

Daily Fluctuations in Hormonal and Performance Markers in Collegiate Weightlifters

Received 02nd June 2018
Accepted 10th June 2018

Kyle D. Peterson ^{a,*}, Matthew J. Andre ^b

www.ijpefs.com

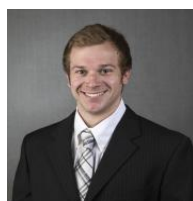
^a Sports Science, University of Iowa, Carver-Hawkeye Arena, 1 Elliot Dr, Iowa City, IA, USA.

^b Department of Exercise and Sport Science, University of Wisconsin-La Crosse, Mitchell Hall, 1820 Pine Street, La Crosse, WI, USA.

* Corresponding Author: Ph: +1-952-212-1419; E mail: kyle-d-peterson@uiowa.edu

Abstract: The purpose of this study was to assess relationships between daily fluctuations in hormonal and performance markers in weightlifters. Nine male collegiate weightlifters gave daily pre-practice salivary samples for one week and were tested daily for standing broad jump distance; first jump (BJ1) and best jump (BJB) were recorded. Volume-load was heavy on Monday (47%), light on Tuesday (13%), and medium-heavy on Wednesday (40%). To determine if variables differed by day, RM ANOVAs were used with partial-eta squared effect sizes (η^2_p) to calculate meaningful changes. RM ANOVA models suggest daily differences occurred for T ($F=4.027$, $p=.024$, $\eta^2_p=.402$), T/C ($F=11.735$, $p=.019$, $\eta^2_p=.898$), and BJ1 ($F=6.229$, $p=.004$, $\eta^2_p=.509$), but not for C ($F=1.623$, $p=.219$, $\eta^2_p=.213$) nor BJB ($F=1.088$, $p=.379$, $\eta^2_p=.154$). Daily fluctuations in BJ1 shared a moderate inverse relationship with daily fluctuations in C ($r = -0.42$), whereas BJB revealed no association with hormonal markers. T, T/C, and BJ1 appeared to be meaningfully affected by the previous day's training stress in collegiate weightlifters, suggesting that BJ1 may be indicative of hormonal status and that a one-day reduction in VL may enhance acute athlete readiness.

Key Words: Athlete Monitoring, Assessment, Microcycle, Broad Jump, Testosterone



Kyle Peterson is the Sports Performance Analyst at the University of Iowa, where he is also a PhD Candidate in Informatics. He specializes in simulating adaptation from athlete monitoring data.

[2]. The testosterone/cortisol ratio (T/C) is the amount of testosterone found in a blood or saliva sample divided by the amount of cortisol found in the same sample. Studies suggest that T/C is positively correlated with the physiological readiness of strength/power athletes [3, 4].



Matthew Andre is an assistant professor of exercise and sport science at the University of Wisconsin-La Crosse, who specializes in athlete monitoring and exercise endocrinology.

Regular monitoring of hormones throughout the training process can serve a number of possible roles for strength and conditioning practitioners, such as assessing responses and adaptations to various training protocols [5]. For instance, as cumulative training stimuli increases over time, T/C tends to decrease, which may lead to temporary attenuations in athletes' physiological readiness [6]. Continuous testing may also allow instigation of appropriate interventions, and thus, may assist in the optimization of the program design. However, strength and conditioning practitioners may not always have access to biochemical monitoring equipment, which has directed researchers to investigate the possible existence of relationships between field-based performance capacities and endocrine levels [7]. Additionally, establishing non-

1 Introduction

The endocrine response to resistance training has been proposed as a necessary stimulus for adaptation to occur [1]. In sports science, testosterone (T) and cortisol (C) have gained extensive attention for their dual actions upon the neuromuscular system

invasive evaluations that do not require exhaustive maximal efforts of the athlete has been suggested by previous research [8]. Therefore, since the horizontal standing broad jump is considered to be a well-known and accepted field-based test in the assessment of anaerobic power [9], it has been chosen to serve as a performance marker in the estimation of the athletic readiness of the subjects in the present study.

While previous studies have addressed weekly, monthly, and quarterly changes in T/C and performance markers [3, 4], to our knowledge no study has measured daily changes. Therefore, the purpose of this study was to monitor daily hormonal and performance fluctuations in collegiate weightlifters to investigate whether broad jump performance is indicative of hormonal concentrations.

2 Methods

2.1 Subjects

Nine male intermediate collegiate weightlifters (21.3 ± 0.8 years, height = 1.83 ± 0.10 m, body mass = 98.7 ± 18.2 kg; Sinclair Coefficient = 239.3 ± 34.2), with a minimum of six months of competitive weightlifting training from the same weightlifting club, were the chosen sample to represent anaerobic power-dominant athletes. Each participant voluntarily signed an informed consent, which was approved by the University Institutional Review Board and conforms to the ethical standards of the Declaration of Helsinki.

2.2 Design

A within-group, repeated measures design was used to test the effects of daily fluctuations in training stress on daily fluctuations in hormones and jump performance. A single-factor (time) repeated measured model was used for each dependent

variable (T, C, T/C, first broad jump (BJ1), and best broad jump (BJB)) to determine the effects of the previous day's training.

2.2 Procedures

All salivary samples were collected pre-practice, in the afternoon, at the exact same time, Monday through Thursday, for one week. Subjects abstained from eating or drinking for 2 hours prior to collection, rinsed their mouths with water, and then held an oral swab (Salimetrics Oral Swab, Salimetrics, PA, USA) in their mouths for 2 minutes before releasing the swab into a centrifuge tube. Samples were frozen at -80° C and stored for later analysis. Saliva is a safe, reliable, non-evasive method for measuring T and C and is strongly correlated with serum values [10].

Immediately after the salivary sample was obtained, subjects performed a brief dynamic warm-up and then were tested for standing broad jump distance: first jump (BJ1) and best jump (BJB) out of three were recorded. Broad jump distances were measured with the use of a measuring tape fixed to the floor. Subjects began with their toes behind the 0-centimeter mark of the tape and the distance of the rearmost heel strike from the starting line was used for measurement. During practice (peaking phase of a competition cycle), which occurred after saliva acquisition and broad jump measurements, volume-load (VL) was heavy (H) on Monday (47% of the 3-day VL), light (L) on Tuesday (13% of the 3-day VL), and medium-heavy (MH) on Wednesday (40% of the 3-day VL). This large daily variation in planned training stress was used to assess the effects of the previous day's training load on the current day's performance and T/C. Refer to Table 1 for a detailed illustration of the training regime.

Table 1. Overview of training regime.

Mon (H)				Tue (L)				Wed (MH)			
Exercise	Sets	Reps	1RM	Exercise	Sets	Reps	1RM	Exercise	Sets	Reps	1RM
Snatch	3	1	90%	P Snatch	2	2	70%	Snatch	3	1	85%
Clean & Jerk	2	1	90%	P Clean	3	1	70%	Clean & Jerk	2	1	85%
Back Squat	1	4	80%					Front Squat	1	3	80%
	1	2	84%						3	2	86%
	2	3	88%					Snatch Pull	3	1	105%
Clean Pull	3	1	110%								
47% VL				13% VL				40% VL			
All exercises performed with standard 20 kg competition barbell. Classic lifts were performed with full competitive movement, unless specified otherwise. P = Power (catch above 90° knee flexion); Pull = no catch involved.											

Assay plates, with samples, standards, and controls all added in duplicate, were read in a plate reader (Epoch, Biotek Instruments, USA). The minimal concentration that can be distinguished from zero with these assays (Salimetrics, PA, USA) is less than 0.03 nmol/L and 0.20 nmol/L for T and C, respectively. Correlations with serum T and C for these assays are strong ($r = .96, p < .001$; $r = .91, p < .001$; for T and C, respectively).

2.4 Statistical Analysis

Descriptive statistics for salivary hormones (T, C, T/C) and broad jumps (BJ1, BJB) were expressed as means and standard deviations (\pm SD). Repeated-measure analysis of variance (RM ANOVA) models were conducted to examine if variables differed by day. If global changes were identified, Fisher's least-significant-difference (LSD) pairwise comparisons was used with partial-eta squared effect size (η^2_p) to supplement the determination of meaningful differences. Due to the small n-size, significance was determined a priori when η^2_p surpassed Cohen's large threshold (> 0.26) [11]. Pearson correlation coefficients were used to evaluate the degree of linear relationship between salivary hormones and broad jump performances. Precision of estimates were indicated with 90% confidence limits (CL) to represent the degree of uncertainty.

Magnitude of linear dependencies were qualitatively assessed with Cohen's suggested criteria: trivial < 0.10 , small $0.11-0.30$, moderate $0.31-0.50$, large $0.51-0.70$, very large > 0.71 [11]. A relation was inferred to be unclear if its CL spanned across both positive and negative small threshold (± 0.10).

3 Results

Intra-assay variation was 2.8% and 2.5% for T and C, respectively. Overall RM ANOVA models suggest that daily differences occurred for T ($F(3,18) = 4.027, p = .024, \eta^2_p = .402$), T/C ($F(3,4) = 11.735, p = .019, \eta^2_p = .898$), and BJ1 ($F(3,18) = 6.229, p = .004, \eta^2_p = .509$), but not for C ($F(3,18) = 1.623, p = .219, \eta^2_p = .213$) nor BJB ($F(3,18) = 1.088, p = .379, \eta^2_p = .154$). For T, Wednesday was greater than Monday ($p = .052, \eta^2_p = 1.609$), Tuesday ($p = .034, \eta^2_p = .556$), and Thursday ($p = .032, \eta^2_p = .565$). For T/C, Tuesday was lower than Monday ($p = .032, \eta^2_p = .562$) and Wednesday was higher than Monday ($p = .064, \eta^2_p = 1.026$), Tuesday ($p = .013, \eta^2_p = .671$), and Thursday ($p = .089, \eta^2_p = .399$). For BJ1, Monday was greater than Tuesday ($p = .024, \eta^2_p = .330$) and Thursday ($p = .005, \eta^2_p = .535$), and Wednesday was greater than Thursday ($p = .002, \eta^2_p = .807$) (Table 2 and Figure 1). Refer to Table 3 for Pearson correlations.

Table 2. Daily fluctuations in hormonal concentrations and jump performance (mean \pm SD).

	<u>T (nmol/L)</u>	<u>C (nmol/L)</u>	<u>T/C Ratio</u>	<u>BJ1 (m)</u>	<u>BJB (m)</u>
Mon (H)	0.48 \pm 0.09 [†]	4.9 \pm 2.9	0.13 \pm 0.06 ^{§†}	2.49 \pm 0.22 ^{§†}	2.52 \pm 0.22
Tue (L)	0.46 \pm 0.14 [†]	5.9 \pm 2.4	0.09 \pm 0.03 ^{*†}	2.41 \pm 0.21 [*]	2.52 \pm 0.21
Wed (MH)	0.65 \pm 0.11 ^{*§†}	3.6 \pm 2.20	0.24 \pm 0.11 ^{*§†}	2.43 \pm 0.18 [‡]	2.49 \pm 0.22
Thu	0.48 \pm 0.08 [†]	4.2 \pm 0.72	0.12 \pm 0.03 [†]	2.38 \pm 0.19 ^{*†}	2.49 \pm 0.21
*Different from Mon; §Different from Tue; †Different from Wed; ‡Different from Thu ($\eta^2_p > 0.26$).					

Table 3. Linear correlations between salivary hormones and broad jump performances ($r \pm 90\%$ CL) with Cohen's qualitative inference.

	T	C	T/C Ratio
BJ1	0.29 (± 0.25) Small	-0.42 (± 0.24) Moderate	0.26 (± 0.26) Small
BJB	0.04 (± 0.28) Unclear	0.05 (± 0.28) Unclear	0.04 (± 0.28) Unclear

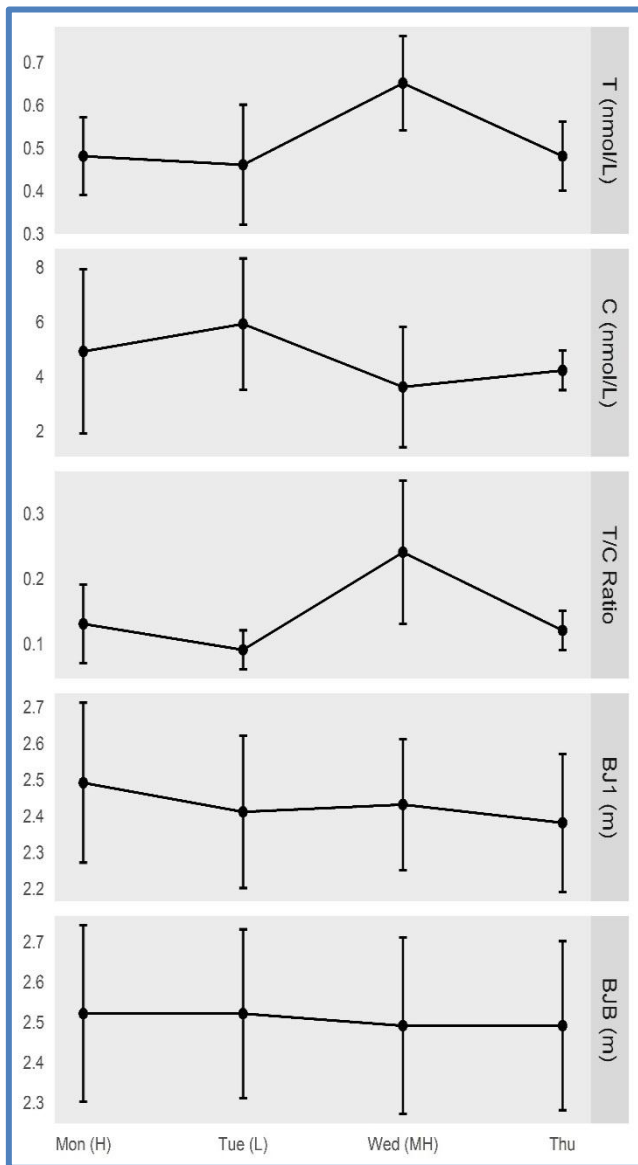


Figure 1: Graphical representation of daily hormonal and performance markers (mean ± SD).

4 Discussions

According to the Fisher LSD, T, T/C, and BJ1 values meaningfully fluctuated day-to-day. The particular endocrine responses from the preceding day's VL dovetails previous research [4, 6], which observed decreases in T/C and performance subsequent to high VL. However, the present study measured a spike in T/C values on the third day of the training week (after L session), which was accompanied by insignificant changes in broad jump performances. This discrepancy between T/C and anaerobic power expression perhaps was due to residual effects of the central nervous system from

Monday's H session [12]. Nevertheless, this chronological sequence of H and L sessions may be pertinent to augment acute neuroendocrine recovery in weightlifters.

The inconsistency found between BJ1 and BJB is interesting to note and of practical utility for practitioners who monitor daily jumps as a means to gauge physiological readiness. Since BJB did not reveal meaningful changes, the first jump attempt of the day (BJ1) may reflect an athlete's physiological status better than BJB, as BJB may misrepresent the athlete's readiness due to the neural potentiating nature of performing successive jumps [13]. Additionally, although individual variability prohibited global trends for C, BJ1 exhibited the most linear relationship with C out of the three hormonal markers. This moderate inverse relationship indicates that daily changes in BJ1 and C fluctuated concurrently in opposite directions, especially from Mon to Tue and Wed to Thu.

5 Conclusions

The present study monitored daily hormonal and performance fluctuations in collegiate weightlifters. T, T/C, and BJ1 appeared to be meaningfully affected by the previous day's training stress. Although C did not reveal daily changes, BJ1 demonstrated a moderate inverse relationship with C. The present study suggests that practitioners should track BJ1 instead of BJB when monitoring the physiological readiness of weightlifters, as BJ1 may provide a reflection of current salivary C concentrations.

References

- [1] W. Kraemer, S. Mazzetti, *Strength and Power in Sport*, Blackwell Scientific Publishing, (2008) Boston, USA.
- [2] M. Cardinale, M.H. Stone, Is testosterone influencing explosive performance? *Journal of Strength and Conditioning Research* 20 (2006) 103–107.
- [3] Nelson, J. Winchester, L. Stewart, M. Stone, Hormonal markers and physical performance during a peak-taper cycle in elite track and field athletes, *Medicine and Science in Sport and Exercise*, 41 (2008) 336-337.
- [4] G. Haff, J. Jackson, N. Kawamori, J. Carlock, M. Hartman, J. Kilgore, R. Morris, M. Ramsey, W. Sands, M. Stone, Force-time curve characteristics and hormonal alterations during an eleven-week training period in elite women weightlifter, *Journal of Strength and Conditioning Research*, 22 (2008) 433-436.

- [5] M. Cardinale, *Strength and Conditioning: Biological Principles and Practical Applications*, (2011) *John Wiley & Sons Ltd*, West Sussex, UK.
- [6] X. Schelling, J. Calleja, N. Terrados, Hormonal analysis in elite basketball during a season, *Journal of Applied Sport Psychology*, 18 (2009) 363-367.
- [7] C. Bosco, J. Tihanyi, A. Viru, Relationships between field fitness test and basal serum testosterone and cortisol levels in soccer players, *Clinical Physiology*, 16 (1996) 317–322.
- [8] D. Cooper, *The Endocrine System in Sport and Exercise*, (2005) *Blackwell Scientific Publishing*, Boston, USA.
- [9] J. Hoffman, *Norms for Fitness, Performance and Health*, (2006) *Human Kinetics*, Champaign, Illinois.
- [10] E. Papacosta, G.P. Nassis, Saliva as a tool for monitoring steroid, peptide and immune markers in sport and exercise science, *Journal of Science and Medicine in Sport*, 14 (2011) 424–434.
- [11] J. Cohen, *Statistical power analysis for the behavioral sciences*, (1988) Lawrence Erlbaum Associates, Hillsdale, New Jersey.
- [12] Viru, Defense reaction theory of fatigue, *Schweizerische Zeitschrift für Sportmedizin*, 23 (1975) 171-186.
- [13] Guillich, D. Schmidtbleicher, MVC-induced short-term potentiation of explosive force, *New Studies in Athletics*, 11 (1996) 67-81.

Acknowledgements:

The authors would like to thank the UW-La Crosse Research, Service, and Educational Leadership Grant Program for supporting this project.

Competing Interests:

The authors declare that they have no competing interests.

About The License:



The text of this article is licensed under a Creative Commons Attribution 4.0 International License