THE CHANGES IN CHOICE REACTION TIME RELATED TO TYPE OF MUSCULAR CONTRACTION AND THE CONCENTRATION OF AMMONIA

by

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The objective of this research project was the determination of changes in choice reaction time during graded exercise efforts with different types of muscular contraction i.e. mixed, concentric and eccentric. The shortest reaction time was also compared with a level of ammonia threshold.

Ten, healthy male students of the Academy of Physical Education in Katowice took part in the study between April and May of 1997. The average age, body height and massed were 22±1,35 years, 177±5,7 cm and 75±4,8 kg respectively.

The research project included 3 running tests on the treadmill of the graded intensity, performed until volitional exhaustion:

- test 1 performed on a treadmill set at 0º in relation to horizontal level (mixed muscular work),
- test 2 performed on a uphill setting of the treadmill equal 15º (concentric muscular work),
- test 3 performed on a downhill setting of treadmill equal 15º (eccentric muscular work).

After each workload, during the 1 min. rest interval blood samples were drawn from the antecubital vein for the evaluation of plasma ammonia (NH_3) concentration.

At rest and during the last 2 min of each workload choice reaction time (CRT) was measured with the MRK device produced by ZEAM.

The changes in choice reaction time during graded exercise have a threshold character regardless of the type of muscular work used. The ammonia threshold and the shortest reaction time occur at a similar workloads in the mixed and concentric exercise protocols. In the eccentric exercise the shortest reaction time occurred slightly below the AT. Regardless of the type of muscular work used the concentration of ammonia in the blood shows a significant relationship with the CRT after exceeding the AT. Eccentric work causes great impairment of psychomotor performance even under small workloads expressed in oxygen uptake.

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Introduction

Psychomotor fitness plays a key role in everyday activities and especially important in competitive sports. It can be used for the evaluation of the state of the central nervous system and the level of fatigue (Grandjean 1980, Elsass 1986, Martin et al. 1993). One of the commonly applied method for evaluating psychomotor performance under different conditions of physical activity includes the measurement of reaction time (Woodworth and Schlosberg 1966, Fröhlich 1987).

Many authors (Murell 1970, Dickinson et al. 1979, Spirduso 1980, Rikli and Busch 1986, Baylor and Spiriduso 1988, Lowe 1988, Chmura et al. 1994, 1995, Ziemba et al. 1999) attempted to determine the influence of physical activity on psychomotor fitness. Most often reaction time was measured at rest and immediately after a particular type of physical activity, during the restitution period. The results frequently showed a positive effect of physical activity on psychomotor performance.

Very few evaluated psychomotor performance directly during physical effort at submaximal and maximal intensities (Seiler 1990, Schmidt 1990, Chmura 1993, Chmura et al. 1994, 1998). The results of these research are not univocal and do not determine if physical effort influences psychological behaviors in humans.

The methods used for determining the level of the anaerobic threshold include evaluation of plasma ammonia concentration during continuous exercise of progressive intensity.

The objective of this research project was the determination of changes in choice reaction time during graded exercise efforts with different types of muscular contraction i.e. mixed, concentric and eccentric. The shortest reaction time was also compared with a level of ammonia threshold.

Material and methods

Ten, healthy male students of the Academy of Physical Education in Katowice took part in the study between April and May of 1997. The average

age, body height and massed were 22±1,35 years, 177±5,7 cm and 75±4,8 kg respectively.

The research project included 3 running tests on the treadmill of the graded intensity, performed until volitional exhaustion:

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- test 2 performed on a uphill setting of the treadmill equal 15º (concentric muscular work),
- test 3 performed on a downhill setting of treadmill equal 15º (eccentric muscular work).

The treadmill test was began with the following workloads:

- in the mixed work test the starting velocity was 7 $km \cdot h^{-1}$ ($1,9 m \cdot s^{-1}$) which was increased every 3 min. by 2 $km \cdot h^{-1}$ ($0,6\ m \cdot s^{-1}$) until maximal individual speed was reached,
- in the concentric work test the starting velocity was 5 $km \cdot h^{-1}$ ($1,4 m \cdot s^{-1}$) which was increased every 3 min. by 1 $km \cdot h^{-1}$ ($0,3\ m \cdot s^{-1}$),
- in the eccentric work test the starting velocity was 9 $km \cdot h^{-1}$ ($2,5 m \cdot s^{-1}$) which was increased every 3 min. by 4 $km \cdot h^{-1}$ ($0,8\ m \cdot s^{-1}$).

Each workload lasted for 3 min. and was preceded by a 1 min rest interval.

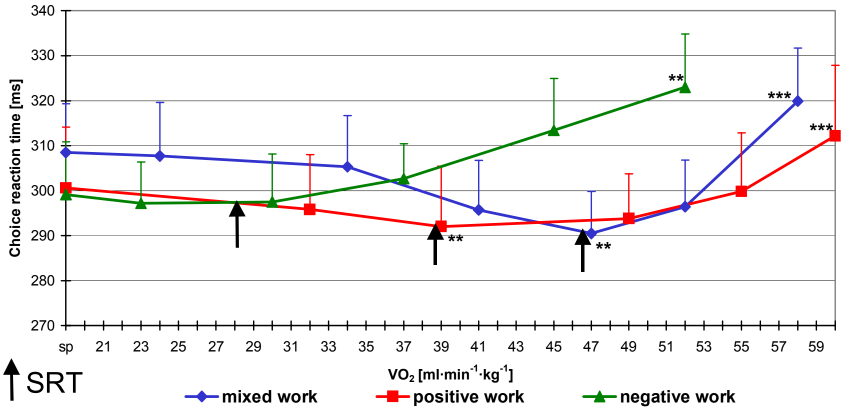
The 3 applied tests were separated by 14 days of rest.

The choice of treadmill velocity allowed for the performance of similar amount of work bouts under each test condition. Preliminary tests were performed to calculate proper running velocity for this exercise protocol. After each workload, during the 1 min. rest interval blood samples were drawn from the antecubital vein for the evaluation of plasma ammonia (NH_3) concentration.

At rest and under each workload oxygen uptake was measured (VO_2 [$l \cdot min^{-1}\ kg^{-1}$]) with the use of Beckman MMC gas analyzer. The ammonia threshold (AT) was calculated using the two-segmental linear regression (log NH_3 vs. log workload according to Beaver et al. (1985). At rest and during the last 2 min of each workload choice reaction time (CRT) was measured with the MRK device produced by ZEAM (Poland). The CRT test included 15 positive (red light or a sound) and 15 negative (green and yellow light) stimuli applied in randomized order. The subjects were asked to press and release, as quickly as possible a button on a right handlebar of the cycloergometer in response to a red light, the button on the left handlebar in response to a sound, and not to react to negative stimuli. The CRT was determined to the nearest 0,01 s and the results are given as a mean of 15 responses to the positive responses. The stimuli were emitted arythmically with break period lasted from 1 to 4 s. Each stimulus was emitted during 1 s ±2% and the whole program 107 s. In case of auditory stimulus low acoustic signal was used with frequency of 500 HZ ±2%.

Results

During the gradually increased workload under all types of muscular work the CRT decreased in comparison to resting values until the load at which the shortest reaction time (SRT). After passing the SRT point the CRT increased statistically significantly (fig. 2). The longest values of CRT were reached at the point of exhaustion under each test condition. Under comparable level of oxygen uptake, the values of CRT decreased by the highest margin in case of negative workload (fig. 1). The SRT obtained under all three types of muscular contractions did not differ significantly between each other.



*- statistically significant at p≤0,01
**- statistically significant at p≤0,001

Fig. 1. Choice reaction time under conditions of mixed, concentric and eccentric workload conditions

The lowest running velocity corresponding to the SRT was obtained during eccentric work (table 1). Higher running velocities ($p \leq 0,001$) were reached during the concentric and mixed exercise protocols.

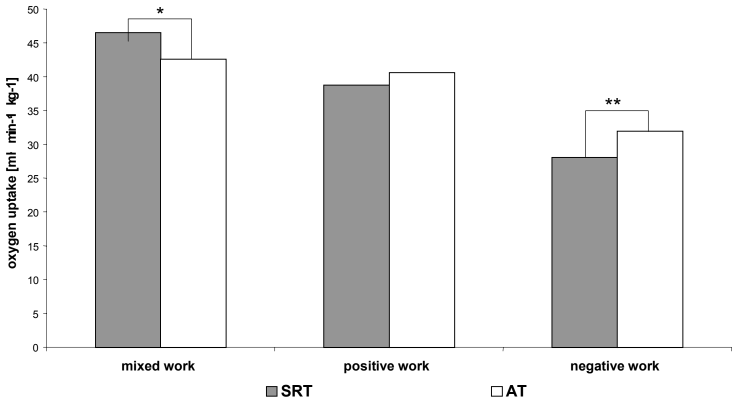
Oxygen uptake measured at points of the SRT was significantly higher ($p \leq 0,001$) during mixed workload conditions in comparison to eccentric work (table 1). Statistically significant ($p \leq 0,001$) differences in this variable were also observed between concentric and eccentric workload conditions (table 1).The SRT obtained during mixed work occurred past the ammonia threshold, expressed the running velocity and oxygen uptake ($p \leq 0,05$)(table 1, fig. 2).During concentric work the SRT occurred below the ammonia threshold. The variables registered at the level of SRT were lower in comparison to threshold values. These differences were statistically insignificant (table 1, fig. 2).

During the eccentric work the SRT was also reached below ammonia threshold (table 1, fig. 2). Significantly lower values of running velocity were registered ($p \leq 0,01$) at the point of SRT in relation to the ammonia threshold. The oxygen uptake was also significantly lower ($p \leq 0,001$) at the point of SRT in relation to the ammonia threshold (table 2).

Table 1. Workload values at the level of SRT and ammonia threshold under conditions of mixed, concentric and eccentric muscle work

		Velocity [km·h^{-1}]		**VO_2** [ml·min^{-1}·kg^{-1}]	
Muscle **work**		SRT	**AT**	**SRT**	**AT**
mixed	**X** **SD**	12,83 ±0,56	11,56 ±0,65	46,52 ±1,23	42,60* ±1,75
positive	**X** **SD**	5,94 ±0,41	6,07 ±0,23	38,74 ±1,61	40,62 ±1,35
negative	**X** **SD**	11,24 ±0,66	12,81** ±0,96	28,07 ±1,72	31,93** ±1,31

The relationship between the ammonia threshold and SRT in relation to the workload expressed by oxygen uptake was statistically significant ($p \leq 0,001$) and correlation coefficient was 0,86. A significant relationship was obtained (r=0,36-0,53) between CRT and NH_3 during workloads above the ammonia threshold under all types of muscular work.



*- statistically significant at p≤0,01
**- statistically significant at p≤0,001

Fig. 2. The shortest reaction time and the ammonia threshold during different types of muscular contraction

Discussion

A two-phasic character of changes in CRT during graded continuous exercise has been observed by many authors (Levitt and Gutin 1971, Sjöberg 1975, Bender and McGlynn 1976, Buła and Chmura 1984, Chmura et al. 1994). Such a type of psychomotor reactions are explained by changes in the level of CNS the activation. The relationship between the activation of the CNS and psychomotor performance can be presented graphically as an inverted letter "U". According to other authors and this research the changes in psychomotor fitness do not show a symmetrical shape when presented graphically. The graph shows gradual improvements in RT until the point of optimal stimulation is reached and the shortest reaction time obtained. After this point a drastic drop in CRT occurs which causes a significant decrease in psychomotor performance. Such an outcome is with accordance to the "catastrophe theory" (Fazey and Hardy 1988, Hardy and Parfitt 1991).

During eccentric exercise the impairment of the psychomotor performance occurs faster than in case of other exercise protocols in plasma. The literature related to the effects of eccentric work on psychomotor fitness are scarce. The analysis of correlation coefficients between SRT and AT indicate a rather simultaneous occurrence of the shortest reaction time and the onset of the anaerobic threshold. It can be assumed that metabolic changes occurring in skeletal muscles and in the brain have and significant impact on the activation of the CNS, at the same time impairing psychomotor performance.

Resuming, it can be stated that the CRT is impaired to the greatest degree under conditions of eccentric exercise, where CRT reaches the longest values. These results indicate that eccentric exercise causes are associated with a high physiological cost. The causes of such reactions must consider not only the metabolic aspects but also the motor potential of humans in which mixed work is dominant in everyday life. Independent of the type of muscular work, metabolic changes significantly influence psychomotor fitness, which is exemplified by a relationship between SRT and AT as well as high correlation coefficients between CRT and NH_3 concentration after exceeding the AT.

A drastic increase of blood plasma ammonia, which can to overcome the blood-brain barrier may influence the CNS in negative way, impairing its psychomotor performance. The lengthening of CRT after passing the AT justifies this.

The following conclusions can be drawn from this study:

1. The changes in choice reaction time during graded exercise have a threshold character regardless of the type of muscular work used. The ammonia threshold and the SRT occur at a similar workloads in the mixed and concentric exercise protocols. In the eccentric exercise the shortest reaction time occurred slightly below the AT.
2. Regardless of the type of muscular work used the concentration of ammonia in the blood shows a significant relationship with the CRT after exceeding the AT.
3. Eccentric work causes great impairment of psychomotor performance even under small workloads expressed in oxygen uptake.

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