THE EFFECTS OF DIFFERENT EXERCISE WORKLOADS ON VISUAL PERCEPTION SKILLS IN ELITE SERBIAN FEMALE JUDOKAS

Patrik Drid[1], Nebojša Majstorović[2] and Miodrag Drapšin[3]

[1]Faculty of Sport and Physical Education, University of Novi Sad, Serbia
[2]Department of Psychology, Faculty of Philosophy, University of Novi Sad, Serbia
[3]Department of Physiology, Faculty of Medicine, University of Novi Sad, Serbia

Original scientific paper
UDC 796.853.23:159.937:796.015.62(497.11)

Abstract:

The purpose of this study was to investigate the effects of intense physical activity on visual perception skills in elite female judokas. The sample consisted of 18 female judokas, who were all members of the Serbian national team. They were divided into two groups according to their international ranking and/or results, Group A: more successful, Group B: less successful. Both groups scored similarly in visual perception skills on the Landolt test at the starting point. At a 60% workload, significantly higher scores in the visual perception efficacy were recorded for both groups. At 75% and 90% workloads, a significant decline in visual perception skills was detected in both groups. These findings suggest that the visual perception apparatus resources were activated at a 60% workload. The further increase of exercise workloads, however, caused progressive exhaustion of these resources in both groups. Even though a tendency for a greater decrement of visual perception skill was noticed in Group B than in Group A, the differences between the groups did not reach any statistical significance. On the other hand, the within-group changes in the Landolt test, occurring as a result of increased workloads were statistically significant for both groups (p=.01). Results obtained indicate that intense exercise affects visual perception accuracy, a finding that may help coaches and trainers when making tactical preparations for a judo bout, as well as in the selection of young female judokas.

Key words: *visual perception, judo, Landolt test, exercise workload*

Introduction

Judo can be regarded as one of the oldest academic sports. A more significant evolution of judo as a martial art began with its recognition as an Olympic sport. The uniqueness of judo is reflected primarily in its specific throws and controlled techniques. Situations that arise in a judo match demand an excellent visual perception of the fighting area, as well as of the opponent's posture and body language. Based on their visual perception, judokas can anticipate the rival's intentions, direction of attack, and make appropriate decisions about their own actions (Drid & Obadov, 2006). Therefore, in selection for judo, one needs to focus on the psychological characteristics and abilities that have the greatest impact on athletic performance and/or results.

There is a number of reports of low correlation between intelligence and simple-task performance, unlike more complex, non-habitual movement structures, with which intelligence has shown to be highly correlated (Ismail, 1967; Mejovšek, 1975; Mejovšek, 1979). A previous study on the relationship between cognitive space and gymnastics pointed to the great relevance of the efficacy of an entire system of cognitive variables, as well as that of the parallel cognitive processor (Madić, 2000). The same paper did not find a statistically significant correlation between the efficacy of the perceptive (GIT-1) and serial processors (GAL-4), and gymnastics performance. Similarly, Bala (1999) found that long-term training of certain kinetic activities, combined with frequent exposures to performance-related stress, greatly contribute to relatively specific cognitive functioning, resulting from a strong interaction of the parallel, serial and perceptive processors. Based on these and other similar findings (Yagi, Coburn, Estes, & Arruda, 1999; Brisswalter, Collardeau, & Alcerin, 2002; Higashiura, et al., 2006), as well as long practical experience and tradition, one has come to the conclusion that the more complex the sports activity structure is, the more effective an athlete's cognitive abilities must be.

For these very reasons, the scientific community still wonders, more than ever before, what the ideal structure of cognitive abilities is most effective for an athletic performance and/or results. In order to answer this question successfully, one must analyse each and every activity, and the respective roles of cognitive processes in them (Malacko & Rađo, 2004).

Furthermore, researchers are also interested in the relationship between habitual exercise workload and athletes' cognitive efficacy (e.g. performance in memory and perceptive-discriminative tasks, mental calculations, anticipation of coincidence, etc.). It has been demonstrated that the findings are rather conflicting, to say the least, because they imply no such relationship (Fleury, Bard, & Carrere, 1981; Lulofs, Wennekens, & Van Houten, 1981), neither positive (Paas & Adams, 1991; Colcombe & Kramer, 2003; Etnier, et al., 1997; Etnier, Nowel, Landers, & Sibley, 2006; Chodzko-Zajko, 1991; Tomporowski, 2003) nor negative correlation (Salmela & Doyle, 1986; Grego, et al., 2004). However, a number of reports regarding decision--making tasks during exercise have had consistent outcomes (Delignieres, Brisswalter, & Legros, 1994; Brisswalter, Arcelin, Andffren, & Delignieres 1997; Chmura, et al., 1998). The studies' designs applied progressive workloads while working on cognitive tasks. These experiments recorded steady improvements of the scores in psychological tasks up to the heart rate (HR) of 120 bpm. After this point, increases in the workload led to a steady decline of all measured cognitive abilities. These and similar investigations have confirmed the hypothesis that exercise has a systematic impact on the efficacy of cognitive processes.

A judo match lasts 5 minutes of effective bout time. However, with interruptions of play, it may take as long as 9 minutes. It represents a high--intensity anaerobic physical activity (Bompa, 1999), and, according to the authors investigating the structure of the combat itself (Sikorski, Mickiewicz, Majle, & Laksa, 1987; Castarlenas & Planas, 1997; Svischev, 2001; Kakhabrishvili, Akhalkatsi, & Kvinikadze, 2003), it consists of 12-15 sections of active fighting (lasting 10-30 sec), and breaks or rests (10-15 sec). One of the practical implications of the present research should be the application of the Landolt test in the process of selecting candidates who are able to maintain perceptual precision longer than the others over an increasing workload during a judo bout. Furthermore, the results could be used for the planning of match strategy and tactics (attack vs defence) based on the individual athlete's (anticipated) perception efficacy over the course of a bout.

Taking into account the great impact of visual perception skills on achieving maximum results in judo, the primary goals of this study were: 1) to determine the impact of different exercise workloads on the efficacy of visual perception skills in elite Serbian female judokas, and 2) to analyse and study any possible differences between the less and more successful athletes.

Methods

Participants

Subjects were 18 adult female judokas, from the Serbian national team (age: M=20.61±3.09 yrs; body height: M=165.89±7.27 cm; body mass: M=61.11±8.6 kg). The participants were assigned either to Group A (more successful) or to Group B (less successful), according to their international results and rankings. Group A consisted of 9 judokas competing in the categories between 48 – 78 kg, who have, in the last five years, won at least one individual medal at international senior competitions/championships. Hence Group A has been designated as the top-level, elite group of female judokas. Group B was comprised of 9 girls (categories also from 48 – 78 kg) who have never won an individual medal internationally. The training experience of all the subjects ranged from 7 – 20 years (M=11.33±3.74 yrs), with similar training regimens over that time (2 hrs/day 5 days/week). Apart from judo training, all the subjects had been involved in some kind of conditioning and fitness training over the years (at least 4 hrs/week), both in- and out of-season.

Testing procedures

The testing was conducted just prior to the training camp for the Balkan Championships 2008 in Montenegro, at the Functional Diagnostics Laboratory of the Department of Physiology, Faculty of Medicine, University of Novi Sad.

Instruments

The protocol began with the Landolt test, followed by three separate bicycle rides on the bicycle ergometer (SECA CARDIOTEST 540) at three different workloads. Each ride was performed at a pre-set workload that was progressively increased to 60%, 75% and 90%, based on the estimated individual maximum heart rate. HR was monitored by the polar HR monitor, whereas the workloads were set on the bicycle ergometer in Watts (W). Following each 10-min period of bike ride, during which the workload was increased gradually until a new steady-state was reached and maintained for at least 6 min, the subject took the Landolt test (Sisoev, 1996). The test measures vision, as well as the speed and accuracy of visual information processing. It is designed especially for high-risk professions (e.g. police forces, fire fighting forces, military and rescue forces), and consists of small circles lined in a 10 x 10 matrix (Figure 1).

All subjects had to complete the test four times during the study: prior to exercise, and after each ride on the cycle ergometer. The Landolt test was performed in the following way: the athletes had 20 seconds to round up all the circles with the exact same opening (openings were located in 8 different positions on the circle). The location of the opening that was to be found was chosen at random by the experimenter and communicated to the subject immediately before the test. Following the test, the total number of visually scanned circles, and the total number of errors (either a wrong answer or no answer) were counted. The correct score was calculated by the following formula:

Landolt score = (total number of visually scanned circles – errors × 8) / 20

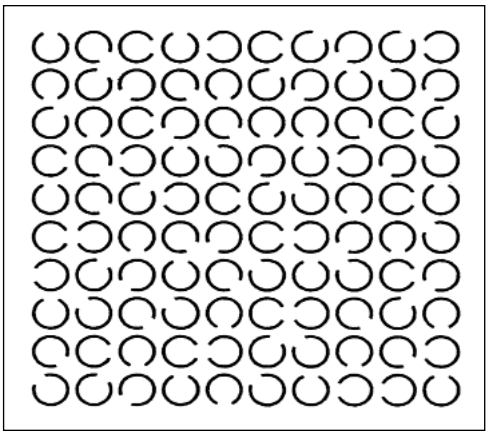

Figure 1. Landolt test.

The reliability measured via Cronbach`s alpha was .702 for both tested groups of subjects in this study.

The variables under consideration were the correct scores on the Landolt test (Landolt), errors on the Landolt test (Landolt errors) and the total number of visually scanned (TNOVS).

Data analysis

Repeated-measures analysis of variance (ANOVA) was used to test the effects of exercise at different intensities on the visual perception skills of elite female judokas, as estimated by the scores on the Landolt test. Also, the differences in these effects were analysed between the two experimental groups.

Results

In this section, we will first present the results from the Landolt test in the form of correct scores, then total errors, and, in the end, the total number of visually scanned circles. The first measurement indicated the efficacy of the perceptive processor, the second its inefficiency, whilst the third estimated the capacity of the system to approach and generally analyse a certain number of stimuli regardless of its accuracy.

The Landolt test analysis: correct scores

Changes in correct scores due to different exercise workloads were statistically significant (p=.01).

Based on the results, one can notice an initial increase, followed by a significant decrease in the last two series of measurements. The characteristics of the correct score series on the Landolt test for different conditions may be seen best in the profile graph (Figure 2). It can be noted that both groups had similar, almost identical results (p=.864) at rest (Start). At the 60% workload, better scores in both groups were recorded, with a tendency toward greater improvements in Group A than in Group B. At 75% and 90% exercise workloads, there was a significant deterioration of correct scores in both groups. The fall was a kind of linear one for Group A, and much more dramatic for Group B. It seems that the 60% workload positively affected the visual perception apparatus, whereas further increases in exercise intensity appeared to cause substantial perceptive fatigue. The observed trend pointed to a greater deterioration of visual perception skills in Group B when compared to Group A, although the differences were not statistically significant.

The Landolt test analysis: errors

The effects of changes in the number of errors due to different exercise workloads were found to be significant (p=.03).

It can be observed that, after an initial decrease of errors, their number increased significantly

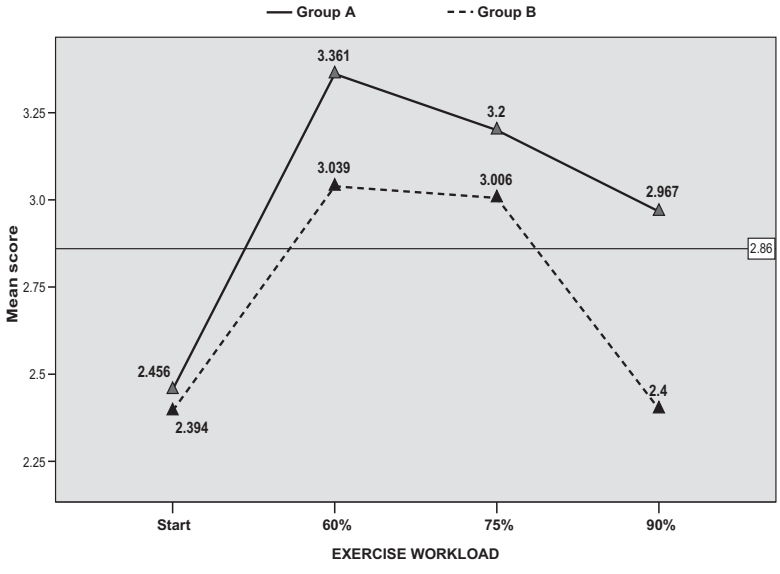

Figure 2. Correct scores for different conditions.

over the last two workloads. The characteristics of the error series on the Landolt test for different conditions may be seen best in the profile graph (Figure 3).
It can be noted that both groups had rather similar results at rest. At the 60% workload, the number of errors was reduced slightly in both groups. At 75%, there was a small, but steady rise in errors in both groups. Finally, at the 90% workload, the number of errors kept increasing, but to a smaller extent in Group A than in Group B (not significant).

The Landolt test analysis: total number of visually scanned circles

The changes due to increases in exercise workloads were statistically significant at (p=.01). The differences between groups in total number of visual scanned circles were not found to be statistically significant.

After the initial abrupt leap in the number of visually scanned circles at the 60% workload, the scores remained fairly constant throughout the test. The characteristics of the visually scanned circles series in the Landolt test for different conditions may be seen best in the profile graph (Figure 4). It can be noted that both groups had rather similar results at rest. At the 60% workload, the total number of visually scanned circles increased in both groups, more in Group A than in Group B (not significant). At the 75% and 90% workloads, the results remained fairly unchanged for both groups, keeping them slightly apart in favour of Group A.

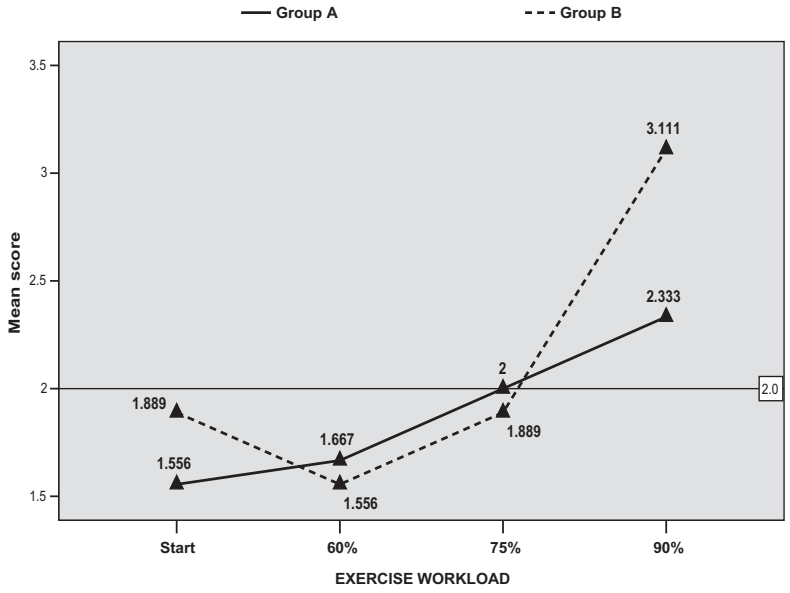

Figure 3. Number of errors for different conditions.

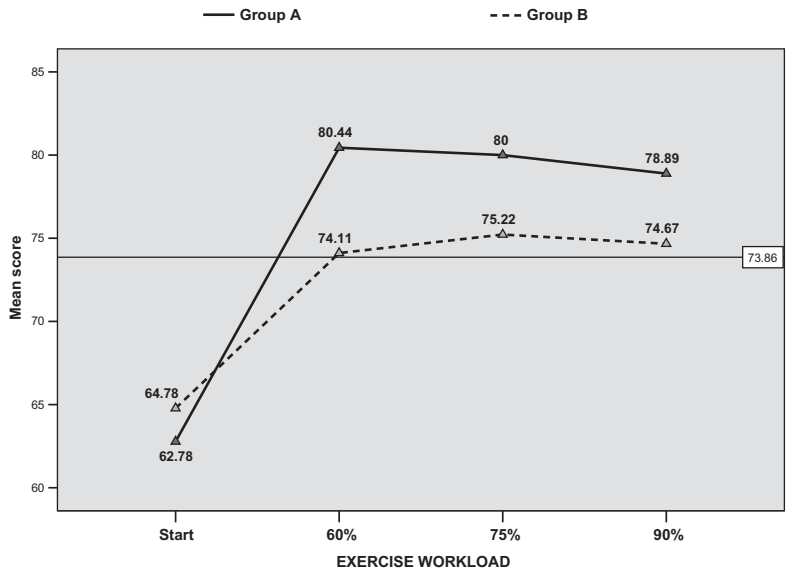

Figure 4. Total number of visually scanned circles for different conditions.

Discussion and conclusions

The purpose of this study was to determine the effects of exercise on the efficacy of perceptive abilities in elite Serbian female judokas, and also to analyse the differences in these skills, if any, between the *more successful* (Group A) and the *less successful* (Group B) athletes. Differences in the functioning of the perceptive processor were assessed by the Landolt test's correct scores, total errors, and total number of visually scanned circles. The results showed no significant difference in perception at rest between the groups. At the 60% exercise workload, there was a significant activation of the perceptive apparatus in both groups, whereas further increments in workload led to substantial fatigue of the perceptive apparatus, irrespective of the group. However, there was a persistent trend of more pronounced decrements in all measured variables for Group B when compared to Group A.

The analyses of correct scores found that there was a significant increase at the 60% and 75% workloads, regardless of the group. Similarly, both groups had significantly lower scores at 90% compared to 60% workloads.

Findings for the Landolt test errors were quite comparable to those for correct scores. The total number of errors significantly

deteriorated during the most severe effort at 90% workload as compared to the state of rest or 60% workload. Once again, this may suggest that moderate exercise at 60% has beneficial effects on the activation of the perceptive processor potentials, which is in accordance with previous research (Chodzko-Zajko, 1991; Paas, 1991; Tomporowski, 2003). Furthermore, in line with some other papers concerning the relationship between exercise and decision-making abilities (Delignieres, 1994; Brisswalter, 1997; Chmura, 1998), we here report significant negative effects of high-intensity exercise (at 90% workload) on the number of perception-related errors. Even though we found no significant differences between the groups at rest or during exercise, there was a consistent trend of somewhat poorer performance by Group B.

The results for visually scanned circles also improved from the state of rest to 60% workload, with a clear tendency toward better scores in Group A than in Group B. The values remained fairly constant, even at higher workloads, indicating the trend of generally poorer performance by Group B may stem from a higher cognitive structure which could be involved in this task. We suspect that it may concern the central cognitive processor which evaluates information processing, allocates additional resources for the analysis and correction, when necessary. It seems that most subjects scan a similar number of circles in 20 seconds, but also that Group B appears to be less aware of making the errors. Hence, it could be concluded that there is a negative effect of the general cognitive efficacy on the visual perception accuracy of Group B. Furthermore, there may be a more noticeable impact of fatigue on the impairment of this function, especially in those athletes whose central processor has a lower potential (presumably Group B). However, the role of the central processor and fatigue in perceptual efficacy by these groups of sportspersons needs to be empirically examined in the future. We would assume that including the measure of general cognitive efficacy, measures of quality of the perceptual self-evaluation, as well as some additional measures of perceptual efficacy could provide enough information for understanding the tentative differences between more and less successful female judokas. Without such evidence all further explanations of findings from this study would be only in the domain of speculation.

Remembering that certain indicators of cognitive functioning have been shown to be valid predictors of motor abilities (Bala, 1999), our findings suggest that both the condition and efficacy of visual perception skills might explain, at least in part, the variance of competitive success of elite female judokas.

We also believe that this kind of research has significant practical applications, primarily for the planning of match strategy and/or individual tactics. For example, athletes making fewer perception errors at high workloads can increase the pressure on their opponent towards the end of a bout, and possibly cause an error that can make way for relatively easy points and an eventual win. Conversely, for those athletes whose visual perception becomes poor during intense fatigue, the opposite applies: points should be won in the first or second minute of a bout, after which the plan would be to back off a little, and try defending the lead with active fighting for the rest of the match.

Summing up, the outcomes of this study undoubtedly show the impact of exercise on the accuracy of the perception apparatus in elite female Serbian judokas, as demonstrated by the Landolt test of visual perception skills. It was found that the 60% workload activated the perceptive processor potential, while further increases in the workload diminish its efficacy, but not its capacity. In other words, increased workloads do not affect the size of the visually scanned perceptive field; they only reduce the accuracy and quality of visual perception. Further research of the role of the general cognitive efficacy on visual perception accuracy within the conditions of increased exercise workloads is recommended. Some of the practical applications of these results would be to plan an individual match strategy and tactics, and to use these findings in the selection of young female judokas. It is also recommended that future research should include analyses of the relationship between perception skills and competitive international successes of elite female judokas.

References

Bala, G. (1999). Struktura relacija motoričkih i kognitivnih dimenzija studenata fizičke kulture pod nelinearnim modelom [The structure of the relations of motor and cognitive dimensions of physical education students under a linear model. In Serbian.] *Psihologija*, *3-4*, 241-258.

Bompa, T.O. (1999). *Periodization. Theory and methodology of training.* Champaign, IL: Human Kinetics.

Brisswalter, J., Arcelin, R., Andffren, M., & Delignieres, D. (1997). Influence of physical exercise on simple reaction time: Effect of physical fitness. *Perceptual and Motor Skills*, *85*, 1019-1027.

Brisswalter, J., Collardeau, M., & Alcerin, R. (2002). Effects of acute physical exercise on characteristics on cognitive performance. *Sports Medicine*, *32*(9), 555-66.

Castarlenas, J.L., & Planas, A. (1997). Estudio de la estructura temporal del combate de judo [The temporal structure of judo bout. In Spanish.] *Apunts*, *47*, 32-39.

Chmura, J., Krysztofiak, H., Ziemba, A.W., Nazar, K., & Kaciuba-Uscilko, H. (1998). Psychomotor performance during prolonged exercise above and below the blood lactate threshold. *European Journal of Applied Physiology*, *77*, 77-80.

Chodzko-Zajko, W.J. (1991). Physical fitness, cognitive performance and aging. *Medicine & Science in Sports & Exercise*, *23*, 868-872.

Colcombe, S.J., & Kramer, A.F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychology Science*, *14*, 125-130.

Delignieres, D., Brisswalter, J., & Legros, P. (1994). Influence of physical exercise on choice reaction time in sports experts: the mediating role of resource allocation. *Journal of Human Movement Studies*, *27*, 173-188.

Drid, P., & Obadov, S. (2006). Povezanost perceptivnih i motoričkih sposobnosti džudista. [The relationship between perception and motor skills of judokas. In Serbian.] In: Abstract book: *Fis-komunikacije* (pp. 49-54). Niš: Fakultet fizičke kulture.

Etnier, J.L., Nowel, P.M., Landers, D.M., & Sibley, B.A. (2006). A meta-regression to examine the relationship between aerobic fitness and cognitive performance. *Brain Research Reviews*, *52*, 119-130.

Etnier, J.L., Salazar, W., Landers, D.M., Petruzello, S.J., Han, M., & Nowell, P. (1997). The influence of physical fitness and exercise upon cognitive functioning: a meta-analysis. *Journal of Sport Exercise Psychology*, *19*, 249-277.

Fleury, M., Bard, C., & Carrere, L. (1981). Effects of physical or perceptual work loads on coincidence/anticipation task. *Perceptual and Motor Skills*, *53*, 843-850.

Grego, F., Vallier, J.M., Collardean, M., Bermon, S., Ferrari, P., Candito, M., Bayer, P., Magnié, M.N., & Brisswalter, J. (2004). Effects of long duration exercise on cognitive function, blood glucose and counter regulatory hormones in male cyclists. *Neuroscience Letters*, *364*, 76-80.

Higashiura, T., Nishihira, Y., Kamijo, K., Hatta, A., Kim, S.R., Hayashi, K., Kaneda, T., & Kuroiwa, K. (2006). The interactive effects of exercise intensity and duration on cognitive processing in the central nervous system. *Advances Exercise & Sports Physiology*, *12*(1), 15-21.

Ismail, A.H. (1967). The effect of a well-organized physical education program on a intellectual performance. *Research in Physical Education*, *1*(2), 31-38.

Kakhabrishvili, Z.G., Akhalkatsi, V.Y., & Kvinikadze, D.G. (2003). Ispolzovanie specifičeskih testov dlja ocenki funkcionalnova sastojanija borcov džudo [Estimation of Functional State of Judokas with Special Tests Use. In Russian.] *Teorija i praktika fiz. kulturi*, *2*, 36-37.

Lulofs, R., Wennekens, R., & Van Houten, J. (1981). Effect of physical stress time pressure on performance. *Perceptual and Motor Skills*, 52, 787-793.

Madić, D. (2000). *The relationship between anthropological dimensions of physical education students and their performance in sports gymnastics.* (Unpublished doctoral dissertation, University of Novi Sad). Novi Sad: Faculty of Sport and PE.

Malacko, J., & Rađo, I. (2004). *Tehnologija sporta i sportskog treninga* [Technology of sports and sports training. In Bosnian.] Sarajevo: Fakultet sporta i tjelesnog odgoja.

Mejovšek, M. (1975). T*he relations of cognitive abilities and some parameters of simple and complex movement speed.* (Unpublished doctoral dissertation, University of Zagreb). Zagreb: Faculty of Sport and PE.

Mejovšek, M. (1979). Relacije kognitivnih motoričkih sposobnosti [The relations of cognitive motor abilities. In Croatian.] *Kineziologija*, *9*(1-2), 83-90.

Paas, F.G., & Adams, J.J. (1991). Human information processing during physical exercise. Ergonomics, 34, 1385-1397.

Salmela, J.H., & Doyle, O.D. (1986). Cognitive distortions during progressive exercise. *Perceptual and Motor Skills*, *63*, 1067-1072.

Sikorski, W., Mickiewicz, G., Majle, B., & Laksa, C. (1987). Structure of the contest and work capacity of the judoist. In *International Congress Judo-Contemporary Problems of Training and Judo Contest, Proceedings* (pp. 58-65). Spala: European Judo Union.

Svischev, I.D. (2001). Teorija vzaimodejstvij: obšie zakonomernosti vzaimodejstvij učastnikov sarevnovanij v edniborstvah i sportivnih igrah. [The Theory of Interactions: General Consistent Patterns of Competitions Participants' Interactions in Single Combats and Sports Games. In Russian.] *Teorija i praktika fiz. kulturi*, 4, 39-43.

Sisoev, V.M. (1996). Test E. Landolta [Landolt test. In Russian.]. Sankt-Peterburg: Imaton.

Tomporowski, P.D. (2003). Effects of acute bouts of exercise on cognition. *Acta Psychologica*, *112*, 297-324.

Yagi, Y., Coburn, K.L., Estes, K.M., & Arruda, J.E. (1999). Effects of aerobic exercise and gender on visual and auditory P300, reaction time, and accuracy. *Europen Journal of Applied Physiology*, *80*, 402-8.

UTJECAJ RAZLIČITIH TRENAŽNIH OPTEREĆENJA NA VIZUALNE PERCEPCIJSKE SPOSOBNOSTI VRHUNSKIH SRPSKIH JUDAŠICA

Cilj ovog istraživanja bilo je utvrđivanje utjecaja intenzivne fizičke aktivnosti na vizualne percepcijske sposobnosti vrhunskih judašica. Uzorak ispitanika je činilo 18 članica nacionalne izabrane vrste. Ispitanice su bile podijeljene u dvije skupine u skladu s dosadašnjim međunarodnim rangiranjem i/ili rezultatima: skupina A – *uspješnije* i skupina B – *manje uspješne*. Obje su skupine postigle slične rezultate na Landoltovu testu vizualnih percepcijskih sposobnosti u inicijalnom mjerenju. Na 60% opterećenja zabilježeni su značajno bolji rezultati u učinkovitosti vizualne percepcije u obje skupine. Pri opterećenju od 75% i 90% je zabilježeno značajno opadanje percepcijskih sposobnosti obje skupine. Rezultati ukazuju na činjenicu da su se resursi perceptivnog aparata aktivirali pri opterećenju od 60%. Daljnje je povećanje radnoga opterećenja, međutim, izazvalo progresivno iscrpljenje tih resursa u obje skupine. Iako je primijećena veća tendencija smanjenja sposobnosti percepcije u skupini B nego u skupini A, razlike između skupina nisu postigle statističku značajnost. S druge strane, promjene unutar skupina u Landoltovu testu, koje su se javile kao rezultat povećanja opterećenja, bile su statistički značajne za obje skupine (p=,01). Dobiveni rezultati pokazuju da intenzivna fizička aktivnost utječe na percepcijsku točnost (preciznost). Taj nalaz može pomoći trenerima i instruktorima u provođenju taktičke pripreme za judo borbu, kao i u selekciji mladih judašica.

Ključne riječi: *vizualna percepcija, judo, Landoltov test, trenažno opterećenje*

Submitted: February 23, 2009
Accepted: July 8, 2010

Correspondence to:
Patrik Drid, PhD
Faculty of Sport and Physical Education,
University of Novi Sad
Lovcenska 16, 21000 Novi Sad, Serbia
Phone: +381 64 111 8884
Fax: +381 21 450 199
E-mail: patrik@eunet.rs