Measuring Recovery in Elite Rugby Players: The Brief Assessment of Mood, Endocrine Changes and Power.

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Abstract

Purpose: There is demand in applied sport settings to measure recovery briefly and accurately. Research indicates mood disturbance as the strongest psychological predictor of mental and physical recovery. The Brief Assessment of Mood (BAM) is a shortened version of the Profile of Mood States that can be completed in less than thirty seconds. The purpose of this study was to examine the BAM as a quick measure of mood in relation to recovery status in elite rugby players alongside established physiological markers of recovery. *Method:* Using elite rugby union players (*N*=12), this study examined the utility of BAM as an indicator of mental and physical recovery in elite athletes by exploring pattern change in mood disturbance, energy index, power output, cortisol, and testosterone, 36 hours before, and 12, 36, and 60 hours following a competitive rugby match. *Results:* Repeated measures MANOVA indicated significant changes in all variables across the four time points (p <.05, η^2 range = .20 to .48) concurrent with previous. Although visual inspection of the graphs indicated that the pattern of change for mood disturbance and energy index mapped changes in all physiological variables, only a low correlation was observed for power output (r = -.*34*). *Conclusions:* While BAM scores changed significantly over time in accordance with the hypotheses, further testing is required to confirm the utility of the BAM as a measure of recovery. The results indicate that the BAM could be used as one indicator of recovery status alongside other measures.

Keywords: Perception, hormones, neuromuscular, Rugby Union, elite

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For elite athletes recovery from competition is a key facet of the weekly preparation and training regime (Kellmann, 2002). Short-term fatigue resulting from insufficient recovery manifests itself physiologically (e.g., changes in hormonal markers; McLellan, Lovell, & Gass, 2010), directly via performance (e.g., reduced force output; Kellmann, 2002) and psychologically (e.g., reduced motivation, disturbed mood; Main & Grove 2009). However, monitoring indices of physiological recovery is often a time consuming, specialized, and costly process.

Psychological research has typically measured recovery based on perceived stress, behavioral symptoms associated with fatigue (e.g., insomnia), current mood, or a combination of all three (Main & Grove, 2009). Mood in particular shows a consistent dose-response relationship in response to training stress (Bouget, Rouveix, Michaux, Pequignot, & Filaire, 2006) and has been assessed successfully in relation to performance and training recovery (Raglin, Koceja, Stager, & Harms, 1996). Although little research has examined the precise mechanisms that link the mood response to high intensity exercise, these changes have been suggested to be a function of both endocrine response and other perceptual factors (e.g., reflections on personal performance; Berger & Motl, 2000).

Mood is most commonly measured using the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971, 2003). However, the scale is long (65 items) and time consuming to complete (at least 10 minutes), with practitioners frequently indicating athletes and coaches generally resent completing long psychological inventories (Kellmann, Patrick, Botterill, & Wilson, 2002; p. 220). The length of these scales therefore potentially limits their practical utility as a monitoring tool in elite

sport settings and although shortened versions of the POMS exist (e.g., POMS-B; McNair et al., 2003: shortened POMS, Shacham, 1983), at 30 and 37 items respectively, they are still too long for practical purposes within elite sport environments.

From a practical perspective in terms of monitoring, mood scales need to take less than 1 minute to complete to ensure long-term adherence, and there are only two mood-based measures that match this description. The first, developed by Raglin and Morgan (1994), is a 7-item scale consisting of five Depression items and two Anger items from the POMS. These items were selected as they consistently predicted training distress in athletes identified subjectively by their coaches as having compromised performance. However, the subjective measure of 'compromised performance' provided by the coaches is less objective than physiological measures of recovery (e.g., power output). Furthermore, as the sample consisted of non-elite varsity swimmer/athletes it is not directly applicable to elite sport. More importantly however, the scale over-emphasized the depressive mood states at the cost of others that could also indicate recovery status (i.e., vigor and fatigue). The second measure, the Brief Assessment of Mood (BAM; Dean, Whelan, & Meyer, 1990), is a six-item scale that simply asks participants to rate their mood based on the six factors of the POMS (i.e., anger, tension, depression, vigor, fatigue, and confusion). Although there are noted issues with concurrent validity using single item/factor questionnaires (e.g., Lee & Bobko, 1994), Robins, Hendin, and Trzesniewski (2001) have argued that single item measures are more likely to generate a true response than measures that use multiple versions of the same question (as per the POMS). The BAM correlates well with the full versions of the POMS (Bourgeois, Leunes, & Burger, 2010, Leunes & Burger, 2000), indicating that it holds a degree on concurrent validity with the

original measure. Furthermore, it has been used successfully to monitor training stress alongside measures of cortisol (Perna et al., 1998) and as an adjunct measure alongside neuromuscular fatigue (West et al., 2014). However, until now the BAM's ability to function as a measure of recovery status has not been properly examined.

Despite some equivocal findings (e.g., Filaire, Bernain, Sagnol, & Lac, 2001), there is considerable evidence that measures of mood are related to specific objective physiological markers (e.g., neuromuscular power output, testosterone, cortisol, and cytokines; Bouget et al., 2006; Main, Dawson, Heel, Grove, Landers, & Goodman, 2010; Odigari, Shimomitsu, Iwane, & Katsumura, 1996; Raglin et al., 1996: Twist & Highton, 2013). A short-form measure of mood that maps changes in physiological variables associated with recovery would be a valuable applied resource in elite sport. Therefore, the present study aimed to examine if the BAM could be used as an indicator of recovery status by comparing mood disturbance and energy index (cf. Kentta, Hassmen, & Raglin, 2006; Odigari et al.) against physiological and endocrine markers of recovery measured longitudinally before and after intense physical competition. Although the BAM has not been validated in traditional psychometric terms in a peer-reviewed journal, our aim was not to investigate the psychometric properties or validity of the scale, but instead to examine its ability to map physiological markers of recovery. For hypothesis one, we expected all dependent variables to exhibit significant changes matching the classic quadratic profile of degeneration and recovery associated with intense physical overload (Stone, Plisk, & Collins, 2002). For hypothesis two we expected TMD would display a negative relationship with power output (measured during a counter movement jump), testosterone, and energy index (cf. Aarts & van Honk, 2009; Raglin et al.). In contrast, for hypothesis three, we expected cortisol would have a positive relationship

with TMD as shown in previous research (O'Connor, Morgan, Raglin, Barksdale, & Kalin, 1989).

Method

Participants

Participants were 12 elite male rugby union players (M_{age} = 24.91 years, SD_{age} = 4.35) competing in domestic and European competition for a professional regional rugby union team in South Wales, UK. Participants had a mean of 72.41 (*SD* = 50.93) first-class playing appearances. Participants played *M* = 81.58 minutes (*SD* = 11.16) of the game incorporated within the study (total game length = 88 minutes, includes time added on for stoppages).

Measures

Brief Assessment of Mood. The BAM (Dean et al., 1990) was used to measure mood disturbance and energy index of the participants. The BAM is a 6-item brief version of the Profile of Mood States (McNair et al., 1971) that comprises 6 mood adjectives (Angry, Vigor, Fatigued, Depressed, Confused, and Tense) rated along a 5-point likert scale anchored by 1 (*not at all*) and 5 (*extremely*) with participants responding regarding how they feel *right now*. To calculate Total Mood Disturbance (TMD), the vigor score is subtracted from the sum of the five other mood items, with higher scores indicating greater TMD. Energy index is calculated as a ratio of vigor to fatigue, where a higher score indicates a greater level of recovery. Energy index is more informative than fatigue and vigor scores alone as it accounts for the opposing effects of both constructs. Energy index has been shown previously to correlate with changes in neuroendocrine responses to Ironman competition (Odigari et al., 1996). During initial validation on college students (*N* = 621) BAM

TMD scores were highly correlated with POMS TMD scores (r = .88, p < .001) and Cronbach coefficient alpha for the BAM TMD was acceptable (a= .75; Dean et al.). Most recently, scores for the BAM have correlated with all other alternate mood measures including POMS (r = .73 to .83; Bourgeois et al., 2010).

Power. A Kistler portable force platform with built-in charge amplifier (type 92866AA, Kistler Instruments Ltd, Farnborough, UK) was used to measure ground reaction force time history of the counter movement jump (CMJ). A sample rate of 1000 Hz was used for all jumps and the platform's calibration was confirmed pre and post testing. Power was calculated using standard procedures established in previous investigations (West, Owen, Cunningham, Jones, & Kilduff, 2011; Owen, Watkins, Kilduff, Bevan, & Bennett, 2014). Test-retest reliability (ICC) for PO is 0.979.

Testosterone and cortisol. Testosterone and cortisol was measured in saliva, a non-invasive and compliant medium for determining the free hormone (Arregger et al., 2007). Before testing, participants provided a 2 ml saliva sample by passive drool into a 10 ml container, which was stored at -60°C. After thawing and centrifugation (2000g x 10 minutes) saliva samples were assayed in duplicate for free testosterone and cortisol concentrations using a commercial enzyme-immunoassay kit (IBL, Hamburg) and the manufacturer's instructions. The minimum detection limit for the testosterone assay was 2.0 pg/ml with intra- and inter-assay coefficients of variation of 2.0-9.8%. The cortisol assay had a detection limit of 0.3 ng/ml with intra- and inter-assay coefficients of variation of 3.5-8.7%.

Procedure

The research was approved by the institutional review board before any testing began. In addition, all participants provided informed consent before testing and their right to withdraw at any point was made explicit to them. Testing was completed over

a period of 96 hours, with baseline data collection taken 36 hours (0700hrs) before a domestic league match that the team won. Three further data collections were made at 12, 36, and 60 hours (0700hrs) respectively post-game and participants were instructed to follow their normal individual recovery strategies during this period. Although no GPS data was taken, match statistics indicated a high intensity physical encounter, with 78 tackles made in total by the team during the game, and the 'ball in play' for 39:40 min (season average of 36:18 min.). At each time point the schedule of measures was the same and completed within one hour. Participants completed the passive drool measurement for the testosterone and cortisol measures, followed immediately by administration of the BAM. Once completed, a standardized five-minute warm-up was performed before 3 counter movement jumps were undertaken on the force platform (to measure neuromuscular fatigue via power). To isolate the lower limbs, participants stood with arms akimbo (Hatze, 1998). After an initial stationary phase of at least 2s in the upright position (for the determination of body mass) participants performed the CMJ, dropping to a self-selected depth and then exploding upwards in an attempt to gain maximum height. Participants landed back on the force platform with their arms kept akimbo throughout the movement. The best CMJ score of the three attempts was retained for analysis.

Data Analysis

Data was screened for univariate and multivariate normality before the main data analysis was completed. A repeated measures MANOVA was then used to assess differences in each of the dependent variables over the four time points; baseline (36 hours before match), and 12, 36 and, 60 hours post match. As part of the MANOVA procedure, simple tests of within subject contrasts were used to identify the pattern (i.e., linear, quadratic, or cubic) and significance of change for each of the five

variables. In addition, pairwise comparisons were used to identify where differences occurred in each variable by comparing scores from the baseline to each of the remaining three time points. Finally, a Pearson's correlation was completed on a collapsed data set (N=48) to examine the relationship between the psychological and physiological variables.

Results

Mean and standard deviations for all variables over time are displayed in Table 1. TMD scores increased from baseline to 12 hours post game (56.09%) and decreased to 33.23% and 7.54% above baseline scores at 36 and 60 hours post game respectively (Figures 1). Energy index scores decreased from baseline to 12 hours post game (-29.79%), and increased to -23.00% and 14.02% below baseline at 36 hours and 60 hours respectively (Figures 1). Power output decreased from baseline to 12 hours post game (-8.01%) and increased to -5.78% and -2.27% below baseline values at 36 and 60 hours post game respectively (Figure 1). Similarly, mean (free) testosterone decreased from baseline to 12 hours post game (-27.98%), and increased to -14.85% and -4.72% below baseline values at 36 and 60 hours post game respectively (Figure 1). In contrast, mean (free) cortisol increased from baseline to 12 hours post game (43.69%), and again at 36 hours post game (64.82%), before decreasing towards baseline score at 60 hours post-game (32.11%; Figure 1).

For the repeated measures MANOVA analysis, Mauchly's test of sphericity indicated that TMD, energy index, and power output violated the assumption of non-sphericity. Therefore, significant main effects for these variables were assessed using the Greenhouse-Geisser method. A significant main effect for time was found for all variables (p <.05; see Table 2) except energy index (F = 2.76 (3, 33), p = .09),

indicating that these variables all changed significantly over the time course of the study. In addition, partial eta squared effect sizes indicated small to moderate effects sizes for all variables ranging from .20 to .48 (Table 2). Again, energy index (η^2= .20) had the smallest effect size of all variables measured. Furthermore, tests of within subject contrasts indicated a significant quadratic change over time for all variables, with non-significant results (p > .05) for the associated linear and cubic trend contrasts (Table 3). Partial eta squared for quadratic change for TMD, EI and power indicated a strong effect, while a moderate effect was observed for testosterone and cortisol (Table 3). The parabolic pattern of variation over time for all variables largely matched what was expected based on the hypothesized athlete response to the competitive load. Pairwise comparisons were then used for each variable to examine if post match measures differed from baseline. For all variables, scores were significantly different from baseline at either or both 12 hours, and 36 hours post match. There were no significant differences between baseline and 60 hours post match for any variable (Table 4). This pattern of change describes more clearly the changes over time highlighted by the within subject contrasts and demonstrates a clear recovery profile post-match for all variables. Finally, Pearson's correlations between all variables indicated a low relationship between TMD and power output over the time course of the study (r = -.34, p = .02) suggesting how both variables changed inversely over time as expected. Visual inspection of the absolute values confirmed this relationship (see Figure 2).

Discussion

The aim of this study was to appraise if the BAM (Dean et al., 1990) could be used as an indicator of recovery status by comparing scores of TMD and energy index

against neuromuscular and endocrine measures known to monitor recovery in elite athletes (Bouget et al., 2006). For hypothesis one, all measures showed significant quadratic growth curves over time, consistent with the changes observed in previous high intensity exercise literature and indicative of a classical recovery profile following competitive load (Main et al., 2010; West et al., 2014). For hypothesis two and three, the descriptive statistics and graphs indicated that the BAM had visible concurrence with all physiological markers, but only power and TMD showed a significant correlation over time, with changes in TMD inversely mapped by changes in power output. The lack of significance with the other markers limits the conclusions that can be drawn concerning their relationship with the BAM, and therefore at this stage, we tentatively propose that the BAM is a useful indicator of acute neuromuscular fatigue in elite athletes.

Although no significant inferences can be made, comparison of the plots for the percentage change in the dependent variables provide insight regarding the recovery rate for each variable (Figure 1). While TMD, energy index, power output and testosterone all begin to recover 12 hours post game, the plot for cortisol does not peak until 36 hours post-game, indicating continued secretion of the hormone for an extended period. Although it is not exactly clear why there is a delay in recovery of cortisol compared to mood markers, we suggest four possible explanations. First, whereas muscle contraction is under conscious control, hormonal release occurs via humoral, neural, or hormonal stimuli (Marieb & Hoehn, 2007). Consequently, while an individual can reflect accurately on how tired or sore their muscles feel, they are not consciously aware of their hormonal status. Indeed, degradation in performance associated with muscle soreness (Delayed Onset of Muscle Soreness; DOMS) is manifested centrally rather than through acute exercise-related physiological or

biochemical alterations (Racinais, Brinsgard, Puchaux, Noakes, & Perrey, 2008). Therefore, it is reasonable to suggest mood disturbance represents one of these central manifestations. Second, although both mood disturbance and hormonal changes are initially triggered by fatigue, the continued release of hormones until 36 hours post-game could also be driven by the mood disturbance in the first 12 hours post game. Third, the faster recovery in TMD may reflect global changes in response to the competition itself, i.e. the positive emotions experienced as a function of reflecting on a victory may have overridden any impact of cortisol on mood (Zilioli & Watson, 2013). If the game had been lost, the mood measures might have mapped cortisol more closely. Finally, some of the differences in mood and hormonal response might reflect individual-level differences in the sample. For example, evidence indicates different hormonal responses as a function of strength (Beaven et al., 2008) and individual sometimes have impaired cortisol removal following illness (Boonen et al., 2013). If these differences were present in the current sample the statistical relationship to mood disturbance would have been effected.

There are a number of limitations that may have influenced the non-significant relationships between mood and the hormonal measures. First, our sample size was limited and more participants would have increased statistical power. Indeed, post hoc power analysis indicates that a total sample size of 37 would be needed to achieve a power of 0.8, which was not possible in this instance. Second, the considerable inter-individual variation in the scores for all variables might reflect each player's physical contribution to the game, which was not directly measured and cannot be controlled in field studies. However, both these limitations must be balanced against the advantages of using elite participants in a highly competitive environment, making data inference more meaningful to elite sport. A third limitation was the likert-scale

on the BAM itself. Some participants indicated difficulties differentiating how they felt daily using a 5-point likert scale. A wider scale range (e.g., 0-100) may have allowed participants to utilize their full discriminative capacity and therefore more accurately map hormonal marker changes. Finally, due to the transient nature of mood and the influence of other perceptual factors on mood-related measures (e.g., injury), we cannot rule out some changes observed were a function of factors unrelated to the physiological distress caused by the match. However, given the team won the match, the increased TMD and perceptual fatigue immediately post-game indicates this measure is still sensitive enough to measure recovery status.

A number of future research directions emerge as a consequence of the current study. First, the analysis of the data in our study was limited to traditional difference and correlation tests, largely due to the limited sample size. In particular, the Pearson correlation to examine the relationship between the psychological and physiological variables was completed on a collapsed data set (i.e., all repeated measures analyzed as independent cases). There are issues with this method in terms of independence of data and collinearity, however given the small sample size this was considered the best option to provide an indication of the relationship between all variables during the time course of the study. With a larger sample size and a greater number of time points (e.g., 3 competitive games and recovery periods), longitudinal multi-level modeling is feasible. This technique would allow more accurate examination of the relationship between variables over time, and would account for the fact that each variable is nested within individuals (i.e., variables measured for one participant are more likely to be correlated than to those of other participants). The examination of competition and recovery over a number of competitive cycles would provide useful information regarding the short and long-term effects of competition on mood and

hormonal markers. In addition, as mood is a highly transient state, longitudinal research would establish greater understanding of the reliability of mood-based measures of competition and training stress.

Although we compared the BAM to known physiological measures of fatigue, the BAM still requires a comprehensive examination of its validity before it can be fully supported for use in elite athlete contexts. Due to the lack of factor structure of the BAM, traditional factorial validation is not possible, however, other types of validation can be achieved. For example, criterion validity could be assessed by measuring the extent to which BAM predicts scores on a longer measure of mood, such as the original POMS (McNair et al., 1971). In addition, although we measured minutes played as an indicator of athlete workload, GPS and accelerometer techniques allow for more accurate assessment of game intensity enabling conclusions to be drawn concerning the predictive validity of BAM by mapping individual changes in workload against mood disturbance and energy index.

Our study has also highlighted a number of specific practical implications and recommendations. First, the expense and time-consuming nature of direct measures of fatigue means a true short-form measure (i.e., < 1 minute to complete) such as the BAM allows for regular unobtrusive measurement of recovery status. Second, due to its brief nature the BAM in particular seems useful to compliment other measures of recovery (e.g., countermovement jump) and could serve to indicate the underlying causes of an athlete's fatigue (i.e., stress, sleep, etc.). However, although mood scores may indicate recovery, the recovery profile of cortisol in this study suggests that practitioners should be aware that athletes might still be fatigued hormonally, making them more susceptible to injury/illness in the long-term.

What does this article add?

Based on its relationship with power output, our study indicates the BAM can monitor recovery status in elite athletes. This demonstrates that mood state, in isolation of other previously use perceptual markers of recovery (e.g., RPE, sleep), is sensitive enough to monitor recovery status while using the briefest format of the original POMS possible. However, a better understanding of the temporal relationship between endocrine markers and mood is needed to allow full confidence in its use as a standard measure of recovery status.

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Table 1

Mean, Standard Deviations, and Relative Percentage Change from Baseline for all Dependent Variables across Four Time Points

	Baseline	**Post 12 hrs**	**Post 36 hrs**	**Post 60 hrs**
Mood disturbance	4.92, (2.27),	7.67, (4.49), Δ56.09%	6.33, (2.96), Δ33.23	5.17, (3.56), Δ7.53
Energy Index	1.52 (1.19)	0.86, (0.60), Δ-29.9%	0.92, (0.60), Δ-23.00%	1.26, (0.70), Δ14.03%
Power (W)	6119 (526)	5628, (660), Δ-8.02	5777, (684), Δ-5.78	5976, (497), Δ-2.28
Testosterone (pg/ml)	204.90, (80.80),	147.60, (60.10), Δ-25.22%	163.60, (68.50), Δ-14.85%	186.00, (79.70), Δ-4.74
Cortisol (ug/dl)	0.40, (0.10),	0.55, (0.11), Δ43.69	0.61, (0.20), Δ64.82	0.52, (0.23), Δ32.11

Table 2

Repeated Measures MANOVA Significant Main Effects over Time.

	F	*df*	*p*	*Partial* η^2
TMD	4.15	3, 33	.03	.27
EI	2.76	3, 33	.09	.20
Power	10.33	3, 33	.001	.48
Testosterone	3.34	3, 33	.03	.23
Cortisol	4.9	3, 33	.01	.31

Table 3

ANOVA Tests of Within Subject Contrasts to Show Quadratic Change over Time

Measure	Time	*F*	*p*	*Partial* η^2
TMD	Linear	.055	.820	.005
	Quadratic	28.553	.000	.722
	Cubic	1.291	.280	.105
EI	Linear	.470	.507	.041
	Quadratic	11.834	.006	.518
	Cubic	.365	.558	.032
Power	Linear	3.055	.108	.217
	Quadratic	16.936	.002	.606
	Cubic	3.291	.097	.230
Test	Linear	.397	.542	.035
	Quadratic	7.204	.021	.396
	Cubic	1.617	.230	.128
Cort	Linear	4.019	.070	.268
	Quadratic	8.918	.012	.448
	Cubic	.310	.589	.027

Table 4

Pairwise Comparisons for Post-Match Scores Versus Baseline for all Variables Measured

Measure	Baseline	Post Match	Mean Difference (* = $p < .05$)	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
TMD	1	2	-2.75*	-4.487	-1.013
		3	-1.41*	-2.729	-.104
		4	-.25	-1.856	1.356
EI	1	2	.66	-.082	1.401
		3	.60*	.013	1.193
		4	.26	-.513	1.038
Power	1	2	490.123*	214.222	766.033
		3	341.21*	193.994	488.431
		4	142.21*	32.153	252.272
Testosterone	1	2	57.34*	16.803	97.884
		3	41.31*	3.864	78.763
		4	18.86	-26.268	64.003
Cortisol	1	2	-.15*	-.221	-.079
		3	-.21*	-.364	-.069
		4	-.11	-.254	.018

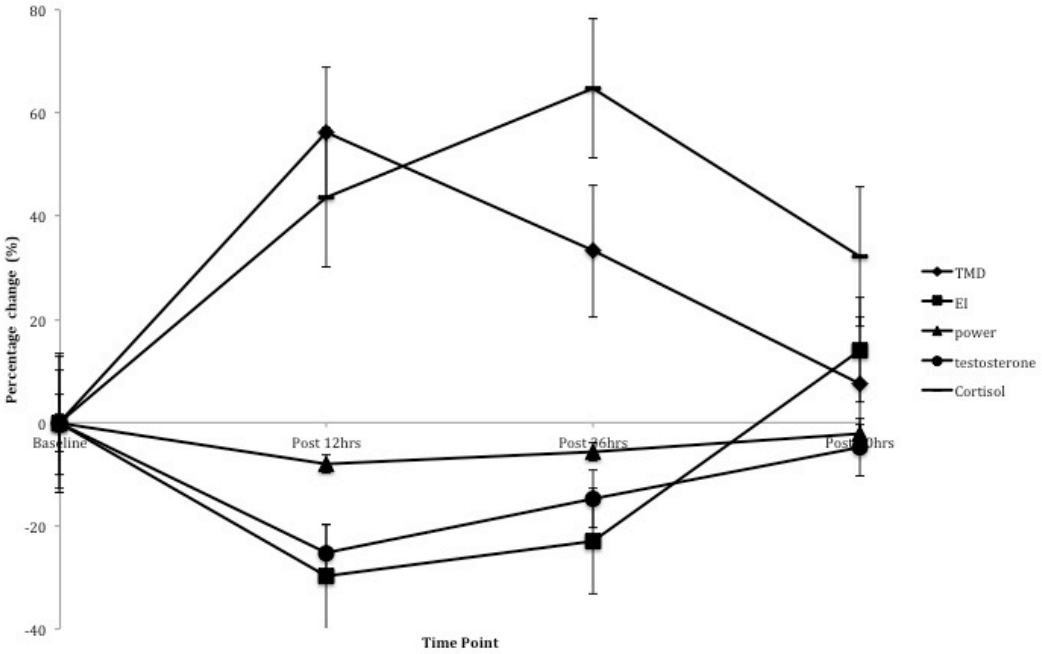

Figure 1: Percentage change in all variables across all time points

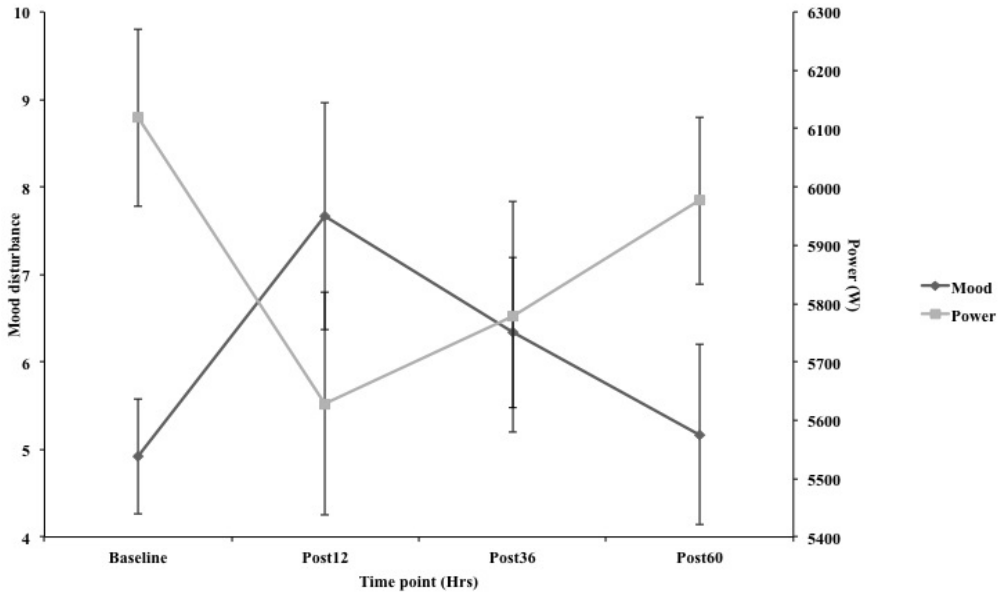

Figure 2: Relationship between mood disturbance and power across all time points.