Original Article

DOI: http://dx.doi.org/10.16926/par.2017.05.19

Influence of a 9-week training intervention on the reaction time of fencers aged 15 to 18 years

Authors' Contribution:

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Manuscript Preparation
E – Funds Collection

Štefan Balkó[1ABDE], Miroslav Rous[1BD], Iva Balkó[1AD], Jan Hnízdil[1CD], Zbigniew Borysiuk[2AD]

[1] Faculty of Education, J.E. Purkyně University in Ústí nad Labem, Czech Republic
[2] Faculty of Physical Education and Physiotherapy, Opole University of Technology, Poland

Abstract

The purpose of the present study was to determine if it is possible to affect the level of simple (SRT) and choice (CRT) reaction time of fencers with a specific 9-week (in total 350 minutes) training intervention. The research sample consisted of 19 healthy fencers (12 boys, 16±1.1 years and 7 girls, 16.4±0.9 years). Five of the tested subjects were selected as the control group that did not participate in the reaction time training. The training of the experimental group was conducted on an Electronic Fencing Target (EFT-1). All tested individuals completed an entrance and exit reaction time test on the Fitrosword device, which consisted of hitting the target with an epée from the guard position after lighting of an LED light (green, red, yellow) by using various motor responses of the armed arm. No difference in reaction time (SRT, CRT) was found between the experimental and control groups for the entrance test. A significant difference between groups was found for results of the CRT ($p = 0.116$, $d = 0.722$) after the 9-week training. A significant difference in CRT was also found between the entrance and the exit tests in the experimental group ($p = 0.013$, $r = 0.469$). This difference was not significant in the case of the control group ($p = 0.345$, $r = 0.298$). Based on these results, we can assume a positive impact of specific reaction time training on response speed. We can use these results in the training process to improve reaction time, which is an important component of overall sports performance in many combat disciplines, such as karate, boxing, taekwondo, judo, and fencing, as well as motorsports, ball games, etc.

Keywords: *simple reaction time; choice reaction time; visual stimulus; fencing; training process*

Address for correspondence:
Štefan Balkó, J.E. Purkyně University in Ústí nad Labem; České mládeže 8; 40096; Ústí nad Labem; Czech Republic; email: stefan.balko@ujep.cz

Recevied: 26.05.2017; Accepted: 7.06.2017; Published online: 20.09.2017

INTRODUCTION

Reaction time plays a key role in everyday life situations (e.g., fast reaction of a driver, catching an item falling off a table, etc.). Reaction speed is no less important among elite athletes in several ball sports (e.g., goalkeeper's reaction to a flying ball, batter´s reaction to an incoming ball) and in combat sports (e.g., blocking an attack during a karate match). In different sport areas, athletes must react rapidly to different stimuli (tactile, visual, and audio). It is obvious that the major types of stimuli in fencing are tactile and visual, as was demonstrated previously by Borysiuk and Waskiewicz [1]. It is thus necessary to keep in mind that there are other significant factors that influence fencing performance. These factors include intermuscular coordination, the level of technique, tactics [2], psychological aspects [3] and several other influences. Reaction time also contributes to the overall duration of specific movement tasks. It is then possible to say that, for example, in boxing, karate, taekwondo or fencing, this variable is highly important because the overall movement time can be shortened thanks to a faster reaction. Unlike other combat sports, in which physical strength plays an essential role in performance [4], in fencing the important components of performance are reaction time and the level of muscle coordination during the movement (e.g., lunge, fleche, etc.). The athlete's performance is reflected in the effectiveness of motor control [5,6]. If some of the factors responsible for sports performance are not sufficiently included or if the athlete has not achieved a required level of proficiency, the so-called "compensation" process or "highlighting" of other factors comes in place. During practice, the fencer is faced with a vast variety of variables that he/she must react and adapt to.

It is natural to expect a decrease in reaction time duration in relation to experience in a particular sport, which was confirmed by Tyshler and Tyshler [7]. Differences in the reaction time in relation to the length of sport practice have been identified in studies by Czajkowski [8], Johne, Poliszczuk, Poliszczuk, and Dąbrowska-Perzyna [9] and Schmidt and Wrisberg [10]. It is therefore necessary to identify techniques and methods that will influence this variable. Fencing belongs to the anticipation category of sport disciplines. Many authors agree that reaction time plays a key role in fencing performance [11,12,13,14,15]. When comparing the reaction times of karate fighters and fencers, Colin [16] found that fencers exhibited shorter reaction times. The significance of simple reaction time in terms of sports performance was discussed in a study by Gierczuk et al. [17]. In this study, the researchers found that elite Greco-Roman wrestlers, who achieved higher levels of sport performance, did not experience significant changes in reaction time during matches.

If we consider the significance of visual stimulation in fencing, it is necessary to bear in mind that the stimulus processing consists of detection via the sensory organs to muscle activation across the central nervous system (CNS). The detected information is analyzed in the somatosensory area of the cortex, which processes over 60% of visual stimuli, and is then compared with previous experience in association areas of the brain [18]. The passage of the signal through nerve pathways and the CNS (the associative brain areas) is the most time-consuming processing activity; thus, processing in this part of the CNS can influence reaction time. In this context, Šteffl and Bartůňková [19] state that reaction time is affected by the number of synaptic connections in the retina and the rate of release of neurotransmitters in these synapses, which are responsible for sending information to the brain. Based on these facts, one can conclude that there are potential techniques that will positively influence reaction time. However, questions remain as to which methods and procedures can be used in practice, as reaction time can only be influenced by up to 10-15% of its original level. This change in reaction time may affect disciplines where only a fraction of a second determines the winner of the match.

MATERIAL AND METHODS

Participants

The research sample consisted of 19 epée fencers ages 15-18 years (12 boys, 16±1.1 years and 7 girls, 16.4±0.9 years). Five test subjects were selected as a control group. This group was measured only on the entrance and exit tests and did not undergo any specific reaction time training. The others (14 subjects) formed the experimental group and underwent reaction time training. The research study was approved by the ethical committee of the J.E. Purkyně University in Ústí and Labem under the registration no. 2/2015/11 on the 6th of November 2015. The test subjects provided their informed consent. In the case of youths under 18 years of age, parents were asked to sign the informed consent form indicating voluntary participation of their child in the research. Before the first testing took place, the test subjects were informed about the measurement and testing procedures. None of the test subjects had health difficulties during the testing period.

Procedures

The results for simple and choice reaction time were first collected on a Fitrosword device (Fitronic, s. r. o., Slovak Republic) during the entrance test (TEST1). Test subjects reacted with a specific movement maneuver of the armed arm and tried to hit the target, which was set specifically to the height of a particular fencer (the middle of the target was placed at the height of the fencer's xiphisternum while standing in an upright position). The software SWORD (Fitronic, s. r. o., Slovak Republic) generated three different LED stimuli (red, green, yellow) above the target according to a predetermined protocol. Test subjects had to perform a direct hit with the Uhlmann epée (750 g) by extension of the elbow joint when the red LED light was illuminated, or bounced the horizontal obstacle and then hit the target when the green LED light was illuminated. When the yellow LED light was illuminated, the test subjects were told not to react to the stimulus by any movement. Each fencer stood in a guard position before the stimuli occurred (the angle in the elbow joint was 90 degrees) with the weapon guard placed on the horizontal obstacle (Figure 1), which was 125 cm away from the target. A vertical obstacle was placed halfway to the target (for right handed fencers to the left, for left-handed to the right) (Figure 2).

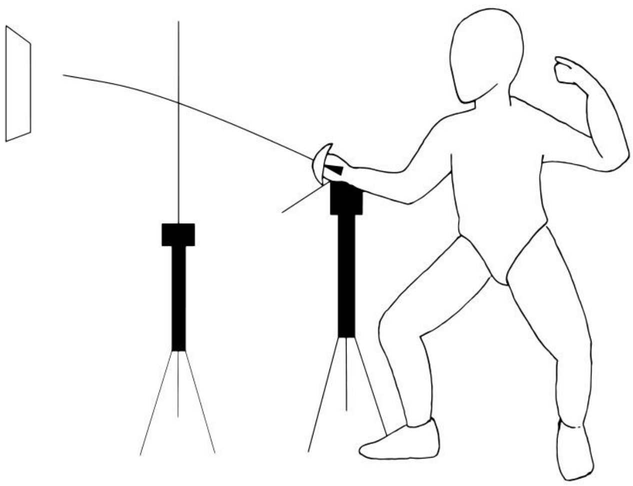


Figure 1. Fencer in guard position before the LED light stimulus.

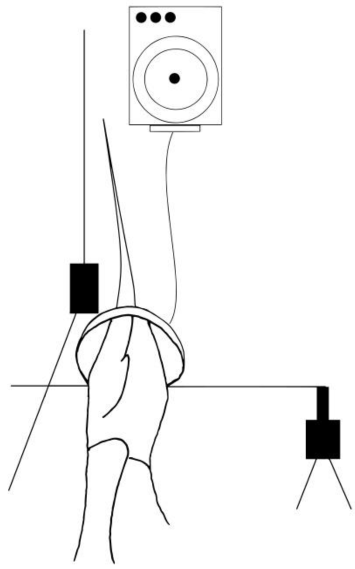


Figure 2. The position of the weapon of the right-handed fencer before the LED light stimulus.

For the simple reaction time (SRT), 20 stimuli were generated during the testing when the red LED light was illuminated (interval of the stimuli occurrence was 500 – 2000 ms). For the CRT, a randomized sequence of 10 stimuli of the red LED, 10 stimuli of the green LED, and 7 stimuli of the yellow LED was set with different durations between the occurrence of the stimuli (500 – 2000 ms). The reaction time training was conducted using the Electronic Fencing Target (Favero EFT-1), which makes it possible to let the fencer hit one of five small targets after it lights up. Participants of the experimental group trained twice a week for a 9-week period. The overall training time was 350 minutes. In each training session, they used a repetition method to affect the reaction time level. For the SRT training, they hit one of the five small targets on the EFT-1. During the choice reaction time (CRT) training, the program was set so that the light would illuminate randomly on one of the five targets. A total of 50 stimuli occurred during one sequence for both the SRT and CRT training. Between the SRT and CRT trainings, a two-minute rest period was provided. This process continued until the test subjects had finished the 15-minute training. This maximum training duration was determined by potential fatigue of the muscles of the arm in which the test subjects had a weapon. Both groups (experimental and control) underwent an exit test (TEST2) using the Fitroword device after the 9-week training period. The reaction time training took place during the preparatory period (January – February 2016) so as not to interfere the performance during championship competitions.

Statistical Analysis

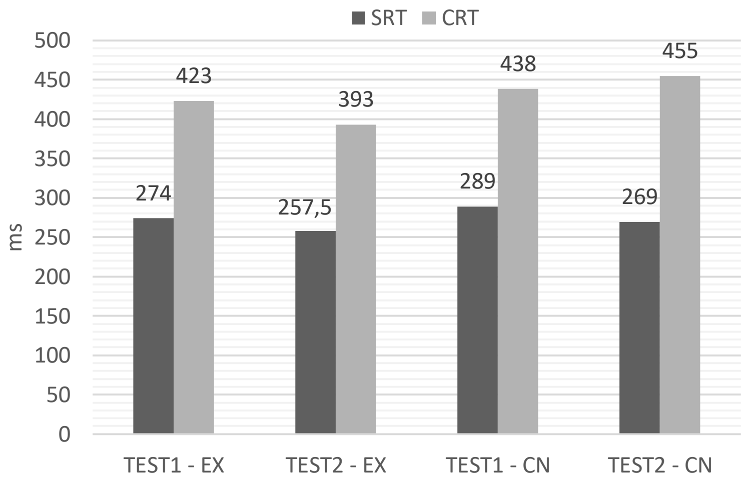
The results from the SWORD software were processed with the software Statistica (StatSoft Inc, 2016). Anticipated and error attempts were excluded from the sample; in the case of the SRT, this included times under 100 ms or above 1000 ms, and in the case of CRT, this included times under 160 ms or over 2000 ms. For statistical analysis, 15 "correct" attempts (i.e., excluding the anticipated and error attempts) in a sequence were used. The Shapiro-Wilks test confirmed that the data were not normally distributed. The median difference between the groups (experimental vs. control) was determined with the Mann-Whitney test. Median differences in one group (TEST1 vs. TEST2) were examined with the Wilcoxon test. Because of the small number of test subjects, the effect size was also calculated. Statistical significance was defined as $p < 0.05$. The significant difference was determined when a middle effect size was found.

RESULTS

Based on the statistical procedures, we can conclude that the levels of selected variables manifested significant differences. The results show that the level of SRT and CRT may have been affected by the reaction time training intervention. The differences are presented in Figure 3 and Table 1.

Table 1 shows that the reaction time of the experimental group was significantly improved in terms of CRT (p = 0.013, r = 0.469). The middle effect size was also found for SRT (p = 0.109, r = 0.303).

Table 2 shows that the experimental and control group had no difference in CRT in the entrance test (TEST1) and in the exit test (TEST2). No difference between the groups was apparent, even in SRT on the exit test (TEST2). Interestingly, CRT in the exit test (TEST2) was shorter in the experimental group than the control group. This difference was determined as significant in terms of effect size (p = 0.116, d = 0.722).



TEST1–EX= entrance test in experimental group; TEST2–EX= exit test in experimental group; TEST1–CN= entrance test in control group; TEST2–CN= exit test in control group; SRT= simple reaction time; CRT= choice reaction time

Figure 3. Reaction time among the observed groups.

Table 1. Differences in reaction time after the training intervention.

Group	Reaction	p	r
EG	SRT	0.109	0.303*
	CRT	0.013	0.469**
CG	SRT	0.418	0.256
	CRT	0.345	0.298

*r>0.3; **p<0.05 and r>0.3; EG = experimental group; CG = control group; SRT simple reaction time; CRT = choice reaction time

Table 2. Differences between the experimental and control group of fencers.

Type of test	p	d
SRT (TEST1)	0.211	0.573†
SRT (TEST2)	0.781	0.127
CRT (TEST1)	0.991	0.000
CRT (TEST2)	0.116	0.722†

†0.5<d>0.8; SRT (TEST1) = simple reaction time in entrance test; SRT (TEST2) = simple reaction time in exit test; CRT (TEST1) = choice reaction time in entrance test; CRT (TEST2) = choice reaction time in exit test.

DISCUSSION

The ability to influence reaction time is difficult, and authors have reported varied findings in this regard. Wang [20] states that the level of simple reaction time can be efficiently influenced by training. Based on the genetic predispositions of this variable, Měkota and Novosad [21] and Barcelos et al. [22] state that reaction time improvement is limited. Most studies investigating reaction time have included comparisons of reaction time among different performance groups of athletes. Athlete levels are then compared with the non-sport active population. Less frequent are studies that observe the progression of reaction time in relation to training. To a certain extent, the level of reaction time can be influenced by the repetition, sensory or analytical methods [23].

The critically sensitive period for reaction time improvement occurs approximately 13 – 14 years of age. The sensitive period for choice reaction time is slightly shifted to 15 – 20 years. However, Havel and Hnízdil [24] stated that the positive trend in reaction time progression is possible to observe in the fifteenth year of life, and after that phase the reaction time stabilization period follows. In the present study, fencers were selected within the range of the "sensitive age period," where it is possible to expect progression in the observed variables. It is, however, important to add that a certain amount of progression depends on many individual factors. Authors of many publications state that reaction time also depends on factors such as age, warm-up, air temperature, type of the occurring stimuli, nerve pathways quality, receptor sensitivity, etc. Alter [25] states that an optimally performed warm-up can positively influence the conductivity of the nerve pathway and signal transfer. On the other hand, Behm et al. [26] state that there is a negative influence of static stretching on the reaction time. Given this finding and in order to assure standardized and equal conditions for all test subjects, the same type of stretching and warm-up was utilized (either static or dynamic) before the entrance and exit test. Numerous prior studies have analyzed differences in reaction time with the use of different intervention techniques (caffeine, nicotine, changes in the light or sound conditions, exhaustion thresholds, etc.). Further, the possibilities of influencing reaction time and the speed of stimuli processing have been investigated from a variety of views by many authors [27,28,29,30].

It is universally acknowledged that experienced athletes are faster and better in terms of information processing than beginners. Schmidt and Wrisberg [10] state that the sufficient amount of experience could significantly influence reaction time. In extreme cases, elite athletes seem to have automatic reactions. On the other hand, Barcelos et al. [22] state that there are no significant differences in simple reaction time between athletes that have been active and sport inactive people (p = 0.8065). This finding correlates with the study results of Kida et al. [31], who also did not find a statistically significant difference in this variable between a group of elite baseball batters and beginners. These conclusions support the assumption that in some sports, the reaction time is not the main predictor of a successful sport performance. Anticipation plays an important role in sport performance. In many sport areas, athletes are able to predict the following turn of events and adequately choose the type and timing of a suitable reaction movement [10]. This relates to the so-called "automatization" during information processing in the central nervous system. The automatization training is more efficient in situations when we use the same stimulus, which always initiates the same response. The shortening of reaction time occurs not only during repeating the same stimuli combination for a simple reaction but also during choice reaction time when one reacts to two or more stimuli. We are convinced that based on these findings, it is possible to verify whether there are efficient methods that could decrease the levels of reaction time in a sports area where this variable plays a key role in overall sport performance. The results of the statistical analysis in the present study show that the levels of simple and choice reaction time manifest differences. The level of choice reaction time during which test subjects reacted to three stimuli significantly decreased in the experimental group following the training (p = 0.013, r = 0.469). A middle effect size between the entrance and exit test among this group of fencers was also overt in the case of a simple reaction to one stimulus (p = 0.109, r = 0.303).

Based on the results of the present study, it is possible to conclude that choice and simple reaction time can be positively influenced by suitable training. In terms of assessing changes in reaction time, differences in simple and choice reaction time among the experimental and control groups were observed. No significant difference between the groups was observed in terms of simple reaction time for the exit test after the training process. The interesting finding was that choice reaction time of the experimental group was significantly shorter than that of the control group after the training intervention. This difference was in the middle effect size level (p = 0.116, d = 0.722). A shorter simple reaction time was also identified for the experimental group in the entrance test (p = 0.211, d = 0.573) in comparison to the results of the control group. The reaction time training utilized conditions that were similar to real fencing situations, during which fencers reacted to visual stimuli from the guard position by an adequate movement of the armed arm. This procedure assured the training was "optimal" according to actual fencing conditions. Some previous studies have used interventions that should influence reaction time, but in these studies, the entrance and exit tests were conducted on a table reactimeter (the device for the measurement of the reaction time) in a seated position. However, the reaction time measured by a reactimeter cannot be equal to the reaction speed that corresponds to real conditions in a particular sport. For this reason, the results from the table reactimeter cannot always be considered to be predicative of performance because differences in reaction time are observed between the table reactimeters and other devices. That simply means that the reactions of a particular body part responsible for fine motor control are not as fast as the responses of body parts for gross motor control. We can say that the entrance and exit tests were measured under standard conditions for fencing. In some studies [32,33], authors have stated that reaction time is shorter in men than in women. However, there are studies where the opposite phenomenon has been demonstrated [34]. For this reason, it is not possible to say with certainty that reaction time is shorter in men than in women. It should also be noted that in most studies, only mature individuals were observed. It despite the results of the reaction time it is necessary to mention that obtaining of maximum effectiveness in championship competitions is associated with effort, complex skills, predisposition and other factors [35,36,37].

CONCLUSION

Based on the results of the present study, we can conclude that reaction time training utilizing real situations of a particular sport can positively influence the reaction time level. More test subjects of different age groups should be used in future research in this area. Results from other studies could be supported by utilizing a longer time period of specific training for improvement of reaction time. Furthermore, it would be appropriate to compare the differences in reaction time between girls and boys in future studies. We are aware that the reaction time level is just one of many possible factors influencing overall performance in fencing. Bearing in mind the limitations of this study, trainers could use the knowledge provided to construct suitable training methods that would lead to improved performance of their athletes.

ACKNOWLEDGEMENT

The research was conducted with the support of the Specific University research grant SGS in the J.E. Purkyně University in Ústí nad Labem. We thank all tested participants for their participation in this study. The authors declare that there are no conflicts of interest.

REFERENCES

1. Borysiuk Z, Waskiewicz Z: Information processes, stimulation and perceptual training in fencing. Journal of Human Kinetics 2008; 19: 63-82
2. Czajkowski Z: Tactics in fencing – preparatory actions. Studies in Physical Culture and Tourism 2009; 16(4): 371-377
3. Gracz J, Tomczak M: Selected temperamental properties and achievement motivation of fencers. Studies in Physical Culture and Tourism 2008; 15(2): 109-118
4. Iermakov S, Podrigalo LV, Jagiełło W: Hand-grip strength as an indicator for predicting the success in martial arts athletes. Arch Budo 2016; 12: 179-186
5. Balkó. Š. The surface electromyography in fencing. The analysis of the acyclic movement in three different performance level groups of fencers. Opole: Opole University of Technology, 2016
6. Wąsik J, Góra T: Impact of target selection on front kick kinematics in taekwondo–pilot study. Phys Activ Rev 2016; 4: 57-61
7. Tyshler D, Tyshler G: Fencing. Moscow: Physical Education and Science Press, 1995
8. Czajkowski Z: Understanding Fencing: the unity and practice. Staten Island, NY: SKA Swordplay Books, 2005
9. Poliszczuk T, Poliszczuk D, Dąbrowska-Perzyna A, Johne M: Asymmetry of complex reaction time in female épée fencers of different sports classes. Polish Journal of Sport and Tourism 2013; 20(1): 25-29
10. Schmidt RA, Wrisberg CA: Motor learning and performance: A situation-based learning approach. 4th ed. Champaign IL: Human Kinetics, 2008
11. Borysiuk Z: Psychomotor reactions in fencing dependence of stimuli type. Rev Bras Cineantropom Desempenho Hum 2008; 10(3): 223-229
12. Borysiuk Z: The significance of sensorimotor response components and EMG signals depending on stimuli type in fencing. Acta Universitatis Palackianae Olomucensis Gymnica 2008; 38(1): 43-54
13. Harmenberg J, Ceci R, Barvestad P, Hjerpe K, Nyström J: Comparison of different tests of fencing performance. Int J Sports Med 1991; 12: 573-576
14. Williams LRT, Walmsley A: Response amendment in fencing: differences between elite and novice subjects. Percept Motor Skill 2000; 91: 131-142
15. Williams LRT, Walmsley A: Response timing and muscular coordination in fencing: A comparison of elite and novice fencers. Journal of Science and Medicine in Sport 2000; 3(4): 460-475
16. Colin W: Apects of fencing technology. Sword 2008; 94: 24
17. Gierczuk D, Lyakh V, Sadowski J, Bujak Z: Speed of Reaction and Fighting Effectiveness in Elite Greco-Roman Wrestlers. Percept Motor Skill 2017; 124(1): 200-213
18. Kohlíková E: Pohybový systém a jeho řízení. In S. Bartůňková et al. (eds.), Fyziologice pohybové zátěže, Praha: FTVS UK, 2013; 58-81[in Czech]
19. Šteffl M, Bartůňková S: Fyziologické základy tréninku. In S. Bartůňková et al. (Eds.), Fyziologice pohybové zátěže, Praha: FTVS UK, 2013; 125-141 [in Czech]
20. Wang J: Reaction-time training for elite athletes: a winning formula for champions. International Journal of Coaching Science 2009; 3(2): 67-78
21. Měkota K, Novosad J: Motorické schopnosti, Olomouc: FTK UPOL, 2005 [in Czech]
22. Barcelos JL, Morales PA, Maciel RN, Azevedo MMA, Silva VF: Time of practice: a comparative study of the motor reaction time among volleyball players. Fitness Performance Journal 2009; 8(2): 103-109
23. Dovalil J: Výkon a trénink ve sportu. Praha: Olympia, 2009 [in Czech]
24. Havel Z, Hnízdil J: Rozvoj a diagnostika rychlostních schopností. Ústí nad Labem: PF UJEP, 2010 [in Czech]
25. Alter MJ: Sport stretch. 311 stretches for 41 sports. Champaign, IL: Human Kinetics, 1998
26. Behm DG, Bambury A, Cahill F, Power K: Effect of acute static stretching on force, balance, reaction time and movement time. Medi Sci Sport Exer 2004; 36: 1397-1402.
27. Arcelin R, Brisswalter J, Delignieres D: Effect of physical exercise duration on decisional performance. J Hum Movement Stud 1997; 32: 123-140

28. Davranche K, Audifren M: Facilitating effects of exercise on information processing. J Sport Sci 2004; 22: 419-428
29. Chmura J, Krysztofiak H, Ziemba AW, Nazar K, Kaciuba-Uscilko H: Psychomotor performance during prolonged exercise above and below the blood lactate threshold. Eur J Appl Physiol O 1998; 77: 77-80
30. Kashihara K, Nakahara Y: Short-term effect of physical exercise at lactate threshold on choice reaction time. Percept Motor Skill 2005; 100: 275-291
31. Kida N, Oda S, Matsumura M: Intensive baseball practice improves the Go/No go reaction time, but not the simple reaction time. Cognitive Brain Res 2005; 22(2): 20-27
32. Flegr J, Novotná M, Lindová J, Havlíček J: Neurophysiological effect of the Rh factor. Protective role of the RhD molecule against Toxoplasma-inducted impairment of reaction times in women. Neuroendocrinol Lett 2008; 29(4): 475-481
33. Jaworski J, Tchórzewski D, Bujas P: Involution of simple and complex reaction time among people aged between 21 and 80 – the results of computer tests. Human Movement 2011; 12(2): 153-158
34. Štulrajter V: Situation-specific reaction time measurement in sportsmen (fencers). Activ Nerv Super 1987; 29(3): 170-171
35. Ortenburger D, Wąsik J, Góra T. Selected dimensions of the self-esteem and a kinematic effect of the intentional target at taekwondo athletes. Arch Budo Sci Martial Art Extreme Sport 2016; 12: 117-121
36. Ortenburger D, Wąsik J, Góra T. Report of the 1st World Congress on Health and Martial. Arts in Interdisciplinary Approach 17-19 September 2015 Czestochowa. Phys Activ Rev 2015; 3: 49-51
37. Ortenburger D, Wąsik J, Bukova A. Taekwondo training in the context of dealing with negative emotions. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 99-104

Cite this article as:
Balkó S, Rous M, Balkó I, Hnízdil J, Borysiuk Z. Influence of a 9-week training intervention on the reaction time of fencers aged 15 to 18 years. Phys Activ Rev 2017; 5: 146-154