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Human Kinetics
ORIGINAL INVESTIGATION

Mental Rehearsal Improves Passing Skill and Stress Resilience in Rugby Players

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Purpose: Mental rehearsal is commonly employed, with positive visualization proposed to enhance complex skill performance. Additionally, video stimulus has been associated with enhanced kinesthetic sensations and rapid hormone fluctuations that may contribute to enhancing mental rehearsal and the conscious and unconscious emotional state for skill execution. Here, we assessed the impact of a 15-minute mental rehearsal intervention on rugby-specific tasks and the associated hormone profile. ***Methods:*** Professional rugby players (N = 10) volunteered for a randomized crossover study. They completed three 15-minute preparatory phases (positive or negative video-guided mental rehearsal or self-directed mental rehearsal alone) prior to an exercise stressor and rugby-specific passing task. Salivary testosterone and cortisol were monitored to assess stress responses. ***Results:*** Performance during the rugby passing task was improved following the positive video condition (91% [7.4%]) compared to the negative video (79% [6.0%]; ES: 1.22 ± 0.75) and self-visualization (86% [5.8%]; ES: 0.58 ± 0.75), with a significant correlation observed between passing performance and salivary testosterone ($r = .47 \pm .34$, $P = .0087$). Positive video imagery prior to an exercise stressor also significantly enhanced physiological stress resilience ($r = .39 \pm .36$, $P = .0352$). ***Conclusions:*** This pilot study demonstrates that mental rehearsal was enhanced by appropriate, context-specific video presentation. We propose that the interaction between sex steroids, the adrenal axis, and subsequent conscious and unconscious behaviors may be relevant to competitive rugby. Specifically, we suggest that relatively elevated free testosterone imparts a degree of stress resilience, which may lead to enhanced expression of competitive behaviors and provide an enhanced state for rugby skill execution.

Keywords: testosterone, cortisol, visualization, video, motivation

The ability of humans to reason through problems in virtual space and envisage future actions in order to improve subsequent performance has been suggested to differentiate humans from nonhuman primates.[1] Interestingly, brain imaging studies have demonstrated that the act of mental rehearsal elicits remarkably similar activation patterns to those induced by actual motor execution.[2, 3] As a result, the extrapolation of mental rehearsal as an adjunct to aspects of skill acquisition, performance improvement, and as a stress-coping strategy has been applied in a variety of fields including music,[4] public speaking,[5] and sporting environments.[6]

In a sporting context, variants of mental rehearsal have proved effective in enhancing performance across a range of diverse activities including golf,[7] volleyball,[8] basketball,[9] figure skating,[10] and athletics.[6] The ability to enhance complex coordinated movements in sport-related open-ended motor activities using mental rehearsal has been suggested to manifest via the construction of a schema that can be accessed and implemented without conscious preparation.[8] Interestingly, negative imagery (visualizing narrowly missing the hole) has been associated with impaired golf putting accuracy[7] and "excessive autonomic discharge" shown to be detrimental to performance in a volleyball serve-receipt task.[8]

One of the limitations of mental rehearsal is the inability to standardize or control the nature of the mental imagery. Ryan and Simons[11] demonstrated superior performance in a novel balancing act in participants reporting strong visual and kinesthetic imagery compared to those reporting less vivid imagery. Hall and Erffmeyer[9] compared the visualization incorporating a video tape with visualization alone and reported that the use of a sports-specific visual cue enhanced the kinesthetic sensations resultant from mental rehearsal and improved basketball shooting performance. Thus, the use of mental rehearsal incorporating a video has the potential to improve subsequent sport-specific tasks with the additional benefit of providing a standardized stimulus that can be tailored with sports-specific cues.

Early work by Hellhammer et al[12] demonstrated that the presentation of a movie clip could alter mood state and rapidly modulate salivary testosterone levels. There is direct evidence to support the thesis that testosterone is capable of influencing unconscious aspects of approach- and withdrawal-related emotion.[13] Within this construct, Cook and Crewther[14] identified the preexercise hormonal milieu as a "window of opportunity," whereby the hormonal modulation achieved by viewing a brief movie, altered subsequent voluntary performance. Furthermore, strong relationships between voluntary workload and relative testosterone levels have been demonstrated in elite netball athletes in training ($r = .67–.83$), suggestive of a behavioral driver that may underlie subsequent adaptive responses.[15] Stress-related hormones, including testosterone and cortisol, have also been suggested to relate to attentive skill in rugby players and subsequent motor execution.[16] Given the potency by which sex steroids act on the adrenal axis,[17] here we test the hypothesis of whether the presentation of a brief movie to enhance mental rehearsal can improve

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performance in a sport-specific task (rugby passing) and potentially induce increased resilience to a subsequent physical stressor.

Materials and Methods

Subjects

Ten professional male rugby players (mean [SD], age: 20.6 [1.3] y; height: 1.85 [0.05] m; body mass: 97.6 [8.3] kg) were recruited and provided written informed consent. All subjects were nonsmokers, had a professional training history of at least 2 years, and were well accustomed to the repeated sprints, strength exercises, and rugby-specific complex motor skill passing task employed in the current study. The study had a randomized crossover design, was approved by a university ethics committee, and complied with national legislation and The Code of Ethical Principles for Medical Research involving Human Subjects of the World Medical Association (Declaration of Helsinki).

Experimental Protocol

On 3 separate days within a 2-week period and at the same time of day, the players arrived at the training facility where they were accustomed to training and sat quietly for 5 minutes before providing a saliva sample (prepreparatory phase sample: T1; see Figure 1). The players were then instructed to enter a room alone and mentally rehearse the sport-specific task of accurately passing a rugby ball for 15 minutes using one of 3 preparatory methods. Two of the mental rehearsal methods consisted of the presentation of a movie constructed from real rugby game situations, while the third method (self-visualization) presented no movie and relied on self-visualization without visual cues. The 2 conditions that involved the presentation of a movie were either presented with a positive antecedent discriminatory stimulus that showed the player performing their individual tasks well (positive video), or a negative antecedent stimulus that highlighted errors in the individual's performance of the same task (negative video). Each player performed all 3 of the preparatory phase conditions (self-visualization, positive video, and negative video) in a randomized manner within the 2-week period. Five minutes after the preparatory phase, a second saliva sample was collected (postpreparatory phase sample: T2; see Figure 1). The player was then instructed to warm-up on a cycle ergometer at 100 W for 10 minutes while continuing to mentally rehearse the specific aspects of their passing performance. Upon completion of the cycle warm-up, a third saliva sample was collected (prestressor sample: T3; see Figure 1), and the physical stressor was then begun.

The physical stressor involved three 6-second maximum effort cycling sprints, followed shortly (~2 min) thereafter by three 10-m maximum effort running sprints. All sprint efforts were interspersed with 24-second active recovery. The players then performed 5 sets of 3 repetitions of heavy squats (3-repetition maximum; ie, the maximum weight that could be lifted 3 times) with 3-minute rest between sets. Similar brief high-intensity exercise is known to elicit rapid increases in both testosterone and cortisol.[18] The players then completed the passing accuracy task that required the players to attempt to pass a rugby ball 10 times through a hoop 5 m away alternating between their dominant and nondominant hands. A time limit of 2 minutes was enforced for the passing accuracy task and accuracy was determined by the number of passes that went through the hoop. Five minutes after the completion of the accuracy test a fourth saliva sample was collected (poststressor sample: T4; see Figure 1).

Hormone Assessment

For each sample, participants were asked to provide 2 mL of saliva via passive drool into a sterile centrifuge tube. Saliva samples were stored at −20 °C until assay. Salivary steroid samples were taken in this study as they are minimally invasive and have the advantage of reflecting free steroid concentrations.[19] To minimize the possibility of any blood contamination of saliva, which would result in an overestimation of hormone concentrations, the players were advised to avoid brushing their teeth, drinking hot fluids, or eating hard foods (eg, apples) in the 2 hours before data collection. Saliva samples were analyzed in duplicate for testosterone using commercial enzyme immunoassay kits as per manufacturer's instructions (Salimetrics LLC). The detection limits for the testosterone and cortisol assays were 19 pmol·L^{-1}, and the respective intraassay and interassay coefficients of variation were <7.7%.

Statistical Analyses

Differences in the means of the hormone responses and athletes' passing accuracy were assessed using a repeated-measures analysis of variance with mental rehearsal method as a factor. Changes and errors were expressed as percents via analysis of log-transformed values to reduce bias arising from nonuniformity of error.[20] Data were analyzed for practical significance using magnitude-based inferences and calculated using appropriate between-subject SDs. Magnitudes of the standardized effects were interpreted using thresholds of 0.2, 0.6, and 1.2 for small, moderate, and large effect size (ES), respectively.[20] Standardized effects of between −0.19 and 0.19 were termed trivial. Quantitative chances of higher or lower differences were evaluated qualitatively as follows: <1%, almost certainly not; 1% to 5%, very unlikely; 5% to 25%, unlikely; 25% to 75%, possible; 75% to 95%, likely; 95% to 99%, very likely; and >99%, almost certain.[20] The effect was deemed "clear"

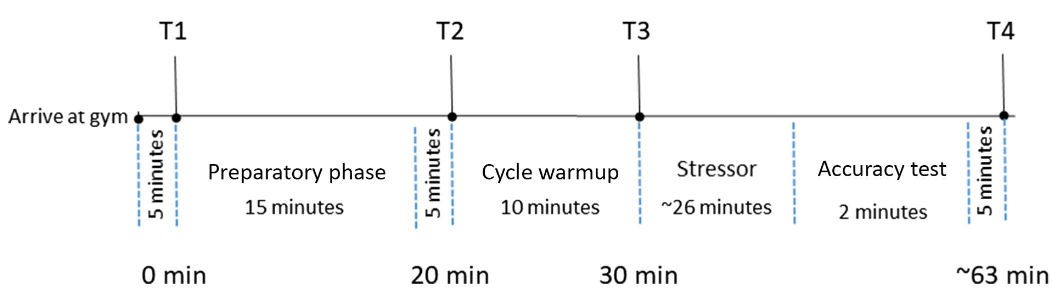

Figure 1 — Experimental design.

if the 95% confidence interval did not overlap the thresholds for small positive and negative effects. Bivariate relationships between the salivary hormones and passing accuracy performance using absolute hormonal values (30 observations) were examined using Pearson product moment correlation coefficients (r). Magnitudes of correlations were interpreted using thresholds of .1, .3, .5, and .7 for small, moderate, large, and very large correlations respectively.[20] 95% confidence limits are presented in brackets following correlation coefficients and ESs. Significance was set at an alpha level of $P \leq .05$.

Results

The average resting salivary testosterone (Sal-T) and cortisol (Sal-C) concentrations were 487.6 (91.6) pmol·L^{-1} and 5.55 (1.08) nmol·L^{-1}. The salivary hormone levels are illustrated in Figure 2 and show a moderate difference between the Sal-T (ES: 0.47 ± 0.19) and Sal-C (ES: −0.46 ± 0.30) responses to the positive and negative video presentation (T2–T1). There was also a significantly greater Sal-T response to the exercise stressor (T4–T3) following the positive video presentation (ES: 0.26 ± 0.15) and concomitantly a likely attenuation of the Sal-C response (ES: −0.35 ± 0.34). In general, the self-visualization condition was intermediary; however, a very likely attenuation of the Sal-C response during the preparatory phase was observed when compared to the negative video condition (ES: −0.52 ± 0.27).

Accuracy during the passing task was enhanced in the positive video condition (91% [7.4%]) compared to the visualization (86% [5.8%]; ES: 0.58 ± 0.75) and the negative video presentation (79% [6.0%]; ES: 1.22 ± 0.75). A significant moderate correlation was observed between the rugby passing accuracy task and prestressor Sal-T (T3: $r = .47 \pm .34$; $P = .0087$; Figure 3A) but not the initial Sal-T (T1: $r = .35 \pm .37$; $P = .0618$). In addition, a moderate negative relationship was observed between the change in Sal-T during the preparatory phase (T2–T1) and the acute Sal-C response to the physical stressor (T4–T3: $r = -.39 \pm .36$; $P = .0352$; Figure 3B).

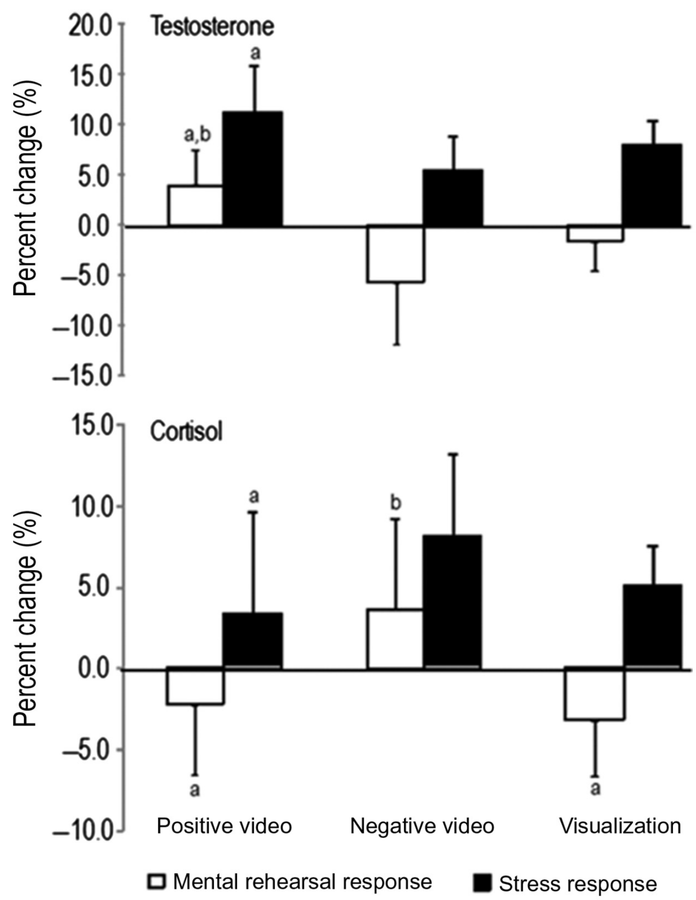

Figure 2 — Salivary hormone responses to a 15-minute mental rehearsal condition and subsequent exercise stressor. (A) Substantially different from the negative video condition response. (B) Substantially different from the self-visualization condition response.

Discussion

Here, we provide some preliminary evidence that the presentation of a context-specific video can elicit distinct hormonal changes that are associated with improved rugby-specific motor skill execution, and impart a degree of physiological stress resilience (attenuation of the stress hormone response to a subsequent physical stress). Previous research with professional rugby players has demonstrated that the presentation of 4-minute videos can positively influence hormone responses and weight lifting performance and suggested an effect of hormones on an athlete's motivation to perform.[14] Such associations have also been reported in elite female athletes whereby individuals presenting to training with relatively elevated testosterone lifted heavier loads during a self-selected near-maximal leg exercise suggestive of a positive relationship between Sal-T and training capacity or motivation.[15] Of note, video clips combined with positive feedback have also been demonstrated to positively affect subjectively rated rugby performance indices in a real competitive environment.[21]

As a result, we have proposed the concept of testosterone influencing training motivation in an athletic context.[15] Testosterone has demonstrated a range of behavior-modifying effects in humans, including increasing unconscious motivation,[22] aggression,[23] and risk taking,[24] while decreasing empathetic behaviors[25] and fear.[26] Thus, rapid changes in the bioavailable concentration of testosterone, in addition to the known effects on cortical circuitry controlling voluntary muscular movements[27] and muscular excitation–contraction coupling,[28] may modulate motivation and punishment reward sensitivity. Research has also suggested roles for cortisol and testosterone in both elite female netball competition and in attentive behaviors relative to motor tasks in rugby players.[18,19] These behavioral drivers have the potential to influence subsequent training adaptation and the expression of competitive behaviors likely to be beneficial to performance in a range of competitive contact sports, including rugby.

Our pilot data illustrate a relationship between rugby-specific motor skill performance after the physical stress and salivary testosterone, a relationship that was increased when the temporal proximity of the sampling time to the task was decreased (ie, T3 vs T1). In addition to the discussed effects of testosterone on self-efficacy and motivation (*vide supra*), studies have demonstrated associations between endogenous bioavailable testosterone levels and visuospatial processing.[29] Researchers have suggested that elevated free testosterone concentrations may facilitate improved performance via modulation of information encoding and comparison, and the rate of the initiation of decision and response processes.[30] It is of note that we assessed salivary testosterone which allowed multiple, noninvasive sample collection time points

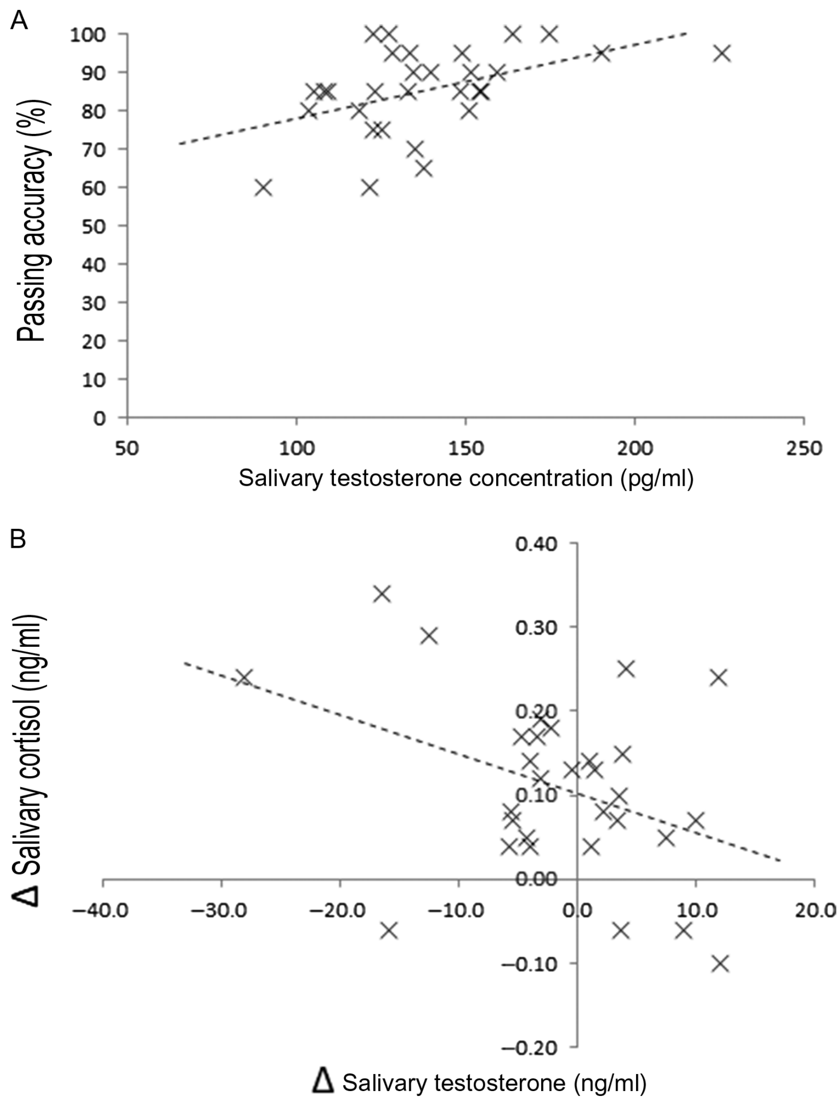

Figure 3 — Correlations between hormone levels and performance. (A) Correlation between passing accuracy and prestressor salivary testosterone (T3). (B) Correlation between salivary testosterone response to the preparatory phase (T2–T1) and salivary cortisol response to the stressor (T4–T3).

in close temporal proximity to the mental rehearsal condition and the exercise stressor. Thus, salivary monitoring provided information regarding the concentration of free testosterone capable of passing the blood–brain barrier and thereby interacting with receptors in the brain to influence cognitive processing and behaviors.[31]

Here we also provide preliminary data supporting the hypothesis that an enhanced acute testosterone response resultant from the Positive Video, when combined with mental rehearsal, is associated with a suppressed cortisol response to the subsequent exercise stressor in addition to the improved accuracy during the rugby-specific passing task. Similarly, it has been posited that attenuated autonomic nervous system responses are associated with better performance in volleyball players.[8] Testosterone has been demonstrated to inhibit the hypothalamic–pituitary–adrenal axis response to stress[32] and elicit anxiolytic properties that can be effectively blocked via androgen receptor antagonism.[33] Indeed, van Honk et al[13] demonstrated that, in contrast to a lack of effect on cognitively attributed anxiety measures, testosterone was effective in reducing an *unconscious* fear response and attributed their results to effects in the subcortical affective pathways of the brain. Speculatively then, the enhanced testosterone response observed herein may contribute to self-efficacy and confidence, and potentially enhance performance by providing a more optimal emotional state for skill execution.[34]

It should be noted that, while the video presentation was intended to enhance the kinesthetic sensations elicited by mental rehearsal and provide a standardized stimulus, individual differences in life experiences and personality types will undoubtedly contribute to interindividual differences in how the stimulus was perceived and subsequent physiological responses.[35] A strong caveat is the low subject number in this study. Professional rugby players have large demands on their training time so recruitment was limited, and thus we view this as a pilot study. Significantly higher numbers are needed to confirm this work although other studies with larger numbers, such as the work of Serpell et al,[16] do support the general notion. We also acknowledge as a limitation that it is likely that prior experience with mental rehearsal training and individual imagery ability would affect the efficacy of the self-visualization condition.[10]

Conclusions

In this pilot study in elite rugby players, we have demonstrated that the effects of mental rehearsal were enhanced by utilizing a context-specific positive antecedent discriminative video stimulus. This stimulus improved rugby passing motor-skill execution and imparted a degree of physiological stress resilience to an acute physical stressor. As these observations were associated with an altered hormonal state, we suggest that there may be interactions between sex steroids, the adrenal axis, and subsequent conscious and unconscious behaviors. The ability to rapidly modulate bioavailable hormone concentrations via self-visualization or a context-specific 15-minute video is in line with previous research that has demonstrated positive priming in a similar cohort.[14, 21]

Practical Applications

The preliminary findings support the practical use of mental imagery to improve rugby training and match performance. Practitioners can use positive videos to increase passing accuracy, and thus, video presentation may represent an effective tool to enhance other sport-specific skills, for example, kicking and lineout throwing. Current practice of performance analysts involves the creation of video content to identify strengths and weaknesses of various opposition. These same processes could be utilized to provide content that specifically focuses on skill sets being performed well that could be incorporated into prematch routines. The elevated testosterone levels resultant from the positive video presentation also have the potential to improve self-efficacy, motivation, and visuospatial processing, and decrease anxiety, all of which have the potential to directly impact on rugby skill performance.

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