THE RELATIONSHIP BETWEEN THE INTENSITY OF EXERCISE AND SIMPLE REACTION TIME IN AMATEUR SPORTSPEOPLE

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- aerobic work-out.

Abstract:
The aim of this study was to assess the relationship between the type of exercise and reaction times for individuals who do not practise sport professionally. The analysis involved 17 men aged 21 (body height: 182.6±6.7 cm; weight: 78.9±6.2 kg; BMI: 23.6±1.2). Each of them underwent tests including running for 300m to represent an anaerobic lactic acid work-out and a Cooper test representing aerobic work-out. The measurement of reaction time was performed five times: before exercise, immediately after it, 3 minutes, 6 minutes and 9 minutes after work-out. The analysis showed that the anaerobic lactic acid work-out significantly affects the level of reaction time causing its shortening. The study also found that there were no significant changes in the level of reaction time after aerobic work-out.

INTRODUCTION

Body fatigue caused by exercise can take different routes. Depending on the type of exercise there are different symptoms of fatigue. During lengthy work-outs fatigue occurs in the lower limbs, trunk and respiratory muscles. It is accompanied by an increase in body temperature, increased sweating and increased heart rate and respiration [Krakowiak R., *et al*. 2013]. In short duration effort with maximum intensity work-out of the nervous and muscle systems reach the limit values. The human body is therefore unable to maintain maximum stimulation for any length of time. The flow of impulses is so rapid that a defensive braking process arises in the cortex, which leads to a reduction in fatigue of the nervous system. High intensity short duration work-outs also lead to an impairment of muscle tone process, a reduction in ATP production, and dyspnoea (because the demand for oxygen is ten times greater than the delivery capabilities) [Chmura J. and Wiśnik P. 2008; Amann M. *et al.* 2009]. Fatigue affects the level of psycho-motor abilities including responsiveness and efficiency in performance [Chmura J. and Wiśnik P. 2008].

Many studies do not provide conclusive evidence concerning the effects of fatigue on the level of motor coordination abilities including the speed of reaction [Aune T. K. et al. 2008]. The differentiator in changes of psychomotor dispositions is the intensity of the effort. The direction of this differentiation is not explicit [Davranche K. et al. 2006; Utter A.C., et al. 2007]. Studies show that an optimal state of stimulation of the central nervous system conditioning the high level of psychomotor performance is maintained during moderate intensity exercise [Aune T. K. et al. 2008]. The results indicate the need to analyse changes in the level of response time due to fatigue [Mc Morris T., et al. 2005; Labelle V., et al. 2013; Davranche K. et al. 2006]. Tests assessing the level of these abilities have varying effects. One case study shows that the biggest progress of reaction time concerns tests of finger or hand movements, or voice response [Audiffren M., at. al. 2008; Shinohara M., et al. 2003].

Others have shown statistically significant deterioration of the parameter in the test involving the entire body of the subject after intense exercise [Davranche K., et al. 2006; Mc Morris. T., et al. 2005; Delignieres D., et al. 1994; Szafraniec R., et al. 2012].

A quick response plays a significant role, it may be a factor which allows to avoid mistakes in making everyday decisions. In situations of fatigue responding too early or too late may be the cause of many accidents [Jurecki R. S., Mikołajczyk R. 2006]. Reaction time is also an important factor in an individual's performance in different sports. In most cases reaction time brings the competitor closer to victory. In disciplines such as swimming or athletics it determines the final result [Tonnessen E., et al. 2013; Nuri L., et al. 2013; Balilionis G., et al. 2012]. In martial arts including karate or taekwondo there are also a great many movements which require: a quick response. In these cases reaction time is the key element because performance is based on explosive techniques [Boroushak N., et al. 2014; Chaabene M. H. et al. 2012; Bołoban W., 2009]. A kick can be executed faster than the reaction to a blow, especially when it is not indicated by the opponent [Bołoban W., 2009]. However in team sports games the speed of reaction and quick selection of an appropriate motor response can gain an advantage over the opponent [Subramanyam V. and Kuldeep S., 2013].

The body undergoes various changes depending on the duration of the work-out and its intensity. During a work-out done at a supercritical rate an increase in lactic acid and the creation of a large oxygen debt are observed, which makes it impossible to continue the exercise.

Exercising at a critical speed is connected with increased oxygen consumption, increased frequency of contractions of the heart and an increase in blood lactate [Brickley G., et al. 2002]. It was observed that the growth of lactic acid followed a continuous work-out at constant intensity [Smith C. G. and Jones A. M., 2001]. Such exercises are not without an effect on the alertness of an athlete. The research conducted by Audiffren *et al*. shows that a 40-minute ride on a bicycle ergometer intensified changes in an athlete's body and caused a prolongation of reaction time [Audiffren M., et al. 2008].

A properly rapid response may be a factor in allowing people to avoid errors when making daily life decisions. Therefore the aim of the study was to determine the response time in individuals not practising sports. The main contribution of this work is to determine the relationship between the type of workout, time of rest (fatigue) and the level of reaction time.

MATERIAL AND METHODS

The analysis involved 17 men aged 21 (Table 1). The somatic built of subjects was characterized with basic somatic features (body height: 182.6±6.7 cm; weight: 78.9±6.2 kg; BMI: 23.6±1.2). The study group consisted of individuals who do not do any sports professionally.

Each of the men underwent tests including running for 300m representing an anaerobic lactic acid work-out. Participants in the study began the race from a standing start. Cooper test representing aerobic work-out. The experiments were conducted at an interval of two weeks. In both cases, the response time was measured before exercise (t_0), immediately after exercise (t_1), and 3 min (t_2), 6 min (t_3) and 9 min after exercise (t_4). Measurement of reaction time was made by using a reaction-time meter (MRK 432, Zabrze, Poland). Each of the men underwent tests including running for 300m representing an anaerobic lactic acid work-out. The reaction time study was conducted in a separate room so that external conditions would not significantly affect the measurement. The day before, and the day of testing, participants were asked not to consume any caffeine or alcohol or to carry out any intense exercise. Each study was performed individually in order to eliminate the possibility of remembering pacing impulses. The attempt involved a random selection of impulses to minimize the effect of learning. 20 impulses were used within 41 seconds. A signal light was hung at eye level of the person being tested who was meant to respond urgently to an irregularly-appearing light stimulus. To do this, participants pressed the button in response to a green light. After rejecting the extreme measurements the device provided the average reaction time. The result of measurement was given in milliseconds.The results obtained were statistically analysed by using basic statistical measures.

To assess the significance of differences the ANOVA for repeated measures was applied. The normality of the studied traits was verified by the Shapiro-Wilk test. The scope and project research has been assessed by the Bioethics Committee of the University of Rzeszów, which noted the absence of any contraindications and ethical violations (Resolution No. 02/05/2016 dated February 2, 2016 year).

Table 1. Characteristics of the study group (N = 17)

Variable		$\bar{x}$	x_{min}	x_{max}	sd	V [%]
Body height [cm]		182.6	173.0	198.0	6.7	4
Weight [kg]		78.9	67.0	89.0	6.2	8
BMI [kg/cm^2]		23.6	21.4	25.6	1.2	5
300 m distance	Time [s]	45.2	40.1	50.9	3.2	7
Cooper test	Distance [m]	2798.2	2400.0	3300.0	274.7	10

RESULTS

Table 2 presents the numerical characteristics of the measured reaction time. The analysis shows that the best reaction time after anaerobic work-out was achieved during the 9th minute after exercise (t_4), while the worst was recorded immediately before the test (t_0). When analysing the dispersion of individual measurements, it is noted that the largest dispersion for anaerobic exercise is characteristic for a time measured before the run (t_3).

Table 2. Characteristics of reaction times before and after exercise

Intensity	Times	Reaction time [ms]				
		$\bar{x}$	x_{min}	x_{max}	sd	V [%]
Run over 300m	t_0	252.8	216.2	301.5	18.3	7.3
	t_1	243.8	212.3	260.8	10.9	4.5
	t_2	234.7	209.2	259.2	10.8	4.6
	t_3	230.2	205.4	256.2	12.2	5.3
	t_4	225.3	206.9	246.2	12.8	5.7
Cooper test	t_0	271.5	244.6	332.3	23.0	8.5
	t_1	272.3	236.2	330.8	25.3	9.3
	t_2	273.6	219.2	320.0	31.4	11.5
	t_3	270.0	230.8	322.9	31.1	11.5
	t_4	272.3	230.8	330.8	32.1	11.8

In the case of aerobic work-out the best time was recorded immediately before exercise, and the worst three minutes after exercise. In all the measurements of reaction time for aerobic exercise the dispersion of results was greater than is the case for anaerobic exercise. Additionally, in order to better illustrate the results obtained the average values for the individual measurements were juxtaposed on Figure 1. As the analysis clearly shows, reaction times for aerobic exercises are significantly greater than the reaction times for anaerobic work-out. While analysing the response times for anaerobic work-out a downward trend was noted. With the passage of time a shortening reaction time after physical exercise has been observed.

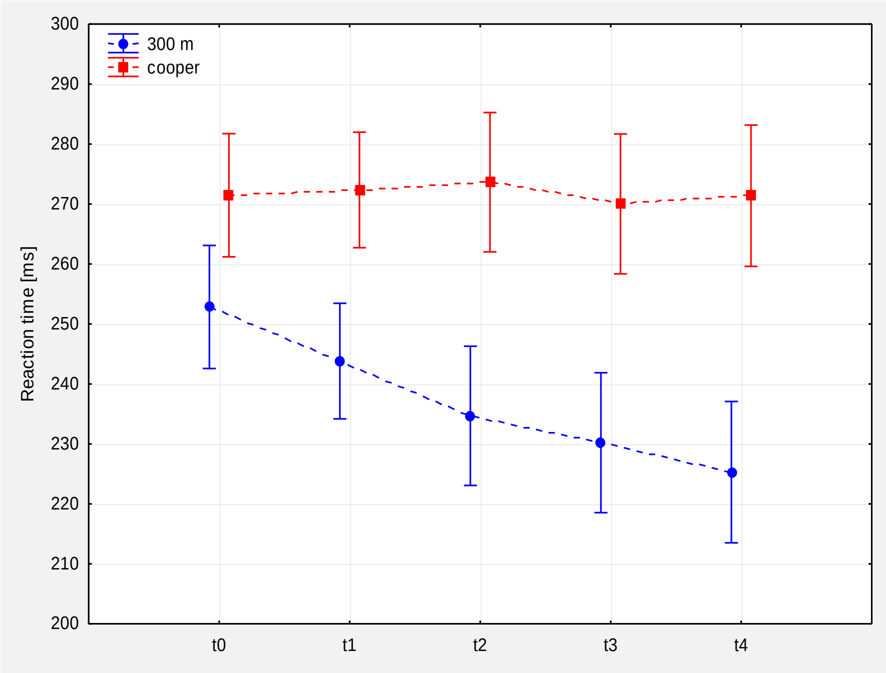

Figure 1. Mean values and confidence interval of reaction times

The statistical analysis with a post-hoc Bonferoniego test showed that the differences in consecutive measurements indicate statistical significance. The difference observed, in anaerobic work-out case, shows no statistical significance only between t_1 and t_3 (Table 3). However individual measurements for aerobic work-out can be considered permanent, because no difference shows statistical significance (Table 3). It is worth mentioning the fact that the type of work-out significantly differentiates most of the measurements of reaction time.

Table 3. Matrix of probability for the different reaction times before and after work-out

Intensity		Run over 300m					Cooper test				
Times		t_0	t_1	t_2	t_3	t_4	t_0	t_1	t_2	t_3	t_4
Run over 300m	t_0		1	0,006	0,001	0,001	0,807	0,601	0,385	1,000	0,825
	t_1	1		1	0,168	0,004	0,028	0,019	0,011	0,050	0,029
	t_2	0,006	1		1	1	0,001	0,001	0,001	0,001	0,001
	t_3	0,001	0,168	1		1	0,001	0,001	0,001	0,001	0,001
	t_4	0,001	0,004	1	1		0,001	0,001	0,001	0,001	0,001
Cooper test	t_0	0,807	0,028	0,001	0,001	0,001		1	1	1	1
	t_1	0,601	0,019	0,001	0,001	0,001	1		1	1	1
	t_2	0,385	0,011	0,001	0,001	0,001	1	1		1	1
	t_3	1	0,050	0,001	0,001	0,001	1	1	1		1
	t_4	0,825	0,029	0,001	0,001	0,001	1	1	1	1	

DISCUSSION

The paper analysed the course of reaction time after physical exercise of varying intensity. The subjects attempted two bouts of exercise: running for 300 m as maximum intensity effort (lactic acid anaerobic work-out), and a "Cooper test" reflecting a work-out based on aerobic processes. Body fatigue caused by physical exercise influences the level of psychomotor disposition in a variety of ways.

The first measurement of reaction time in both the 300m and Cooper test did not differ significantly. It was noted however that on the day on which the Cooper test was performed the times measured were longer. It can be assumed that the stress resulting from the adoption of long-term physical effort had had an impact on the speed of response. The research conducted by Mogg *et al*. has shown that fear can cause poor response [Mogg *et al*. 2008]. The study also shows that reaction time is affected by many other external factors. Jarraya stated that the time of day and sleep deprivation are an important influence on the level of reaction time [Jarraya *et al.*, 2014]. Similar conclusions were reached by Cote *et al.* [Cote *et al.* 2009], who also stated that sleep deprivation influences response time. It can thus be concluded that differences noticeable between the two measurements before exercise result from the determinants described earlier.

After anaerobic exercise a marked shortening of reaction time was observed during each measurement, as compared to the baseline as well as in relation to the previous measurement. It can therefore be assumed that the state of stimulation of the central nervous system is relatively high and persists for a long period of time after stopping exercise during the recovery phase (the last measurement was carried out 9 minutes after the work-out). One of the factors influencing a decrease in reaction time after work-out, in this case, may be a change in muscle tone. The increase in muscle tension accompanying the anaerobic lactic acid work-out allows for faster brain activity which indirectly affects the recorded reaction time (). The conclusions of the research carried out by Entyre *et al*. prove that isometric muscle contraction may affect the decrease in reaction time [Etnyre *et al*. 2002]. In turn, studies conducted by Davranche show that physical exercise increases the response rate of the individual which may lead to an improvement in reaction time. According to Davranche a reaction time recorded after a physical work-out was 13 msec shorter than the one measured after rest. [Davranche *et al.* 2006]. In this paper the biggest difference in the level of reaction time was noted between the measurements at rest (t_0) and the last measurement (t_4) (over 27 ms). In most cases the increments noted between various measurements are statistically significant.

The reaction time level after aerobic work-out is quite different. In this case, the value of this parameter does not generally change significantly with subsequent measurements after the cessation of the work-out as well as in relation to the baseline. The research carried out by Lemmink *et al*. confirmed the lack of dependency between aerobic work-out and reaction time. The research included a group of footballers divided into two sub-groups. After completing the training session the first sub-group performed an 8-minute work-out on an ergometer, while the second was resting. The analysis has shown that reaction speeds did not differ significantly between the groups [Lemmink *et al*. 2005]. Simiar conclusions were shared by Xi *et al* [Xi *et al.* 2015]. In this case the research studied men who performed a 20-80% VO2max work-out. The average reaction time for a work-out at 90% PWC (physical working capacity) was 301.8 msec; at 75% PWC – 288,6 ms; at 50% PWC – 294,9 msec, and at 25% PWC – 310,5 ms. The results obtained showed low correlation between VO2max and reaction time [Xi *et al*. 2015]. In our study the biggest increase was recorded between the third (t_2) and sixth minute (t_3) of the recovery phase, while the progress recorded does not show any significant features.

In summary it can be said that the speed of reaction time is significantly affected by an anaerobic work-out while an aerobic work-out does not directly affect changes in reaction time.

CONCLUSIONS

The analysis allows the following conclusions to be drawn:

- The physical effort of maximum intensity exercise (lactic acid anaerobic work-out) is a factor that greatly affects the reaction time and causes a significant reduction.
- There were no significantly bigger changes to the level of reaction time after aerobic workout; therefore it can be assumed that physical work based on aerobic processes, does not have a significant influence on the level and duration of reaction time.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of the article.

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