Seasonal variation of selected performance parameters in épée fencers

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In this study, anthropometric measurements were carried out on seven British international male épée fencers, using a maximal treadmill running test, a 20-s Wingate-type test, and isokinetic dynamometry. Testing was conducted on two occasions, 5 to 6 months apart, during mid-off-season (preparation) and mid-in-season (competition) periods. Maximal oxygen intake ($\dot{V}O_{2\max}$) and maximal respiratory exchange ratio ($R_{\max}$) were among the parameters obtained from the treadmill test, while peak and mean anaerobic power outputs were measured during a 20-s maximal effort. Knee extensor and flexor muscle forces from both dominant (leading) and non-dominant (trailing) legs were assessed at 1.04, 3.14 and 4.19 rad sec⁻¹. Statistical analyses revealed lower mean $\dot{V}O_{2\max}$ ($P < 0.05$) and mean $R_{\max}$ values ($P < 0.02$) at the in-season assessments compared with off-season. In-season testing also demonstrated significantly lower peak torques for both dominant and non-dominant knee extensors compared with off-season assessments at all velocities ($P < 0.05$ to $P < 0.004$). Furthermore, in-season peak torque for the non-dominant leg flexors was lower ($P < 0.03$) at 4.19 rad sec⁻¹ than off-season. We concluded that current training practices may account for the observed seasonal variations in performance related physiological parameters in fencers.

Keywords: International épée fencers, seasonal variations, fitness

Although swordsmanship can be traced back to ancient civilizations, the inclusion of fencing in the first modern Olympic games (Athens 1896) secured its status as a major sport. The art of épée fencing is based on the principle 'hit without being hit'. The resulting spectacle may be described as a game of chess played at high speed. Épée is fenced on a piste 18 m in length and 2 m wide, and competitions can last for 2 days with the fencer often being active for 8–12 h on each competition day.

Unlike many major spectator sports such as soccer, athletics and swimming, there has only been limited research into fencing. Moreover, attempts to correlate success in fencing with certain motor and perceptual

skills, such as reaction time, accuracy and balance, have been far from conclusive^{1–5}.

However, research on the physiological characteristics of fencers has demonstrated relationships between performance and certain physiological parameters relating to fitness. For example, world class épée fencers have shown considerably higher values both for maximal oxygen intake ($\dot{V}O_{2\max}$) and for isometric and dynamic strength than normal untrained men of comparable age⁶. Muscular strength variables have also been included in equations designed to predict Olympic team potential⁷.

Seasonal variations in key physiological parameters have been observed in rowers⁸, middle- and long-distance runners⁹, wrestlers¹⁰ and skiers¹¹. In most of these investigations, levels of performance related parameters have been found to be lower during periods of competition, compared with preparation periods. Therefore, the purpose of this study was to determine whether seasonal variations among appropriate physiological parameters could also be observed in épée fencers.

Subjects and methods

Seven international British men épée fencers with a mean(s.d.) age of 25.6(3.7) years and mean(s.d.) height of 181(4.3) cm, were recruited for this study. All subjects were physiologically assessed at the middle of the off-season (preparation) period and again during the middle of the in-season (competition) period of the same year. The off-season months of training are from October to March, while in-season competition months run from April to August. The same tests were used for the two assessments, which were administered after an 8–12-h overnight fast, and 24 h after training. No history of injury was reported.

Body fat assessments

Suprailiac, subscapular, triceps and biceps skinfold thicknesses were assessed using Harpenden calipers. Body fat percentages were calculated from the mean of three readings per site according to the formula of Durnin and Rahaman¹².

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Physiological assessments

Maximal treadmill test

The protocol consisted of a 5-min steady-state treadmill run, followed by progressive 1-min increments to exhaustion. A calibrated automatic gas analyser (Jaeger Sprint, Wertsberg, Germany) was used to record respiratory parameters every 30 s during testing, while subjects inspired room air through a low-resistance two-way Rudolph valve (Hans Rudolph Inc., Wyandotte, Missouri, USA). The $\dot{V}_{O_{2\max}}$ maximal respiratory exchange ratio ($R = \dot{V}_{CO_2}/\dot{V}_{O_2}$), maximal pulmonary ventilation ($\dot{V}_E$), and the $\dot{V}_{O_2}$ at the respiratory anaerobic threshold (T-vent), were among the breathing parameters determined. The T-vent was defined for each subject to occur immediately before a systematic increase in the ventilatory equivalent of oxygen without a corresponding increase in the ventilatory equivalent for carbon dioxide¹³. Heart rates (HR) were also monitored during ergometry using a three lead ECG.

Anaerobic test

A Wingate-type test was performed on a Monark cycle-ergometer (model 864 with weights) (Monark, Varberg, Sweden). The test duration was 20 s, while the resistance was calculated as 8% of the subject's body weight. This percentage produces a resistance setting which closely approximates that of 75 g kg^{-1} body weight, often used for assessing lower body anaerobic potentials¹⁴. During the last 10 s of the warm-up (5 min at 80 W) the subjects increased their pedalling frequency to a maximum and on the command 'Go' the full resistance was applied. The following parameters were determined.

Mean power (MP) – the average power produced during the test. This parameter is considered to be related to anaerobic capacity, reflecting both the glycolytic and phosphagen components of anaerobic metabolism¹⁵.

Peak power (PP) – the highest power obtained at any 5-s period of the test. This should relate to phosphagen stores¹⁶, given that PP is normally attained during the first 10 s of the test.

Isokinetic dynamometry

A LIDO isokinetic dynamometer (Loredan Biomedical, Davis, California, USA) was used to assess knee extensor and flexor peak torques obtained from both dominant and non-dominant legs. The dominant leg was defined as the leading one used during fencing.

After 10 to 15 min of warm up, each subject was asked to sit on the isokinetic dynamometer, without shoes, and with the hip and the knees flexed at 110° and 90° respectively. Subjects were coupled to the dynamometer by aligning the lateral femoral condyle with the axis of rotation of the dynamometer, and attaching the ankle cuff just proximal to the lateral malleolus.

Gravitational corrections were made for the effect of limb weight on torque generation. Calibration of

the dynamometer-recorder system was dynamically checked before the first test of the day by placing a known weight on the lever arm which was set at a known length.

The measurements were made over 90° for both knee extension and flexion in three maximal, reciprocal concentric contractions at the angular velocities of 1.04, 3.14 and $4.19 \text{ rad sec}^{-1}$; the sequence of the three velocities was randomized to eliminate any dependent ordering effect. Rests of 2–5 min were allowed between tests.

Statistical analyses

Means and standard deviations were calculated for all parameters. A two-tailed paired *t* test was employed for testing differences attained at the two physiological assessments, while differences between dominant and non-dominant legs at the three angular velocities were tested by one-way repeated measures analysis of variance. The criterion for statistical significance was set at $P < 0.05$.

Results

Table 1 shows the subjects' anthropometric data obtained during the two stages of the experimental procedures. Although no statistical differences were found, a trend towards greater body weight, body mass index, and percentages of body fat were apparent during the in-season compared with off-season measurements.

Table 2 shows mean(s.d.) and *t* test results for the parameters assessed during the maximal treadmill and anaerobic tests. At the in-season period, the mean $\dot{V}_{O_{2\max}}$ of $54.8 \text{ ml kg}^{-1} \text{ min}^{-1}$ was significantly lower ($P < 0.05$) than the off-season measures (mean $\dot{V}_{O_{2\max}} = 58 \text{ ml kg}^{-1} \text{ min}^{-1}$). Similarly significant differences ($P < 0.02$) were shown between the $R_{\max}$ obtained from the off-season (mean $R_{\max} = 1.18$) and the in-season (mean $R_{\max} = 1.13$) measurements. There were no statistical differences between the two Wingate assessments.

Results from the isokinetic dynamometry appear in Table 3. At all three angular velocities, in-season peak torques for both dominant and non-dominant knee extensors were significantly lower than the values obtained during the off-season measurements ($P < 0.05$ to $P < 0.004$). Conversely, knee flexors were found to generate lower in-season peak torques only at $4.19 \text{ rad sec}^{-1}$ ($P < 0.03$). One-way analysis of variance revealed no statistical differences between

Table 1. Anthropometric data obtained from the off-season and in-season assessments ($n = 7$)

	Weight (kg)	Body mass index (kg m^{-2})	Skinfold measurement (% body fat)
Off-season	72.5(3.6)	21.0(1.1)	14.5(4.3)
In-season	73.4(3.5)	22.4(0.9)	15.3(3.9)
<i>t</i>	n.s.	n.s.	n.s.

Values are mean(s.d.); n.s. = not significant

Table 2. Mean(s.d.) and *t*-test results for the maximal treadmill and 20-s anaerobic tests performed during the off-season and in-season assessments (*n* = 7)

	$\dot{V}O_{2\max}$ (ml kg ⁻¹ min ⁻¹)	<i>T</i> -vent (% $\dot{V}O_{2\max}$)	$V_{E\max}$ (l min ⁻¹)	$R_{\max}$	$HR_{\max}$ (beats min ⁻¹)	PP (W)	MP (W)
Off-season	58.0 (2.6)	82.4 (5.7)	162 (17)	1.18 (0.04)	184 (11)	785 (40)	634 (29)
In-season	54.8 (3.7)	79.0 (5.2)	155 (19)	1.13 (0.03)	188 (13)	809 (38)	673 (32)
<i>t</i>	2.57 <i>P</i> < 0.05	n.s.	n.s.	3.54 <i>P</i> < 0.02	n.s.	n.s.	n.s.

T-vent, $\dot{V}O_2$ at respiratory anaerobic threshold; $HR_{\max}$, maximum heart rate; PP, peak power; MP, mean power; n.s. = not significant

Table 3. Peak torques (Nm) at three angular velocities for the knee extensors and flexors obtained during the off-season and in-season assessments (*n* = 7)

	Off-season	In-season	<i>t</i>	<i>P</i>
Knee extension				
Dominant leg				
1.04 rad s ⁻¹	276(36)	248(34)	4.33	0.005
3.14 rad s ⁻¹	203(35)	189(30)	4.63	0.004
4.19 rad s ⁻¹	181(34)	165(23)	2.54	0.04
Non-dominant leg				
1.04 rad s ⁻¹	270(34)	248(34)	2.86	0.03
3.14 rad s ⁻¹	202(30)	188(28)	4.53	0.004
4.19 rad s ⁻¹	179(32)	162(17)	2.46	0.05
One-way analysis of variance	n.s.	n.s.		
Knee flexion				
Dominant leg				
1.04 rad s ⁻¹	143(27)	144(12)	—	n.s.
3.14 rad s ⁻¹	114(25)	119(11)	—	n.s.
4.19 rad s ⁻¹	97(12)	95(13)	—	n.s.
Non-dominant leg				
1.04 rad s ⁻¹	147(14)	143(15)	—	n.s.
3.14 rad s ⁻¹	117(17)	115(09)	—	n.s.
4.19 rad s ⁻¹	100(09)	93(09)	2.73	0.03
One-way analysis of variance	n.s.	n.s.		

Values are mean(s.d.); n.s. = not significant

either knee extensors or flexors of the dominant and non-dominant leg at any of the three angular velocities.

Discussion

The present anthropometric data are in line with published information⁵ whereby World class épée fencers were approximately 184 cm in height, and 77 kg in weight. However, mean body fat percentages found in the present study were relatively higher than the figure of 12.2% reported for national class collegiate fencers¹⁷. Nevertheless, our data support work by Haymes and Dickinson¹⁸ who found a significant increase in both body weight and fatness from the beginning of on-snow training until the end of the competition season in members of the US women's ski team. Lack of systematic high-volume training during the competition period may account for these findings.

The present $\dot{V}O_{2\max}$ values of 58 and 54.8 ml kg⁻¹ min⁻¹ obtained during the off-season and in-season respectively are lower than the 67 ml kg⁻¹ min⁻¹ reported for six World class members of the Swedish national team⁶, but higher than the 50.2 ml kg⁻¹ min⁻¹ reported for leg work performed by fencers of lower competition standards¹⁷.

One of the main findings of this study was that $\dot{V}O_{2\max}$ demonstrates a significant seasonal variation, with the in-season values lower than those of the off-season. Given that aerobic power during activities lasting over 2 min contributes to sporting success¹⁹, such a decline in $\dot{V}O_{2\max}$ levels may result in an impaired competitive fencing performance. This finding reflects the fencers' unsystematic approach to prolonged, steady-state (aerobic) training during the competition period. Our experience has indicated that lack of such aerobic exercise during the competition period is normally associated with: (1) the demanding competition schedules; (2) increased focus and time spent on technical aspects of fencing; and (3) limited encouragement by fencing coaches.

Elevated $\dot{V}O_{2\max}$ levels, however, are normally associated with higher aerobic capacities and, thus, an increased ability to work at near maximal rates when high concentrations of lactic acid may also occur²⁰. The fact that $R_{\max}$ also demonstrates a decline during the in-season compared to off-season measurements, again highlights the lack of appropriate training during the competition period.

The present results showed no statistical differences for the PP and MP outputs obtained in both off- and in-season periods, indicating that the competition itself may have been sufficient to maintain reasonable anaerobic power levels throughout the in-season competition period.

These findings partly agree with published data²¹ whereby no significant changes were noted in PP and MP measurements made during the pre-season and competition season in skiers. It could be said therefore, that fencers and/or skiers engaged in competition of a short but intensive nature are able to maintain anaerobic fitness established during off-season training.

Another set of interesting results was derived from the isokinetic dynamometer. Significantly lower in-season peak torque levels were found for both knee flexors and extensors at all three angular

velocities, compared with peak torque values obtained during the off-season assessments. As in the case of $\dot{V}O_{2\max}$, such variations in muscular strength are likely to impair fencing performance given the need for requisite strength levels for success in sports involving rapid whole body acceleration²².

Lack of appropriate strength training during in-season could explain the present results. Indeed, the only formal strength training traditionally followed by most fencers lasts for only a few weeks, at the beginning of the preparation period. The remainder of the training year is normally devoted to improving fencing technique. On the other hand, elite wrestlers, whose training philosophy differs from that of fencers, have demonstrated significant increases in body muscular strength in-season compared with off-season strength measurements¹⁰.

The lack of statistical differences in strength between dominant (leading) and non-dominant (trailing) legs also contradicts published information on World class épée fencers⁶. Differences in performance levels of the subjects used by the two studies and/or differences in test protocols may account for this discrepancy.

In conclusion, the present results have shown that significant seasonal variations in key physiological parameters can be observed in international fencers during the competition season. This may be owing to lack of appropriately sequenced fitness training. Fitness training programmes to improve muscle strength and cardiorespiratory fitness should be followed throughout the year.

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