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Original research

The effect of oral contraceptive use on salivary testosterone concentrations and athlete performance during international field hockey matches

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ABSTRACT

Objectives: To investigate the effect of oral contraceptive (OC) use on salivary testosterone (sal-T) concentrations and performance-related statistics in international field hockey matches.
Design: A cohort observational study with repeated measures.
Methods: Twenty-three elite female athletes were monitored across four international field hockey matches over a nine-day period. Salivary T was assessed 45 min before each match and several match performance statistics were collated; load (i.e. ratings of perceived exertion × playing time), video-derived positive actions (PA) and negative actions (NA), plus coach and player ratings of performance. The sal-T and match performance profiles of OC (n = 7) and Non-OC (n = 16) players were compared and predictive relationships tested.
Results: Pre-match sal-T concentrations were 35% higher in the Non-OC than the OC group ($p = 0.001$), representing a large effect size (ES) difference of 0.96. The OC and Non-OC groups did not differ on any performance statistic ($p \geq 0.348$) with ES differences from −0.22 to 0.11. Salivary T was positively related to the number of PA during match play ($p = 0.017$). Additional linkage between sal-T and NA emerged, but with opposing slopes ($p = 0.008$) in the OC ($B = -1.783$, $p = 0.030$) and Non-OC ($B = 0.692$, $p = 0.127$) groups.
Conclusions: OC usage by elite women athletes was accompanied by lower sal-T concentrations, but the performance outputs of the OC and Non-OC groups were similar. This suggests that the T differences had no impact on match performance. On an individual (population-averaged) level, sal-T was associated with PA and NA during these matches, though the response curves predicting NA differed for OC and Non-OC athletes.

1. Introduction

There is growing interest in the role of testosterone (T) in mediating women's performance during athletic competition.[1,2] Testosterone has been linked to behavioral outcomes (e.g. social connectedness, aggressiveness and bonding) in female rugby and soccer players,[3,4] which in turn could influence performance. The perceived abilities of soccer players (as rated by teammates) also correlated with pre-match salivary T (sal-T)[3] and recent work identified a performance advantage for some track and field athletes (e.g. 400 m, pole vault, hammer throw) with high blood-free T.[1] Similarly, winning in sport can elevate sal-T, relative to losing,[5,6] with further implications for recovery and performance. However, most studies have been conducted on sub-elite women, thereby limiting knowledge development and transfer into elite sport, and they typically involved one-off testing when longitudinal data is

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needed to establish causation between endogenous T and competitive performance.

Oral contraceptive (OC) usage is another important consideration for women athletes, as some synthetic steroids can lower blood total T and free T concentrations by 31% and 61%, respectively, in healthy women.[7] The T profiles of OC users and non-users (Non-OC) in sport agree with these findings.[8–10] Given the potential importance of endogenous T in women's sport, this baseline shift in androgen status might also help to regulate competitive performance, over and above normal biological variability. In fact, the OC effect could be magnified in elite women athletes from speed-power based sports, since they can exhibit more than twice the amount of sal-T than non-elites.[11] As a result, any relative decline in T could lead to a larger absolute T change in this population. To our knowledge, no studies have examined the impact of OC's on T physiology and competitive performance in elite women athletes in a speed-power sport.

Addressing the aforementioned issues would provide new insight regarding the causes and consequences of women's T variation within elite competitive sport. Possible benefits include tailoring approaches to improve athlete training and management by assessing the impact of individual OC use on T and relevant performance metrics. The information gained could then provide a stronger framework for developing and applying T-focused priming strategies (e.g. watching videos, selected coach feedback, caffeine ingestion)[12,13] to optimise individual and team performance. Greater awareness of these outcomes might also lead to more effective pre-screening and monitoring procedures in sport. Therefore, a study on elite women athletes was conducted to investigate the effect of OC usage on sal-T concentrations and performance statistics across four international field hockey matches.

2. Methods

Twenty-three elite female hockey players were recruited, with a mean age, height and weight of 25.6 ± 3.6 years, 168.1 ± 8.2 cm and 62.8 ± 6.9 kg, respectively. Pre-screening indicated that all participants were healthy and injury-free. The players were also questioned about hormone-based contraceptives (e.g. oral pill, implantable or patch-delivered). The OC users (n = 7) reported taking oral pills only, with the remaining players classified as Non-OC users (n = 16). Regular menstrual cycles were reported by the Non-OC group without any noticeable problems. The players maintained their normal training each week, which included several conditioning sessions (e.g. aerobic training, weight training, skill and match-play) and club matches played in a semi-professional hockey league. Written informed consent was provided before the project commenced. This study was conducted with ethical approval from the Swansea University Research Ethics Committee (Number 2010.001R).

A cohort observational study with repeated measures was employed. The athletes participated in four international field hockey matches (all home games) over a nine-day period. Two games were played against one opponent (Days 1 and 2) and two against another (Days 8 and 9). This team was ranked number three in Europe and their opponents were ranked number five and eight, respectively. Three matches started at 2:00 pm and another at 10:30 am, due to the prior scheduling of these contests. To account for circadian variation, time of day was entered as a covariate during data analyses. The matches were played in two × 35-min periods and 16–18 athletes participated. Each athlete played 2.9 ± 0.8 matches (range 2–4) across this study. A consistent match-day routine was followed, starting with a standard breakfast and light midday meal (for the 2.00 pm matches) before a team briefing 90 min before each match to formalise goals and strategies. Next, a standard warm-up was completed (<45 min) comprising of light aerobic activity, individual and team drills/skill work at increasing intensities, interceded with dynamic stretching of the major muscle groups. No other priming strategies were employed before these competitions.

Salivary T was assessed before each game and compared to several match-related performance statistics (see below). Saliva samples (~1 ml) were collected 45 min before each match to account for a pre-competition rise in hormones.[4,6] No food or drinks, except water, were taken 60 min beforehand to limit any possible contamination. The samples were taken by passive drool and stored at −80 °C. After thawing and centrifugation, the samples were assayed in duplicate for T by a commercial lab (HFL Sport Science, UK). The sal-T assay had a detection limit of 6.1 pg/ml with inter-assay coefficients of variation (CV) of <12%. This variance was eliminated by testing each athlete's samples within the same assay plate. Duplicate samples with CV's in excess of 12% were retested. Some care must be taken when using sal-T as a surrogate of blood total T among female populations.[14] Pilot testing on a young cohort of athletic women (n = 23) revealed a moderate relationship (r = 0.69) between sal-T and blood-free T concentrations to verify its application herein.

Common match performance statistics were recorded,[3,6,15] including: load, positive actions (PA), negative actions (NA), plus coach and player ratings of performance (CRP and PRP). To calculate match load, a post-match rating of perceived exertion was taken on a Likert scale from 1 (extremely light) to 10 (maximal effort) and multiplied by playing time. The PA and NA were collated by the team statistician from video footage. The PA included possession on basic passes, pass penetrations, dribble penetrations and goals scored, whereas the NA included shots off target, missed traps, loss of possession and lost possession on tackles.[16] No such data were available for the goalies (1 × OC, 1 × Non-OC), as their involvement could not be quantified from this footage, so 4 out of 66 data points (~3%) were missing. Still, the goalies were included to better represent the team response and to maintain a reasonable sample size. To further index performance, three coaches rated each player on a Likert scale from 1 (extremely poor) up to 10 (excellent) and these were aggregated to derive a single CRP. The players also rated their own performance, or PRP, using the same scale.

A generalized estimating equation (GEE) with an exchangeable correlational structure was used to examine the study data. The GEE is appropriate for testing longitudinal data with non-normal response variables, unbalanced or incomplete datasets.[17] To establish if the OC and Non-OC groups differed in their match-day profiles, we examined sal-T and each performance statistic with OC group (OC = 0, Non-OC = 1) as a fixed factor. Day of testing and time of day were entered as covariates. Cohen's effect sizes (ES) were also calculated (with 95% confidence intervals [CI]) as follows; <0.2 = trivial, 2 to <5 = small, 5 to <8 = medium, ≥0.8 = large. Next, population-based predictions of each performance statistic were developed using a two-step process; day of testing, time of day, sal-T and OC group were entered as predictors in step 1; sal-T × OC group in step 2. Following a significant interaction, slope testing was used to examine the results at one SD above and below the mean. Before analysis, the continuous variables were standardized to reduce multicollinearity and the interaction term was calculated from their product. Data were analysed using IBM SPSS Statistics 24 with the significance level set at $p \leq 0.05$.

3. Results

Testing of the group means revealed significantly higher sal-T concentrations in the Non-OC (vs. OC) athletes (Table 1), representing a large ES difference of 0.96 (95% CI 0.43; 1.48). In terms of

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