Svetlana Petronijević[1], Adam Petrović[1,2], Nemanja Ćopić[1], Srecko Jovanović[1] and Ivanka Gajić[1,2]

THE INFLUENCE OF MATURATION ON THE SPEED OF THE INDIVIDUAL HAND MOVEMENTS IN FENCING

[1]Faculty of Sport, University „Union – Nikola Tesla", Belgrade, Serbia
[2]Faculty of physical education and sport, Tambovski state university - G.R. Derzhavin, Russia

Original research

Abstract
The problem of this research is: what is the characteristic of the speed of individual hand movements, and how to change the response time in children aged 8 to 14 years? The aim of the study is to determine the response time i.e. the speed characteristics of individual movements of the dominant hand, the non-dominant hand and the dominant hand with the fencing foil in relation to age. The hypothesis is that maturation affects the speed of individual hand movements and the simple reaction time (SRT) i.e. response time.The sample consisted of 184 subjects aged 8 to 14 years. The study used the one-target shot - Electronic Fencing Target on the Favero Scoring device. The speed of individual movement of the dominant hand (Dom_H), the speed of individual movement of the non-dominant hand (NDom_H) and the speed of individual movement of the dominant hand with fencing foil (Dom_H _F) were tested. Multivariate analysis of variance (MANOVA) found that the criterion of age, or maturation, has statistically significant influence on the speed of individual hand movements (Wilks' Lambda = 0.519; F = 4.105; p = 0.000). The highest maturation effect was found in the speed of individual movement of the dominant hand with fencing foil (Dom_H_F - F = 6.923; p = 0.000; PES = 0.289), while in the Dom_H test (F = 4.782; p = 0.000; PES = 0.220) and NDom_H (F = 4.671; p = 0.000; PES = 0.216) was found a slightly lower effect. Maturation has a positive effect on the speed of individual hand movements in children aged 8 to 14. The effect is the highest when the fencing foil is used.
Key words: fencing foil, dominant hand, non-dominant hand, simple reaction time

Introduction

Speed is one of the most important abilities for success in sports. It has been the subject of many researches in various sport's disciplines (de Brito & Silva, 2011; Dube, Mungal, & Kulkarni, 2015; Nakamoto & Mori, 2008; Sheppard & Young, 2006). Also, the speed has its place in many theoretical concepts as an integral part of theory of motor abilities motor skills theory (Kukolj, 2006; Petrović, 2014; Platonov, 1999, 2004).

The speed of a human is divided onto the speed in a straight line - maximum speed, as well as onto the speed of change of direction - agility (Petrović, 2014).

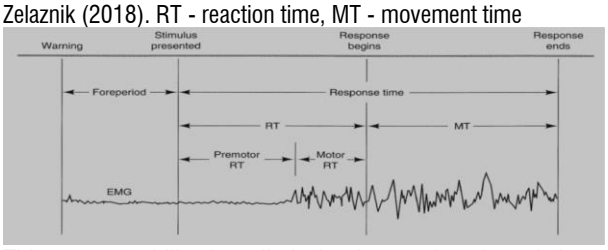
Speed structure as a motor ability consists of basic forms (Kukolj, 2006):

1) the speed of reaction refers to the time elapsed from a sign to the beginning of movement;
2) the speed of a individual movement means the shortest time it takes to perform a particular movement;
3) the frequency of movement represents the frequency of movement in the unit of time.

When it comes to the speed of individual movements and simple reaction time (SRT), this ability is expressed in numerous sports' disciplines and is the subject of many studies (Bhabhor et al., 2013; Kida, Oda, & Matsumura, 2005; Rotella & Bunker, 1978). Fencing is a sport where speed is dominant and specifically manifested.

Direct point technique without contact with a weapon is one of the basic techniques in fencing. This technique involves maximum quick reaction and performing a dominant hand movement with the fencing foil in conditions where target is moving.

Figure 1 Important moments involved in the reaction time paradigm, adapted from: Schmidt, Lee, Winstein, Wulf, and Zelaznik (2018). RT - reaction time, MT - movement time



This type of ability is called simple reaction time. It is expressed when there is only one stimulus that requires

only one type of response. The paradigm and theoretical concept of this phenomenon is shown in Figure 1.

Based on Figure 1, it can be seen that the structure of this movement includes:

1) warning, stimulus presented, response begins, response ends;
2) fore period, response time;
3) reaction time and movement time;
4) premotor reaction time and motor reaction time.

In fencing, this phenomenon is examined in relation to: different abilities (Chan, Wong, Liu, Yu, & Yan, 2011), athlete's level of success (Poliszczuk, Poliszczuk, Dąbrowska-Perzyna, & Johne, 2013), simple reaction time between beginners and trained athletes (Balkó, Borysiuk, & Šimonek, 2016), the relationship between reaction and executive functions (Xu et al., 2015). The unknown fact is related to the change in the speed of individual movement and the SRT during maturation. It is important to find it out, so the age differences and this phenomenon could be understood more precisely, as well as to supplement the knowledge of this phenomenon.

The problem of this research is: what is the characteristic of the speed of individual hand movements, and how to change the response time in children aged 8 to 14 years? The aim of the study is to determine the response time i.e. the speed characteristics of individual movements of the dominant hand, the non-dominant hand and the dominant hand with the fencing foil in relation to age. The hypothesis is that maturation affects the speed of individual hand movements and the SRT i.e. response time.

Methods

Study design

The research strategy involves a traditionally quantitative research approach with transversal studies design. This cross-sectional study covered a period of 7 years and 7 age categories, aged 8 to 14.

Sample

The study was conducted on the sample of 184 subjects aged 8 to 14 from Serbia. The study involved 84 male (M) subjects and 100 female (F) subjects. The sub-sample referring to: 8 years consisted of 20 subjects (M=8 and F=12); 9 years 19 (M=12 and F=7); 10 years 33 (M=12 and F=21); 11 years 35 (M=19 and F=16); 12 years 21 (M=8 and F=18); 13 years 26 (M=13 and F=13); 14 years 19 (M= 7 and F=12). All subjects are beginners in fencing, with no competitive experience.

Variables

Four variables were used in study, one independent and three dependent:

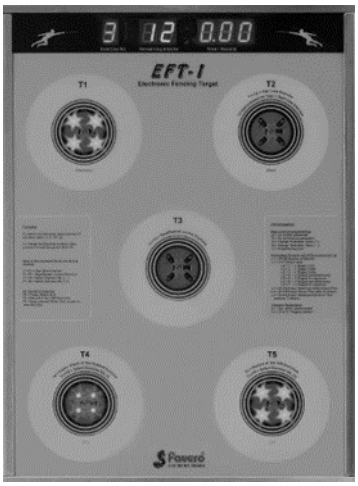
1) Age
2) The speed of dominant hand (Dom_H);
3) The speed of dominant hand with fencing foil (Dom_H_F);
4) Non-dominant Hand Speed (NDom_H).

Research procedures and equipment

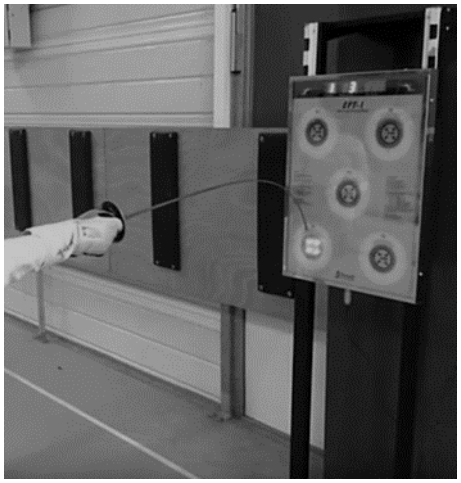
All subjects were divided into 7 age groups. During the four days, two groups were tested at 9 am. On the first day, groups of 8 and 9 years old were tested, on the second day groups of 10 and 11 years old, on the third day groups of 12 and 13 years old, and on the fourth day groups of 14 years old. In the study we used the one-target-one touch test - Electronic Fencing Target on the Favero Scoring device.

Figure 2 a) Test one target - one touch; b) Test one target - one shot; Electronic Fencing Target on Favero Scoring

a)



b)



In the first test, the subjects were given a task with touching one target (three middle fingers) as quickly as

possible with the dominant hand, which changed its position in five different fields (figure 2a). In the second test, the subjects had the same task, but this time with a non-dominant hand (figure 2a). Distance between the instrument and fingers is 20 cm, for both tests. In the third test, they were given the same task of conducting the dominant hand, but this time they used the "fencing foil" (figure 2b). Distance between the instrument and the top of fencing foil is 20 cm. Fencing foil's weight is 500g. As a result, in all tests, the mean expressed in seconds was taken, 10 successful attempts per test.

First, the speed of the dominant hand was tested (Dom_H), then the speed of the non-dominant hand (NDom_H), while in the third test, the speed of the dominant hand with the fencing foil (Dom_H_F) was tested. Tests were conducted separately and sequentially. When all subjects have completed the first test, they moved on to the second and then to the third test.

Data analysis

Descriptive statistics for all monitored variables are expressed through basic descriptive indicators (average value, standard deviation, variance, minimum and maximum). The relations of variables were determined by using the Pearson correlation coefficient. For determining the differences between the examined variables on the total sample - we used Independent - samples T-test. Multivariate analysis of variance (MANOVA) with Post Hoc analysis and Bonferoni test were applied to calculate the influence of independent variable (maturation, age) on dependent variables Dom_H, NDom_H, Dom_H_F. The significance threshold for statistical differences had 95% of probability, at $p = 0.05$. All statistical procedures were calculated using Microsoft ® Office Excel 2007 and SPSS for Windows, Release 17.0 (Copyright © SPSS Inc., 1989–2002).

Results

Table 1 shows descriptive indicators of dependent variables related to Mean (Mean), Standard Deviation (SD), Variance (Var), Minimum (Min), Maximum (Max), and sample size (N).

Table 1 Descriptive indicators for the variables examined

Variable	Mean± SD	Var	Min	Max	N
Dom_H (s)	0.70±0.14	0.020	0.45	1.23	178
Dom_H_F (s)	1.05±0.18	0.019	0.59	1.30	169
NDom_H (s)	0.66±0.14	0.021	0.17	1.07	120

Dom_H – dominant hand;
Dom_H_F – dominant hand with fencing foil;
NDom_H – non-dominant hand.
*Statistical significance ** p <0.01; * p <0.05*

The relationship between dependent variables is expressed by Pearson's correlation coefficient (r). All results are shown in Table 2. There is a slightly higher correlation between Dom_H and NDom_H variables $r = 0.576$, $n = 119$, $p < 0.01$, while a slightly smaller correlation between Dom_H and Dom_H_F variables $r = 0.42$, $n = 168$, $p < 0.01$ and the smallest between the Dom_H_F and NDom_H variables $r = 0.328$, $n = 117$, $p < 0.01$.

Table 2 shows the results of the T-test representing that there are statistically significant differences between the variables Dom_H & Dom_H_F ($t = -31.306$, $p < 0.01$) and the variables Dom_H_F & NDom_H ($t = 24.673$, $p < 0.01$), while between the variables Dom_H & NDom_H are no statistically significant differences ($t = 1.756$, $p > 0.05$). This test was applied to calculate difference between tested variables.

Table 2 Correlation and differences between the examined variables

Variables	Correlation		T test		
	N	*r*	Mean±SD	SEM	t
Dom_H & Dom_H_F	168	0.42**	-0.36±0.15**	0.011	-31.30
Dom_H & NDom_H	119	0.57**	0.02±0.12	0.011	1.76
Dom_H_F & NDom_H	117	0.33**	0.38±0.17**	0.015	24.67

Dom_H – dominant hand; Dom_H_F – dominant hand with fencing foil;
NDom_H – non-dominant hand.
*Statistical significance ** p <0.01; * p <0.05*

Table 3 shows the basic indicators of multivariate analysis of variance (MANOVA) with aim to calculate the effects of maturation on the speed of hand in fencing. Three dependent variables were used: the speed of dominant hand, the speed of dominant hand with fencing foil, and the non-dominant hand speed. The independent variable was maturation (age). Preliminary testing verified the assumptions about the homogeneity of the variance and covariance matrix as well as the variance equality. A statistically significant difference was found between the different age groups of 8 to 14 years Wilks' Lambda $= 0.519$, $F = 4.105$, $p < 0.01$. Also, statistically significant difference was found in the examined dependent variables related to age. For the Dom_H variable we calculated values $F = 4.782$, $p < 0.01$, PES $= 0.220$; Dom_H_F $F = 6.923$, $p < 0.01$, PES $= 0.289$; NDom_H $F = 4.671$, $p < 0.01$, PES $= 0.216$.

Table 3. Basic indicators of multivariate analysis of variance (MANOVA)

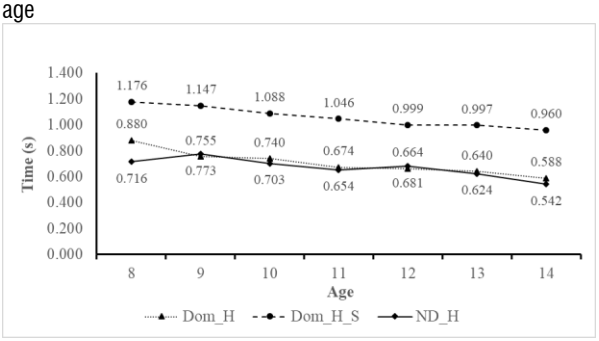
Variables	Effect	Value	F	*p*	Partial Eta Squared
Age	Wilks' Lambda	0.519	4.105	0.000	0.196
Age	Dom_H		4.782	0.000	0.220
	Dom_H_F		6.923	0.000	0.289
	NDom_H		4.671	0.000	0.216

*Dom_H – dominant hand; Dom_H_F – dominant hand with fencing foil; NDom_H – non-dominant hand; Statistical significance ** p <0.01; * p <0.05*

Table 4 shows the calculated values of the Post Hoc analysis using the Bonferoni test. Results show a statistically significant difference of (Dom_H) between 8 and 12 years p = 0.031, 8 and 13 years p = 0.009, 8 and 14 years p = 0.000; 9 and 14 years p = 0.012; 10 and 14g. p = 0.031. Regarding the speed of the dominant hand with fencing foil Dom_H_F, there are statistically significant differences between 8 and 12 years p = 0.015, 8 and 13 years p = 0.017, 8 and 14 years p = 0.001; 9 and 11 years p = 0.024, 9 and 12 years p = 0.003, 9 and 13 years p = 0.003, 9 and 14 years p = 0.000; 10 and 14 years p = 0.021. In the test of speed for non-dominant hand (NDom_H) there are tatistically significant differences between 9 and 13 years p = 0.026, 9 and 14 years p = 0.000, 10 and 14 years p = 0.004, 12 and 14 years p = 0.042.

Figure 3 Mean values expressed in seconds (s) for all age groups are shown. An increasing trend in hand speed was observed for all measured variables. The results show that there is a slight difference in the speed of the dominant and non-dominant hand, and that the speed of the dominant hand with the fencing foil is smaller than the speed of the non-dominant and dominant hand.

Figure 3 Response time - indicators of mean value related to age



Discussion

The results show that the speed of individual movement and the required reaction time when using the fencing foil decreases over the age range from 1.176s to 0.960s, and it is known that for top fencers this time can be reduced up to 0.262s, while the same study shows that SRT in beginners aged 21.3 years is 0.292s (Balkó et al., 2016). The reaction time of top fencers can go up to 0.216s when the target moves (Gutiérrez-Dávila, Rojas, Caletti, Antonio, & Navarro, 2013). It was found that the speed of individual movement (response time) of the dominant and non-dominant hand were approximately the same, there are no statistically significant differences between mentioned variables. However, when the fencing foil is added, while performing the task, the movement speed and response time decrease significantly. This can be explained by the fact that the speed of individual movement decreases in the situation when the external load and complexity of movement increases which is in

Table 4 Indicators of Post Hoc analysis of the examined variables using the Bonferoni test.

Dependent	Age		Mean Difference (I-J)	Std. Error	*p*	95% CI	
						Lower	Upper
Dom_H	8	12	0.165804*	0.051	0.031	0.008	0.324
		13	0.175776**	0.048	0.009	0.025	0.326
		14	0.226723**	0.050	0.000	0.070	0.383
	9	14	0.150294*	0.042	0.012	0.019	0.282
	10	14	0.122136*	0.037	0.031	0.006	0.238
Dom_H_F	8	12	0.196696*	0.056	0.015	0.021	0.372
		13	0.185093*	0.054	0.017	0.018	0.352
		14	0.233277**	0.056	0.001	0.059	0.407
	9	11	0.149167*	0.045	0.024	0.010	0.288
		12	0.187292**	0.047	0.003	0.039	0.335
		13	0.175688**	0.044	0.003	0.038	0.314
		14	0.223873**	0.047	0.000	0.078	0.370
	10	14	0.140495*	0.041	0.021	0.011	0.270
NDom_H	9	13	0.148986*	0.045	0.026	0.009	0.289
		14	0.231569**	0.047	0.000	0.084	0.379
	10	14	0.161393**	0.042	0.004	0.031	0.292
	12	14	0.13886*	0.044	0.042	0.002	0.275

*Dom_H – dominant hand; Dom_H_F – dominant hand with fencing foil; NDom_H – non-dominant hand. Statistical significance ** p <0.01; * p <0.05*

accordance to the theoretical concept of motor abilities and interpretation of the concept of speed (Kukolj, 2006; Petrovic, 2014).

The speed of movement of the hands increases with the maturation of a person and is approximately equal to the increase in the speed of the left and right sides, i.e. the dominant and non-dominant hands. In general, the phenomenon of the reaction of the dominant and non-dominant hand develops equally when considering other types of reaction at the age of 15 and 18 (Poliszczuk et al., 2013). Age affects dominantly the speed of individual movement when the fencing foil is added. This may indicate that at the same time, under the influence of maturation, speed and coordination abilities are improved. The explanation may lie in the fact that during maturation motor abilities are differentiated. Accordingly, the greater the participation of several different abilities, in a particular movement during maturation, the greater effect of maturation is when performed more complexly than performing simple movements. Based on the results presented in this study, the hypothesis confirmed that maturation influences the speed of individual hand movements, and the greatest maturation effect was found on the speed of the dominant hand with the fencing foil.

The results indicate that this period is a minimum of two years when referring to the speed of dominant hand with fencing foil, and four years for speed of dominant and non-dominant hand. This leads us to the fact that around the age of 9, the child's organism is in a sensitive or "critical" period for maturation or increasing speed and coordination abilities, as confirmed by other studies (Kukolj, 2006).

There is a relative balance of motor abilities between boys and girls up to 12-13 years (Kukolj, 2006). This may be explained by the reason why it takes more time for qualitatively fast movement when examining the speed of movement without a fencing foil. Complicating the movement further examines the involvement of different abilities in a given activity, therefore that kind of ability is more sensitive to examination. It takes more time to notice the difference between boys and girls when one ability is monitored as well as less time when more than one ability is monitored.

Conclusion

The speed of individual movements and simple reaction time have become one of the most important topics of research in many sports. There is a relatively uniformed motor development between male and female, and accordingly to the speed of the dominant hand and the non-dominant hand does not differ significantly between 7 and 14 years. There is a trend of increasing speed, but this difference is not significant. The difference in speed occurs when movement is more complex i.e. when the fencing foil is used. The speed of the dominant hand with the fencing foil is mostly influenced by maturation. It was found that minimum two years were needed to make a qualitative difference in the speed of the dominant hand when using the fencing foil, and the critical period began at the age of 9. It was found that minimum four years were needed to make a qualitative difference in the speed of the dominant and non-dominant hand.

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Coresponding Author
Svetlana Petronijevic,
Faculty of Sport, University „Union – Nikola Tesla“, Belgrade, Serbia
email: svetlana.petronijevic@fzs.edu.rs

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