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PHYSIOLOGICAL RESPONSES AND ENERGY EXPENDITURE TO SIMULATED EPEE FENCING IN ELITE FEMALE FENCERS

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Abstract Understanding the physiological and energy expenditure responses required during the unique nature of fencing is important for the development of training/nutritional programmes for athletes involved in fencing. This study therefore examined the physiological responses of four elite female epee fencers during a simulated fencing task. Peak physiological measurements were determined during an incremental exercise test to exhaustion on a treadmill. In addition, oxygen consumption, heart rate and finger tip blood lactate samples were taken throughout a series of simulated fencing fights. The fencing fights consisted of 3 x 3 minutes of fencing, with 1 minute rest between each bout. The results demonstrated peak oxygen uptake (47±5 ml·kg·min^{-1}) to be similar to that of other elite female fencers. High peak energy expenditures were elicited over short exercise durations (range 10.6–11.4 Kcal·min^{-1}). Low blood lactate levels were evident and possibly due to the contribution of phosphocreatine for ATP regeneration.

Key words: Fencing, energy expenditure, training

INTRODUCTION

The analysis of the demands and characteristics of sporting disciplines has been popular in the last decade. Most of this work tends to be mono-disciplinary in nature and is focused on sports such as football and cycling [1, 6]. Surprisingly, little work has been conducted on the Olympic sport of fencing (foil, sabre or epee). Fencing is a unique sport, which is reflected in the asymmetrical development of the muscles involved [9]. Furthermore, the intermittent nature of fencing puts demands on both the aerobic and anaerobic metabolic systems [8]. The duration of an international fencing competition can be between 9-11 hours [8]; however, of that time only 18% will be actual fencing bouts [8]. Unpublished data from our laboratory have shown a work:rest duration of 8s:10s for male fencers during simulated competition. The intermittent nature of fencing suggests that there is a high demand on the phosphocreatine system, especially with a work:rest of 8s:10s. A World Class fencer should therefore have developed both their aerobic and anaerobic capacities. Previous research has demonstrated the heart rate to be in the range of 167 to 191 beats·min^{-1} for 60% of the fencing duration during a Women's epee competition [3, cited in 8]. Understanding the physiological and energy expenditure responses required during the unique nature of fencing is important for the development of training/nutritional programmes for athletes involved in fencing.

Few studies reported physiological responses of elite female fencers [5]. Determining the physiological responses and energy expenditure of these athletes is also important for talent identification and the development of training protocols. Therefore, the aims of the present study were first to determine the peak physiological responses of a small sample of elite female epee fencers and secondly to determine the physiological demands of epee fencing using a simulated competition. The hypothesis of the study was that results would demonstrate fencers to have similar peak physiological responses as other intermittent sports players. In addition, it was hypothesised that large blood lactate values would be achieved during the simulated fights due to the intermittent nature of the sport and the demand on the anaerobic system.

MATHERIALS AND METHODS

SUBJECTS

Four members of the Polish female epee team, which included the 2007 World Champion (Mean ± SD; age 24.8±3.3 yrs, height 178.5±8.7 cm, body mass 68.0±6.9 kg, body mass index 21.3 ±1.3 kg/m^2) volunteered to take part during pre season training. University Ethics Committee approval for the study's experimental procedures was obtained along with written informed consent and followed the principles outlined in the Declaration of Helsinki.

PEAK PHYSIOLOGICAL MEASUREMENTS

Participants completed an incremental treadmill test to determine peak oxygen consumption (VO_{2peak}) and peak heart rate (HR_{peak}). The fencers ran at a 1% gradient at a speed of 6 km·hr^{-1} for three minutes. Treadmill speed was then increased by 2 km·hr^{-1} every three minutes until volitional exhaustion. Expired gas was continually analysed and monitored via an online breath by breath system (Cosmed K4; Srl, Rome, Italy). An estimate of the anaerobic threshold was calculated from ventilatory equivalent data within the analysis software. The system was calibrated with room air and known gas concentrations for oxygen (16%) and carbon dioxide (5%). Heart rate was monitored via a telemetric device (Sport Tester Polar 720i, Kemple, Finland).

SIMULATED FENCING

On a different day, a series of simulated fights were undertaken with each fencer completing three fights. Each simulated fight consisted of 3 x 3 minutes of fencing with 1 minute rest between each bout replicating the maximum duration of an epee fight in an international competition. The rest period between each fight was 10 minutes.

During each simulated fight mean oxygen consumption (VO_2; mL·kg·min^{-1}) was determined by a portable online gas analyser (Cosmed K4; Srl, Rome, Italy). The face mask for the gas analyser was placed over the nose and mouth and then the fencing mask was fitted over the face mask. Heart rate was monitored via a telemetric device (Sport Tester Polar 720i, Kemple, Finland) and an average was determined for each three minute bout and one minute rest period. Energy expenditure (Kcal·min^{-1}) was also estimated from the gas analysis software for each three minute bout and one minute rest period. Blood lactate (Dr. Lange Miniphotometer 2, Dr. Lange, Berlin, Germany) was determined from fingertip samples at rest and at the end of each three minute bout.

STATISTICAL ANALYSIS

Data were analysed using a repeated measures two-way analysis of variance (ANOVA). Significance was taken as $P<0.05$. As ANOVA resulted in low statistical power (7 – 27% for the fight × time interaction), nonparametric analysis (Friedman's Test) was also undertaken. However, the statistical outcomes were the same as for parametric analysis.

RESULTS

PEAK PHYSIOLOGICAL RESPONSES

Mean VO_{2peak}, HR_{peak} and anaerobic thresholds obtained during the incremental exercise test (Table 1) were 47±5 ml·kg·min^{-1} (range; 40.9 – 51.8), 196±8 beat·min^{-1} (range; 184 - 202) and 82.8± 6.9 % VO_{2peak} (range; 73.6 – 89.7). Two fencers reached a peak treadmill velocity of 16 km·h^{-1} and two reached 12 km·h^{-1}.

Table 1. Peak physiological responses for all 4 fencers during incremental exercise test

Fencer	VO_{2peak} (mL·kg·min^{-1})	HR_{peak} (beat·min^{-1})	Peak Velocity (km·h^{-1})
1	49.3	195	16
2	52.8	184	16
3	41.9	201	12
4	46.6	202	12
Mean	46.9	196	14
SD	4.7	8	2

SIMULATED FENCING FIGHTS

There were no differences in VO_2, HR or blood lactate between the three minute bouts or during each fight (p = 0.94, 1.00, 0.88, respectively; Table 2). During the simulated fights fencers worked at an average exercise intensity of 74±4% VO_{2peak} and 87±3% HR_{peak}. Energy expenditure for each simulated fight was

11.4±2.3, 10.6±2.5 and 10.7±2.6 Kcal·min^{-1}. Maximal values within each bout for each fencer were 20.6, 12.6, 17.7, 16.7 Kcal·min^{-1}, respectively. It was noted that those fencers with greatest body mass demonstrated the greatest energy expenditures. Blood lactate concentrations at rest and at the end of each bout were similar (Table 2).

Table 2. Mean (±SD) physiological responses during each 3 minute bout of simulated fencing and recovery

		Fencing bout and rest					Post fight recovery (min)				
		Sim 1	Rest 1	Sim 2	Rest 2	Sim 3	1	2	3	5	9
VO2 (mL·kg^{-1}·min^{-1})	F1	34.5±4.6	26.7±2.4	36.6±2.9	25.8±4.3	36.0±3.8	22.0±2.1	12.0 ±1.4	7.9 ±6.4	-	-
	F2	32.6±5.8	24.3±3.8	35.5±4.0	25.9±4.6	34.1±5.1	21.4±5.5	11.4 ±3.5	7.5 ±2.4	-	-
	F3	35.3±2.0	26.2±3.5	36.1±3.1	22.0±3.6	34.1±2.7	21.9±3.4	14.2 ±1.8	9.0 ±2.1	-	-
%$VO2_{peak}$	F1	74.2±13.9	57.0±3.2	78.6±10.2	55.3±10.0	77.5±14.3	47.2±3.8	25.6 ±1.3	16.9 ±1.4	-	-
	F2	70.1±14.0	51.8±5.9	75.8±6.6	55.0±5.5	72.8±2.8	45.5±10.5	24.1 ±3.4	16.0 ±4.3	-	-
	F3	75.7±4.7	55.7±3.2	77.1±3.1	47.0±2.6	72.8±2.6	46.5±2.7	30.2 ±1.3	19.5 ±5.7	-	-
HR (beats·min^{-1})	F1	169±19	152±19	172±14	149±17	175±16	161±10	123 ±12	1 07 ±15	-	-
	F2	171±16	154±16	172±21	150±25	173±17	148±30	118 ±23	1 08 ±24	-	-
	F3	172±12	157±8	176±16	152±19	172±15	159±23	123 ±16	10 9 ±22	-	-
%HR_{peak}	F1	86.5±11.2	77.7±9.2	87.9±9.5	76.3±11.0	89.6±10.3	82.6±7.9	62.8 ±6.7	54.7 ±8.4	-	-
	F2	87.7±10.7	79.1±11.0	88.3±13.4	77.2±15.9	89.0±12.3	75.9±12.7	60.6±13.1	55.5±14.3	-	-
	F3	88.2±8.9	80.5±11.6	90.2±11.2	78.1±13.2	88.2±12.3	81.5±14.6	63.3 ±9.8	55.9±13.1	-	-
Blood Lactate (mmol·L^{-1})	F1	3.1±1.0	-	2.8±0.5	-	2.4±0.5	-	-	-	2.2 ±0.5	1.6 ±0.5
	F2	2.7±1.1	-	2.4±1.0	-	3.8±2.6	-	-	-	3.1 ±1.6	2.5 ±1.4
	F3	2.9±1.7	-	2.6±1.3	-	2.6±1.5	-	-	-	2.4 ±0.9	2.2 ±0.7

DISCUSSION

The VO_{2peak} values obtained by the fencers in the present study were similar to those observed for elite female fencers (45.7 mL·kg·min^{-1}; [9] but lower than for male collegiate fencers (50.2 mL·kg^{-1}·min^{-1}; [10] and elite male fencers [5]. As two athletes reached just 12 km·h^{-1} during the preliminary VO_{2peak} test, aerobic endurance could be improved which may aid recovery between bouts and fights.

The exercise intensity of the simulated fights in the present study was ~87% HR_{peak}, with blood lactate concentrations of ~2.8 mmol·L^{-1}. Previous research has demonstrated the heart rate to be in the range of 167 to 191 beats·min^{-1} for 60% of the fencing duration during a Women's epee competition [3, cited in 8]. In addition, HR has been shown to be above anaerobic threshold level for only 41±34% of the time [8]. The heart rate intensities from the present study therefore suggest that the simulated protocol was of lower intensity than a true fencing competition.

Unpublished data from our laboratory have shown a work:rest duration of 8s:10s for male fencers during simulated competition. Relatively lower blood lactate values and high cardio respiratory strain have been observed for high intensity intermittent running for work:rest durations of 6s:9s when compared to 24s:36s suggesting a greater reliance on phosphocreatine for ATP regeneration [7]. Greater phosphocreatine use may therefore contribute to the lower blood lactate values observed during fencing. As exercise intensities during competition are greater than during training, partly due to greater catecholamine release [2], this may additionally contribute to the low blood lactate values observed in this study.

In addition to determining specific exercise intensities undertaken during standard training procedures, an important aspect of this study was to determine energy expenditure. Energy expenditure values of between 10 – 12 Kcal·min^{-1} were observed for each fencing bout, which are similar to estimated values based on body mass (not gender specific) of 8.8 – 12 Kcal·min^{-1} for competition and 4.4 – 6.0 Kcal·min^{-1} for training [4]. However, maximal values of ~21 Kcal.min^{-1} were recorded from individual breath by breath measurements. This shows that although fencing bouts are of relatively short duration, high energy expenditures can be achieved. Furthermore, predicted values for training appear lower than those observed. Although only four athletes were monitored, those with the lowest body mass elicited the lowest energy expenditures. These results may be important for nutritional interventions and nutritional support of elite female fencers. Future research should focus upon these areas in conjunction with time motion analysis and evaluation of more competitive scenarios to inform specific athlete interventions.

CONCLUSION AND PRACTICAL APPLICATION

The data outlined in this study suggest that fencing training should focus on developing both aerobic and anaerobic (Creatine Phosphate and Alactic) metabolism. Introducing specific training that simulates the demands of a competitive bout could help develop the necessary fitness for competitive fencing. Given the high intensity nature of fencing, it is important that athletes replenish the energy lost during competition to ensure that performance is not adversely affected.

REFERENCES

1. Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Science*, 24(7), 665-677.
2. Hoch, F., Werle, E., & Weicker, H. (1988). Sympathoadrenergic regulation in elite fencers in training and competition. *International Journal of Sports Medicine*, Suppl **2**, S141-145.
3. Li, J. X., So, R. C. H., Yuan, Y. W. I. et al (1999). Muscle strain and cardio- vascular stress in fencing competition. *Proceedings of the 5th IOC World Congress on Sport Sciences*, Oct 31-Nov 5, 31. Sydney: 222.
4. McArdle, W. D., Katch, F. I., & Katch, V. (2001). *Exercise Physiology; Energy, Nutrition and Human Performance (5th edition).* Baltimore: Lippincott, Williams and Wilkins, (pp 1106).
5. Nystrom, J., Lindvall, O., Ceci, R., Harmenberg, J., Svedenhag, J., & Ekblom, B. (1990). Physiological and morphological characteristics of world class fencers. *International Journal of Sports Medicine*, 11(2), 136-139.
6. Padilla, S. I., Mukikta, I., Orbananos, J., & Angulo, F. (2000). Exercise intensity during competition time trials in professional road cycling. *Medicine and Science in Sports and Exercise*, 32(4), 850-856.
7. Price, M., & Halabi, K. (2005). The effects of work-rest duration on intermittent exercise and subsequent performance. *Journal of Sports Science*, 23(8), 835-842.
8. Roi, G. S., & Bianchedi, D. (2008). The science of fencing: implications for performance and injury prevention. *Sports Medicine*, 38(6), 465-81.
9. Sapega, A. A., Minkoff, J., Valsamis, M,. & Nicholas, J. A. (1984). Musculoskeletal performance testing and profiling of elite competitive fencers. *Clinics in Sports Medicine*, 3(1), 231-244.
10. Vander, L. B., Franklin, B. A., Wrisley, D., Scherf, J., Kogler, A. A., & Rubenfire, M. (1984). Physiological profile of national-class National Collegiate Athletic Association fencers. *Journal of the American Medical Association*, 252(4), 500-503.

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