COMPETITION INTENSITY AND FATIGUE IN ELITE FENCING

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ABSTRACT

Turner, AN, Kilduff, LP, Marshall, GJG, Phillips, J, Noto, A, Buttigieg, C, Gondek, M, Hills, FA, and Dimitriou, L. Competition intensity and fatigue in elite fencing. *J Strength Cond Res* 31(11): 3128–3136, 2017—As yet, no studies have characterized fencing competitions. Therefore, in elite male foilists and across 2 competitions, we investigated their countermovement jump height, testosterone (T), cortisol (C), alpha-amylase (AA), immunoglobulin A (IgA), heart rate (HR), blood lactate (BL), and rating of perceived exertion (RPE). Average (±*SD*) scores for RPE, BL, and HR (average, max, and percentage of time ≥80% HRmax) were highest in the knockout bouts compared with poules (8.5 ± 1.3 vs. 5.7 ± 1.3, 3.6 ± 1.0 vs. 3.1 ± 1.4 mmol·L, 171 ± 5 vs. 168 ± 8 b·min^{-1}, 195 ± 7 vs. 192 ± 7 b·min^{-1}, 74 vs. 68%); however, only significant ($p \leq 0.05$) for RPE. Countermovement jump height, albeit nonsignificantly ($p > 0.05$), increased throughout competition and dropped thereafter. Although responses of C, AA, and IgA showed a tendency to increase during competition and drop thereafter (T and T:C doing the opposite), no significant differences were noted for any analyte. Results suggest that fencing is a high-intensity anaerobic sport, relying on alactic energy sources. However, some bouts evoke BL values of ≥4 mmol·L and thus derive energy from anaerobic glycolysis. High HRs appear possible on account of ample within- and between-bout rest. The small competition load associated with fencing competitions may explain the nonsignificant findings noticed.

KEY WORDS Epee, foil, sabre

INTRODUCTION

The sport of fencing has been investigated numerous times to describe the kinetics, kinematics, and physical requisites of the attacking lunge (27,68,69). As yet, however, no studies have looked to describe competition intensity and residual fatigue. Such detail pertaining to biochemical and physiological changes can greatly inform training programme design and recovery strategy implementation. For example, measures of heart rate (HR), blood lactate (BL), and ratings of perceived exertion (RPE) taken within competition can determine metabolic workload and the demands placed on energy metabolism (28,70). Recently, RPE has been shown to be a valid method within fencing, showing high correlations ($r = 0.73–0.99$) with HR-based methods (Bannister's and Edwards's training impulse) across training sessions and competition bouts (67). Saliva analysis can reveal the (physical and emotional) stress of competition (and requirements for rest and recovery) by describing hormonal fluctuations in testosterone (T) and cortisol (C) as previously reported in other sports (11,45). In addition, it can show signs of mucosal immunity depression through reductions in secretory immunoglobulin A (SIgA) (38,50), and activation of the sympathetic nervous system (SNS) through concentration changes in salivary alpha-amylase (sAA) (4,5). For example, McLellan et al. (47) monitored the T:C response after a rugby league match and reported significant reductions which did not return to baseline values until 48 hours postmatch. Kivlighan and Granger (33) showed that a 2-km ergometer rowing increased sAA levels, the magnitude of which was positively associated with performance. This trend has also been noted in marathon running (40), triathlon (64), 60-minute cycle races (72), and a taekwondo competition (5). Finally, the incidence of upper respiratory tract illness (URTI) is associated with increases in training load and a reduction in SIgA levels (38,50,58). This association is supported by longitudinal studies examining triathletes (38), swimmers (23), kayakers (42), distance runners (43), football players (18), and rowers (50). Specifically, Neville et al. (50) reported that when SIgA concentration dropped below 40% of an athlete's mean healthy levels, they had a 1 in 2 chance of contracting a URTI within 3 weeks. Furthermore, 82% of the illnesses reported in a previous study were associated

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with a preceding decrease in SIgA (18). Given that illness ultimately results in the loss of training days or important competitions, coaches are understandably eager to use predictive measures.

Measures of stretch-shortening cycle capability are considered indicative of neuromuscular fatigue (31,32), with research showing that fatigue accumulation, normally lasting 48–72 hours postexercise or competition, is detected through a continued deficit in jump performance (10,31). For example, McLellan et al. (47) found that after a competitive rugby league match, force-time data from a countermovement jump (CMJ) showed that peak rate of force development, peak power, and peak force all dropped immediately after the match and lasted for 48 hours. These findings mimicked the body's stress response as measured by salivary C concentrations, and as such, salivary analysis coupled with measures of neuromuscular fatigue may provide the temporal requirements to dissipate fatigue and return to full training without risking injury (21), illness (50), and reductions in both competition and training performance (15).

The physiological demands of elite fencing have not been examined; therefore, the aim of this study was to describe these so as to inform training programme design. It is hypothesized that fencing will be deemed a largely anaerobic sport, inducing reductions in measures of power across the competition days, mirrored by the salivary analytes T, SIgA, and SAA, with increases in C.

METHODS

Experimental Approach to the Problem

An observational research design was used as data were collected in actual competitions. Data were intended to inform future training and recovery strategies within elite fencing, and thus, results used to affect the wider fencing community. As such, scores for each athlete were averaged across 2 competitions to better enable the generalization of results and controlling for the between-day fluctuations in variables. Data were collected across 2 competitions (an international and a national competition) spaced 1 week apart. Saliva samples and CMJ height were collected at the following time points: 48 hours and 30 minutes precompetition, 30 minutes after the poule stages, and 30 minutes, 48, and 72 hours postcompetition. All data were collected between 09:00 and 09:30 hours with the exception of postpoule and postknockout collection points, which were collected at ~13:00 hours and ~19:00 hours, respectively. To avoid the acutely high concentrations consequent to the cortisol awakening response (8), fencers were requested to wake up at least 1 hour before saliva collection and to record time of day for both waking up and saliva collection, to check their compliance. Finally, on each competition day, fencers wore HR monitors throughout, and BL and RPE were taken after each bout. Fencers rested 24 hours postcompetitions, engaged in recovery sessions 48 hours postcompetitions, and given their proximity, performed only light to moderate training sessions at all other time points, consisting of technical blade work, 5-point match sparring, and reduced volume resistance training. Collectively, these measures describe competition demand and the requirements for recovery, affecting exercise selection and the programming and periodization of these.

Subjects

Nine elite male fencers (foil) gave written, informed consent to participate in this study. On average (mean ± *SD*), fencers were 22.3 ± 2.8 years of age, 179.2 ± 5.5 cm tall, 74.2 ± 6.4 kg in mass, and had 14.3 ± 3.6 years of fencing experience. All fencers were free from injury and were of good fitness and health. Before the start of the study, all fencers attended a presentation outlining the purpose and benefits of the study and were familiarized with all test procedures prior to providing signed informed consent. All procedures were granted ethical approval from Middlesex University, in accordance with the Declaration of Helsinki.

Procedures

Incidence and Severity of Illness Symptoms. Each morning, fencers were asked to complete a logbook, which asked for the following coded health problems: (a) no health problems today; (b) cold symptoms (runny stuffy nose, sore throat, coughing, sneezing, colored discharge); (c) flu symptoms (fever, headache, general aches and pains, fatigue and weakness, chest discomfort, cough); (d) nausea, vomiting, or diarrhea; (e) muscle, joint, or bone problems/injuries; (f) other health problems (describe) (52,53). Severity was rated using the following scale: 1 = very mild; 2 = mild; 3 = moderate; 4 = strong; 5 = very strong/severe. If fencers had cold or flu symptoms for a minimum of 2 consecutive days, they were identified as symptomatic (52).

Saliva Sampling Procedures. Fencers were requested to collect 2 ml of unstimulated saliva through passive drool, into a cryovial for the analyses of C, T, SIgA, and sAA (2,57). To preserve the integrity of samples, fencers were requested to avoid food, fluid (except water), and brushing their teeth, 1 hour before collection; 10 minutes before collection, fencers had to rinse out their mouth with water (26). After collection, samples were immediately frozen at −20° C, before being transported to and stored at −80° C until analysis (25).

For SIgA and sAA, flow rates were calculated. Saliva collections were timed (s), to facilitate the calculation of saliva flow rate (Salfr) as described elsewhere (14). Saliva density was assumed as 1.00 g·ml (72). Secretory immunoglobulin A and sAA flow rates were then calculated as the product of the absolute concentration of each and Salfr, (ml·min) (43). Unlike the other tested biomarkers within this study, SIgA has been provided with a reference point to warn of a forthcoming risk of illness, to which sport scientists can take guidance (50). Therefore, the data of each athlete were also examined to identify drops below 40% of the baseline values (48 hours precompetition).

Salivary Analysis. All salivary markers were analyzed in duplicate through commercially available enzyme-linked immunosorbent assays (Salimetrics LLC; State College, PA, USA) using an automated microplate reader (Fluostar Omega; BMG Labtech, Aylesbury, United Kingdom). The assay ranges were SIgA 2.5–600 $\mu g \cdot ml$; sAA 3.28–980 $i\mu \cdot mL$; cortisol 0.33–83 $nmol \cdot L$; testosterone 3.4–2,080 $pmol \cdot L$; and sIL-6 2.08–100 $pg \cdot ml$. The intra-assay coefficient of variation (CV) was sIgA 8.9%; sAA 5.2%; cortisol 5.3%; and testosterone 5.3%. The interassay CV was SIgA 11.2%; sAA 6.0%; cortisol 8.3%; testosterone 3.3%; and sIL-6 1.0%. Standard curves were constructed as per the manufacturer's instructions, and commercially available standards and quality control samples were used for the assays (Salimetrics LLC). All samples were analyzed in the same series to avoid interassay variability.

Neuromuscular Fatigue. Neuromuscular fatigue through CMJ height was measured using an optical measurement system (Optojump, Microgate, Italy) and recorded to the nearest 0.01 cm. Fencers were instructed to keep their hands in contact with their hips for the duration of the test. Any movement of the hands away from the hips would have resulted in the jump being disqualified. After take-off, fencers were also instructed to maintain full extension until contact had been made with the floor on landing. The best of 3 attempts was used in subsequent analysis and produced an intraclass correlation coefficient (95% confidence interval) of 0.95 (0.92–0.96) and CV of 2.9%.

Heart Rate, Blood Lactate, and Rating of Perceived Exertion. Fencers wore HR monitors (Polar team^2 Pro, Warwick, United Kingdom) throughout the competition, where average HR, maximum HR (HRmax), and time spent above 80% HRmax were calculated. Blood lactate ($mmol \cdot L$) was measured through finger prick of the nonfencing hand using a Lactate Pro. Rating of perceived exertion was collected, using the Borg category ratio 10-point scale (3). These measures were taken 5 minutes after each bout, with the former also taken before the start of the competition. All scores were averaged across both competitions and separated to define poule bouts (first to 5 hits) and elimination bouts (first to 15 hits). Furthermore, scores were also analyzed to determine if increases were noted after each bout, as the competition progressed.

Statistical Analyses

Measures of normality were assessed using the Shapiro-Wilk statistic. To determine the reliability of jumps, single-measures intraclass correlations (2-way random with absolute agreement) and the CV were calculated. Repeated measures analyses of variance with Bonferroni correction were performed to investigate temporal changes in CMJ and biomarker values. This test is also considered valid for nonparametric data (19). During pilot testing, large interindividual variations were noted in salivary analyte concentrations, and thus, it was anticipated that these would ultimately invalidate significance testing. Therefore, effect size (ES) analysis was also used (30) and interpreted according to Rhea (61), with athletes classed as "highly trained." Differences in RPE, HR, and BL values, between poules and knockouts, were assessed using a paired samples *t*-test. Pearson's product-moment correlation was used to investigate associations between biomarkers and CMJ data. All statistical analyses were conducted using SPSS version 21 with the level of significance set as $p \leq 0.05$.

RESULTS

All data were reliably assessed, and all variables were normally distributed except for C. Therefore, when C was assessed for relationships with all other variables, data were ranked and analyzed using Spearman's correlation coefficient.

No significant correlations among variables were noted. Scores for RPE, BL, and HR are presented in Table 1, where values for each are highest in the knockout rounds compared with the pools; however, only this difference is significant in time of bout and RPE. Scores for each variable did not show a trend of increasing subsequent to each bout.

Countermovement jump height increased throughout the competition and dropped thereafter, changes, however, were not significant. Relative to 48 hours precompetition scores, ES-interpreted changes were classed as "moderate" through

TABLE 1. Mean (±*SD*) results from 2 competitions, separated according to pool and knockout stages.*

	Time (min)	RPE	BL ($mmol \cdot L$)	HRave ($b \cdot min^{-1}$)	HRmax ($b \cdot min^{-1}$)	>80% HRmax
Pools	5.33 ± 2.15	5.7 ± 1.3	3.1 ± 1.4	168 ± 8	192 ± 7	68
Knockout	15.09 ± 5.24†	8.5 ± 1.3†	3.6 ± 1.0	171 ± 5	195 ± 7	74

*Time = length of bout in minutes; RPE = rating of perceived exertion; BL = blood lactate; HRave = average heart rate (HR); HRmax = maximum HR; >80%HRmax = percentage of time spent above 80% of HRmax.

†Significantly different from pool bouts.

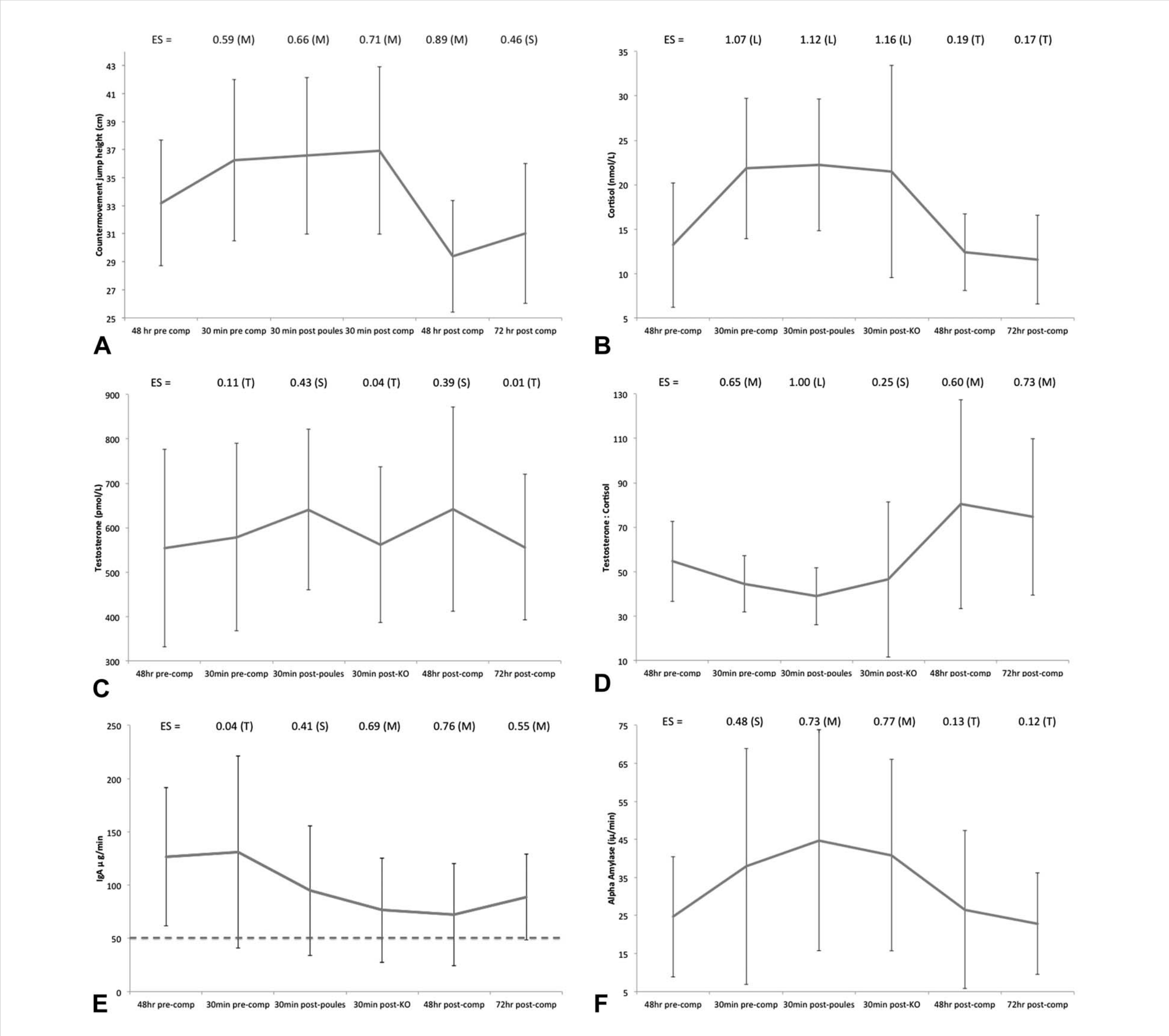

Figure 1. A–F) Although countermovement jump height (A), cortisol (B), testosterone (C), and salivary alpha-amylase (E) appeared to increase during competition and drop thereafter, testosterone to cortisol ratio (D) and S_{fr} (F) showed the opposite, and no significant differences were noted across time points for any of the measured salivary biomarkers. Magnitude of change is identified using effect size (ES) analysis and interpreted according to Rhea (61), where T = trivial, S = small, M = moderate, and L = large. Effect size scores represent changes from 48 hours precompetition. Error bars represent the SD. The dashed line (F) represents the value corresponding to 40% of baseline. According to Neville et al., (50) when values drop below this, they have a 1 in 2 chance of contracting an upper respiratory tract infection.

to 48 hours postcompetition, and then a "small" change at 72 hours postcompetition (Figure 1A). Although C, T, and sAA appeared to increase during competition and drop thereafter, SIgA and T:C showed the opposite. No significant differences were noted across time points for any biomarker (Figures 1B–F). Effect size analysis, however, did reveal "large" changes in C and T:C, "moderate" changes in SIgA and sAA, and "small" changes in T. Effect size values and descriptors are illustrated in Figure 1.

On average, SIgA flow rate ($SIgA_{fr}$) never dropped below 40% of baseline values (48 hours precompetition, identified through the dashed line in Figure 1F). However, on an individual basis, 6 of the 9 fencers did on at least 1 occasion, with 2 athletes remaining below this threshold during and after competition. These 2 and 1 other fencer of the 6 also reported a URTS on at least 2 consecutive days and were thus classed as symptomatic (52).

Discussion

This study is the first to monitor the physiological intensity of a fencing competition and the time course restoration of its inherent fatigue; this information can inform the training programme design of these athletes and their requirements for recovery after competition. Our hypothesis was only partially correct. Although we conclude that fencing is an anaerobic and largely alactic sport, we found no evidence of significant physiological fatigue. These findings are likely to challenge the traditional approaches to fitness training for these athletes. Scores for RPE, BL, and HR (max and >80% max) were highest in the knockouts compared with the poules (Table 1), with differences in perceptions of RPE being significantly different between the 2. Countermovement jump height increased throughout the competition including immediately after, before declining below baseline thereafter. These changes were not significantly different; however, ES analysis did reveal these changes as moderate. Changes in biomarker concentrations were also not significantly different throughout the testing period, although C, T, and sAA_{fr} appeared to increase during competition and drop thereafter, with $SIgA_{fr}$ and T:C showing the opposite. Effect size analysis revealed that these changes were meaningful.

The high and sustained HR values, coupled with high RPE scores, suggest that fencing (foil) is a high-intensity anaerobic sport, and for the most part, relies on alactic energy sources (i.e., phosphocreatine). That said, the spread of data (i.e., the SD) suggests that some bouts (both poules and knockouts) evoke BL values of $\geq$4 mmol·L and thus derive energy from anaerobic glycolysis.

A large percentage of poule and knockout bouts are spent at >80% HRmax (68 and 74%, respectively), which is surprising given the length of each (5.33 and 15.09 minutes, respectively). However, given the ample opportunity for rest within foil fencing, with work-to-rest ratios reported as 1:3 (5 seconds work to 15 seconds rest) (62), this may not be a surprising finding and may also explain how BL values, on average, remained <4 mmol·L. Although only an anecdotal observation, fencers can also prolong within-bout rest periods through methods such as "fixing" the equipment responsible for electronic scoring, realigning swords, and tampering with protective clothing, for example. It should also be noted that although a fencing competition lasts around 10 hours (62), actual bout time only accounts for ~10% of this, and there can be anywhere between 15 and 180 minutes between bouts (62). Therefore, there is also sufficient opportunity to rest and recover between bouts, which one would assume if done correctly would provide adequate time (given the brevity of bouts) to alleviate much of the residual fatigue. Finally, scores for RPE, HR, and BL did not appear to increase after each bout. If an accumulation of fatigue was present, this may be an expected observation. It is more likely that the opponent dictates each bout's intensity. Bouts that are won or lost easily would be less intense than those that are evenly matched and thus last longer. In addition, these bouts could evoke psychological stress and anxiety around the uncertainty of the result. Subsequent to this, there may be increased hypothalamic-pituitary-adrenal axis activity (HPA) and SNS activity (1), which, in turn, could lead to increased cortisol and AA output, cardiovascular response, fatigue, and increased risk and susceptibility to infection (55), again indices not noted here. The above finding is perhaps unsurprising during the poule stages, as the competition is less evenly matched, i.e., it is possible to go from a close match (e.g., 5–4 on points) to an easy match (e.g., 5–0) and thus experience greater relative recovery. It is a more surprising finding during the knockout stages, when only the better competitors are left and matches are more evenly contested. As aforementioned, however, it may simply be that there are enough breaks between bouts to not carry over residual fatigue regardless of opponent or stage of competition. Also, the tested participants were elite, and fitness training involves conditioning work that is designed to exceed that of competition; results here may support the efficacy of this training.

Because of the expected muscle damage and soreness associated with fencing, assumed on the basis of performing a high frequency (140 per competition) of lunges (62), with associated high landing forces (>3 times body weight) and eccentric muscle force (27,68), CMJ scores were expected to drop throughout the competition and remain below baseline for as long as 72 hours thereafter (47). In fact, CMJ height actually increased during competition (and moderately so, according to ES analysis) and immediately after. Therefore, results here actually found a potentiating effect of competition, presumably linked to muscle temperature (73) and the psychological arousal and concomitant excitability of the nervous system (20,71), both of which seemingly outweighed fatigue. The increases in CMJ height are supported by the increases seen in both cortisol and sAA_{fr}, markers of SNS excitability (4,5). Assuming that muscle damage is present, then CMJ height may not be indicative of this, or there was limited damage on account of the repeat bout effect response (7,46) and further indication of the highly trained status of the tested athletes. It should also be noted, however, that although the CMJ is generally regarded as a useful fatigue-monitoring test, Gathercole et al. (22) recently showed that the same fatiguing stimuli can elicit markedly different effects between individuals and across CMJ variables, e.g., peak power, impulse, eccentric, and concentric duration and flight time. Therefore, neuromuscular fatigue may also manifest itself as an altered movement strategy rather than just a reduction in CMJ output, and as such, the use of a full CMJ variable battery appears most prudent for sensitive NM-fatigue detection (22). Future studies should, therefore, investigate fatigue with respect to these variables.

It would appear that competitions do not involve acutely significant central nervous systems or peripheral muscle fatigue in elite fencers; a statement supported by HR, BL, RPE, and CMJ data. Fatigue may have been masked by central nervous system excitability and increases in muscle temperature; also nutritional interventions associated with elite athletes. Interestingly, however, CMJ scores showed a small decline (through ES analysis) after the competition that was still apparent 72 hours postcompetition. Also, similar observations were made regarding $SIgA_{fr}$ (discussed later), where 3 of 9 fencers could also be diagnosed with a URTI through logbook reviews of health problems. As such, some caution must be exerted during training at this point.

Cortisol and testosterone are considered valid markers of training load (10,47). The latter has been described as the primary anabolic marker for protein signaling and muscle glycogen synthesis, and the former a stress hormone which suppresses immunity, mediates catabolic activity, increasing protein degradation, and decreasing protein synthesis in muscle cells (11). Cortisol is also associated with anxiety (1), HPA activity (14), depression, and creatine kinase, which is a marker of muscle damage (34). The nonsignificant increases in C levels noted herein are in contrast with that reported in rugby league (47), rugby union (16), soccer (35), American football (29), and swimming (14), for example. However, it is clear that values did increase, especially when considering that the within-competition measurements would typically be lower than early morning measurements on account of circadian variation (60). These assertions are supported by the large changes noted during competition as revealed by ES analysis (Figure 1B). The individual variation and high variability of scores between athletes, seen here and elsewhere (14), also left it unlikely that statistically significant differences would be noted. Furthermore, given our findings regarding actual exercise duration, results are in support of others who found that although increases in C are dependent on exercise intensity (≥60% of maximal oxygen uptake), secretion is also dependant on exercise duration, at least 20–30 minutes is required, and the biofeedback regulation by the HPA axis (65,66). Although above this relative threshold, large elevations in blood C levels can occur, insignificant changes are noted below this threshold. Furthermore, the 30-minute precompetition C levels appeared higher than the 48-hour precompetition, suggesting anticipatory stress to competition (1,34). Based on the biofeedback regulation theory, the 30-minute precompetition C levels perhaps were already too high for exercise to induce a significant response (14). However, increases in C have also been found in a kickboxing (48) and wrestling (9) match. Although this may be on account of muscle damage, the rise in C has also been suggested to coincide with the onset of BL accumulation (56,59), and our findings reveal that, on average, they operate under this threshold. Collectively, these findings also support the (nonsignificant) changes found in T, which shares similar volume load thresholds to C (39,41). Furthermore, T release has been found to correlate with a high strength training age (i.e., ≥2 years strength training experience) (36) and strength capacity (e.g., being able to back squat ≥2 times body weight) (12), factors that the tested athletes did not meet. Given these findings, T:C providing an indication of the anabolic/catabolic balance in response to training and competition (10) also provided no significant changes. In fact, T:C increased postcompetition, largely on account of the drop in C. This drop may be attributed to the reduction in competition anxiety (34). Again, given that T and C exhibit diurnal variations whereby concentrations are typically higher in the morning and drop throughout the day (37), it may be that there was some elevation in recorded levels, but these were offset by the natural decline in release patterns occurring late in the afternoon and evening, when samples were taken at competition. Finally, postcompetition values suggest that athletes can begin full training again 72 hours postcompetition.

Salivary alpha-amylase monitoring, like C, reflects the stress response to psychological and physical stress (24,33,49). However, unlike C, which represents the slower endocrine response to stress (i.e., release through the HPA axis), sAA represents the faster activation of the sympathetic branch of the autonomic nervous system (ANS) and the release of catecholamines (6). Collectively, therefore, they may provide a more precise prescription of training and recovery cycles in athletes (54). Unlike C, which is transported from blood to saliva, sAA is produced locally in the salivary glands and controlled by the ANS (4,63), and given that physical exercise causes activation of the SNS, it is expected that sAA will display increases in response to exercise (33). Such observations have been reported previously as aforementioned. Again, increases in sAA appear mostly dependent on exercise intensity (2) with a relationship between measures of sAA and BL also reported (13); perhaps these findings support why we did not note significant changes. That said, changes were regarded as moderate, but again, we should note that sAA exhibits a pronounced decrease within 60 minutes after awakening and a steady increase of activity during the day (49). We must therefore acknowledge that the increase seen in the sAA_{fr} values might have also been attributed to circadian variations.

Secretory immunoglobulin A functions as the first line of defense to viral pathogens entering the body through mucosal surfaces (44), thus acting to prevent infections of the upper respiratory tract. Nieman (51) reported a "J-shaped" relationship between training load and susceptibility to URTIs, where decreases in SIgA accompany a high training load (38,50), thus increasing its incidence. Low levels of physical activity also increase this risk, whereas moderate levels provide a protective effect. Short bouts (<30 minutes) of high-intensity exercise (>80% $\dot{V}O_2max$) have also been found to increase SIgA concentration (2,51) and typically, assuming testing does not follow strenuous long-term training, SIgA recovers within 24 hours postexercise (2). Here and albeit nonsignificant, $SIgA_{fr}$ showed moderate decreases during the competition, which had not returned to baseline 72 hours later. Also, considering $SIgA_{fr}$ is subject to a morning nadir in circadian release patterns, with levels rising throughout the day (14) and coupled with large increases in the immunosuppressive hormone C, findings appear more meaningful. That said, it may not be until SIgA levels drop below 40% of baseline values that athletes are at greater risk of illness and infection, and a so-called "open window" is thus exposed (50). On average, $SIgA_{fr}$ never dropped below 40% of baseline values. However, on an individual basis, 6 of the 9 athletes did on at least 1 occasion, with 2 athletes remaining below this threshold, and 3 reporting URTS on at least 2 consecutive days. Furthermore, our findings showed that 50% of those fencers with $SIgA_{fr}$ below 40% of baseline values were also URTI symptomatic at least during the postcompetitive period, supporting previous studies that reported that ~95% of all infections start at mucosal surfaces (17). Our data appear to support the notion of a 1 in 2 chance of contracting a URTI when mean healthy levels of SIgA drop below 40% (50). Nevertheless, biomarkers associated with illness development, either previously reported or within this study, do not guarantee whether a person will stay healthy or develop illness, which further supports the multifactorial nature of immunity.

Practical Applications

The between-bout timings of a fencing competition are unpredictable as is the quality of opposition; thus, it is advisable to prepare athletes for the worst-case scenario; a short break followed by a maximum point bout (i.e., 29 hits) on account of an evenly contested match. In this scenario, RPE is likely to be >8 and BL >4 mmol·L, and given the nature of the fight, high-intensity interval training is recommended. This type of training ensures that athletes are exposed to high concentrations of BL, building a buffering capacity and tolerance of hydrogen ions as a consequence.

Our results appear to show that the tested fencing competitions did not evoke significant acute central or metabolic fatigue in elite fencers. The lack of within-competition fatigue may not be surprising given the format of a fencing competition, which provides ample opportunity for recovery. In fact, and assuming consistent psychological stress and appropriate nutrition, it should be conceivable that fencers can fence at maximal intensity throughout the duration of the competition. Subsequently, and beyond strength and conditioning practices, the sport science support teams of these athletes should investigate various recovery strategies around fuel and fluid replacement (i.e., nutrition) and psychological interventions to cope with the high stress that may, in turn, increase intensity and fatigue.

Finally, given the small risk (albeit still above 40% of baseline values) indicated by reduced $SIgA_{fr}$, recovery-based sessions and training up to and including 72 hours postcompetition could consider commencing training from late morning or early afternoon. This is due to circadian rhythms whereby C (an immunosuppressive) is highest in the morning, and SIgA, which is already below baseline, is at its lowest. The high interindividual and intraindividual variability of the selected biomarkers' response to exercise seen in this study reinforces the importance of individual monitoring, especially of elite athletes.

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