PRINT: ISSN 0973-5070 ONLINE: 2456-6772

Ethno Med, 10(4): 404-410 (2016)
DOI: 10.31901/24566322.2016/10.04.03

An Analysis on the Acute Effects of Blood Lactate Level and the Exercises Performed with Different Loading-Intensity on the Performance of Hand-Eye Coordination

Halil Ibrahim Ceylan, Ozcan Saygin and Kemal Goral

Mugla Sitki Kocman University, Faculty of Sport Sciences, Mugla, Turkey

KEYWORDS Athletes. Exercise Intensity. Hand-Eye Coordination. Lactate Levels.Male. Treadmill

ABSTRACT The purpose of this research is to investigate the acute effects of the exercises performed at the intensity of seventy percent and ninety percent on the performance of hand-eye coordination, and to examine the relationship between blood lactate level and the performance of hand-eye coordination. Twenty-one male athletes participated in this paper voluntarily. In the analysis of the data, Paired T- test and Pearson's Correlation Test were used. As the result of the statistical analyses, a significant difference was found between the exercises performed at the intensity of seventy percent and ninety percent during the turning and placement tests ($p<0.05$). A significant positive relationship was found between the blood lactate level measured after the exercise performed at the intensity of ninety percent and the hand-eye coordination (turning test) measured 20 seconds after the measurement of lactate level ($p<0.05$). Consequently; it can be stated that the performance of hand-eye coordination during the exercises with high intensity was affected in a negative way with the increase in lactate; thus, such points should be taken into consideration while planning the training programs.

INTRODUCTION

Fatigue is a multi-factorial process that weakens exercises and sports performance (Hargreaves 2007). It is defined as the impairment (perceived or real) in mental and physical performances (MacInstosh et al. 2005). It is an element that restricts the performance by not only affecting the motor processes but also the perceptual ones (Thomson et al. 2009). To be able to understand the cause of fatigue, it is necessary to have the knowledge of energy metabolisms (Fox 2007) and to take into consideration a number of processes within the central nervous system (Taylor and Gandevia 2008). In the course of intensive exercises, such as sprint-type activities in which the rate of energy demand is high, the lactic acid is produced more rapidly than the rate of its removal from the tissues, and its density increases as well. When not removed, however, the lactic acid, by decomposing, transforms into lactate and hydrogen ions. The accumulation of hydrogen ions gives rise to acidosis within the muscle and causes a sense of fatigue (Fox 2007). Fatigue progresses during the performance, and the body begins to relax when the exercise is stopped. At the time of exercising, fatigue sometimes lead to a decrease in power or in the measurable maximal voluntary strength, which totally depends on the intensity of muscular activity. If the exercises performed are submaximal, fatigue occurs without any decrease in the task performance (Taylor and Gandevia 2008). Along with the increasing intensity of the exercises, the blood lactate concentration generally starts to increase rapidly during the exercise protocol (in 50 percent and 70 percent of the maximal load) (Chmura and Nazar 2010). In a number of sports branches, such as team sports, martial arts and racket sports, athletes are exposed to cognitive and physiological loads (Davranche and Audiffren 2004). Physical activity, particularly with high intensity, triggers the development of fatigue symptoms by creating a negative effect on the homeostatic balance of the organism (Aslan et al. 2011). Therefore, it is important to protect and maintain the visual perception for maximal performance during intensive exercises (Ando et al. 2012).

In most of the sports, athletes are supposed to make quick and accurate decisions despite their high physical efforts (Delignieres et al. 1994), so they need to possess high visual, cog-

Address for correspondence:
Halil Ibrahim Ceylan
Research Assistant
Faculty of Sport Sciences,
Mugla Sitki Kocman University,
Mugla, Turkey
E-mail: halil.ibrahimceylan60@gmail.com

nitive and perceptual skills in order to be able to succeed (Ando et al. 2012; Mankowska et al. 2015; Meng et al. 2015). For instance, in sports like football or basketball, players collect visual information from around the visual field to see other players and objects outside the central visual field (Ando et al. 2012). The visual system plays a critical role in sports performance (Williams et al. 2005; Du Toit et al. 2012), in the speed and accuracy of reaction time, in reaction response, and in the initialization ability (Meng et al. 2015). The visual system varies according to the environmental demands associated with sports. These environmental demands are paired with a task-specific motor reaction (Du Toit et al. 2012). In order to promote sports performance by developing the visual perception, it is required that the visual demands in different sports branches are understood. It should be considered that the evaluation of the degree of varying visual parameters can be adapted by coaching the visual skills (Ellison et al. 2014). The hand-eye coordination which is one of the visual skills, and is important for high level sports performance. It plays a pivotal role in many kinds of sports, especially in ball games which require a lot of reaching and catching (Ma and Qu 2016). There have been studies conducted on the importance of hand-eye coordination in several sports branches such as football (Nagano et al. 2004) and basketball (Tsang et al. 2014). Hand-eye coordination involves a number of sensorimotor systems such as cognitive features including visual system, vestibular system, proprioception, eye-head-arm and control systems as well as attention and memory (Crawford et al. 2004).

Until recently, it has been suggested by sports psychologists that low and high-intensity exercises caused poor cognitive performance, whereas moderately intensive exercises led to optimal performance in line with the primary conventional hypothesis of Inverted-U Model (Sabzi et al. 2014) used for identifying the relationship between stimulation and performance (Draper et al. 2010). In the literature, some studies support the Inverted-U hypothesis, while others do not. In the conducted studies, high-intensity exercises were reported to have affected the visual system in a negative way. Ando (2013) demonstrated that intensive exercises (those above the respiratory threshold) had caused negative effects on the performance of peripheral visual perception. Duncan et al. (2015) reported that a 40-minute bout of continuous cognitive activity leading to mental fatigue negatively affect manual dexterity. Thus, when literature is reviewed, it is seen that the fatigue or the high-intensity exercises experienced in the course of competitions/races in particular impair the performance as well as negatively affecting hand-eye coordination, one of the significant properties for high-level-sportive performances. The purpose of this paper, however, is to examine the acute effects of the exercises performed with a different loading intensity on the performance of hand-eye coordination and to analyze the relationship between the blood lactate level and the hand-eye coordination measured in the wake of the exercises performed with a different loading intensity. Separately, this paper is of significance in terms of including intensive practices that will allow hand-eye coordination performance to be developed within the training programs in order to achieve high level perceptual-cognitive performance in sports.

METHOD

Subjects

Twenty-one male athletes (age: 22.23±1.92 year, height: 179.01±4.37cm, body weight: 73.25±.04 kg) who were the students of the Faculty of Sport Sciences and who had no sports injuries or any disabilities in terms of health in taking part in the exercises participated in the paper voluntarily. Before starting the measurements, all participants were informed about the methodological model of the paper and they signed an informed consent form. One day before each time frame when the data were collected, the participants were also informed about avoiding heavy physical exercises as well as keeping away from alcohol and caffeine.

Determining the Exercise Intensity (the Karvonen Method)

The loading intensity of those that took part in the research was determined according to the number of their heart rates. The maximal number of heart rates were calculated through the Karvonen Method, and the loading intensity was specified as follows;

The Number of Maximal Heart Rates = Age – 220.

The Number of Target Heart Rate = Exercise Intensity (percent) x (Number of Maximal Heart

Rates – Number of Rested Heart Rates) + Number of Rested Heart Rates (Ozer 2006).

Test Protocol

When the literature was examined, It was seen that exercises which performed in the target rate of seventy percent "moderate" and the exercises performed in in the target rate of ninety percent "high intensity" in papers (Alaei 2015; Duncan et al. 2016).

Subjects were given 15 minutes to warm up before each exercise protocol (70 and 90 percent), and then they were subjected to the running exercise on the treadmill at seventy percent and ninety percent exercise intensity in accordance with the number of target heart rates calculated through the Karvonen Method. The changes in the heart rates in the course of the exercises were followed by means of RS 400-brand polar watch. The test protocol started on with the running/foot speed of 5 mph on the treadmill, and the load was speeded up at 1 mph at each 30th and 60th seconds since the participants were asked to attain seventy percent and ninety percent of the target heart rate, in other words, the Steady-State mode (Duncan et al. 2013). Subjects continued the exercise for a certain period in the steady-state mode and ended later on. At the outset of the exercise and 30 seconds after it ended, the lactate blood levels of the subjects were measured with the tool called 'The Lactate Plus' (L^+, Nova Biomedical, USA). 20 seconds after the measurement of the blood lactate levels, two different tests (turning and placement) were performed on the subjects by means of the Minnesota Dexterity Test used for measuring hand-eye coordination (Drid et al. 2010) and the obtained data were recorded on the SPSS program. The anthropometric measurements along with the entire physical and physiological measurements of the athletes were performed in a quiet and serene environment in the Laboratory of The Exercise Physiology of the Faculty of Sports Sciences, *Mugla Sitki Kocman* University. All the data regarding the research were collected during the morning hours on weekdays when the subjects were available. The measurements of the paper were completed in 1 week. The participants were called to visit the measurement session in groups of five on different days of the week, and their measurements for seventy percent intensive-exercise protocol were completed in the first place. After each subject rested one day and then they participated in the ninety percent intensive-exercise protocol.

Data Collection Tools

Body Weight and Height

While weights were being measured via an electronic scale of 0.1 gram sensitivity, heights were measured by means of a digital height-measuring device of 0.01 cm sensitivity (Tamer 2000).

Measurement of Hand-Eye Coordination

In the measurement of hand-eye coordination performance, The Minnesota Dexterity Test was used. This commonly-used test examines the rapid hand-eye and finger movement capacities. This test was performed on the subjects in 2 different forms as placement and turning tests. Prior to the start of the measurement process, the protocol was introduced to the subjects and the subjects were asked to perform a few practices on it. The subjects raced against time, and their performances were recorded via a chronometer in terms of seconds. After this test was performed by the subjects for 3 times, the best score was recorded for the statistical analysis (Lafayette Instrument 1998).

Lactate Plus (L^+, Nova Biomedical, USA)

This device uses an electrochemical lactate oxidase biosensor for full blood lactate assay/measurement. A 0,7 Ll blood sample is required; the duration of sample analysis is 13 seconds. No test strips, calibration codes or special calibration strips are required for L^+. To ensure an accurate functioning of the analyzer, the quality control solution of L^+ is used on 2 levels before the test (level 2: 4, 0-5, 4 mM, level 1: on the level of 1, 0-1, 6 mM) (Tanner et al. 2010). The blood lactate measurement was performed by means of Lactate Plus tool by receiving blood from the fingertips of the athletes by expert both before the exercise with seventy percent and ninety percent intensity and 30 seconds after the exercise was ended. The obtained values were recorded in terms of $mmol^{-1}$.

Statistics

The statistical calculations were performed on the SPSS (version 16.0) program. All the variables were seen to have showed a normal distribution. In order to find out the difference between the exercises performed at seventy percent and ninety percent intensity in the turning and placement tests, the Paired t-test was used, since the data showed a normal distribution; and also to find the relationship among the variables, the Pearson's Correlation test was used. The significance level was accepted as $p<0.05$.

RESULTS

As seen in Table 1, a significant difference was found between the exercises performed at seventy percent and ninety percent exercise intensity in the turning and placement tests and also in the lactate value measured 30 seconds after the exercises were ended ($p<0.05$). No significant difference was found in the resting lactate values ($p>0.05$).

As seen in Table 2, no significant relationship was found between the blood lactate levels measured during the resting period and 30 seconds after the exercise with seventy percent intensity ended and the hand-eye coordination tests (turning and placement) performed 20 seconds after the blood lactate levels were measured ($p>0.05$).

As seen in Table 3, a significant relationship in a positive direction was found between the blood lactate levels measured 30 seconds after the exercise with ninety percent intensity was completed and the hand-eye coordination test (turning) performed 20 seconds after the blood lactate value was measured ($p<0.05$).

Table 2: The relationship between the blood lactate levels measured during the resting period and after the exercise with 70 percent intensity and hand-eye coordination

		Turning test (sec)	*Placement test (sec)*
Resting Lactate	r	-.016	.061
(m/mol)	p	.947	.793
Lactate 30 sec	r	-.105	.257
later (m/mol)	p	.650	.261

Table 3: The relationship between the blood lactate levels measured during the resting period and after the exercise with 90 percent intensity and hand-eye coordination

		Turning test (sec)	*Placement test (sec)*
Resting Lactate	r	.205	.267
(m/mol)	p	.372	.243
Lactate 30 Sec Later	r	.510	.248
(m/mol)	p	.018*	.278

*p<0.05

DISCUSSION

Hand-eye coordination is the one of the important parameters which involves several sensorimotor (perceptual and motor) systems (Crawford et al. 2004), and important for the performances in team sports like handball, basketball and volleyball along with the individual sports as well as racket sports (Menevse 2011). Good hand-eye coordination increases the ability of the athletes as to perform a complex movement and to give an effective response towards the

Table 1: Comparing the effects of the exercises performed at 70 percent and 90 percent-intensity on hand-eye coordination performance

Variables		*Number*	*X± S.D.*	*t*	*p*
Turning Test(sec)	70%	21	53.61±4.65	-4.811	.001*
	90%	21	59.67±8.38		
Placement Test(sec)	70%	21	49.54±5.00	-4.651	.001*
	90%	21	53.38±5.46		
Resting Lactate(m/mol)	70%	21	1.86±.53	-1.750	.095
	90%	21	2.21±.80		
Lactate 30 Sec Later (m/mol)	70%	21	9.04±3.31	-2.641	.016*
	90%	21	11.30±2.58		

*p<0.05

external stimulants as well as to pose a fluent action/movement (Paul et al. 2011).

The purpose of this paper, however, is to examine the acute effects of the exercises performed with a different loading intensity on the performance of hand-eye coordination and to analyze the relationship between the blood lactate level and the hand-eye coordination measured in the wake of the exercises performed with a different loading intensity. In this paper, a significant difference was found between the exercises performed with seventy percent and ninety percent intensity during turning and placement tests ($p<0.05$). The hand-eye coordination proved to be better after the exercises performed with seventy percent intensity. It was seen that as the intensity of the exercise increased, the performance of the hand-eye coordination due to fatigue was seen to have been negatively affected (Table 1). Apart from the fact that there are limited number of studies in the literature that investigate the acute effects of the exercises performed with different intensities on the hand-eye coordination or on the visual system, there are no studies investigating the association between this subject and blood lactate levels. Duncan et al. (2016) indicated that perceptual-cognitive performance was deteriorated when exercise intensity was high (90%). Drid et al. (2010) reported that intense exercise (at 90% workload) affects visual perception accuracy negatively. In a paper, Bard and Fleury (1978) investigated the effect of the exercise on the visual capacity when the exercise was performed until one got exhausted on the cycling ergometer. Consequently, it was reported that metabolic fatigue had not affected the visual capacity. Fleury et al. (1981), in a paper they conducted, reported that there was no weakening in the test performances involving the visual perception tasks of 31 physically fit male individuals on the average of $MaxVO_2$ = 62.39 ml.kg $(^{-1})$ min $(^{-1})$ after performing exhausting exercises (on the treadmill, after VO_2 max test).

The measurement of the reaction time has a significant place in determining the performance of hand-eye coordination (Menevse 2011). Apart from the studies that investigate the acute effect of the exercise on the visual system, there are also studies found in the literature that have been conducted on the reaction time, which is an important parameter for cognitive performance. There are, again, studies in the literature in which acute exercises performed at different intensities affect the reaction time in a positive way (Kashihara and Nakahara 2005; Chmura and Nazar 2010; Draper et al. 2010; Mroczek et al. 2011; Ashnagar et al. 2014), and some other studies in which they do not cause any impact (Yildiz 2010; Draper et al. 2010) and some others in which such exercises lead to a negative effect (Senel et al. 2010). In a conducted paper, Jin et al. (2015) could not find any significant difference in the reaction time performance during uncharged/unloaded pedaling and during the exercises they performed at different exercise intensities, such as twenty-five percent, fifty percent, seventy-five percent and ninety percent, on the cycling ergometer. The reaction time was reported to have been at its best with the exercise intensity of seventy-five percent in the course of the exercises. Mcmorris and Keen (1994), however, found that the simple reaction time at the time of a maximal exercise was significantly slower than the resting period and the seventy percent exercise intensity. Thomson et al. (2009), on the other hand, reported that the maximal exercise had negatively affected the speed and accuracy of the decision-making process based on perceptual-cognitive tasks. Brisswalter et al. (2002) and Tomporowski (2003), in the studies they conducted, reported that the aerobic-style, that is, the steady-state exercises performed at moderate intensity increased the cognitive reaction rate (speed) but did not change the rates of mistakes/errors; whereas, they determined that the change in these parameters was less prominent after performing high-intensity-exercises. Mekari et al. (2015) reported that the exercises at high intensity (85% of the peak power output) had affected the reaction time in a negative way when compared with those performed at low intensity (40 percent of the peak power output), which was also associated with the low oxygenation of the brain within the prefrontal cortex. In the paper conducted, Chmura and Nazar (2010) stated that during the exercises, the reaction time had shortened at the time of the psychomotor fatigue threshold (the running rate was 15.8±0.17 km/h, while the maximal speed was 87 percent, and the starting point of blood lactate accumulation was 9.2 percent), and that the reaction time was disrupted as the intensity of the exercise increased (running rate) towards the end of the exercise.

It was also pointed out that although the aerobic exercise at 70 percent intensity had elevated the blood lactate level, it remained too insufficient to affect the performance of hand-eye coordination in a significant way. Besides, there was a significantly positive relationship found between the blood lactate level measured in the wake of the exercise with 90 percent intensity and the hand-eye coordination measured 20 seconds after the measurement of the lactate levels ($p<0.05$) (Tables 2 and 3). In this paper, the blood-lactate level was taken as the fatigue criterion. Zwierko et al. (2008) reported that the blood lactate level measured 4 minutes after the specific anaerobic (10X30m, at 20 sec-intervals) test that caused the occurrence of fatigue had risen from 2.04±0.48 up to 12.04±2.42, and that there was a relationship between the blood lactate level and the peripheral perception. Chmura et al. (1994), on the other hand, performed a multi-cycling ergometer test on their 22 football players whose work load increased by 50W until they got exhausted. Compared to the resting moment, the optional reaction time during the exercises performed at moderate intensity proved to be better. Exercise sessions comprise the exercises at the increasing intensity of 3 minutes as well as a 1-minute-resting time after each 3-minute-exercise. The reaction periods of the subjects extended during the final load (approximately 300W). While the blood lactate level during the best reaction time was 5 mmol, it proved to be 10 mmol during the final exercise session. The best reaction time (the exercise performed at 75 percent of the physical work capacity) was reported to have been measured at the time of the lactate threshold or at the time close to the lactate threshold.

CONCLUSION

In conclusion, it was concluded that although the exercise at seventy percent intensity elevated the blood lactate level, it still remained too insufficient to affect the performance of the hand-eye coordination in a significant way, in addition to which the performance of hand-eye coordination was affected negatively along with the lactate increase during the exercises at ninety percent intensity.

RECOMMENDATIONS

It is assumed that after the necessary adaptation of athletes to the activities at high intensity has been maintained, it will be beneficial if coaches take the exercise-intensity factor into consideration while planning exercises that improve the visual system. By allowing athletes to perform trainings on lactate threshold, their tolerance to lactate should be improved and their adaptation to the intensity of the exercise should be ensured. It is recommended carried out comprehensive studies on elite athletes in different sports as compared with having low fitness groups.

REFERENCES

Alaei F 2015. *Effects of Exercise Intensity and Stimulus Speed on Coincidence Anticipation Timing with Respect to Gender in Adolescent Badminton Players*. Ph. D. Thesis, Unpublished. Ankara: Middle East Technical University.

Ando S, Kokubu M, Nakae S, Kimura M, Hojo T, Ebine N 2012. Effects of strenuous exercise on visual perception are independent of visual resolution. *Physiology & Behavior*, 106(2): 117-121.

Ando S 2013. Peripheral visual perception during exercise: Why we cannot see. *Exercise and Sport Science Review*, 41(2): 87-92.

Aslan A, Guvenc A, Hazir T, Acikada C 2011. Genc futbolcularda yuksek siddette yuklenme sonrasinda toparlanma dinamikleri. *Spor Bilimleri Dergisi: Hacettepe Üniversitesi*, 22(3): 93-103.

Ashnagar Z, Shadmehr A, Jalaei S 2014. The effects of acute bout of cycling on auditory and visual reaction times. *Journal of Bodywork and Movement Therapies*, 19(2): 268-272

Bard C, Fleury M 1978. Influence of imposed metabolic fatigue on visual capacity components. *Perceptual and Motor Skills*, 47: 1283-1287.

Brisswalter J, Collardeau N, Arcelin R 2002. Effects of acute physical exercise characteristics on cognitive performance. *Sports Medicine*, 32: 555–566.

Chmura J, Nazar K, Kaciuba-Uscilko H 1994. Choice reaction time during graded exercise in relation to blood lactate and plasma catecholamine thresholds. *International Journal of Sports Medicine*, 15: 172-176.

Chmura J, Nazar K 2010. Parallel changes in the onset of blood lactate accumulation (OBLA) and threshold of psychomotor performance deterioration during incremental exercise after training in athletes. *International Journal of Psychophysiology*, 75(3): 287-290.

Crawford JD, Medendorp WP, Marotta JJ 2004. Spatial transformations for eye–hand coordination. *Journal of Neurophysiology*, 92(1): 10-19.

Davranche K, Audiffren M 2004. Facilitating effects of exercise on information processing. *Journal of Sports Sciences*, 22(5): 419-428.

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

Draper S, McMorris T, Parker JK 2010. Effect of acute exercise of differing intensities on simple and choice reaction and movement times. *Psychology of Sport and Exercise*, 11(6): 536-541.

Drid P, Majstorovic N, Drapsin M 2010. The effects of different exercise workloads on visual perception skills in elite Serbian female judokas. *Kineziologija*, 42(2): 201-207.

Duncan M, Smith M, Lyons M 2013. The effect of exercise intensity on coincidence anticipation performance at different stimulus speeds. *European Journal of Sport Science*, 13(5): 559-566.

Duncan MJ, Fowler N, George O, Joyce S, Hankey J 2015. Mental fatigue negatively influences manual dexterity and anticipation timing but not repeated high-intensity exercise performance in trained adults. *Research in Sports Medicine*, 23(1): 1-13.

Duncan MJ, Smith M, Bryant E, Eyre E, Cook K et al. 2016. Effects of increasing and decreasing physiological arousal on anticipation timing performance during competition and practice. *European Journal of Sport Science*, 16(1): 27-35.

Du Toit PJ, Van Vuuren PJ, Le Roux S, Henning E, Kleynhans M, Terblanche HC et al. 2012. The effect of sport specific exercises on the visual skills of rugby players. In: Proceedings of World Academy of Science, Engineering and Technology, 71: 1194. *World Academy of Science, Engineering and Technology*, 6(11): 3077-3080.

Fleury M, Bard C, Jobin J, Carriere L 1981. Influence of different types of physical fatigue on a visual detection task. *Perceptual and Motor Skills*, 53: 723-730.

Fox Zachary G 2007. *The Effect of Aerobic and Anaerobic Exercise Protocols on Postural Control.* Ph.D. Thesis, Unpublished. USA: The University of North Carolina.

Jin X, Eason B, Loftin M 2015. Effect of exercise intensity level on choice reaction time 1. *Comprehensive Psychology*, 4(3): 2-6.

Kashihara K, Nakahara Y 2005. Short-term effect of physical exercise at lactate threshold on choice reaction time. *Perceptual and Motor Skills*, 100: 275-291.

Lafayette Instruments: Examiners Manual 1998. Minnesota Manual Dexterity TestMODEL# 32023. From<http://www. meetinstrumentenzorg. nl/Portals/0/bestanden/141_2_N.pdf> (Retrieved on 15 December 2015).

Ma AWW, Qu L 2016. The effect of exergaming on eye-hand coordination among primary school children: A pilot study. *Advances in Physical Education*, 6(2): 99-102.

MacInstosh B, Gardiner P, McComas A 2005. *Skeletal Muscle: Form and Function.* 2nd Edition. Champaign, IL, USA: Human Kinetics.

Mankowska M, Poliszczuk T, Poliszczuk D, Johne M 2015. Visual perception and its effect on reaction time and time-movement anticipation in elite female basketball players. *Polish Journal of Sport and Tourism*, 22(1): 3-8.

McMorris T, Keen P 1994. Effect of exercise on simple reaction times recreational athletes. *Perceptual Motor Skills*, 78: 123-130.

Mekari S, Fraser S, Bosquet L, Bonnery C, Labelle V, Pouliot P et al. 2015. The relationship between exercise intensity, cerebral oxygenation and cognitive performance in young adults. *European Journal of Applied Physiology*, 115(10): 2189-2197.

Menevse A 2011. Examination of the relationship between muscle palmaris longus and reaction time. *World Applied Sciences Journal*, 12(1): 114-118.

Meng KY, Zuhairi NA, Manan FA, Knight VF, Padri MNA et al. 2015. Role of gender, age and ethnicities on visual reaction time and visual anticipation time of junior athletes. *Australian Journal of Basic and Applied Sciences*, 9(5): 129-134.

Mroczek D, Kawczynski A, Chmura J 2011. Changes of reaction time and blood lactate concentration of elite volleyball players during a game. *Journal of Human Kinetics*, 28(1): 73-78.

Nagano T, Kato T, Fukuda T 2004. Visual search strategies of soccer players in one-on-one defensive situations on the field. *Perceptual & Motor Skills*, 99(3): 968–974.

Ozer K2006. *Fiziksel Uygunluk.* 2. Baski. Ankara: Nobel Yayin Dagitim.

Paul M, Biswas SK, Sandhu JS 2011. Role of sports vision and eye hand coordination training in performance of table tennis players. *Brazilian Journal of Biomotricity*, 5(2): 106-116.

Sabzi AH, Hasanvand B, Roozbahani M 2014. The effect of different intensity exercise-induced arousal on discriminative reaction time. *International Journal of Sport Studies*, 4(6): 671-675.

Senel O, Duvan A, Toros T 2010. Maksimal yuklenme yogunlugunun elit turk eskrimcilerin görsel reaksiyon zamanlari uzerine etkisi. B*eden Egitimi ve Spor Bilimleri Dergisi*, 4(3): 146-151.

Tamer K 2000. *Sporda Fiziksel Ve Fizyolojik Performansin Olculmesi ve Degerlendirilmesi.* Ankara: Bagirgan Yayimevi.

Tanner RK, Fuller KL, Ross ML 2010. Evaluation of three portable blood lactate analysers: Lactate pro, lactate scout and lactate plus. *European Journal of Applied Physiology*, 109(3): 551-559.

Taylor JL, Gandevia SC 2008. A comparison of central aspects of fatigue in submaximal and maximal voluntary contractions. *Journal of Applied Physiology*, 104(2): 542-550.

Thomson K, Watt A, Liukkonen J 2009. Differences in ball sports athletes speed discrimination skills before and after exercise induced fatigue. *Journal of Sports Science and Medicine*, 8: 259-264.

Tomporowski PD 2003. Effects of acute bouts of exercise on cognition. *Acta Psychologica*, 112: 297–324.

Tsang WW, Fong SS, Cheng YT, Daswani DD, Lau HY, Lun CK et al. 2014. The effect of vestibular stimulation on eye-hand coordination and postural control in elite basketball players. *American Journal of Sports Science*, 2(2): 17-22.

Williams MA, Davids K, Williams JGP 2005. *Visual Perception and Action in Sport.* New York: E & FN Spon.

Yildiz G 2011. *Super Lig De Oynayan Bayan Hentbolculerin Farkli Yorgunluk Duzeylerinde Ki Reaksiyon Zamanlari Ve Isabetli Kale Atislarinin Incelenmesi*. Yuksek Lisans Tezi, Yayinlanmamis. Lefkosa: Yakin Dogu Universitesi.

Zwierko T, Glowacki T, Osinski W 2008. The effect of specific anaerobic exercises on peripheral perception in handball players. *Kinesiologia Slovenica*, 14(1): 68-76.

Paper received for publication on January 2016
Paper accepted for publication on September 2016