25 **), SLJ - standing long jump (.18 *), 20R - 20m run from the standing start (.25 **), MTL - medicineball throw from supine lying (-.33 **), ISH - indurance of seated hang (.23 **) and cognitive variable S-1 - efficiency of parallel processor (.24 **). By inspection of table 3 it can be observed that the system of predictor motor variables have statistically significant multivariate effect on the level of .000 (p =.000) on the criterion variable IT-1 - efficiency of perceptive processor, that the coefficient of multiple correlation is .453 (Ro =.453), and common variability 206% ($Ro^2$=.206). With further analysis of the same table it is clearly evident that the system of predictor motor variables have statistically significant multivariate effect on the level of .002 (p =.002) on the criterion variable S-1 - efficiency of parallel processor, that the coefficient of multiple correlation is .407 (Ro =.407), and common variability .166 ($Ro^2$=.166). The system of predictor motor variables have multivariate statistically significant impact on the level of .000 (p =.000) on criterion cognitive variable AL-4 - efficiency of serial processor, the coefficient of multiple correlation is .546 (Ro =.546), and common variability .298 ($Ro^2$=.298).

## Discussion

The research started from the general assumption that motor mechanisms are in statistically significant interaction with cognitive mechanisms, and that in joint relationship they can significantly influence the success of handball game, because it is known that cognitive mechanisms cannot be the

only crucial thing for success in an activity, including the activities of the handball sport. Cognitive test IT-1 - efficiency of perceptive processor has been designed with the intention to measure the perceptive faculty which is a synthesis of perceptual analysis skills, perceptual structuring and perceptual identification. The results showed that this cognitive test is in interaction with latent motor variables for assessment of the regulation of intensity of excitation, structure and regulation of motion of duration of excitation. The largest and statistically significant impact on cognitive criterion variable IT-1 - efficiency of perceptive processor has predictor motor variable 20R - 20m run from the standing start (β =.000 *) and SLJ - standing long jump (β =.050*) for assessment of regulation of intensity of excitation. Variable FHB - feet and hands banging (β =.026 *) to assess the structure of motion and variable ISH - indurance of seated hang (β =.045 *) to assess the regulation of duration of excitation. The established interactions show that handball players achieve good results in latent motor variables of regulation of intensity of excitation, structure of motion and regulation of duration of excitation if they have increased value of cognitive variables in the efficiency of perceptive processor (IT-1). Test S-1 - efficiency of parallel processor has been designed with the intention to establish relations in the area or to solve problems that can be defined as space problems. The results showed that this cognitive test is in interaction with latent motor variables for assessment of structure of motion and regulation of intensity of excitation. The criterion cognitive variable S-1 - efficiency of parallel processor bears the largest and statistically significant effect of predictor motor variable FHB - feet and hands banging (β =. 001 *) for assessment of the structure and motion and SLJ - standing long jump (β =. 030 *) to assess the regulation of intensity of excitation. This shows that handball players achieve good results in the structure of motion and regulation of intensity of excitation, if they have increased value of cognitive variable efficiency of parallel processor (S-1). Cognitive test AL-4 - efficiency of serial processor - symbolic reasoning is for assessment of verbal understanding and represents the process of abstraction and generalization, which is responsible for the ability to operate with symbols, rapid application of successive analysis and processing of information stored in verbal form, which is a good indication of the efficiency of processor for serial processing of information. The study showed that this cognitive test is in interaction with latent motor variables for assessment of structure of motion, tonus regulation and synergy regulation, regulation of intensity of excitation and regulation of duration of excitation. The largest and statistically significant effect on the criterion cognitive variable AL-4 - efficiency of serial processor have predictor motor variables COS - coordination with the stick (.006 *) to assess the structure of motion, DPB - deep pull-up hang on the bench (.010 *) and SOL - standing on one leg (.038 *) to assess tonus regulation and synergy regulation, MTL - medicineball throw from lying supine (.012 *) to assess the regulation of intensity of excitation and ISH - indurance of seated hang (.024 *) to assess the regulation of duration of excitation. The established interactions show that handball players achieve good results in structure of motion, tonus regulation and synergy regulation, regulation of intensity of excitation and regulation of duration of excitation if they have increased value of cognitive variable efficiency of serial processor (AL-4).

## Conclusions

On the basis of this empirical research the general assumption that the cognitive mechanisms (IT - 1 - the efficiency of perceptive processor, S - 1 - the efficiency of parallel processors and AL - 4 - the efficiency of serial processor) are in statistically significant interaction with the motor mechanisms (structure of motion, muscle tone regulation and synergy regulation, regulation of intensity of excitation and regulation of the duration of excitation) of top handball players was confirmed. Cognitive test IT-1 - efficiency of perceptive processor interacts with latent motor variables for assessment of regulation of intensity of excitation, structure of motion and regulation of duration of excitation. Test S-1 - efficiency of parallel processor interacts with latent motor variables for assessment of the structure of motion and regulation of intensity of excitation. Cognitive test AL-4 - the efficiency of serial processor - symbolic reasoning is in interaction with latent motor variables for assessment of structure of motion, tonus regulation and synergy regulation, regulation of intensity of excitation and regulation of duration of excitation.

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## INTERAKCIJA MOTORIČKIH I KOGNITIVNIH SPOSOBNOSTI ELITNIH RUKOMETAŠA

### Sažetak

*S ciljem utvrđivanja statistički značajne interakcije između motoričkih latentnih varijabli (strukturiranje kretanja, regulacija tonusa i sinergijska regulacija, regulacija intenziteta ekscitacije i regulacija trajanja ekscitacije) i latentnih varijabli kognitivnih sposobnosti (IT–1 - efikasnost perceptivnog procesora, S–1 - efikasnost paralelnog procesora i AL–4 - efikasnost serijskog procesora), na uzorku 180 rukometaša koji pripadaju I i II rukometnoj ligi Srbije bio je primjenjen sustav od 15 varijabli (12 motoričkih i 3 kognitivne). Podaci su obrađeni pomoću regresijske analize iz statističkog paketa IBM SPSS Statistics 19. Rezultati istraživanja su potvrdili generalnu pretpostavku da su kognitivni mehanizmi u statistički značajnim interakcijama sa motoričkim mehanizmima vrhunskih rukometaša. Kognitivni test IT–1 - efikasnost perceptivnog procesora je u interakciji sa latentnim motoričkim varijablama za procjenu regulacije intenziteta ekscitacije, strukturiranja kretanja i regulacije trajanja ekscitacije. Najveći pojedinačni i statistički značajan utjecaj imaju manifestne prediktorske motoričke varijable 20V - trčanje 20m iz visokog starta (β=.000*), SDM - skok u dalj s mesta (β=.050*), BNR - bubnjanje nogama i rukama (β=.026*) i IPR - izdržaj u visu (β=.045*). Test S–1 - efikasnost paralelnog procesora je u interakciji sa latentnim motoričkim varijablama za procjenu strukturiranja kretanja i regulacije intenziteta ekscitacije, a najveći pojedinačni i statistički značajan utjecaj imaju manifestne prediktorske motoričke varijable BNR - bubnjanje nogama i rukama (β=.001*) i SDM - skok u dalj s mesta (β=.030*). Kognitivni test AL–4 - efikasnost serijskog procesora - simboličko rezoniranje je u interakciji sa latentnim motoričkim varijablama za procjenu strukturiranja kretanja, regulacije tonusa i sinergijske regulacije, regulacije intenziteta ekscitacije i regulacije trajanja ekscitacije, a najveći pojedinačni i statistički značajan utjecaj imaju manifestne prediktorske motoričke varijable KOP - koordinacija s palicom (.006*), DPR - duboki pretklon na klupi (.010*), GHC - gađanje horizontalnog cilja (.038*), BML - bacanje medicinke iz ležanja (.012*) i IPR - izdržaj u visu (.024*).*

***Ključne riječi**: rukometaši, motoričke sposobnosti, kognitivne sposobnosti, interakcija, regresijska analiza*

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# QUANTITATIVE AND QUALITATIVE DIFFERENCES IN SITUATIONAL-MOTORIC EFFECTIVITY WITH YOUNG HANDBALL PLAYERS FROM MONTENEGRO

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*Original scientific paper*

***Abstract***
*This research has been conducted on 100 young handball players aged from 14 to 15, from Montenegro. They were divided into 2 (two) groups according to their regional belonging. The first group consists of 50 players from the continental region, and the second group - 50 players from the Mediterranean region. They have been tested by 5 tests for estimating situational-motor abilities, with the aim to compare basic motor abilities between the two groups. After processing the data with the basic descriptive methods, and having established the differences by t-test and discriminative analysis, the conclusion drawn from the research is that within the treated situational-motor space, the handball players from the continental region have achieved far much better results than those of the Mediterranean players.*

***Key words:*** *athletes aged 14-15, t-test, discriminative analysis, situational-motor tests*

## Introduction

Montenegro is a country where the Mediterranean passes to Continental, as well and a real mountain type of climate. This is a consequence of its position, separations and dissections of the relief, relocations and confrontations of air masses of different physical characteristics, proximity to the sea, character of the soil and other factors. The motive of this research was to try in its own community to give importance and contribution to that branch of sport that gave Montenegro most trophies. Regarding that Montenegro is divided into Mediterranean and continental region, the very idea was to be conducted a research in that area on the younger population of boys-who are actively involved in the handball sport. By acquisition of the state independence and the performances of our national team, was given a right opportunity to show Europe and the world what kind of potential Montenegrin handball has. Games, especially sport's games, which operate using a large number of players who are in constant motion simultaneously confronting on the individual, group and collective level, are a unique phenomenon that is not easy to analyze (Rogulj, 2000). The top modern handball requires a high level of acquired motor structures, all in order to solve some specific tasks that occur during the game's phase, defense and attack. In order the players to be able to accomplish the requirements of the modern handball game they are expected to get absolute maximum achievements in the range of technique-tactical and physical preparedness. "Handball is a game where the player's activities is characteristic continuous movement with or without change of direction, woven by fast and sharp sprints, high jumps, various landings and various duels in contact with the opponent" (Pavlin, Šimenc & Delija, 1982). In the sport's activities during the training and competitions in the handball great importance have knowledge, or developing specific situational, technique-tactical elements relevant for the handball success. To the base of the pyramid of success factors are the basic anthropological features, and at the higher levels of specific skills as well and the indicators for situational efficiency in the game of every successful handball player. Every sport discipline is achieved in four main phases: teaching techniques, the adoption of techniques, theoretical and practical tactics' coping and training. From these stages of realization and adoption of sport's disciplines, sport's training has a dominant position.

## Problem and aim

The problem of this research is the determining of the differences at the level of efficiency situational indicators of young handball players, from the Mediterranean and continental regions that are organizationally involved in the handball training. The object of this study were the handball players of age 14-15 years, as well and their situational-motor abilities. The main goal of this study was to determine possible differences at situational-motor abilities among handball players from the continental regions and the handball players from the Mediterranean region. Starting from the goal, the following research tasks were set: - determination of the level of situational - motor abilities at the handball players from the continental region; - determination of the level of situational - motor abilities at the handball players from the Mediterranean region; - to compare situational - motor abilities among handball players from the continental regions and handball players from the Mediterranean region in the manifested space; - to compare situational - motor abilities among handball players from the continental regions and handball players from the Mediterranean region in the latent space. Based on the formulation of the problem, objects, set goal and tasks, hypothesis of this paper could be

formulated as follows: Ho - statistically significant differences are expected in the situational - motor abilities at the young handball players from the continental and Mediterranean region; H1 - statistically significant differences are expected at the situational - motor abilities in the manifested space among the handball players from the continental and Mediterranean region, in favor of the handball players from the continental regions; H2 - statistically significant differences are expected at the situational - motor abilities in the latent space among the handball players from the continental and Mediterranean region, in favor of the handball players from the continental regions.

**Methods**

The measurement was conducted in Niksic (RK "Sutjeska") and Berane (RK "Berane") from continental region, and Danilovgrad (RK "Danilovgrad") and Bar (RK " Mornar") from Mediterranean region. In this study was used a sample of 100 male respondents, consisting of young handball players involved into systematic handball training.
The sample was divided into two subsamples (groups), as follows: - The first group (50), handball players from continental regions (Niksic and Berane); - The second group (50), handball players from the Mediterranean region (Danilovgrad and Bar). Variables used were: 1. The precision from a jump shot from 9 m (SRP9SK), 2. The ability to throw and catch balls bounced from the wall (SLOZ), 3. Slalom in the area between 6-9 m (SSL 6-9), 4. Speed running ball in a square (SVLK), 5. Movements in the triangle using basic defensive position (SKUT). The data obtained by testing were analyzed by the procedures of basic (primary) descriptive statistics: The normality of results' distribution was tested by the method of Kolmogorov and Smirnov. The quantitative differences between the two groups of respondents in the situational - motor abilities were determined by the t-test for large independent samples. The qualitative differences in situational - motor abilities were processed by discriminative analysis between the groups according to the region.

**Results**

The results from the tables 1 and 2e logical and expected. No significant deviations are noted regarding the represented values of skewness, kurtosis and Kolmogorov – Smirnov test. For determining significance of the differences between the arithmetic means of handball players from the continental region and the Mediterranean region was applied t-test for large dependant samples, while the difference is treated for statistical significance at the level of 0.05 (5%). According to the gained results, among the treated groups of respondents, statistically significant difference between them was found at 3 variables: slalom at space 6-9m (SSL 6-9), speed of running a ball in a square (SVLK) and moving in a triangle using basic defensive position (SKUT).

The respondents from the group of handball players from the Mediterranean region (G_2) achieved significantly better results than the group of handball players from the continental region (G_1), and only in variable the ability to throw and catch the ball bounced from the wall (SLOZ). In the variable that do not show any statistically significant difference, handball players from continental regions (G_1) had better results than groups of handball players from the Mediterranean region (G_2) at variable precision of a jump shot from 9m (SRP9SK). According to the gained results of the general hypothesis Ho- statistically significant differences are expected in situational - motor abilities at the young handball players of continental and Mediterranean region is partially accepted.

Table 1. The basic descriptive parameters of the applied variables at the handball players from the continental region

| Variable | SRP9SK | SLOZ | SSL 6-9 | SVLK | SKUT |
|---|---|---|---|---|---|
| Mean | 5.26 | 19.24 | 12.64 | 6.41 | 7.04 |
| Min | 0.00 | 9.00 | 10.25 | 5.31 | 6.15 |
| Max | 10.00 | 28.00 | 15.53 | 7.93 | 8.31 |
| St.D. | 2.79 | 4.87 | 1.08 | 0.60 | 0.60 |
| St.Error | 0.39 | 0.69 | 0.15 | 0.08 | 0.08 |
| Skew | 0.14 | -0.69 | 0.10 | 0.61 | 0.59 |
| Kurt | -0.91 | -0.39 | 0.65 | 0.04 | -0.20 |
| K-S | 0.17 | 0.14 | 0.46 | 0.70 | 0.25 |

Table 2. Basic descriptive parameters of applied variables at the handball players from the Mediterranean region

| Variable | SRP9SK | SLOZ | SSL 6-9 | SVLK | SKUT |
|---|---|---|---|---|---|
| Mean | 4.80 | 21.10 | 13.25 | 6.65 | 7.53 |
| Min | 1.00 | 14.00 | 11.44 | 5.15 | 6.21 |
| Max | 8.00 | 27.00 | 16.63 | 8.31 | 9.94 |
| St.D. | 1.92 | 2.99 | 1.08 | 0.55 | 0.80 |
| St.Error | 0.27 | 0.42 | 0.15 | 0.08 | 0.11 |
| Skew | -0.21 | -0.42 | 1.39 | 0.35 | 0.74 |
| Kurt | -0.26 | -0.04 | 2.41 | 1.13 | 1.03 |
| K-S | 0.07 | 0.62 | 0.03 | 0.64 | 0.92 |

Table 3. T-test between the arithmetic means of handball players from the continental region - G_1 and the Mediterranean region - G_2 (df=98)

| Varijable | Mean G_1 | Mean G_2 | t-value | p |
|---|---|---|---|---|
| SRP9SK | 5.26 | 4.80 | 0.96 | 0.34 |
| SLOZ | 19.24 | 21.10 | -2.30 | 0.02 |
| SSL 6-9 | 12.64 | 13.25 | -2.82 | 0.01 |
| SVLK | 6.41 | 6.65 | -2.13 | 0.04 |
| SKUT | 7.04 | 7.53 | -3.47 | 0.00 |

Table 4. Discriminant analysis of the situational - motor tests among handball players from the continental and Mediterranean region

| Eigen-value | Canonicl R | Wilks' Lambda | Chi-Sqr. | df | p-level |
|---|---|---|---|---|---|
| 0.30 | 0.48 | 0.77 | 25.18 | 5 | 0.00 |

Table 5. The structure of discriminative function of situational - motor tests among handball players from the continental and Mediterranean region

| Varijable | Root 1 |
|---|---|
| SRP9SK | 0.18 |
| SLOZ | -0.42 |
| SSL 6-9 | -0.52 |
| SVLK | -0.39 |
| SKUT | -0.64 |

Table 6. The group of centroids situational - motor tests between the handball players from the continental regions (G_1) and the handball players from the Mediterranean region (G_2)

| Centroids | Root 1 |
|---|---|
| G_1 | 0.54 |
| G_2 | -0.54 |

By the discriminative analysis were determined and differences in motor situational tests among handball players from the continental and Mediterranean region. According to Table 4, values of the canonical correlation coefficient (0.48), hi-square test (Chi-Sqr. = 25.18), with 5 degrees of freedom, was found a statistically significant difference between treated groups of handball players according to the region at the level of 0.00. In the table 5 is shown a single discriminant function for handball players from the continental and Mediterranean region. According to its values, for more expressed discriminativness, we can say that it has at 4 of totally 5 treated variables. To the statistically significant discrimination led variables: the ability to throw and catch balls bounced off the wall (SLOZ), slalom in space between 6-9m (SSL 6-9), the running speed in a square (SVLK) and moving in a triangle using basic defensive position (SKUT). At the variable accuracy of the jump shot from 9m (SRP9SK) by a projection of 0.18 was not established significant discrimination among treated handball players from the continental and Mediterranean region. In the table 6, which shows the group of centroids, the higher the value of the centroids is at the handball players of the continental region (G_1=0.54) compared to handball players from the Mediterranean region (G_2=- 0.54). This leads to the conclusion that in the treated motor - situational area, handball players from the continental regions have achieved significantly better results compared to the handball players from the Mediterranean region. According to the hypothesis results H2 - are expected statistically significant differences in the motor - situational abilities in latent space among the handball players from the continental and the Mediterranean region, in favor of the handball players from the continental regions is fully accepted.

**Conclusions**

Based on studies realized on a sample of 100 respondents - handball players by region (50 from the continental and 50 from the Mediterranean region) where were applied a total number of 5 variables (tests) from situation motorics, we can conclude the following: 1. The general conclusion would be that in the treated situational - motor tests the handball players from continental regions have achieved better results than handball players from the Mediterranean region; 2. The results achieved in the treated variables for both groups of respondents are logical and in accordance with the expectations; 3. Respondents, handball players from continental regions have achieved statistically more significant and better results than the handball players from the Mediterranean region in 3 variables; 4. Respondents, handball players from the Mediterranean region have achieved statistically more significant and better results than the handball players from the continental regions in one variable; 5. In the latent situation - motor space, using discriminant analysis, we can conclude or confirm the conclusion that the established differences were inclined in favor to the group of handball players from the continental regions.

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## KVANTITATIVNE I KVALITATIVNE RAZLIKE U SITUACIONO-MOTORIČKOJ EFIKASNOSTI MLADIH RUKOMETAŠA IZ CRNE GORE

### Sažetak

*Ovo istraživanje je realizirano sa 100 mladih rukometaša uzrasta od 14 do 15 godina iz Crne Gore. Oni su bili podijeljeni u 2 (dvije) grupe prema regionalnoj pripadnosti. Prva grupa - 50 igrača iz kontinentalne regije, a druga grupa – 50 igrača iz mediteranske regije. Na njima je primjenjeno pet motoričkih testova za procjenjivanje situaciono-motoričkih sposobnosti, s ciljem da se usporede te dvije tretirane grupe. Nakon obrade podataka osnovnim deskriptivnim metodama i nakon utvrđene razlike t-testom i diskriminativnom analizom, zaključeno je da su rukometaši kontinentalne regije postigli značajno bolje rezultate od rukometaša mediteranske regije u tretiranom situaciono-motoričkom prostoru.*

***Ključne riječi:*** *sportisti uzrasta 14-15 godina, t-test, diskriminativna analiza, situaciono-motorički testovi*

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# MOTOR DIFFERENCES OF YOUNG KICK-BOXER CATEGORIES BASED ON RESULT SUCCESFULNESS

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*Original scientific paper*

***Abstract***
*The research has been conducted on 69 junior (18-20) and senior (21 and above) kick boxers from Vojvodina. They are classified according to achieved sporting results into four (4) categories: : I category – athletes who achieved the best results by winning one of the medals at the World or European championship, II category – athletes who won medals at the international tournaments (competitions), III category - athletes who achieved results by winning one of the medals at the national championship, IV category – athletes who did not achieve any significant results. Discriminant analysis provides three discriminant functions. First function divides I category (most successful athletes) from locally successful (III category). Second function separates groups in the manner that group II (internationally successful) separates from all others. Third function (p>0.05) divides unsuccessful athletes from athletes that accomplish some local result. It is to be concluded that for top result achievement in kick-boxing, it is necessary to direct selection and training in the way that in athletes have to be incorporated complete and integrated assembly with energetic and informatics component of movement regulation, as we speak about general motor dimensions. Surely, in future analyses it has to be built in important information about specific motor knowledge, for completing set of sports knowledge.*

***Key words****: kick-boxing, motor dimensions, successfulness, harmony*

## Introduction

The term motor dimensions consists of a number of skills defined in different ways and are responsible for the quality of movement and successful dealing with the widest range of motion tasks (Bonacin, Do., Bilić & Bonacin, Da., 2008). It is about skills such as speed, coordination, static strength, flexibility, stamina, precision, etc. Each of them is important for sports; however, some sports require more distinct skills of one type while other sports require more distinct skills of another type. Based on centuries of experiences in martial arts, athletes' complex motor engagement is evident from which there is a requirement for specific motor features. Man is a complex being and lives in such environment. In order to study humans, scientists divided them, according to some logic, on virtual "systems" consisting of interconnected segments that are explored by different sciences. But in the end, all these systems function as a whole – individual entity. The environment in which man lives is divided according to the significance for society, institutions and for entity itself on the basis of some pre-established rules and specific relations. Engaging in sports is one way of making relations and in order to study these relations we also have to study specific systems. Man's motor system i.e. motion features, is certainly one of the most important systems. The term motor dimensions usually implies a system of basic anthropological latent dimensions responsible for all other measurable motor manifestations. Although there were different models, nowadays this is usually observed on the basis of mathematical models through various forms of motion control (Bonacin, Do., Bilić & Bonacin, Da., 2008). Furthermore, every sport has its own rules and requires the athletes to have certain specific characteristics, for instance, weight dominates in sumo wrestling, while height dominates in basketball and volleyball etc. For modern man, martial arts represent legal and humane form of martial competition, with restrictions that change the real fight between two men into symbolic destruction of opponents. (Ćirković & Jovanović, 1992). "Kickboxing belongs to group of polistructural acyclic sports, in which acyclic unpredictable movements are dominant. The result represents a binary variable (win-lose), with the purpose to avoid as many hits as possible and to deliver as many hits as possible with hands and legs. The work takes place in an anaerobic/aerobic mode with submaximal and/or maximal intensity." It is obvious that this sport requires specific motor features. It is interesting to explore how much influence motor features have on athlete's success in order to adequately adapt oneself to the training process. One of the basic goals of sport is the result, the best result if possible; therefore it is interesting to see how and how much motor features influence the result i.e. the differences of these motor dimensions among different athletes in kickboxing.

## Topic, problem and goal

The topic of this paper is kickboxing athletes and their selected motor features and who are classified according to achieved results into four categories: *I category* – athletes who achieved the best results

by winning one of the *medals* at the World or European championship, *II category* – athletes who won medals at the international tournaments (competitions), *III category* - athletes who achieved results by winning one of the medals at the national championship, *IV category* – athletes who did not achieve any significant results. The problem the paper is addressing is to determine motor differences among athletes that belong to defined categories of kickboxing in order to recognize potential influence of these motor differences on sporting success of athletes.

## Methods

The sample is composed of selected kickboxing athletes from Vojvodina, cadet and junior age (age 18 and older, N=69), who are the best young kick boxers in Serbia. The athletes are standard representatives of Serbia in kickboxing and participants at the European and World championship and also multiple winners of the World and European medals. A good medical history, continuous training kickboxing six months to a year, and participation at national championships (at least), were precondition for engagement in the sample. Sample variables for assessment of motor status include: *general coordination* (the figure "8" with bending – MAGOSS, side steps – MAGKUS, ascending and descending the wall bars and the bench – MBKPIS), *movement frequency* (hand-tapping – MBFTAP, arm circles – MBFKRR, leg-tapping – MBFTAZ) *flexibility* (bending MFLISK, bench forward bend – MFLPRK, forward bend with feet apart – MFLPRR), *explosive strength* (lying medicine-ball throw – MFEBNL, standing long jump – MFESDM, standing high jump – MFESVM), strength (pull-ups on the shaft – MRAZGP, torso lifting with weight – MRCDTT, half squats with weight – MRLPCT), *stamina* (running 1500m – IZ1500). A multivariate discriminant analysis was conducted within motor dimensions in order to achieve the goal.

## Results and discussion

Table 1 Basic motor parameters

| | X | SE | Med | Mod | SD | Skew | Kurtosis | Rang | Min | Max |
|---|---|---|---|---|---|---|---|---|---|---|
| MAGOSS | 18.85 | 0.24 | 18.50 | 18.50 | 1.98 | 0.45 | 0.27 | 8.08 | 15.37 | 23.45 |
| MAGKUS | 9.85 | 0.15 | 9.83 | 8.50 | 1.24 | 0.48 | 0.11 | 5.90 | 7.60 | 13.50 |
| MBKPIS | 21.90 | 0.48 | 21.28 | 18.20 | 3.97 | 0.82 | 0.70 | 20.88 | 13.37 | 34.25 |
| MBFTAP | 38.07 | 0.70 | 38.00 | 34.00 | 5.78 | 0.12 | 0.05 | 29.00 | 24.00 | 53.00 |
| MBFTAZ | 34.75 | 0.87 | 32.00 | 29.00 | 7.24 | 1.37 | 1.30 | 32.00 | 25.00 | 57.00 |
| MBFKRR | 40.36 | 0.63 | 40.00 | 38.00 | 5.24 | 0.12 | 0.74 | 28.00 | 28.00 | 56.00 |
| MFKISK | 125.68 | 2.73 | 135.00 | 150.00 | 22.67 | -0.72 | -0.70 | 77.00 | 73.00 | 150.00 |
| MFLPRK | 48.90 | 0.92 | 50.00 | 54.00 | 7.61 | -0.21 | -0.35 | 35.00 | 30.00 | 65.00 |
| MFLPRR | 101.32 | 1.75 | 102.00 | 82.00 | 14.54 | -0.12 | -0.61 | 61.00 | 70.00 | 131.00 |
| MFEBNL | 6.79 | 0.17 | 6.40 | 6.30 | 1.42 | 0.34 | -0.10 | 6.80 | 3.20 | 10.00 |
| MFESDM | 224.51 | 3.07 | 225.00 | 220.00 | 25.51 | -0.43 | 0.27 | 130.00 | 160.00 | 290.00 |
| MFESVM | 48.19 | 0.91 | 46.00 | 45.00 | 7.52 | 0.37 | -0.39 | 30.00 | 35.00 | 65.00 |
| MRAZGP | 11.81 | 0.75 | 10.00 | 10.00 | 6.25 | 0.61 | -0.04 | 29.00 | 1.00 | 30.00 |
| MRCDTT | 26.77 | 1.34 | 27.00 | 30.00 | 11.10 | 0.21 | -0.21 | 49.00 | 3.00 | 52.00 |
| MRLPCT | 26.83 | 1.69 | 25.00 | 10.00 | 14.06 | 0.18 | -0.95 | 56.00 | 2.00 | 58.00 |
| IZ 1500 | 6.07 | 0.10 | 6.10 | 5.20 | 0.80 | 0.42 | -1.03 | 2.55 | 5.00 | 7.55 |

Table 2 Correlation of motor variables

| | oss | kus | pissk | tr | tn | kr | iskret | pnk | pr | bm | sudim | suvim | znv | ptst | pcst | 1500m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| oss | 1 | ,110 | ,250* | -,027 | -,101 | -,154 | ,042 | -,093 | ,265* | -,204 | -,360** | -,344** | -,097 | -,156 | ,085 | ,008 |
| kus | ,110 | 1 | ,343** | -,134 | -,052 | -,250* | -,001 | -,067 | -,311** | ,049 | -,380** | -,216 | -,195 | -,202 | -,261* | ,099 |
| pissk | ,250* | ,343** | 1 | -,223 | -,093 | -,339** | -,006 | -,086 | -,063 | -,348** | -,549** | -,470** | -,308* | -,315** | -,174 | ,204 |
| tr | -,027 | -,134 | -,223 | 1 | ,477** | ,276* | -,281* | ,148 | ,161 | ,305* | ,416** | ,153 | ,193 | ,166 | ,082 | -,129 |
| tn | -,101 | -,052 | -,093 | ,477** | 1 | ,046 | -,571** | -,029 | ,096 | ,103 | ,300* | -,117 | ,235 | ,076 | -,235 | -,206 |
| kr | -,154 | -,250* | -,339** | ,276* | ,046 | 1 | ,035 | ,183 | ,220 | ,323** | ,396** | ,356** | ,325** | ,286* | ,193 | ,049 |
| iskret | ,042 | -,001 | -,006 | -,281* | -,571** | ,035 | 1 | -,005 | -,063 | ,051 | -,119 | ,191 | -,086 | -,024 | ,117 | ,163 |
| pnk | -,093 | -,067 | -,086 | ,148 | -,029 | ,183 | -,005 | 1 | ,408** | ,136 | ,117 | -,082 | ,111 | ,125 | ,105 | ,036 |
| pr | ,265* | -,311** | -,063 | ,161 | ,096 | ,220 | -,063 | ,408** | 1 | ,111 | ,212 | -,055 | ,359** | ,317** | ,281* | ,130 |
| bm | -,204 | ,049 | -,348** | ,305* | ,103 | ,323** | ,051 | ,136 | ,111 | 1 | ,393** | ,411** | ,255* | ,426** | ,167 | -,020 |
| sudim | -,360** | -,380** | -,549** | ,416** | ,300* | ,396** | -,119 | ,117 | ,212 | ,393** | 1 | ,659** | ,355** | ,426** | ,187 | -,084 |
| suvim | -,344** | -,216 | -,470** | ,153 | -,117 | ,356** | ,191 | -,082 | -,055 | ,411** | ,659** | 1 | ,219 | ,210 | ,187 | ,063 |
| znv | -,097 | -,195 | -,308* | ,193 | ,235 | ,325** | -,086 | ,111 | ,359** | ,255* | ,355** | ,219 | 1 | ,426** | ,332** | -,388** |
| ptst | -,156 | -,202 | -,315** | ,166 | ,076 | ,286* | -,024 | ,125 | ,317** | ,426** | ,426** | ,210 | ,426** | 1 | ,575** | -,199 |
| pcst | ,085 | -,261* | -,174 | ,082 | -,235 | ,193 | ,117 | ,105 | ,281* | ,167 | ,187 | ,187 | ,332** | ,575** | 1 | -,117 |
| 1500m | ,008 | ,099 | ,204 | -,129 | -,206 | ,049 | ,163 | ,036 | ,130 | -,020 | -,084 | ,063 | -,388** | -,199 | -,117 | 1 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 Canonical correlation analysis

| Faktor | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 0.89 | 48.90 | 48.90 | 0.69 |
| 2 | 0.63 | 34.50 | 83.40 | 0.62 |
| 3 | 0.30 | 16.60 | 100.00 | 0.48 |

Table 4 Significance

| F | Wilks' Lambda | Chi-square | df | Sig. |
|---|---|---|---|---|
| 1 | 0.25 | 80.74 | 48 | 0.00 |
| 2 | 0.47 | 43.73 | 30 | 0.05 |
| 3 | 0.77 | 15.36 | 14 | 0.35 |

Table 5 Discriminant functions

| | Function | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| IZ 1500 | 0.27 | 0.07 | 0.13 |
| MRLPCT | -0.14 | 0.19 | -0.25 |
| MRCDTT | -0.13 | -0.28 | -0.18 |
| MRAZGP | -0.26 | 0.03 | -0.45 |
| MFKISK | 0.01 | 0.21 | 0.07 |
| MFLPRR | 0.07 | 0.12 | -0.39 |
| MFLPRK | -0.02 | 0.32 | -0.17 |
| MAGKUS | -0.38 | 0.02 | 0.54 |
| MRLPCT | 0.22 | 0.01 | 0.46 |
| MAGOSS | 0.20 | 0.36 | 0.00 |
| MFESDM | -0.08 | -0.12 | 0.00 |
| MFEBNL | -0.13 | -0.01 | -0.37 |
| MFESVM | -0.04 | -0.02 | -0.13 |
| MBFKRR | 0.01 | 0.31 | 0.02 |
| MBFTAP | 0.21 | 0.05 | -0.32 |
| MBFTAZ | 0.11 | -0.21 | -0.15 |
| | Function | | |
| | 1 | 2 | 3 |
| I | -1.95 | 0.57 | -0.23 |
| II | -0.09 | -1.25 | 0.00 |
| III | 0.84 | 0.44 | -0.65 |
| IV | 0.37 | 0.46 | 0.74 |

Considering that discriminant analysis can divide the group to a maximum number of groups – 1, results in this case provide three discriminant functions each having their own contribution in explaining the differences. By testing the significance it is noticeable that only the first two functions are important for group differentiation, while the third is not. In any case, the third function will be interpreted as well, noting that its discrimination is limited. Therefore, the first discriminant function separates the first category (most successful athletes) from the third category (locally successful athletes). The difference is evident in considerably distinct positive value of the "running 1500m" and "side steps" variable (but also a bit less distinct in the whole series of variables). This means that those who are locally successful are predominantly working on the development of strength and stamina, while the basic feature of the most successful athletes are quick movements in the space, which separates them from the others. This kind of situation does not need to be desirable. On one hand, if we assume that motor profile of the best kick boxers at this age has just been identified as ideal then it seems that working on strength and stamina at the local level does not have a full sense for reaching the top. On the other hand, working on the basic energy capacities is essential when it comes to working with young people, especially with those who have less than two years of specialized experience in sport. As is usually the case in the sports training system within the macrocycle etc. question arises whether this kind of work will result in their personal peak at the senior age. It can also easily happen that those who achieved top-ranking results in earlier stages of their sport development will not be able to achieve the same result. On the other hand, remains an open question on the actual current value of the training in both of these concepts, because in the end – the result is the result. Therefore, this matter should be viewed from the position of long-term goals that are wished to be achieved on the top level. The second discriminant function separates the second category (successful at the international tournaments) from all the others. It seems that this category achieved the local (individual) maximum that could possibly be achieved, but this was done at the expense of general skills that can be raised to a certain level regardless of specialized i.e. motor competencies, which are usually segments of strength. It seems that it is a matter of skills that are controlled by energy regulation mechanism, while the whole skill series that are controlled by the information regulation of movement is inherent in the other groups (categories). This clearly indicates that for such a competition rank, especially because of specificity of tournaments, the training is based on strength, while in order to achieve better results it takes totally different system of motor skills and competencies. The same story continues in the third discriminant function, but this time to differentiate unsuccessful athletes from those who achieved some results at the local level (domestic competition). Considering that this function is not statistically significant, it should be taken with reserve, but it still suggests that although IV category of athletes has a basic skill – agility, it still is not enough for achieving results. It can generally be said that those who are the most successful (I category) have a specific motor system dominantly characterized by dimensions which are under a huge influence of genetic dispositions. This also applies to those who are still internationally successful (II category), while others show clear signs of energy trainings attempting to compensate for the lack of motor information typical of successful athletes.

**Conclusion**

The research has been conducted on 69 junior (18-20) and senior (21 and above) kick boxers from Vojvodina. They are classified according to achieved sporting results into four (4) categories: *I category* – athletes who achieved the best results by winning one of the *medals* at the World or

European championship, *II category* – athletes who won medals at the international tournaments (competitions), *III category* - athletes who achieved results by winning one of the medals at the national championship, *IV category* – athletes who did not achieve any significant results. Discriminant analysis provides three discriminant functions of which the first two are statistically significant. The first discriminant function separates the first category (most successful athletes) from the third category (locally successful athletes).The second discriminant function separates the second category (successful at the international tournaments) from all the others.

While the third discriminant function dominantly separates locally successful athletes (III category) from the unsuccessful (IV category). The results of discriminant analysis show the properties of analyzed categories in motor domain in such a way that in order to achieve the best result in kick boxing, selection and training should be directed in a way that the system of energy and information regulation of movement should be integrated in athletes, when it comes to general dimensions. The information on motor competencies should definitely be integrated in future analysis, and only then we will be able to make conclusions on how top-ranking athletes achieved their status.

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## MOTORIČKE RAZLIKE KOD MLADIH KICK-BOKSERA PO KATEGORIJAMA TEMELJENIM NA REZULTATSKOJ USPJEŠNOSTI


### Sažetak

*Provedeno je istraživanje na 69 juniora (18-20 g.) i seniora (21 i više g.) kick-boksra iz Vojvodine. Bili su klasificirani obzirom na postignuti Sportski rezultat u četiri kategorije: I kategorija – sportaši kojima je najbolji rezultat bilo osvajanje medalje na Svjetskom ili Europskom prvenstvu, II kategorija – sportaši koji su osvojili medalju na međunarodnom turniru; III kategorija – sportaši koji su postigli rezultat osvajajući medalju na državnom prvenstvu; IV kategorija – sportaši koji nisu ostvarili nikakav značajniji uspjeh. Diskriminativna analiza dala je tri diskriminativne funkcije, Dakle, prva diskriminativna funkcija dijeli prvu kategoriju (najuspješniji) od treće kategorije (lokalno uspješnih). Druga diskriminativna funkcija pak, dijeli grupe na način da grupu II (uspješni na međunarodnim turnirima) odvaja od svih ostalih. Treća diskriminativna funkcija (p>0.05) razlikuje neuspješne sportaše od onih koji su ipak na lokalnoj razini (domaće natjecanje) ostvarili određeni rezultat. Ukupno se može zaključiti da za ostvarenje vrhunskog rezultata u kick boxingu selekciju i trening treba usmjeriti na način da u sportašu treba biti integriran sklop energetske i informacijske regulacije gibanja, kad se radi o općim dimenzijama. Sasvim sigurno u buduće analize treba ugraditi i informaciju o motoričkim znanjima, pa se tek tada može u cijelosti zaključivati o tome kako su oni vrhunski to zaista i postali.*


***Ključne riječi:*** *kick-boksing, motorika, uspješnost, harmoniziranost*

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# THE APPLICATION OF THE SPORT JEALOUSY SCALE (SJS) AT CROATIAN ATHLETES

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*Original scientific paper*

***Abstract***
*Social comparison processes, that are inherent in sport competition, are researched according to the role of jealousy in sport: it is understood as a negative emotional reaction that is accompanied by thoughts of inadequacy when compared to others. This research has two purposes: to refine the Sport Jealousy Scale developed by Kamphoff et al., (2005) in Croatian population of athletes; to investigate the differences in the sport jealousy, between the athletes: from different sports, team/individual sports, male/female, from different levels of the competition, juniors/ seniors. Seventy three athletes competing at Croatian championships in different sports (football, bowling, volleyball and handball) were examined with Croatian version of Sport Jealousy Scale (SJS-II). Athletes indicated they experienced social comparison jealousy. We have found the differences in the jealousy at the athletes, with higher jealousy scores in: team sports, women, lower competition ranks, juniors. This study can provide a useful start for further research on jealousy in sport in Croatia.*

***Key words****: athletes, sport jealousy, differences*

## Introduction

The research of the jealousy has been conducted mostly outside the sport setting, especially in the area of romantic relationships (Bers & Rodin, 1984; Mathes & Severa, 1981). In the romantic context, jealousy is defined as having a belief or suspicion that a relationship is in danger of being lost (Kamphoff, Gill & Huddleston, 2005). Envy is defined as wanting another's possessions, attributes or reputations (Bringle et al., 1977; 1979). Jealousy is a wish to be "in" a person's shoes (or actually wanting to be another person), whereas envy is wanting "to own" their shoes (to possess someone's property). Jealousy represents a triadic relationship (involving three people) whereas envy represents a dyadic relationship, that involves two people (Bers & Rodin, 1984). Bers & Rodin (1984) and Silver & Sabini (1978) argue that there is differentiating envy and jealousy is artificial, because the emotions, cognitions, and behaviors of both constructs are very similar. Bers & Rodin (1984) name a separate category of jealousy in romantic relationships labeled 'social relations jealousy' which is challenging one's exclusivity in a relationship, which can be 'interpolated' in sport situations. A number of antecedents of social comparison jealous have been found. Silver & Sabini (1978) think that social comparison jealousy results when one person diminishes the status or self-esteem of another person (naming one athlete as team captain). Bers & Rodin (1984) found that people react in a jealous manner when another person is superior in some way or when another achieves something that is desired. Social comparison jealousy is stronger when an event was of greater importance. Salovey & Rodin (1984) found that social comparison jealousy occurs when one receives negative information about oneself from another, and when the other person is similar to oneself.

Social comparison jealousy in sport may be very common because athletes are similar and constantly compare themselves to each other (Kamphoff, Gill & Huddleston, 2005). Therefore, social comparison jealousy is likely to the sport setting, when one athlete diminishes another athlete's status, is superior in some way, is similar to the athlete, and if the event is important (Bers & Rodin, 1984; Salovey & Rodin, 1984; Silver & Sabini, 1978). Social comparison processes, that are inherent in sport competition, are researched according to the role of jealousy in sport. In this context, jealousy is understood as a negative emotional reaction that is accompanied by thoughts of inadequacy when compared to others. Pease (1987) developed the Social Comparison Jealousy Scale (SCJ) and investigated the relationship of social comparison jealousy to sport team cohesion at 71 team sport participants. Results indicated a small negative, but non-significant, correlation between jealousy and team cohesion. Pease found a one-factor structure, argued it that only one factor emerged because it is difficult to differentiate envy and jealousy (Kamphoff, Gill & Huddleston, 2005). Schelling-Kamphoff & Huddleston (1999) compared the level of the jealousy experienced by male and female athletes. They used the Revised Self-Report Jealousy Scale (SRJS-II; Bringle et al., 1977) as a model to develop the Sport Jealousy Scale (SJS). Schelling-Kamphoff & Huddleston (1999) administered the SJS to 233 track and field athletes. The results revealed males and females were moderately jealous (average a 2 on a 5 point scale) and no gender differences were found. Parker (2001) used the Revised Sport Jealousy Scale (SJS-II) to examine jealousy and self-esteem at athletes on both individual and team sports. She found that 77.3% of the athletes reported that they had experienced one of the eleven SJS situations. Females (88%) were more likely than males (66%) to have experienced one of the situations.

In the same research, freshmen and sophomore starters reported more jealousy than freshmen and sophomore nonstarters (Parker, 2001). Jealousy may also have a negative impact on a team's cohesion, which is more important in team sports, comparing with individual sports, where success is more exclusively based on an individual's performance So, it is important to understand cohesion of both interacting and co acting teams, and the possible negative influence of jealousy on cohesion. This study has two purposes. The first purpose, to refine the Sport Jealousy Scale developed by Kamphoff, Gill & Huddleston (2005) in Croatian population of athletes. The second purpose is to use the refined Sport Jealousy Scale to investigate the differences in the jealousy, between: athletes from different sports, interactive/ team and individual sport athletes, male and female athletes, athletes from different levels of the competition, juniors and seniors. Five hypotheses were outlined before the data were collected: 1. It is expected that athletes would indicate they experience social comparison jealousy. 2-5. It is hypothesized that in social comparison jealousy will be found the differences depending of the: type of sport ($2^{nd}$ – higher jealousy scores in team sports), gender ($3^{rd}$ – higher jealousy scores at women), levels of the competition ($4^{th}$ - higher jealousy scores in the lower competition ranks), age ($5^{th}$ - higher jealousy scores at juniors).

## Methods

*Participants*

Seventy three athletes competing at Croatian championships in different sports were examined, with occasional choice of the teams in: First Women Football League, Second Women Volleyball League, First Women Handball League, Third Men Football League, First Bowling League (Men and Women - selected candidates for the national teams). All athletes in chosen teams that were available were tested. Individual ($n$ = 19) and team ($n$ = 54) sports were not equally represented, with athletes from this sample participating in one of four sports: one individual sport (bowling), and three team or interactive sports (football, handball, volleyball). Specifically, 25 football (soccer), 19 bowling, 16 volleyball and 13 handball athletes participated in the research project. Among them 25 athletes were male and 48 female. All volleyball and handball athletes were female. Eight football players were female and 17 were male. Eight bowling athletes were male, and 11 were female. The mean age of the athletes was 21.8 years old, with a range of 15 to 54 years old.

*Measures*

The athletes completed the questionnaire the *Sport Jealousy Scale (SJS-II*). The SJS-II was used to measure the amount of social comparison jealousy an athlete experiences in sport. The SJS-II that was given to our sample contained 11 items with a response format of 1 (*pleased*) to 5 (*extremely upset*), whereas the final version of the SJS-II included 9 items.

The reliability of the original scale was moderately high ($\alpha$ = .79), and the concurrent validity with the non-romantic items on the SRJS-II was reported as moderate ($r$ = .43). The reliability of the final scale (SJS-II) in the research conducted by Kamphoff, Gill & Huddleston (2005) was higher ($\alpha$ = .87). For the Croatian sample, Sindik translated and adapted the original instrument SRJS-II. *Demographics questionnaire .* The demographics questionnaire served as a cover page and included information on the participant's age, gender and sport.

*Procedure*

The questionnaire was administered with five separate data collection procedures. For the data collection, coaches from selected teams from different sports were contacted by phone to obtain their permission to administer the questionnaires to their athletes. Five coaches, agreed to participate. After obtaining permission from the coaches, the researchers met with the athletes before or following the team's practice. The administrator emphasized that participation was voluntary and if in any way it would affect their performance at the meet, they were asked to decline participation. For all participants, the researcher briefly explained that the questionnaire assessed team relations and emotions within the team. Complete confidentiality was guaranteed, no names were requested, their coach would not have access to the data, and only group statistics would be reported. The athlete returned the questionnaire with the signed informed consent to the researcher when they finished.

*Data Analysis*

Data analysis was performed by statistical package SPSS for Windows 7.5. Principal components analysis is performed on all the items (11) of *Sport jealousy scale* on the overall sample of Croatian athletes, with all items loaded over ,40 (correlation between the item and main component that represents sport jealousy). A total score SJS-II was calculated (as a simple linear combination of the estimations for 9 items in the final version of the scale). At last, for the main problems of the research, Kruskal-Wallis and Mann-Whitney U test are used in testing differences, according to athletes': gender, level of competition, type of sport, junior/senior, individual/team sport.

## Results

*Intensity of Jealousy*

In the Table 1 we can see the mean of the 11-item Revised Sport Jealousy Scale (SJS-II) was 23.151, with an average item score of 2,105, indicating the athletes in the sample were "mildly jealous." A total score of 32 on the SJS-II was the most frequent score, with 98,6 % of the participants scoring between 10 and 33. The lowest possible score of 10 was represented in the sample; however, the highest possible score of 45 was not represented. In fact, only one athlete ( 1.4%) indicated extremely jealousy (averaging a 4 or higher on the 5 point scale).

Table 1: Descriptive characteristics of the items in *Sport jealousy scale*

| Item | K-G | p | M | σ | Min | Max |
|---|---|---|---|---|---|---|
| A teammate receives more scholarship money even though you both have equal ability. | 2,39 | <,01 | 2,11 | 1,32 | 1,00 | 5,00 |
| No matter what you do, your coach seems to be more interested in a teammate's performance than in your performance | 1,52 | <,05 | 2,64 | 1,07 | 1,00 | 5,00 |
| In practice, your coach encourages another athlete more than you. | 1,82 | <,01 | 2,81 | 1,10 | 1,00 | 5,00 |
| You and your teammates have worked hard all season. When the team wins a big competition, you are not recognized for your contribution to the win. | 1,74 | <,01 | 2,52 | 1,09 | 1,00 | 5,00 |
| A teammate seems to be receiving preferential treatment by the coaching staff. | 1,62 | <,01 | 2,63 | 1,23 | 1,00 | 5,00 |
| The local paper interviews many of your teammates and fails to interview you. | 2,01 | >,01 | 2,33 | 1,20 | 1,00 | 5,00 |
| A teammate rarely works hard in practice, however, during competition he/she performs better than you. | 1,78 | <,01 | 2,79 | 1,14 | 1,00 | 5,00 |
| Your coach seems to have a better relationship with your teammate than with you. | 1,46 | <,05 | 2,63 | 1,32 | 1,00 | 5,00 |
| Some teammates never seem to worry about their weight. On the other hand, you have to monitor what you eat. | 1,47 | <,01 | 2,29 | 1,16 | 1,00 | 5,00 |
| A teammate is more popular than you are with the other members of the team. | 2,68 | <,01 | 1,77 | 1,06 | 1,00 | 5,00 |
| *Total score* | 0,79 | >,20 | 23,15 | 6,42 | 9,00 | 36,0 |

K-G=Kolmogorov-Smirnov test

Table 2: Principal components analysis of the *Sport jealousy scale* on the sample of Croatian athletes

| Item | $h^2$ | R |
|---|---|---|
| A teammate receives more scholarship money even though you both have equal ability. | ,01 | ,00 |
| No matter what you do, your coach seems to be more interested in a teammate's performance than in your performance | ,22 | ,47 |
| In practice, your coach encourages another athlete more than you. | ,30 | ,54 |
| You and your teammates have worked hard all season. When the team wins a big competition, you are not recognized for your contribution to the win. | ,32 | ,56 |
| A teammate seems to be receiving preferential treatment by the coaching staff. | ,61 | ,78 |
| The local paper interviews many of your teammates and fails to interview you. | ,53 | ,73 |
| A teammate rarely works hard in practice, however, during competition he/she performs better than you. | ,38 | ,62 |
| Your coach seems to have a better relationship with your teammate than with you. | ,46 | ,67 |
| Your coach seems to have a better relationship with your teammate than with you. | ,34 | ,58 |
| Some teammates never seem to worry about their weight. On the other hand, you have to monitor what you eat. | ,18 | ,43 |
| A teammate is more popular than you are with the other members of the team. | ,08 | ,00 |
| Eigenvalue / Total variance explained (%) | 3,4 | 31,13 |

$h^2$= communalities, R = correlation with factor

Table 4: Differences in total score in the *Sport jealousy scale* on the sample of Croatian athletes

| Differences | Differences between pairs | Mann-Whitney U | Significance (p) |
|---|---|---|---|
| Gender differences – same sports | Football – female (14,81), male (12,15) | 27,5 | <,02 |
| | Bowling - male (11,38), female (9,00) | 28 | >,20 |
| Female athletes | football (15,13), handball (8,46) | 17 | <,01 |
| | football (14,75), volleyball (11,38) | 50,5 | >,20 |
| | football (13,56), bowling (7,41) | 12,5 | <,01 |
| | volleyball (17,22), handball (12,27) | 51 | >,20 |
| | volleyball (16,84), bowling (9,86) | 34 | <,01 |
| | handball (13,73), bowling (11,05) | 51 | >,20 |
| Male athletes | football (15,03), bowling (8,69) | 41,5 | >,10 |
| Gender differences – different sports | female volleyball (16,44), male football (17,53) | 105 | >,20 |
| | female handball (12,31), male football (17,94) | 90,5 | >,20 |
| | female handball (11,15), male bowling (10,75) | 47 | >,20 |
| | female volleyball (14,19), male bowling (9,13) | 32,5 | >,05 |
| | male football (16,88), female bowling (10,82) | 58,5 | >,10 |
| | female football (11,56), male bowling (5,44) | 6,5 | <,01 |
| Team vs. individual sports | Team (41,25), Individual (24,92) | 283,5 | <,01 |
| Juniors vs. seniors | Juniors (44,39), Seniors (26,98) | 340,5 | <,01 |
| Levels of the competition | national team candidates (16,26), 1st (23,88) | 128,5 | >,05 |
| | national team candidates (14,18), 2nd (22,53) | 79,5 | <,05 |
| | national team candidates (14,55), 3rd (22,91) | 86,5 | >,20 |
| | 1st (18,17), 2nd (20,09) | 150,5 | >,20 |
| | 1st (18,21), 3rd (21,09) | 151,5 | >,20 |
| | 2nd (16,44), 3rd league (17,53) | 127 | >,20 |

Table 3: Principal components analysis of the *Sport jealousy scale* on the sample of Croatian athletes

| Item | $h^2$ | R | R' | A |
|---|---|---|---|---|
| No matter what you do, your coach seems to be more interested in a teammate's performance than in your performance | ,24 | ,49 | ,37 | ,78 |
| In practice, your coach encourages another athlete more than you. | .31 | .56 | .42 | .77 |
| You and your teammates have worked hard all season. When the team wins a big competition, you are not recognized for your contribution to the win. | ,30 | ,54 | ,39 | ,77 |
| A teammate seems to be receiving preferential treatment by the coaching staff. | .63 | .79 | .66 | .73 |
| The local paper interviews many of your teammates and fails to interview you. | ,50 | ,71 | ,58 | ,75 |
| A teammate rarely works hard in practice, however, | .39 | .62 | .48 | .76 |
| Your coach seems to have a better relationship with your teammate than with you. | ,51 | ,71 | ,58 | ,75 |
| Your coach seems to have a better relationship with your teammate than with you. | .31 | .56 | .42 | .77 |
| Some teammates never seem to worry about their | ,18 | ,43 | ,31 | ,79 |
| Eigenvalue / Total variance explained (%) | 3,37 | 37,39 | C $\alpha$ | ,78 |

*Factor Analysis of the SJS-II*

A factor analysis provided additional evidence for the deletion of the two items, after two iterations, showed in Table 2 and Table 3. KMO and Bartlett's Test was used to test the convenience of the correlation matrix for factorization in two iterations. For the first one, Kaiser-Meyer-Olkin Measure of Sampling Adequacy (,698) and Bartlett's Test of Sphericity (Chi-Square=211,369; p<,01) showed that correlation matrix is good for factorization. For the second one, Kaiser-Meyer-Olkin Measure of Sampling Adequacy (,747) and Bartlett's Test of Sphericity (Chi-Square=170,987; p<,01) showed that correlation matrix is good for factorization, too. First iteration of the Principal Component Analysis (Table 2) revealed a one-factor structure (the main component accounted for 31,131 % of the variance, and these two items had the lowest factor loadings on the main component (both below ,40). Factor analysis was then recalculated after deleting the two items and a one-factor structure would emerge. The main component accounted for 37,385 % of the variance (Table 3). The scree plot of the factor structure indicated a steep drop of eigenvalues, suggesting a one-factor structure.

*Reliability of the SJS-II.*

The final 9-item revision of the Sport Jealousy Scale in our research has good internal consistency ($\alpha$ = .784). But, item the corrected item-total correlations for three items on the SJS-II were below ,40. With the items deleted, the alpha level on the scale rose to ,785 for the last item.

*Differences in Sport Jealousy.*

Kruskal-Wallis test is calculated to investigate differences in jealousy scores between sports and levels of the competition. Mann-Whitney U test is used in testing differences between genders, individual and team sport participants, junior and senior athletes. Kruskal-Wallis test revealed a statistically significant difference between athletes from different sports (Chi-square=16,185; p<,01): mean ranks for each sport were, as following: women football (55,25), women volleyball (46,03), men football (37,59), women handball (31,54), men bowling (27,94), female bowling (22,73).

Also, Kruskal-Wallis test revealed a statistically significant difference between athletes from different levels of competition (Chi-square=8,211; p<,05) – mean ranks: candidates for national team (25,50), 1st league (38,26), 2nd league (42,06), 3rd league (45,53). Specific differences are presented in Table 4. Mann-Whitney U test shows that female athletes scored statistically significantly higher on jealousy than male athletes in football, but not in bowling. Team sport athletes scored higher on jealousy than individual athletes, and junior athletes scored higher on jealousy than seniors.

## Discussion

The results confirm the existence of jealousy in sport and provide psychometric evidence for a measure of sport jealousy for Croatian sample of athletes. Expected differences in jealousy have been proven. As hypothesized, athletes indicated they experienced social comparison jealousy. On average, the athletes were only mildly jealous and only few indicated they were extremely jealous. It would be important to examine sport jealousy to a large variety of athletes to better understand if this sample was just mildly jealous, or if this is a larger trend among athletes, as suggest Kamphoff, Gill & Huddleston (2005). Considering differences, we can say that most of found differences are in direction that we expected. In the previous research (Kamphoff, Gill & Huddleston, 2005) authors suggests that perhaps females experience more jealousy if another athlete has a better relationship with their coach or if another receives more of the coach's attention (especially in an individual sport). On the contrary, in our research female bowling athletes have the lowest jealousy scores, what we can explain by specificity of the bowling. The differences in jealousy found between males and females in football, can be explained with women trend to define themselves in a context of human relationships (Gilligan, 1982). In spite of different types of sports that we researched, we found the difference between the athletes engaged in team sports, comparing with individual sport athletes, in the direction of higher scores in jealousy for team sport athletes. Competing on an individual sport team may produce stronger reactions of jealousy because athletes are typically competing within a team for a spot.

For example, in bowling, only one athlete from one team can compete in particular moment. On the other hand, all individual sport athletes and all top athletes, as well as the most of senior players in our research were from the same sport (bowling), what can have an influence on expected statistically significant trends (in differences) that were found in our research: higher jealousy at juniors (comparing to seniors) and higher jealousy at lower competition ranks. However, differences in jealousy can be explained as a simple reflection of the higher self-confidence at elite athletes, more experienced and older senior athletes. Nevertheless, the specific sample of sports and athletes selected for this research, indicate that our results are suggestive but limited, and further research is needed. Several practical implications arise from this study. The jealousy may have a strong effect on the interpersonal relations within a team. The possible influence of gender, type of sport, the fact is the sport team or individual, how old are athletes and which level of the sport quality they are (top or amateur sport), can be starting points for the coach to understand factors that affect jealousy and to better combat jealousy and possibly improve the performance of the team as a whole or individual athletes. This study can provide a useful start for further research on jealousy in sport in Croatia. However, it is important to consider the limitations of the study and results. First, only highest range of scores on the Revised Sport Jealousy Scale (SJS-II) had been represented, results and group differences might have been different. Secondly, the results from current sample of athletes that we have chosen, cannot be generalized to other sport athletes, or other geographic regions. Thirdly, the questionnaires were administered either before or after team practice, so the athletes may have been in a rush to complete the survey to start practice.

But the main recommendations for future research include continuing the work on the SJS-II, developing a theory of jealousy in sport, collecting qualitative data from coaches and athletes, concerning their experiences with jealousy in sport, investigating social relations jealousy in sport (Kamphoff, Gill & Huddleston, 2005). It would be useful to collect similar data from different types of athletes, male and female, from team or individual sports, different ages and levels of competition, to get more exact conclusions.

**Conclusions**

We have accepted all the hypothesis given. Athletes indicated they experienced social comparison jealousy. We have found the differences in the jealousy, depending of the: type of sport (higher jealousy scores have the athletes in team sports), gender (higher jealousy scores have women, in football, but not in bowling), levels of the competition (higher jealousy scores have the athletes in the lower competition ranks), age (higher jealousy scores have the juniors). This study can provide a useful start for further research on jealousy in sport in Croatia.

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## PRIMJENA SKALE SPORTSKE LJUBOMORE (SJS) NA HRVATSKIM SPORTAŠIMA


### Sažetak

*Procese socijalne usporedbe, svojstvene sportskom natjecanju, istražili smo u skladu s ulogom ljubomore u sportu, koja se tumači kao negativna emocionalna reakcija koja je praćena mislima o neadekvatnosti pojedinca, kada se uspoređuje s drugima. Ovo istraživanje ima dva cilja: karakteristike Sport Jealousy Scale koju su razvili Kamphoff, Gill & Huddleston (2005) provjeriti na hrvatskom uzorku sportaša; istražiti razlike u sportskoj ljubomori između sportaša: iz različitih sportova, timskih/individualnih sportova, muškaraca/žena, iz različitih razina natjecanja, juniora/ seniora. Sedamdeset tri sportaša koji se natječu u hrvatskim prvenstvima u različitim sportovima (nogomet, kuglanje, odbojka i rukomet) ispitali smo hrvatskom verzijom Sport Jealousy Scale (SJS-II). Sportaši su pokazali da doživljavaju ljubomoru nastalu socijalnom usporedbom. Pronašli smo razlike u ljubomori kod sportaša, s većim rezultatima u ljubomori za: timske sportove, žene, niže rangove natjecanja, juniore. Ovo istraživanje može omogućiti koristan početak za buduća istraživanja ljubomore u Hrvatskoj.*


***Ključne riječi**: sportaši, sportska ljubomora, razlike*

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# VOLLEYBALL AS CONTENT OF KINESIOLOGY TRAINING PROGRAMS IN CLASSROOMS

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*Original scientific paper*

***Abstract***

*The aim of this study was to determine whether there are significant differences between students of the fifth grade that the two hours per week of regular physical education classes, involved in playing volleyball, and that the two hours per week of regular physical education classes, are not involved in playing volleyball. The population, from which the sample was drawn, defined as girls in fifth grade of primary school. The sample of respondents, was appointed as the GR-AB, necessarily includes the 51-student, according to the criterion of practicing volleyball divided into two sub-samples, as follows: (1) subsample of 19 subjects (D) that the two hours per week of regular physical education classes, involved in volleyball, and (2) subsample of 12 subjects (N) by two hours a week with regular physical education classes, are not involved in volleyball. In this study, to assess motor skills, the inability of respondents to engage a long drawn out hypothetical choice of the primary motor dimensions that are assumed to be of particular interest in terms of realization of educational kinesiology education of these subjects, namely: to assess explosive power (which is defined as the ability to activate the maximum number of muscle units in time) applied the tests: long jump and running from place to 20 m high start. In this study, the following two methods for data analysis: descriptive statistics (central and dispersion parameters) and univariate analysis of variance (ANOVA).*

***Key words:*** *pupils, school age, volleyball, motor skills, ANOVA*

## Introduction

Content is changing sports games in teaching kinesiology education in classrooms is important in the educational-correctional system. Enable students to acquire information on conserving and improving health of individuals and the environment, which enables them to monitor and take measures to develop and improve the characteristics, abilities, knowledge and achievements. Students for sports games are very interested, why they should be planned, and more than expected existing plans and programs in classrooms. Movements are performed by students in sports games, to foster the development of their biotic and general knowledge of kinesiology motor skills that are important for solving everyday motor tasks in life.

## Problem and objective research

The problem of this research is contained in the questions, whether and to what extent there are significant differences between students that are two hours a week with regular physical education classes, involved in volleyball, named as GR-A student and that two hours a week with regular physical education culture, are not involved in volleyball, named as GR-B, and the aim is to determine statistically significant differences between fifth graders of primary schools which are two lessons a week with regular physical education classes, involved in playing volleyball, and that two hours a week with regular teaching physical education, are not involved in playing volleyball.

## Methods

The population from which the sample was drawn defined as the population of girls in fifth grade primary school. Female students at the time of measurement treated as a healthy and capable of teaching physical education. The sample of respondents, necessarily includes the 31-student, according to the criterion of practicing volleyball divided into two sub-samples, as follows: (1) subsample of 19 subjects (D) by two hours a week with regular physical education classes, involved in volleyball, and (2) subsample of 12 subjects (N) by two hours a week with regular physical education classes, are not involved in volleyball.

Assessment of motor abilities of children is an important assessment of all dimensions that are hypothesized to exist in motor space. Due to the inability of the long engagement of respondents for this survey, drawn hypothetical choice of primary motor dimensions that are assumed to be of particular interest for the realization of the conditions of teaching these subjects kinesiology education, namely: to assess explosive power (which is defined as the ability maximum muscle activation unit time) applied the tests: long jump and running from place to 20 m high start.

## Results and discussion

Some of the best set of data represents a central value or average value, which achieves the greatest number of entities in the sample population.

Table 1. Basic statistical parameters of manifest variables (volleyball)

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Min | Max |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| MFE20VD | 19 | 4.49 | 0.33 | 0.08 | 4.33 | 4.65 | 4.08 | 5.27 |
| MFESDMD | 19 | 13.42 | 1.17 | 0.27 | 12.86 | 13.98 | 10.38 | 16.13 |

Table 2. Basic statistical parameters of manifest variables (regular PE)

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence | | Min | Max |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| MFE20VN | 12 | 4.37 | 0.21 | 0.06 | 4.23 | 4.50 | 4.06 | 4.77 |
| MFESDMN | 12 | 13.51 | 0.98 | 0.28 | 12.89 | 14.13 | 11.88 | 15.38 |

Table 3. Univariate analysis of variance – ANOVA (volleyball) – effects

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| MFE20VD | Between Groups | .735 | 1 | .735 | 10.195 | .005 |
| | Within Groups | 1.225 | 17 | .072 | | |
| | Total | 1.959 | 18 | | | |
| MFESDMD | Between Groups | 4.949 | 1 | 4.949 | 4.281 | .054 |
| | Within Groups | 19.651 | 17 | 1.156 | | |
| | Total | 24.600 | 18 | | | |

Table 4. Univariate analysis of variance – ANOVA (regular PE) - effects

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| MFE20VN | Between Groups | .257 | 1 | .257 | 10.557 | .009 |
| | Within Groups | .243 | 10 | .024 | | |
| | Total | .500 | 11 | | | |
| MFESDMD | Between Groups | 3.738 | 1 | 3.738 | 5.517 | .041 |
| | Within Groups | 6.776 | 10 | .678 | | |
| | Total | 10.514 | 11 | | | |

Some core values, such as mean, median and mode are calculated only in the case of quantitative variables, while others, such as the median (median value, which is located exactly in the middle of the data series arranged by size) and fashion (the dominant value, which results in a number of commonly occurring), used for qualitative variables. The essence of ANOVA (Univariate analysis of variance) is to determine the relationship between the value of variability (variance) of the respondents in the sample. The significance level of difference (Sig) is defined by F-test, with the accepted risk of error to 5% ($p = 0.05$). In this case, ANOVA showed the following: For the girls - the MFE20V variables was statistically significant difference between the GR-A and GR-B, in the girls involved in volleyball in addition to regular attendance at physical education classes and the conclude that dealing with volleyball influenced his results, the variables with the jump seats (MFESDM) was not achieved statistical significance and might suggest that playing volleyball was not affected his results. The MFE20V variables was statistically significant difference, and it could be concluded that playing volleyball influenced his results, the variables MFESDM was no statistically significant difference and it could be concluded that playing volleyball affected his results. For the value of running at 20 m high start (MFE20V) plays an important role pulse and gradient forces, which are related to muscle contraction. With regard to the impulse of force in movements that are performed quickly without an external load greater importance is that starting from the accelerating force of muscles, and their ratio depends on the training level.

Smaller relative differences in sample variables jump from place (SFESDM) of the differences in the sample variables running at 20 m high start (MFE20V) does not contradict the above fact, since the variable running to 20 m high start (MFE20V) takes place and speeding up muscle power. Structured teaching kinesiology education, basic games, sports games, athletics, extracurricular activities, etc.. significantly influenced the results of these motor events. It was found that the variable with the jump seats (MFESDM) has a simple structure, with him, with explosive force, makes the variance of the resolution and speed of the motor tasks and motor awareness (Gredelj et al., 1975). Because the motor information disposition character, with encouraging her to start development at the age of about 5 to 7 years. the most suitable period for its development in age from 11 to 16 years. Organized session of kinesiology education, gymnastics (floor exercise and vault to be characterized by a strong and explosive jumps with certainty that the effect of increasing the long jump), extracurricular activities, basic games, sports games and others affect the performance of these motor events. The man is a biological and social being. And as much as a social being evolved, the biological nature of man is as good as it was at the time of his existence depended almost entirely on his physical abilities. Since the scientific, technical and industrial revolution, among other things, directly reduces the share of people in work, and that means that positive incentives are the man for centuries ensured the maintenance of biological balance, that modern man (regardless of age and gender), and usually less moving, more and more need to shows, conditionally speaking, to assume the role of physical education to establish a balance between modern man and amended way of life and work. Why? Because more and more in the world and our prevailing belief that only the physically and mentally capable person can meet the demands of modern life in and out the ends with the sudden and unexpected situations (Findak, 1992). It can be said that all present knowledge that health and physical ability of the man largely decide how to use one and realize their potential skills and knowledge in everyday life. For optimal growth and development, health, and ultimately for human survival, is much more important to worry about the development of traits and abilities, and global knowledge. Knowledge does not participate in defining health, and the features and capabilities that. The qualities and skills are essential as a basis for growth and development of every man, because of the need to develop qualities and abilities no one naturally released, while knowledge may be larger or smaller, more useful and less useful, theoretical or practical, and not necessarily the same for different people (Metikoš, Mraković & Neljak, 1996). The school system generally follow the theoretical knowledge and evaluate the overall success of the term, while "non-systematic, outside the education system, sometimes follows the characteristics and medical service capabilities, of course, for medical purposes, and usually when something has to be treated." (Metikoš, Mraković & Neljak, 1996). Mraković (1997) warns: "It is absolutely wrong thinking that the time used to play instead of learning, lost time, which is characteristic of primitive communities. These two activities are in general should not oppose, because learning, as well as human labour should be played. But learning is definitely cannot provide normal function, if you neglect exercise. Exercise is, in fact, can improve learning. "Play and sports are an integral part of life of people of different ages and social status of fish that children and adolescents. It is often difficult to have every child, developing not only in their mental, emotional, social and spiritual dimensions, but also in psychomotor. A place that sport occupies in society is of great importance and influence. Sport is a common human good. He is one of the most expressive forms of human creativity. Expression of love for the sport of human abilities, the pleasure in expanding boundaries of human capabilities, spontaneity, and interest in the human drama that takes place in a sports competition, give the sport a special potential, which is especially important for children and young people. For them, playing sport is an expression of life. Sports are human nature, "intrinsic" activity. The biggest change of all the most important characteristics of human phenotype occur in childhood and adolescence, and then up to them and be influenced. Immediate care of the child begins care of his health, which is "complete physical, mental and social wellbeing, not just the absence of disease or infirmity (WHO, 1974 and 1978). As the anthropological space indivisible, violation of one dimension will affect the other. Significant differences in the development of motor skills produced in the period from the fifth to ninth grade, so that the motor skills which are part of the genetic variance is greater than nongenetic (as is the case in this study, with the ability type of explosive strength), show only slightly higher trend of development in comparison to the previous period. Relatively stop in the development of these principles is the mark attributed to the differentiation between human traits and abilities at this age and, in particular, changes in morphological characteristics, which highlighted the growth in height (extension of the limb can be a disturbing factor for the manifestation of otherwise latent characteristics of speed, coordination and explosive strength). Existing differences in this study cannot be attributed to genetic limitations, but also the lack of physical exercise. Students at this age show a much greater interest in sports games and physical education because educators are obliged to use it as a work area, in the process of achieving the tasks kinesiology education, in addition to regular classes, extracurricular activities and have the student. Because they represent an additional activity, it is reasonable to expect that the increased volume of exercise a positive influence on the transformation processes student motor skills. In contemporary society (which is characterized by many positive and negative changes) Kinesiological education becomes increasingly important.

The need for systematic implementation of kinesiology and quality of education from the earliest days comes not only because of lifestyle changes but the fact that in modern conditions of life and work all the more vulnerable precisely those functions and organism capabilities. Kinesiology training that can change quickly and efficiently, develop and improved. Otherwise expect the disturbances in the development of children and youth with far-reaching consequences - not just because of motor and functional abilities, but on possible disturbances in all other traits and abilities, and health in the broadest sense of the word. Excessive mental strain, the neglect of physical activity, threatening the ability of adaptation and development affects the normal cognitive functioning. Continuous development of stress conditions, without adequate relaxation, adversely affect conative factors, and through them to the level of cognitive and motor abilities and motor skills necessary for success in most of the day, work and other commitments. Hipokinesis, officially among the primary risks to human health is an indispensable factor of anthropological status. Basically, a positive result in this study attributed the positive effects of physical exercise in the process of active locomotion system, which is essential for the development of explosive strength. The results of this study are contrary to some other information, to extracurricular activities (volleyball) influence the development of motor abilities of fifth grade girls.

**Conclusion**

According to the Deloro (1989) on primary education should be viewed as a "passport for life", which is necessary to enable each child to master a course of life and used every opportunity to adapt to any situation in order to awaken and enrich their knowledge, and that in this way adapt to a world that is changing. Adoption of general and professional knowledge, equally, if it is not major role in human development and a nurturing his natural skills, abilities and mental and even social welfare generates clear benefits. In this sense, exercise and learning are the unique features of the original human prosperity. The aim of this study was to determine whether there are significant differences between students of the fifth grade that the two hours per week of regular physical education classes, involved in playing volleyball, and that the two hours per week of regular physical education classes, are not involved in playing volleyball. The population, from which the sample was drawn, is defined as the girls of fifth grade primary school. Female students at the time of measurement were healthy and capable of teaching physical education. The sample of respondents, was appointed as the GR-AB, necessarily includes the 51-student, according to the criterion of practicing volleyball divided into two sub-samples, and GR-GR-A and B as follows: (1) subsample of 25 subjects (D) that the two hours per week of regular physical education classes, involved in volleyball, named as GR-A, and (2) subsample of 26 subjects (N), which are two lessons a week with regular physical education classes, are not involved in volleyball.

The sample consisted of motor variables explosive power (which is defined as the ability to activate the maximum number of muscle units of time) applied the tests: long jump and running from place to 20m high start. In fact, in primary stage of ontogenesis transformation processes focused on the optimal development of some of the relevant and dominant feature, also in the direction of learning, development and adoption of certain motor and other programs because they depend on the assumption of a relatively unstable level of anthropological dimension of the pupil. Also, on the assumption of basic motor programs unformed, intensifying the diversification of content transformation needs the motor - the interests of students. On the basis of which to conclude - given the indivisibility of nature and multifunctional multistructural anthropological space – complex development is an important factor in sports games development of younger school age children. Especially when that population is planned for only two hours physical education per week and, in bad organised conditions of its implementation. On the other hand, considering the share of kinesiology Kinesiological activity profiling, and anthropological status of students for them irreparable important development period, it is necessary to study the representative sample from population of students of junior school age and with a representative sample of measuring instruments.

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## ODBOJKA KAO SADRŽAJ PROGRAMA KINEZIOLOŠKE EDUKACIJE U RAZREDNOJ NASTAVI

### Sažetak

*Cilj ovog istraživanja bio je utvrditi postoje li statistički značajne razlike između učenica petog razreda osnovne škole koje su uz dva časa sedmično redovne nastave tjelesne kulture, uključene u igranje odbojke, i koje uz dva časa sedmično redovne nastave tjelesne kulture, nisu uključene u igranje odbojke. Populacija, iz koje je izvučen uzorak ispitanika, definirana je kao populacija djevojčica petog razreda devetogodišnje osnovne škole. Uzorak ispitanica uključuje 31 učenicu, po kriteriju bavljenja odbojkom raspoređenih u dva subuzorka, i to: (1) subuzorak od 19 ispitanica (D) koje su uz dva časa sedmično redovne nastave tjelesne kulture, uključene u igranje odbojke i (2) subuzorak od 12 ispitanica (N) koje uz dva časa sedmično redovne nastave tjelesne kulture, nisu uključene u igranje odbojke. U ovom istraživanju za procjenu motornih sposobnosti, zbog nemogućnosti dužeg vremenskog angažiranja ispitanika izvučen je izbor onih hipotetskih primarnih motoričkih dimenzija za koje se pretpostavlja da su od posebnog interesa za uvjete realizacije nastave kineziološke edukacije, i to: za procjenu eksplozivne snage (sposobnost aktiviranja maksimalnog broja mišićnih jedinica u vremena) primjenjeni su testovi: skok u dalj s mjesta i trčanje na 20 m visokim startom. U ovom istraživanju korištene su sljedeće dvije metode za analizu podataka, i to: deskriptivna statistika (centralni i disperzioni parametri) i univarijantna analiza varijance (ANOVA).*

***Ključne riječi:*** *učenici, školski uzrast, odbojka, motorika, ANOVA*

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# DIFFERENCE IN MOTOR ABILITIES BETWEEN SWIMMERS AND NONPROFESSIONAL ATHLETES

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*Original scientific paper*

***Abstract***

*Most important factors for achieving top results in sport are selection of children, as sportsmen in future, who have in start anthropological characteristics which can be developed to wanted maximum, and training as a specific process of transforming those characteristics. Anthropological characteristics along with morphological and functional characteristics are formed also by motor abilities. On the sample from 80 respondents, males, age 12-14 from which 40 professional swimmers and 40 nonprofessional athletes(NPA), who never did and are not currently do sports, test for evaluation basic-motor abilities were applied. Variables for evaluation of segmentary speed, repetitive and explosive strength, and also variables for flexibility evaluation. For determining differences between motor abilities swimmers and NPA we use besides general statistic parameters also Students T test, and for determination of global quantitative differences in motor space we use canonical discriminant analysis. Based on these results we can conclude that there are significant differences in motor space between swimmers and NPA.*

***Key words:*** *motor abilities, swimmers, NPA, difference*

## Introduction

Swimming belongs to cyclic sports in which according to form and method of execution dominate very simple movements, that are continually the same and are alternately repeating while swimming. Moves effect during swimming despite simplicity of form is very complex, because if we want movements to affect on swimmer's body motion, and to be effective, they need to have their own space, as well as time structure. Every motion is one complex kinetic whole for itself, which means alternately and harmonic connections in one synchronized rhythm. That movement function requires a high level of specific kinetic sense, the sense of water. The swimmer was swimming well, if, in the eyes of spectators he swam beautiful. Later, swimmer was swimming well if he swam fast, and nowadays he swims god if he swims economical. From beautiful to economical, from impression to essence, path leads through science and profession. Swimming as a sport from year to year is constantly advancing hanks to involvement of science in our profession researching. It was said for swimming that it is youth sport. This epithet was given to swimming because of his great and good effect on youth development of anthropological dimensions and especially their motorics. In motor abilities we divide: basic and specific. Basic motor abilities are ground for every motor studies and are representing elementary value in overall space of man's motorics. So far researches identified followed basic motor abilities: strength, speed, endurance, coordination, pliability, balance and precision. Specific motor abilities are acquired and conditioned by specificity of training process from each sport. Kurelić (1975) in his motor researches started from presumption that there are followed latent motor dimensions: explosive, repetitive and static strength, topologically expressed strength, segmentary speed, pliability, balance, precision and coordination. In manifested space there have been found 4 basic motor dimensions which author interpreted with primarily physiological mechanisms. They are: for movement structuring mechanism, synergic automatism and regulation of tonus mechanism, mechanism of intensity excitation regulation and mechanism of duration excitation regulation. Correlation of these mechanisms with man's movements is high. Functioning of whole system is conditioned with adjusted work of two factors from third level which are responsible for man's movement. These are: general factor for central movement regulation and energy regulation factor. Having in mind hitherto researches whit which will be defined closer problems of this study: Zahorjević & Popović (1989) are doing researches on the sample of 45 swimmers (30 boys and 15 girls), who are members of pioneer swimming school, age 7-9 with objective to analyze mutual influence of limbs movement frequency ( in dry) and stroke frequency ( in water) on swimming speed, authors come to the conclusion that not even in one group of examinee there is no statistically significant connection between system of predictor variable and criteria variable. Okičić (1995) has, on the sample of 87 male swimers age 10-12, examined the influence of flexibility on absolut swim speed while swiming freestyle, backstroke and breatstroke. Based on this results he concluded that swimers that have better mobility on shoulder joint, knee joint, and ankle , are faster in swiming. Vidović (2000), has, on the samle of 181 examinee age 18-22, done research with aim to determine level of connection between morfphological and motoric characteristics with stylized forms of

movement in frestyle technic. He used canonic correlative analysis. He concluded, among the other things, that significant relations with stylized forms of movement in freestyle technic have variables for assessment coordination, segmentary speed, flexibility and explosive strenght. Okičić (2003), has, on the sample of 30 swimers age 10-12 on initial and age 11-13 on finals, that compete on state championship, done research with aim to determine hierarchy of factors that influence on swim speed on 100m section freestyle and breatstroke technic at different age categories. He used 8 variables for estimation of motoric abilities, 8 for estimation of specific motoric abilities and 5 for estimation of functional abilities. The final measurement isolated following factors: 1. general physical preparation factor, 2. heart energy factor, 3. breaststroke situation motor factor, 4. swimming versatility factor. Based on structure of isolated factors at initial and final measurement author concludes: most responsible for the result at final measurement were fitness and conditional training abilities (more and more influence is coming from cardio-reparative functions factors). There isn't universal system of practice in which is possible to achieve the level of motor abilities that suits to all forms of movement no matter what age and gender. Motor abilities do not have the same level of variability, and besides that they are congenital in organized system of rest of anthropological dimensions, they are very hard to change independently and individually in desired direction. Hence the object of these researches are motor abilities of swimmers and NPA age 12-14, problem of research are differences that arise under the influence of many years swimming training in space of motor abilities age 12-14. Based on the object of research, and problems connected with him, aims and tasks of the research are defined: Primary goal of research will be to determine level of difference in motor space of swimmers and NPA age 12-14, and research tasks are defined as follows: Determine statistically important differences in motor space of swimmer and NPA. On these grounds we spotlight next hypotheses: H1-There are statistically significant differences in motor space of swimmers and NPA; H1.1-There are statistically significant differences in space of segmentary speed between swimmers and NPA; H1.2-There are statistically significant differences in space of explosive strength between swimmers and NPA; H1.3-There are statistically significant differences in space of flexibility between swimmers and NPA.

## Methods

For this research we use descriptive and statistical method. The sample of examinee in this research is 80 all male, age 12-14. First subsample is made from 40 swimmers members of two clubs "Niš 2005" and ",St. Nikola", who have been training for at least 4 years. Second subsample is made from 40 NPA, who never were and are not currently involved in sports, and they are all students in primary schools.

For achieving goal and tasks of research we use sample of all together 12 variables. Data processing method implies determination of motor abilities level, will be applied basic statistical parameters: Students T-test will be used to determine statistical significance of difference in medium values of variables between swimmers and NPA in all of three analyzed spaces. For determination of global quantitative differences between swimmers and NPA in motor space, canonical discriminative analyses will be used.

## Results

Parameters of distribution of motor variables are shown in table 1. For each variable there are shown values for arithmetic middle (SV), median (MED), standard deviation (SD), minimal result (MIN), maximal result (max), result span (RAS). Analyzing these applied motor tests, we can notice that results are well grouped and distributed normally around arithmetic middle. Values of skewness and kurtosis are within normal limits of result distribution, which is confirmed with Kolmogorov-Smirnov normal distribution test. Insight into the content of basic distribution parameters applied for motor variables (Table 2), for swimmers, we can notice that results are well grouped and distributed normally around arithmetic middle. Also, we can see that there is no significant deviation of results, except somewise taping leg result (MTN), pushups (MSKL), throwing medical ball (MBML) and lifting hull on Swedish bench. In this part of analysis of research results we wanted to answer on basic research problem, what differences there are in motor abilities between students who are not having sport activities and that same age who are swimmers. To have a better view on this problem, analyzing has been done on univariant and on multivariate level, while using methods which give insight in quantitative changes that occur in that period. Analyzing differences of motor tests that measured speed (table 3), we clearly notice that there is significant statistical difference within all tests that measured arm and leg speed (taping with arm, taping with foot, taping with foot on the wall). Highly represented activities that demand fast arm and leg motions contributed that selected swimmers achieve significantly better results. Results shown in Table 4 tell us about the difference between selected swimmers and students NPA same age, in variables that measured repetitive strength of arms, shoulders and belly. In two tests of repetitive strength (pushups and lifting belly), selected swimmers had statistically significantly better result values. It is interesting that the differences are twice as bigger for swimmers, and that is one more proof that intensive training activities had biggest effect on repetitive strength of swimmers. Analyzing results shown in Table 5, where has been analyzed difference in results between group of selected swimmers and students non swimmers same age, with variables that measured explosive strength of examinee, we can conclude that: selected swimmers had statistically significantly better

results in tests of explosive strength, throwing medicine ball and throwing basketball ball, while there is no big difference in long jump from standing place. We assume that it is result of training process, having in mind that in the training of swimmers legs and arms are used, and the structure of training is based on very fast and dynamical work. Results from Table 6 which tell about difference between groups of variables that measured flexibility, clearly determine the fact that selected swimmers considerably flexible. This is also confirmed by results of measured tests spin and forehead extension (MISK). Selected swimmers have statistically significantly better results on these two tests, while on deep bite test there are no big statistic differences. In swimmers training there are many flexibility exercises because of the swimming technique structure. In order to check these motor abilities measured results on multivariate level, it has been carried out canonical discriminative analyze for group of results for selected swimmers and for group of results for NPA. Obtained results are shown in next tables: 1) In table 7 was given canonical correlation of variables with isolated discriminative function (Rc) which makes maximal correlation between linear function of predictor variables (discriminative variables) and linear function of variables which indicate group membership, square coefficient of canonical correlation (Rc2) represents joint variance of factors that allows differentiation of groups based on suitable discriminative variables(functions), size of Bartlet's Hi-square test for significance determination of isolated discriminative functions (HI2), possibility of mistake towards rejecting of hypothesis that function is not important (P) along with suitable number of freedom level (DF), 2) In table 8 are given coefficients for calculating discriminative functions, 3) In table 9 are centroids of discriminative results (m) for both groups. As we can see from results shown in these tables, one significant discriminative function is isolated, which separates measured results for group of examinee that are selected for swimming and group of examinee same age, who are not sportsmen , with accuracy of 93.58%. These results show us that at almost all respondents there is difference in measured results. Function is explains with 67% (Rc2=.67), with correlation .82 (Rc=.82) and statistical significance on level .00 (P=.00). Analyzing the structure of discriminative functions we see that it is best defined with motor tests: taping with arm, lag, leg off the wall, pushups, deep bite, throwing medicine ball, throwing basketball ball and forehead stretch. So, function is defined with all measured motor tests. This function we could define as motor abilities of young selected swimmers function. The place of group centroids entitles us to define function like this, having in mind that they show us the fact that all better results belong to selected swimmers. The difference in results between these two groups was created because much better result values of selected swimmers.

Table 1 Basic statistical parameters of motor tests for NPA

| | N | SV | MED | MIN | MAX | RASP | SD | SKW | KURT |
|---|---|---|---|---|---|---|---|---|---|
| MTAN | 40 | 23,02 | 23,00 | 17,00 | 29,00 | 12,00 | 2,68 | 0,09 | -0,06 |
| MTAR | 40 | 26,38 | 25,50 | 20,00 | 35,00 | 15,00 | 3,48 | 0,49 | -0,38 |
| MTNZ | 40 | 25,22 | 25,00 | 16,00 | 33,00 | 17,00 | 3,46 | 0,03 | 0,61 |
| MSKL | 40 | 11,21 | 10,00 | 1,00 | 30,00 | 29,00 | 7,96 | 0,92 | 0,48 |
| MDTK | 40 | 34,58 | 36,00 | 1,00 | 68,00 | 67,00 | 14,62 | -0,29 | 0,44 |
| MIST | 40 | 41,50 | 40,00 | 0,00 | 84,00 | 84,00 | 17,90 | 0,35 | 1,25 |
| MBML | 40 | 531,70 | 530,00 | 258,00 | 830,00 | 572,00 | 129,62 | 0,08 | -0,10 |
| MSKD | 40 | 146,43 | 150,00 | 100,00 | 192,00 | 92,00 | 20,80 | 0,07 | 0,55 |
| MBKL | 40 | 555,10 | 545,00 | 350,00 | 810,00 | 460,00 | 98,48 | 0,50 | 0,19 |
| MISK | 40 | 72,22 | 73,00 | 47,00 | 99,00 | 52,00 | 11,45 | 0,20 | 0,58 |
| MDPR | 40 | 1,00 | -1,00 | -12,00 | 19,00 | 31,00 | 7,63 | 0,40 | -0,74 |
| MCSP | 40 | 44,90 | 43,50 | 25,00 | 66,00 | 41,00 | 9,81 | 0,20 | -0,43 |

Table 2. Basic statistical parameters of motor tests for swimmers

| | N | SV | MED | MIN | MAX | RASP | SD | SKW | KURT |
|---|---|---|---|---|---|---|---|---|---|
| MTAN | 40 | 25,78 | 25,00 | 16,00 | 32,00 | 16,00 | 3,18 | -0,35 | 1,41 |
| MTAR | 40 | 29,95 | 30,00 | 22,00 | 37,00 | 15,00 | 2,93 | -0,12 | 0,49 |
| MTNZ | 40 | 29,27 | 29,00 | 21,00 | 39,00 | 18,00 | 3,82 | 0,39 | 0,61 |
| MSKL | 40 | 21,70 | 20,00 | 4,00 | 58,00 | 54,00 | 13,17 | 1,21 | 1,45 |
| MDTK | 40 | 41.87 | 40,00 | 33,00 | 65,00 | 32,00 | 6.71 | 1.52 | 2.72 |
| MIST | 40 | 41,51 | 42,00 | 7,00 | 94,00 | 87,00 | 16,74 | 0,39 | 1,48 |
| MBML | 40 | 708,75 | 695,00 | 470,00 | 1000,00 | 530,00 | 164,97 | 0,21 | -1,25 |
| MSKD | 40 | 156,63 | 162,50 | 103,00 | 211,00 | 108,00 | 25,71 | 0,02 | -0,54 |
| MBKL | 40 | 641,85 | 619,00 | 411,00 | 970,00 | 559,00 | 122,65 | 0,69 | 0,27 |
| MISK | 40 | 64,78 | 66,00 | 1,00 | 100,00 | 99,00 | 17,25 | -1,16 | 3,58 |
| MDPR | 40 | 0,42 | -1,00 | -15,00 | 23,00 | 38,00 | 8,65 | 0,72 | 0,80 |
| MCSP | 40 | 39,77 | 38,50 | 24,00 | 68,00 | 44,00 | 11,18 | 0,71 | -0,00 |

Table 3. Significance in differences of motor abilities-speed of alternative movements

| | SV | SD | N | T | DF | P |
|---|---|---|---|---|---|---|
| MTAN | 23,02 | 2,68 | | | | |
| MTANP | 25,77 | 3,18 | 40 | -4,13 | 39 | 0,00 |
| MTAR | 26,38 | 3,48 | | | | |
| MTARP | 29,95 | 2,93 | 40 | -4,90 | 39 | 0,00 |
| MTNZ | 25,22 | 3,46 | | | | |
| MTNZP | 29,27 | 3,82 | 40 | -5,21 | 39 | 0,00 |

Table 4. Significance in differences of motor abilities-repetitive strength

| | SV | SD | N | T | DF | P |
|---|---|---|---|---|---|---|
| MSKL | 11,21 | 7,96 | | | | |
| MSKLP | 21,97 | 13,22 | 39 | -4,41 | 38 | 0,00 |
| MDTK | 34,58 | 14,62 | | | | |
| MDTKP | 88,00 | 55,61 | 40 | -5,90 | 39 | 0,00 |
| MIST | 41,41 | 18,12 | | | | |
| MISTP | 41,51 | 16,74 | 39 | -0,03 | 38 | 0,98 |

Table 5. Significance in differences in motor abilities-explosive strength

| | SV | SD | N | T | DF | P |
|---|---|---|---|---|---|---|
| MBML | 531,70 | 129,62 | | | | |
| MBMLP | 708,75 | 164,97 | 40 | -5,51 | 39 | 0,00 |
| MSKD | 146,42 | 20,80 | | | | |
| MSKDP | 156,62 | 25,71 | 40 | -1,78 | 39 | 0,08 |
| MBKL | 555,10 | 98,48 | | | | |
| MBKLP | 641,85 | 122,65 | 40 | -3,70 | 39 | 0,00 |

Table 6. Significance of differences in motor abilities-flexibility

| | SV | SD | N | T | DF | P |
|---|---|---|---|---|---|---|
| MISK | 72,23 | 11,45 | | | | |
| MISKP | 64,78 | 17,25 | 40 | 2,22 | 39 | 0,03 |
| MDPR | 1,00 | 7,63 | | | | |
| MDPRP | 0,43 | 8,65 | 40 | 0,32 | 39 | 0,75 |
| MCSP | 44,90 | 9,81 | | | | |
| MCSPP | 39,77 | 11,18 | 40 | 2,21 | 39 | 0,03 |

Table 7. Isolated discriminative function in motor space

| L | $Rc^2$ | Rc | WL | $HI^2$ | DF | P |
|---|---|---|---|---|---|---|
| 2,01 | 0,67 | 0,82 | 0,33 | 77,1 | 12 | 0,00 |

**Conclusion**

Based on research results we can draw a conclusion: Analyzing given results we can conclude that in segmentary speed space there is significant difference between swimmer and NPA. Hypothesis H2.1 which reads: There are significant differences in segmentary speed space between swimmers and NPA'' is accepted. Analyzing given results we can conclude that in repetitive strength space there is statistically significant difference on variables: pushups (SSKL), lifting bailey on Swedish bench (MLS). At variables for evaluation of repetitive strength lower back (MIST) there is not big difference between swimmers and NPA.

Table 8. Structure of isolated discriminative function in motor space

| | Root 1 |
|---|---|
| MTAN | 0,36 |
| MTAR | 0,42 |
| MTNZ | 0,41 |
| MSKL | 0,40 |
| MDTK | 0,51 |
| MIST | -0,36 |
| MBML | 0,64 |
| MSKD | -0,58 |
| MBKL | 0,33 |
| MISK | -0,29 |
| MDPR | 0,30 |
| MCSP | -0,33 |

Table 9. Group centroids

| | Root 1 |
|---|---|
| G_1:1 | -1,40 |
| G_2:2 | 1,40 |

Table 10. Difference percentage between groups

| | Percent | G_1:1 | G_2:2 |
|---|---|---|---|
| G_1:1 | 94,87 | 37 | 2 |
| G_2:2 | 92,31 | 3 | 36 |
| Total | 93,59 | 40 | 38 |

Hypothesis H2.2 which reads: There are significant differences in repetitive strength space between swimmers and NPA'' is partially accepted. In space of explosive strength there is statistically significant difference at variables: throwing med ball (MBAC) and throwing basketball ball from chest while sitting (MFEBKL). At variables for evaluation of explosive strength of legs (MSKOKD) there is not big difference between swimmers and NPA. Hypothesis H2.3 which reads: There are significant differences in explosive strength space between swimmers and NPA '' is partially accepted.

In flexibility space there is significant difference at variables: twist (MISK) and forehead stretch (MCSPA). At variable deep bite (MPNA) that is not big difference between swimmers and NPA. Hypothesis H2.2 which reads: There are significant differences in swimmers flexibility space between swimmers and NPA '' is partially accepted. Based on given results at multivariate level in motor space we can conclude that two studied groups differ in almost all measured tests and that in the manner that swimmers examinee have statistically higher values of results, so the hypothesis H which reads: "There are significant differences in motor space between swimmers and NPA ''is fully accepted. Biggest discriminative power has variables which measured explosive strength, repetitive strength and flexibility.

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## RAZLIKE U MOTORIČKIM SPOSOBNOSTIMA IZMEĐU PLIVAČA I NEPROFESIONALNIH SPORTAŠA

**Sažetak**

*Najvažniji faktori za postizanje vrhunskih rezultata u sportu su selekcija kao odabir djece - budućih sportaša, koja u startu posjeduju antropološke karakteristike koje se mogu razviti do željenog maksimuma i trening kao specifičan proces transformacije tih karakteristika. Antropološke karakteristike pored morfoloških i funkcionalnih karakteristika čine i motoričke sposobnosti. Na uzorku 80 ispitanika muškog spola, uzrasta 12-14 godina od kojih 40 sportaša plivača iz plivačkih klubova i 40 nesportaša, koji se nikada nisu i trenutno se ne bave sportom, primjenjeni su testovi za procjenu bazično-motoričkih sposobnosti. Varijable za procjenu segmentarne brzine, repetitivne i eksplozivne snage kao i varijable za procjenu fleksibilnosti. Za potrebe utvrđivanja razlika motoričkih sposobnosti plivaca i nesportaša primjenen je pored osnovnih statističkih parametra i Studentov t-test, a za utvrđivanje globalnih kvantitativnih razlika u motoričkom prostoru primjenjena je kanonička diskriminativna analiza. Na osnovu dobivenih rezultata može se zaključiti da postoje značajne razlike u motoričkom prostoru između plivača i nesportaša.*

***Ključne riječi:*** *motoričke sposobnosti, plivači, nesportaši, razlike*

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# MANAGEMENT POTENTIAL OF STUDENTS

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*Original scientific paper*

***Abstract***
*Purpose of this work was establishing of basic latent dimensions at domain of management potential sociological attributes that really exists in wide student population. Work was drafted in a way that it is only scientifically acceptable, by means of robust methodological apparatus and data processing, to identify existing latent mechanisms that remain in student population. Results have shown stable sets of latent dimensions that can be described, so it was recognized: guidance, opportunism, leadership and delegation. This work has founded comprehensions about student population in the manner that was clearly recognized system of latent dimensions that really exists, that is not usually visible and that surely means starting point for any kind of scientific or practical acting in the future.*

***Key words:*** *students, management, potential, latent dimensions*

## Introduction

Management represents an inevitable process of human existence owing to which humans have become what they are today and it worth for management, politics, economy, anthropology, etc. (*Dragičević, 1993; Visković, 1997; Bahtijarević-Šiber & Sikavica, 2001*). It dates *from the beginning of time* or when viewed from other perspective, *from the beginning of man (Bonacin Da., 2008).* It is noticeable how recent historical periods bring more complex methods of management. In order to manage something at all, one has to be open for new understandings – for learning as a tool for human development (*Bonacin et al., 2008; Bilić & Bonacin, 2007*). Anthropological foundations of human kind were created in a thousand years of continuous interaction between the individual and environment (*Bilić & Bonacin, 2007*). Therefore, it is very important to find the right people for the right things at the right time, especially in management (*Tsuchiya, 1996; Šunje, 2002; Malacko & Rađo, 2006*).

This is true and the entire current international system and its relations prompt all the activities, from establishing proprietary and political relations to development of various economies lays on such conception (*Pojskić, 2006*). One of the basic tasks of the each new generation is, to put it mildly, to give their best in order to make living conditions better for the entire community if possible and in accordance with some kind of common customs (*Haralambos & Heald, 1989; Fanuko, 1995*). This is particularly a problem when it comes to management staff. According to that, the period in which an individual studies is the last phase that can "influence" him/her with arguments i.e. information because that is the reason why student started his/her studies – to gather new information and create new understandings.

## Topic, problem and goal

The subject of this paper is the student population, specific for its many features, primarily because it is about future intellectuals and potential managers in social, cultural and technical sphere. After graduation, it is expected that they will slowly take a decisive role in modeling and implementation of management actions (*Dragičević, 1993*). Therefore the identification of the basic approaches to management that will be implemented later is not of little significance. For these reasons and for research purposes, a complex set of indicators is defined and they can provide information in a broader context of the current status of the student population. Methodologically speaking, it is about status section that needs to provide answers to questions of the current social status of students in management sphere and ***the basic intention of the paper is to recognize the position of management potential of students in the area of selected dimensions of social attributes.*** These settings direct activities towards the identification of social mechanisms that can be correlated with the potential management status of the student population. All this has a clear **purpose**. Although stochastic guidance of individual into high-ranking management segments (companies, education institutions, sport organizations, management bodies etc.) cannot be ignored, it is of key importance to identify the ways in which management activities are manifested in society or in its segments in general. This population was chosen for another reason and that is the fact that their general intensive development is mostly finished or is about to end, therefore they represent almost the final subjects of educational community program and their goals which have been realized to a certain extent. In that case, determining the potential of the management status is not of little significance.

All of that in order to take action on the basis of these understandings (if desired) in terms of selection, guidance or development including investments in particular sets of individuals eligible for action under certain management levels.

**Methods**

In organization of the University of Travnik - Faculty of Education, in 2010/2011, the international project "Research of sociological, management and moral values of students" (Principal researcher doc.dr.Dobromir Bonacin) was conducted. Data required by this paper are derived from that research. For the purposes of this paper a total sample amounts to 406 entities of both sexes aged 19-27 from the previously mentioned international research project. Therefore, a survey was designed in order to comprehensively define potentially interesting dimensions of student status from a representative sample (authors: Bonacin, Da. And Bonacin, D.) on the model of Likert scale where each statement is labeled with modes from "I strongly disagree" to "I strongly agree". The entities are described with a total of 138 indicators divided into seven domains but for the purposes of this study 30 indicators of hierarchical management potential were used. In order to complete the project, the student population was selected from a wider area to ensure intelligibility (Pula, Opatija, Rijeka, Split, Osijek - Croatia, Niš - Serbia, Mostar, Travnik, Kiseljak - Bosnia and Herzegovina). Within the methods of data processing after initial normalization of categorical data and calculated correlations of variables / indicators, factor analysis with rotation into orthoblique position was conducted. All computer procedures were adapted, prepared and coded by dr.D.Bonacin, and in accordance with algorithms published in literature (egg. Bonacin, 2004 and onward).

**Results**

The results of the factor analysis in the field of hierarchical management potential show the existence of four latent mechanisms i.e. factors responsible for variations of the initial indicators (Table 1). With variable analyzing, it is possible to conclude that mechanism described in first factor represents **management (or guidance)**, second factor represents **opportunism.** The third factor is described by variables that define **leadership**, and the fourth factor is described by the variables that define **delegation.** Relations among latent dimensions are uniformed values and all in the same size order.

**Discussion**

The area of hierarchical management potential showed that there are four latent mechanisms i.e. factors responsible for variations of the initial indicators. This means that in the background, within society and sample population there are exactly four mechanisms responsible for what is manifested. Once again, this is about the students. They are still learning, receiving information, understanding and the ways of management activities that exist within the sample have already taken shape. Each of them has a part of these ways, because within such a hierarchical model of management potential there are natural laws and structure (*Kalra, 1997*). What does this mean? One might conclude from the aforementioned how each population knows very well what is what and who is who in society. And now they are on the last step of dependence and the turning point. The first mechanism represents **management.** Awareness of the need for the right leader within the organization is clear; it is obvious how highly positioned "people behind the curtains" often find good solutions, additionally, equally good is the impression of such true managers who pass on their visions and missions to their subordinates, listen to their assistants, jump in and lead when they have to and whose results depend on good management of key segments. In connection to this is the coordination of human resources and organizational blocks and strong link between them with constant monitoring and direct control of individual segments. In addition, expert advice of top-managers, appointment of a temporary project manager and individual direct control are inevitable. The second mechanism represents **opportunism.** Within the population there is an awareness of how a good deal of individual activities for personal benefit is justified because, as some people make a bit primitive conclusions: "if an individual (I) is satisfied in the organization – everybody is satisfied". Using the opportunities is almost always justified and good but the benefit of the organization must always come first. According to Wikipedia, opportunism (lat. opportunus = convenient, suitable) stands for the adjustment to suitable specific or situation or location. Opportunistic behavior is not always in accordance with personal principles, but is useful when it comes to profitableness, taking advantage, especially in political and social context. It is noteworthy how such social classes separate themselves already in the period of being a student. The third factor is **leadership.** Obviously there is awareness in a selected population of how a number of jobs do not demand more complex competencies. It is clear that there should be individuals who are completely outside the system of the organization and that certain actions should be completely independent of the goals of the organization. In this matter, much of the human resources must be available in accordance with manager's needs. What does this mean? It means that there is a mechanism within the population which represents the entire population's awareness that manager is different from leader. What is the difference? There is a difference at least in the fact that in the first case this first "person behind the curtains" will not take any action unless necessary, while the other can "digest" it through education. What does this need to have an individual who is completely outside the system mean? "Hide and seek" game? Everything else points to "pure managers" without any charisma of leaders.

The fourth factor is **delegation.** The existence of awareness that less important jobs should be distributed to less influential persons is evident and that any good organization is based on good bosses. In any case, management of smaller segments of the work should be given to good workers. The results of the analysis showed a mild bipolar distribution of positive values in the management factor, meaning that the sample is polarized in terms of "a leader or not". The sample is divided in that sense. What does this mean? Can we conclude that "Heads" are born? Other factors are normally distributed. Therefore, we can learn to be leaders, we can learn to be opportunists and delegates but we are not born as such. However, managers are born. Since this is about a latent mechanism, the polarization of this mechanism (management) equally emerges from behavior of managers and from those who are not managers, because managers automatically polarize everything around themselves. The space that remains after that is left to the leaders.

Other factors are normally distributed. Positive correlations between factors of high, low and equal values indicate that it is a homogenous space. This means that if we want to, we can carry out the selection and guidance because if someone has distinct characteristics of a manager in accordance with conducted research, we can select and guide them in certain specific and required direction etc. (*Ngai & Cheng, 1997; Smedlund, 2008*).

Homogeneity is important information because if you make impact on one mechanism in the population then you will make impact on other mechanisms as well. However, in this case the connection is not functional because it is not maximal, consequently, it not possible to operate fully, especially directly. The impact should be long-term, planned, and strategic. This is the future division of roles that are solidly connected but not completely functional. This means that delegation demands management, opportunism and leadership and vice versa.

**Results**

Table 1 Pattern matrix of Management potential variables

| Indicators / factors | OBQ1 | OBQ2 | OBQ3 | OBQ4 |
|---|---|---|---|---|
| In every organization there must be a true leader | 0.85 | 0.02 | -0.02 | -0.05 |
| True controls its vision and mission transferred to the subordinates | 0.74 | 0.07 | 0.00 | -0.02 |
| The important decisions is always necessary to hear the opinion of the first assistant | 0.86 | -0.15 | 0.06 | 0.07 |
| The potential leader must be ready to jump in and lead the people | 0.90 | -0.06 | 0.00 | 0.05 |
| The results of the work directly depend on good management of key segments | 0.75 | 0.03 | 0.00 | 0.11 |
| It is very important to coordinate the human resources and organizational individual blocks | 0.59 | 0.15 | 0.01 | 0.12 |
| High-ranking "Shadow People" is often better to recognize good solutions | 0.29 | 0.25 | 0.11 | 0.12 |
| Expert advice top-manager is a very important role | 0.57 | 0.22 | -0.16 | 0.14 |
| Sometimes it is very important to establish a temporary project manager | 0.61 | 0.22 | -0.02 | 0.01 |
| Parts of the organizational structure required a strong link | 0.76 | 0.18 | 0.00 | -0.09 |
| Management processes require continuous monitoring | 0.85 | 0.14 | -0.06 | -0.12 |
| Direct control of certain segments of the organization is inevitable | 0.64 | 0.39 | -0.21 | -0.07 |
| Using the opportunity is almost always justified and necessary | 0.25 | 0.73 | -0.02 | -0.18 |
| Benefit of the organization must always be at the forefront | 0.48 | 0.59 | -0.12 | -0.14 |
| A good part of the individual acting in a personal benefit is justified | -0.36 | 0.92 | 0.10 | 0.04 |
| If an individual is well organized - all is well | -0.83 | 0.84 | 0.06 | 0.31 |
| In the process of managing a very important person of trust | 0.83 | -0.02 | 0.02 | 0.05 |
| Reliable associates are the key people to assist in making the top | 0.75 | -0.05 | -0.01 | 0.18 |
| Parts of the less important tasks should be assigned less influential people | -0.37 | -0.02 | 0.11 | 0.89 |
| Busy with his work colleagues often provide value for the organization | 0.62 | -0.14 | 0.03 | 0.36 |
| Every good organization is based on good bosses | 0.12 | -0.02 | -0.10 | 0.75 |
| Keeping small segments of work should be given to good workers | 0.15 | 0.07 | -0.07 | 0.65 |
| Without the people who carry quality, business tasks is impossible | 0.55 | 0.00 | 0.03 | 0.29 |
| Without the right information to choose which specific tasks can not be made | 0.70 | 0.00 | 0.17 | 0.02 |
| Certain procedures should be completely independent of the goals of the organization | 0.07 | -0.14 | 0.69 | 0.18 |
| It is desirable that the existence of individuals who are completely outside the system of organization | 0.20 | -0.16 | 0.72 | -0.03 |
| It's good to have people in the organization for a number of different operational tasks | 0.71 | -0.10 | 0.39 | -0.10 |
| A good part of human resources must be available for necessary control | 0.46 | 0.09 | 0.51 | -0.21 |
| A large number of jobs does not require too much influence in deciding | -0.22 | 0.21 | 0.85 | -0.11 |
| It is good that many jobs do not require complex competencies | -0.32 | 0.11 | 0.79 | 0.09 |
| | OBQ1 | OBQ2 | OBQ3 | OBQ4 |
| OBQ1 | 1.00 | 0.63 | 0.58 | 0.67 |
| OBQ2 | 0.63 | 1.00 | 0.60 | 0.60 |
| OBQ3 | 0.58 | 0.60 | 1.00 | 0.55 |
| OBQ4 | 0.67 | 0.60 | 0.55 | 1.00 |

## Conclusion

The results of the factor analysis show the existence of "invisible" latent mechanisms of the management potential of students, therefore we can conclude that there is obviously awareness in the population that differentiates management, leadership, opportunism and delegation. Positive correlations between factors of high, low and equal values indicate that it is a homogenous space. This means that affecting one segment would affect all the others. The population is aware of the world around them and we have to consider their capabilities (*Harris & Feild, 1992; Roussillon & Bournois, 1997*). They know the difference between the four segments which means that on the basis on some natural laws they behave "naturally" i.e. divide. Once again this means that we can make impact on students by combining new knowledge and old knowledge which obviously exists (*Brown & McCartney, 2004*). In other words, we, who direct them, can guide individuals in directions we want. Almost always we have to "take into account" extreme position of top-level managers and leaders for modelling optimal human resources in future (*Baum & McKelvey, 2006; Leary-Joyce, 2010; Tansley, 2011*).

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## UPRAVLJAČKI POTENCIJAL STUDENATA

**Sažetak**

*Svrha rada bila je utvrđivanje temeljnih latentnih dimenzija u domeni upravljačkog potencijala sociooloških atributa koji realno egzistiraju u široj studentskoj populaciji. Rad je koncipiran na način da je jedino znanstveno prihvatljivo, uz robustni metodološki aparat i metode obrade podataka, identificirati postojeće latentne mehanizme koji u studentskoj populaciji egzistiraju. Rezultati su pokazali stabilan skup latentnih dimenzija koje su se mogle opisati, pa su prepoznati vodstvo, oportunizam, liderstvo i delegiranje. Ovaj rad utemeljio je saznanja o studentskoj populaciji na način da je bilo jasno prepoznat sustav latentnih mehanizama koji realno egzistira, a koji obično nije vidljiv i koji sigurno znači polazište za bilo kakvo znanstveno ili praktično djelovanje u budućnosti.*

***Ključne riječi:*** *studenti, upravljanje, potencijal, latentne dimenzije*

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In organization of the University of Travnik - Faculty of Education, in 2010, started the international project "Research of sociological, management and moral values of students" (Principal researcher doc.dr.Dobromir Bonacin). This study is a part of that project.

# GUIDELINES FOR AUTHORS

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Sport Science - International Scientific Journal of Kinesiology is published twice a year containing review and scientific (sometimes professional and preliminary communication) articles in all wide areas of kinesiology (human movement science). In addition, articles can be published from other scientific areas if do satisfy higher degree of correspondence with kinesiology.

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