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The effect of two short-term maximal bouts of cycling (2x 10s) on the performance of psycho-motor test among male and female fencers

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Summary

Introduction. The purpose to this study was to evaluate: (i) anaerobic power using two repeated maximal short-term anaerobic exertions , (ii) acute changes in the level of visuo-motor ability using multiple (n=62) motor responses to the fast visual stimuli known as eye-hand coordination task (EHC) induced by mentioned physical exertions.

Material and methods. The study was carried out in 20 male (MF), and 20 female fencers (FF). FF were younger than males on average by 4.2 years. After the familiarization, two attempts of EHC were performed prior to- and directly after two repeated 10s anaerobic bouts (2 x 10s) of cycling . The biomechanical parameters of the exertions were recorded, and were taken into consider those of the better performed bout. The performance of EHC test was rated by number of correct responses separately for each of the four attempts.

Results. FF demonstrated relative lower levels of the biomechanical parameters . Surprisingly, FF showed also significantly worse performance of entire, four attempts of EHC, but in contrast to MF, they demonstrated significant improvement within the successive four attempts. When the performances EHC were normalized to the age, those sex-related difference was not significant.

Conclusions. The results suggest lack of clear effect of two anaerobic bouts on EHC. Age and sex affected the performance of EHC test. Unfortunately, male fencers were older than their female counterparts, therefore, it is hard to indicate which attribute, gender or age is more responsible for recorded differences between sexes.

Introduction

Single fencing bout consistent of several, repeated short physical actions separated by somewhat longer periods of relative lower physical activity. Moreover, a single fencing action, attack or defense, as well as an entire fencing match strongly engages mental attention, because a readiness to performing rapid and unpredictable motions play an important role in an outcome of a competition. Fencing requires high level of lower body anaerobic power, that is need to excellent performing of normal running and three specific movements: lunge, advance and retreat [1]. Another an important factor that plays essential role during a fencing fight is correct information pickup, accuracy of decision-making (Go/No-Go dilemma) and finally well timing of a proper motor responses to the actions of his /her opponent. In fencing, biomechanical parameters of physical exertions are explored since the early 90s till now. As to physical performance the studies covered testing of strength velocity and endurance abilities. Early study was carried out among top level British male epée fencers of mean body mass of 73.4 kg who reached peak power output on average of 803 Watts performing 20s Wingate test [2], and until now, the mentioned research has been the only study on anaerobic cycling in male fencers, while small sample of female counterparts has been examined recently [3]. Using hand-grip dynamometer it was shown in fencers a greater asymmetries of hand strength and cross-sectional area of forearm regarding dominant and non-dominant upper limb compared to those features in age-and body mass -matched controls [4].

The fencing-specific lower extremity abilities play an important role during performing lunge, which is defined as forward stepping movement. Those offensive actions are performed several time during a fencing bout. In sabre, and it is carried out every 23.9 second by men and very 20 second by women [5]. Lunge time is mostly related to drop jumps and thigh cross-sectional area [6]. Likewise, Cronin showed , that time to peak force is the best predictors of lunge performance [7]. It should be stressed, that overall, total lunge time (TLT) is sum of times of two successive components , pre-motor time reaction (TR) and then movement time (MT). The second component strongly depends on movement distance and explosive power, while the first one is a product of speed of information processing, which depends on central nervous system. It was found, that elite fencers are faster for TR and TLT and display higher level of accuracy [8]. Because global fencing movement is composed of simple components, movements of lower extremities (rapid movement forward) and of upper (dominant) extremity engaged in performance of movement pointing towards a target-touche movement it is important to recognize, whether the touche movement is differ when performing alone or with the lunge, and whether elite fencers are differ from novice ones during those tasks. The study showed, that the performance of isolated touche was not dependent on various fencing skills demonstrated by the experts of international levels and the novices, but the sequential touché with lunge were performed better by the experts [9].

Number of kinetic and biomechanical data collected during laboratory studies did not provided information whether instantaneous muscular fatigue reached in result of repeated short-term anaerobic bouts could have a negatively influence on those mental abilities, which are needed during fencing competition. To find the response two groups of fences, males and females were subjected to the exercise and psychometric studies at the same time. The research involve anaerobic exercises and eye-hand sequential time responses tests carried out directly prior to the efforts and directly after them. Based on the studies which revealed lack of effect of menstrual cycle phases on anaerobic [10] and aerobic/endurance capacities [11], that aspect in female fencers was omitted by us.

Material and methods

Twenty male fencers practicing weapon styles, sabre (n=7), epée (n=5), foil (n=8) and 20 females, epée (n=11), foil (n=9) were subjected to the laboratory study in the middle of their training season. For two groups the study comprised of two various tasks, the first were four repeated psychomotor tasks and second were two repeated anaerobic bouts of cycling. The psycho-motor task, was in fact multiple choice eye-hand time responses, but it is commonly defined as eye-hand coordination task (EHC). Two maximal, 10-second anaerobic bouts of cycling were separated by 15-minute intermission for rest. The sequence of those events were as follows: Prior to the first anaerobic bout subjects performed two successive attempts (1st and 2nd) of EHC. The same two psychometric attempts (3rd and 4th) of EHC were performed within fourth minute after the second bout of cycling. Anaerobic cycling was performed on ergometer (Monark) equipped with electronic system recording on-line changes in power output especially time to peak power and its sustain, total work output and cadence with frequency. Those variables were measured with frequency of 1000 Hz. Each attempt of EHC consisted of 62 visual stimuli that appeared with regular frequency. These stimuli were generated randomly and successively, one after the other, by 10 bulbs situated in one row. Those signals (shining light bulbs) changed every 0.486 second Examined subjects were ask to press with his/her index finger of dominant hand an appropriate push-bottom situated below bulb, which gave the signal. Wrong response was when: pressing was delayed, i.e. a time execution was longer then 0.486, a response to a stimulus was omitted, or incorrect bottom was pressed. Performance of a single attempt of EHC was rated by number of correct responses. The conceptual schema of the equipment used for the psychometric tasks is presented below as two various sequences of the trial as follows.

¤	¤	¤	¤	¤	¤	¤	¤	¤	¤
ө	o	o	o	o	o	o	o	o	o

¤	¤	¤	¤	¤	¤	¤	¤	¤	¤
o	o	o	ө	o	o	o	o	o	o

¤ -signal , ө-bottom to be pressed, ¤- bulbs, o- other bottoms

The whole study, exercises and psychometric tasks were carried out before noon (10:00-12:00). Biomechanical anaerobic variables, maximal power output, total work output and fatigue index (the percentage drop of power from the maximal value to that recorded at the end of exertion) were recorded for two successive bouts, but the better performed bout was taken into consider for the calculations . Between-group differences for were calculated by Student t-test for single measurements, and two-way ANOVA with repeated measurements (sex x EHC) with post-hoc Newman-Keuls test for four attempts of EHC. The relationships between variables were tested using analysis of Pearson correlations . The program of STATISTICA software, version 10 StatSoft USA was used for calculation. The experiment was approved by Ethical Commission at Institute of Sport.

Results

Characteristic of the subjects, selected biomechanical variables of 10-second maximal cycling (the better preformed trial) and number of correct responses in PSYCHO-TEST (sequential multiple 62 visual stimuli) named eye-hand coordination task -EHC achieved in 1st, 2nd, 3rd, and 4th attempt are displayed in Table 1. Results of analysis of variance is given in Table 2 . Matrix correlation coefficients between examined variables is given Table 2 and 3 for male and female fencers respectively.

As was shown in Table 1 the male fencers achieved greater absolute and relative (adjusted to body mass) maximal power and workout than the females did. Those gender differences regarding anaerobic power output are well known and has been confirmed in several studies. More interesting dimorphism between sexes was found in regards to psycho-motor abilities. Male fencers demonstrated significantly better performance in all four attempts of EHC. In both sexes there were no significant differences between mean scores in four successive attempts of RHC, however in females slightly, non-significant improvement of EHC performance were observed from the 1st to 4th attempt, while no such trend was occurred in males. Interestingly, there were significant negative correlations between the performance of 1st EHC and difference (4th-1st) *EHC. The coefficients of those correlation were -0.578 in the males and : -0.844 in the females. That indicates the better absolute improvement occurring during entire four-attempt EHC- test when the initial level of the performance (1st EHC) was relatively low. That phenomenon is well known effect of so-called psycho-motor learning occur-

Table 1. Mean variables recorded in male and female fencers

Variables	male fencers (n=20)		female fencers (n=20)	
	Mean ±SD	Min-max	Mean ±SD	Min-max
Age (y)	24.7±5.2*	16.7-34.5	20.5±3,8*	14,9-25.3
BM (kg)	77.8±6.9*	66.8-97.0	63.4±8.1*	50.5-80.0
MPO (Watt)	940.8±111.8*	741.0-1191	641.7±92.2*	494-776
RPO (Watt/kg)	12.09±0.92*	10.15-13.54	10.11±0.65*	8.76-11.03
TW (kJ)	8.32±0.89*	6.82-10.65	5.70±0.82*	4.31-6.90
RTW (kJ/kg)	0.107±0.007*	0.093-0.120	0.090±0.006*	0.077-0.099
FI (%)	9.9±4.2	4.0-20.0	8.5±1.7	5-12
TA (sec.)	2.46±0.35	1.83-3.19	2.54±0.64	1.70-3.63
TS (sec.)	2.81±0.94	1.30-5.03	2.32±0.77	1.34-4.51
1st EHC	55.4±5.0*	46-62	40.6±15.5	11-62
2nd EHC	56.5±5.1*	46-62	44.0±13.0	17-61
3rd EHC	56.7±3.9*	49-62	47.6±10.8	26-61
4th EHC	57.1±4.4*	43-62	47.3±9.4	30-62
mEHC	56.6±3.8*	50.3-62.0	45.0±11.7	21.3-61.8
1st EHC/Age	2.33±0.51	1.42-3.29	1.95±0.63	0.73-2.76
2nd EHC/Age	2.37±0.46	1.71-3.16	2.15±0.57	1.33-3.00
3rd EHC/Age	2.38±0.47	1.61-3.22	2.20±0.49	1.33-3.05
4th EHC/Age	2.39±0.42	1.62-3.16	2.34±0.45	1.67-3.50
mEHC/Age	2.38±0.47	1.62-3.22	2.20±0.49	1.33-3.05

Abbreviations: A-age, BM-body mass, MPO-maximal power output, RPO-relative maximal power output, TW- total workout, RTW-relative total workout, TA-required time to MPO attainment, TM-required time to MPO sustainment, 1st-4th EHC-number of correct responses to successive 62 visual stimuli, mEHC –mean performance of the whole EHC-test calculated from the four attempts of EHC, EHC/Age- EHC performance of EHC adjusted to the age of subjects.
p<0.05 differences between sexes (*).

Table 2. Results of statistical calculation for four repeated attempts of EHC

ANOVA (groups)	F value	p value	examined effect : differences
one-way ANOVA (males, n=20)	F(3,76)=0.46	0.71	between four attempts of EHC among males
one-way ANOVA (females, n=20)	F(3,76)=1.76	0.16	between four attempts of EHC among females
two-way ANOVA (both sexes, n=40)	F (3,152)=2.36	0.07	between attempts of EHC for both sexes
	F(3,152)=69.1	**0.000009**	between sexes difference in four attempts EHC
	F (3,152)=0.86	0.47	interaction attempt*sex

Table 3. Matrix of correlation coefficients of determined variables in the male fencers

Variab.	A	BM	MPO	RPO	TW	RTW	FI	TA	TM	mEHC
A	1	0.266	0.212	0.023	0.104	-0.208	**0.509**	**-0.569**	**-0.453**	0.231
BM		1	**0.786**	0.063	**0.832**	-0.001	0.354	-0.354	-0.180	-0.057
MPO			1	**0.666**	**0.964**	**0.560**	**0.592**	-0.376	**-0.498**	0.042
RPO				1	**0.551**	**0.905**	**0.535**	-0.180	**-0.584**	0.143
TW					1	**0.552**	0.373	-0.314	-0.332	-0.061
RTW						1	0.152	-0.033	-0329	-0.013
FI							1	-0.439	**-0.757**	0.381
TA								1	**0.501**	0.056
TM									1	-0.188
mEHC										1

Significant coefficients s are displayed in bold

Table 2. Matrix of correlation coefficients of determined variables in the female fencers

Variab.	A	BM	MPO	RPO	TW	RTW	FI	TA	TM	mEHC
A	1	0.185	0.282	0.203	0.270	0.190	0.226	-0.427	-0.228	**0.628**
BM		1	**0.886**	0.037	**0.899**	0.080	0.297	**-0.480**	-0.137	**0.653**
MPO			1	**0.495**	**0.994**	**0.518**	0.457	**-0.544**	-0.253	**0.595**
RPO				1	0.456	**0.967**	0.435	-0.225	-0.284	0.033
TW					1	**0.506**	0.375	**-0.572**	-0.190	**0.588**
RTW						1	0.266	-0.310	-0.143	0.029
FI							1	-0.104	-0.403	0.345
TA								1	-0.126	-0.382
TM									1	-0.053
mEHC										1

Significant coefficients s are displayed in bold

ring during repeated psycho-motor test. Positive significant correlations among all four attempts of EHC in the group of males (0.525-0.738) and females (0.868-0.904) confirmed good reliability of employed psycho-motor test.

Among the males their age did not affect EHC, while in the females the correlation age-EHC was significantly positive. When comparing the performances of EHC-test for both sexes after adjustment for age (mEHC/age) the difference was not significant. Surprisingly, female group showed significant correlations between mEHC and some biomechanical variables and body mass, but males did not. In males fatigue index was somewhat greater and it correlated with some other biomechanical variables.

Discussion

The results of this study confirmed well known sexual dimorphism with respect to maximal power output as absolute value or after normalization to body mass, and overall work output realized in short-term anaerobic effort of cycling or running. On the other side there are some finding, that normalizing power output to lean body mass and especially muscle mass of lower extremities removes previous difference in peak power, strongly reduces difference in mean power [12]. The decline power output over the exertion is the symptom of developing neuromuscular fatigue. We noted somewhat higher fatigue index in the males and the similar phenomenon, i.e. the decline of mechanical power was observed in young adults, boys and girl aged 16.4 y during repeated 5-s sprint runs. Moreover, those declines, 46.2% in boys and 33.9% in girls significantly correlated with the mechanical power attained in the 1st sprint [13]. That is similar finding to our observation among male fencers, where fatigue index positively correlated with maximal power output. That suggest, that initial phase of the exertion of maximal intensity play a role in a magnitude of depletion of high-energy source of energy (ATP, PCr), and that explains, that lower fatigue index in exercising females results in smaller reduction of ATP in II muscle fibers [14].

The examination of eye-hand sequential time responses showed significantly better the test performance by male fencers. Earlier studies showed similar differences between sexes when comparing various visuo-movement abilities with predominance of those features among males [15-19]. However, in our study the male group was older than female one, on average by 4y and the same difference was in training experience. For this reason the observed gender difference in EHC performance occurred likely to be due to the length of specific athletic training, which modulate several psycho-motor and cognitive functions [20-22], but the contribution of age is hard to evaluate in this study.

The main objective of that study, the question, whether two repeated anaerobic bouts have an impact on psycho-motor task has not been settled clearly and uniquely. In male fencers the same levels of performance of 2nd (before the exertions) and 3rd (directly after the bouts) EHC was recorded, but in females the performance of 3rd EHC was better (t-test, $p<0.05$) than the 2nd one . That significant improvement of the performance among the female could be the result of motor-learning occurring after successively repeated the attempts, but not only as a direct effect of the exertions. This assumption is supported by the similar improvement noted at rest during the 1st and 2nd EHC. Interestingly, female group reach its steady state of the performance, i.e. lack of further improving of the ability, after their 3rd attempt of the test. As mentioned, in both sexes we noted negative correlations between the level of 1st EHC and the level of improvement occurring following successive attempts of entire task. The same phenomenon was found by Yotani [22], who examined changes of visuo-motor related time (VMRT) over training session. Based on that finding pre-training VMRT the author promotes examination of pre-training VMRT as a predictor of reduction of reaction time due to the training. Effect of learning of the responses to successive stimuli, revealed mainly among the female group, could mask the effect of anaerobic bouts, and that, in fact, limits the quality of the designed study and obtained data. In a future research the effect of learning should be eliminated by the familiarization with psycho-test due to 3-4 the trials performed prior to the study, or due to the inclusion of non-exercising control group to the research.

Moreover, we cannot discuss our results in respect of the other finding, because there is a lack of data about the impact of short-term anaerobic bouts on series of time responses. However, it is worth to mention the several studies on the effects of longer exertions, sub-maximal ones and those of incremental graded intensity, on time responses. Majority of those studies showed, that during exercise of mild intensity choice time reactions tended to decrease, but deterioration that parameters may occurred during continuation of exhaustive exertion. That biphasic change, i.e. intensity-dependent drop-and-rise of time reaction indicated mechanism which governs the exercise-induced balance between stimulation and fatigue of nervous system.

Conclusions

1. Among fencers their age and sex affect the level of EHC performance.
2. Fencers of lower initial performance of EHC demonstrated greater improvement in this task following repeated successive trials.

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