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Effects of Training Volume on Hormones and Mood in Basketball Players

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Mood and basal hormone levels were measured before and after a 4-month training period in 20 professional basketball players on 2 different teams. Training volume was daily quantified by intensities, showing that Team 1 trained nearly twofold the volume of Team 2. Apart from the lack of differences between teams in anthropometric and physical variables, results showed mood improvements in the total sample without differences between teams. However, cortisol levels decreased in Team 1 and increased in Team 2, while the free testosterone–cortisol ratio, free testosterone, prolactin, and luteinizing hormone did not show significant changes. Changes in cortisol were positively related to depression and negatively related to training volume. Results suggest that differences exist in sensitivity and/or timing of both psychological and hormonal responses to 2 given volumes of training.

KEY WORDS: hormones; training; physical stress; mood; professional sportsmen.

INTRODUCTION

Physical training could be understood as a stress process that affects several psychophysiological variables. It can produce an adaptive response in the organism or a dysfunction, as in the case of overtraining, a syndrome that includes a set of different negative effects. Several psychological and hormonal variables

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have been studied to understand the response to training and the underlying mechanisms. Nevertheless, they have usually been examined separately, using different samples and sports, making it difficult to get an overall, integrated view of the subjacent processes (Suay, Sanchis, & Salvador, 1997).

Among the physiological markers, the testosterone–cortisol ratio has been used as an indicator of anabolic and catabolic balance in periods of stress (Fry & Kraemer, 1997). The exact response pattern of this ratio is not clear, increases (Vervoorn et al., 1991) or decreases (Adlercreutz et al., 1986) being described after training although no changes (Rowbottom, Keast, Garcia-Webb, & Morton, 1997; Tsai et al., 1991) have also been reported. These differences can be explained partly by the fact that most of the studies have employed the total testosterone level and others, as in the case of Adlercreutz et al., the free testosterone levels. After considering testosterone or cortisol (C) response separately during training, no unanimity has been found. The majority of the literature indicates that testosterone decreases after systematic training (Arce & De Souza, 1993; Lehmann et al., 1992; Urhausen, Kullmer, & Kinderman, 1987; Wheeler, Singh, Pierce, Epling, & Cumming, 1991), although at other times nonsignificant decreases along a sports season in cyclists (Lopez-Calbet et al., 1993), or increases after 2 years of training in elite body-building men (Häkkinen, Pakarinen, Alén, Kauhanen, & Komi, 1988) have been described. Luteinizing hormone (LH) and prolactin (PRL) responses have also been studied because they permit the inference of the mechanisms involved in the regulation of the production of testosterone. However, no consistent changes have been reported after training (Urhausen, Gabriel, & Kinderman, 1995). Hypercortisolemia is frequent after long training seasons (Tsai et al., 1991), but a decrease in C after increasing the volume of training (Bosco, Colli, Bonomi, Von Duvillard, & Viru, 2000; Lehmann et al., 1992; Uusitalo, Huttunen, Hanin, Uusitalo, & Rusko, 1998) or after a 10-week period of training has also been reported (McDowell, Hughes, Hughes, & Johnson, 1992). On the other hand, the most widely studied psychological marker of adaptation to training is mood, which improves during lower load periods but worsens after overreaching periods (Hooper, Mackinnon, & Hanrahan, 1997; Raglin, Morgan, & O'Connor, 1991). To evaluate variations of mood in sports contexts, the Profile of Mood States (POMS) has been frequently used (Suay, Ricarte, & Salvador, 1998).

These endocrine and emotional responses to training are moderated by several variables such as volume and intensity of exercise, the differences among workloads applied throughout the named studies being one potential factor that could explain this lack of homogeneity. Additionally, training has been expressed in a great variety of ways (Bonifazi et al., 1995; Häkkinen et al., 1988; Seidman et al., 1990; Vervoorn et al., 1991), which makes it difficult to discern to what degree these training volumes are different. Due to this difficulty, it still remains unclear whether hormonal variations observed in some studies and mood changes found in others are related and/or concomitant, even in the rare case in which they were obtained from the same sport. This point emphasizes the need to examine the association between training, hormonal levels, and mood.

In a previous study carried out in sportsmen, we found a significant decrement in the free testosterone–cortisol ratio (FTCR) and no changes in mood after a 5-month training period, although in this study subjects were not homogenous with respect to their training due to the fact that they belonged to different sports modalities such as basketball, judo, and athletics (Salvador, Ricarte, Gonzalez-Bono, & Moya-Albiol, 2001). Taking into account the above data, the aim of the present study consisted of offering a descriptive profile of mood and hormones in the basketball after two different volumes of training distributed in a period of 4 months and in clarifying the pattern of relationship between endocrine variables, mood, and training. To this end, a homogenous sample composed of two teams of professional basketball players was considered, who only differed in volume of training. Based on previous findings, significant variations depending on the workloads applied were hypothesized. As in previous studies (Moya-Albiol et al., 2001; Moya-Albiol, Salvador, González-Bono, Martinez-Sanchis, & Costa, 2001), we have adopted an integrative perspective that includes psychological, endocrine, and physical parameters in the analysis of response to stress.

METHOD

Participants

The final sample was composed of 20 male basketball players belonging to two teams participating in the National League of Spanish Basketball. Both teams finished in the first and second positions of their group (composed of 14 teams). All participants were doping-controlled, and they signed informed consent approved by the standard norms of the local Committee of Medical Ethics. The main characteristics of the sample are shown in Table 1.

Procedure

The experimental design included two test sessions (TS). The first was performed after the holidays, at the beginning of the sports season when no regular training had been carried out in the previous 2 months (TS1). The second session was performed after 4 months of regular training developed by coaches and technical staff (TS2). Habitual training and competitions were performed by players between TSs. Participants were free of exercise 24 hr. before both

Table 1. Mean ± Standard Error of the Mean of the Age, Anthropometric, and Fitness Variables Before 4-Month Training in Both Teams

	Team 1 (n = 11)	Team 2 (n = 9)
Age (years)	21.91 ± 1.07	21.78 ± 1.52
BMI ($Kg \cdot m^{-2}$)[a]	23.95 ± 0.68	24.26 ± 0.48
Fat percentage	9.71 ± 1.06	11.10 ± 0.75
VO_2 max ($ml \cdot Kg^{-1} \cdot min^{-1}$)[b]	44.18 ± 1.09	41.88 ± 1.22
Power max (watt.)	357.27 ± 7.52	341.25 ± 11.25
HR max (bbm)[c]	177.36 ± 2.90	173.50 ± 4.61
LAmax ($mmol \cdot l^{-1}$)[d]	9.52 ± 0.45	9.52 ± 0.75

[a]BMI = body mass index.
[b]VO_2 max = maximum oxygen uptake.
[c]HR max = maximal heart rate.
[d]LA max = maximal lactate.

TS, which took place in the Sports Medical Centre in Cheste (Valencia, Spain). On arrival at the laboratory after overnight fasting, a blood sample was collected between 8:30 and 9:00 a.m. (1–1.5 hr. after awakening) for hormonal determinations, and the Profile of Mood States (POMS) was administered. Afterward, anthropometric measures were obtained by a Holtain skinfold caliper at the subescapular, axilar, breast, triceps, abdominal, suprailiac, and anterior thigh. These data were used to calculate body fat.

Finally, participants carried out a bicycle ergometer test performed as an incremental graded exercise (GXT) in a sitting position on a mechanically braked bike (Monark) and composed of 5-min. warm up of unloaded cycling, test phase, and 5-min. recovery phase of unloaded cycling. The test phase started at 30 watts and thereafter increased 30 watts every minute until voluntary exhaustion. Gas exchange was measured using a breath-by-breath analysis system (Sensor Medics MMC 4400 tc). Heart rate (HR) was continuously registered using a three-lead ECG signal system (CM_5) and monitored in a Hellige Servomed SMS 182. Blood samples were collected from an earlobe for the lactate determination at rest, immediately after, and at 1, 3, and 5 min. of recovery. Lactate was determined by enzymatic procedures (Boehringer Mannheim GmbH, Germany).

Training

Training was registered daily for each participant between TS1 and TS2. Coaches classified every exercise considering its intensity in function of the HR: "maximal" intensity during competition, which elicited an estimated HR of 191–210 bpm that was reserved to time competing, "high" when the exercise elicited a HR of 171–190 bpm, "medium" if the HR was 151–170 bpm, and "low" at 131–150 bpm. Experimenters and coaches checked these criteria in the training field during some previous sessions. Total volume (in min.) was obtained adding the volume performed in all the intensities; Team 1 trained regularly 120 min. per day, and Team 2 trained regularly a mean of 75 min. per day.

Mood

Mood experienced during the week before the session (including that day) was evaluated by means of the POMS (McNair, Lorr, & Droppleman, 1971), which contains 58 items ranked by 5-point Likert cleavage distributed into six scales: Tension, Depression, Anger, Vigor, Fatigue, and Confusion. A total score (POMS-T) was also calculated.

Hormone Assays

Blood samples from the antecubital vein were collected and serum and plasma extracted for hormonal determinations. All the samples of the same participant were run in duplicate in the same assay. Free testosterone (FT) was directly determined by RIA by commercial kit Coat-a-count FT of DPC (Los Angeles, CA). C determinations were carried out by an Amerlex cortisol RIA kit (Amersham International plc, Amersham, UK). PRL was also determined by commercial kit, Coat-a-count of DPC (Los Angeles, CA). For luteinizing hormone (LH), Amerlite LH-30 was the commercial kit employed provided by Kodak Clinical Diagnostics LTD (Amersham, UK). Intra- and interassay variation coefficients for all hormones were below 8%. The ratio, FTCR, was calculated from FT and C values expressed as $pmol \cdot l^{-1}$ and $nmol \cdot l^{-1}$, respectively.

Statistical Analyses

Repeated measures ANOVAs were applied in TS comparisons with 'team' as the between-subjects factor when effects of training on hormonal levels and mood were examined. Spearman or Pearson correlations were performed where appropriate to examine relationships between variables when they significantly changed throughout the season. Mood and hormonal changes were calculated by the difference between values at TS2 minus TS1. Data represent means and standard errors and were processed by SPSS 8.0 for Windows. The level of significance was set at .05.

RESULTS

Differences Between Teams on Several Variables

No significant differences between teams were found in age, body mass index (BMI), fat percentage, and fitness measures (Table 1).

Total training volume was significantly lower in Team 2 than in Team 1, $F1, 19 = 366.41$, Team 2 training at 57.2% of the volume trained by Team 1. As can be observed in Table 2, except for maximal intensity (time competing), this difference is maintained in volume of training for every intensity, $F(1, 19) = 43.76$; $F(1, 19) = 513.52$, and $F(1, 19) = 526.88$, for high, medium, and normal intensities, respectively.

Effects of Training Volume on Hormones and Mood

Hormonal values are presented in Table 3. The C levels showed a significant effect of 'TS*team' interaction, $F(1, 18) = 12.28$, with significant decreases in Team 1, $F(1, 10) = 5.66$, and significant increases in Team 2, $F(1, 8) = 6.37$. The C changes were also different in Team 1 than in Team 2, $F(1, 19) = 12.28$. No other significant effects were found on FTCR, FT, PRL, and LH levels or changes.

An improvement in mood was observed in the total sample with decreases in POMS-T, $F(1, 18) = 12.50$, and in each scale apart from vigor: anger, $F(1, 18) = 10.54$, confusion, $F(1, 18) = 14.90$, depression, $F(1, 18) = 9.58$, fatigue, $F(1, 18) = 7.62$, and tension, $F(1, 18) = 5.60$. No significant effects of 'team' or 'TS*team' interaction were found. When mood changes between TSs were compared, nonsignificant differences between teams appeared. Training volume was not significantly associated with any of the six scales or the total score.

On the other hand, C changes were negatively related to training volume ($r = -0.635$) and positively associated with depression variations ($r = 0.549$).

Table 2. Mean ± Standard Error of the Mean of Time (in min.) Training and Time Training in Each Intensity in Both Teams

	Team 1	Team 2
Total volume	14380.3 ± 243.5	8219.8 ± 193.9
Maximal intensity	209.4 ± 39.5	208.4 ± 39.7
High intensity	7093.3 ± 94.1	5995.7 ± 143.3
Medium intensity	3069.1 ± 73.0	1137.4 ± 29.3
Normal intensity	4008.6 ± 114.4	878.2 ± 54.8

Table 3. Hormonal Levels and Mood Scores in Both TSs for Both Teams

	Team 1		Team 2	
	TS1	TS2	TS1	TS2
Hormones				
FTCR ($\cdot 10^{-3}$)	0.28 ± 0.02	0.32 ± 0.02	0.49 ± 0.16	0.32 ± 0.02
FT (pmol$\cdot$l^{-1})	87.78 ± 6.99	84.09 ± 3.80	84.21 ± 7.98	94.69 ± 8.85
C (μmol$\cdot$l^{-1})	0.31 ± 0.02	0.27 ± 0.01*	0.24 ± 0.03	0.30 ± 0.03*
PRL (ng$\cdot$ml^{-1})	6.11 ± 1.28	5.80 ± 0.98	9.48 ± 4.25	9.34 ± 3.29
LH (mIU$\cdot$l^{-1})	6.76 ± 0.83	5.59 ± 0.74	7.54 ± 1.47	6.50 ± 0.82
Mood				
POMS-T	121.09 ± 7.48	108.36 ± 4.59	119.55 ± 6.36	100.33 ± 2.05
Tension	7.55 ± 1.53	5.82 ± 1.33	8.67 ± 1.49	4.11 ± 0.59
Confusion	6.36 ± 0.99	3.82 ± 0.63	6.67 ± 1.18	3.33 ± 0.67
Anger	9.73 ± 2.11	6.00 ± 1.34	11.67 ± 3.17	4.44 ± 1.02
Depression	6.82 ± 2.61	2.45 ± 1.50	4.55 ± 1.71	1.78 ± 0.55
Fatigue	4.91 ± 0.62	2.0 ± 0.60	5.56 ± 1.52	3.11 ± 0.93
Vigor	14.27 ± 1.66	11.73 ± 1.49	17.56 ± 1.32	16.44 ± 2.16

DISCUSSION

The present study shows how psychological and hormonal markers of training adaptation are not concomitantly sensitive to different volumes of training after a 4-month period. While training modulate C changes, no differences were found in the FTCR and in the hormones studied or in the mood scores obtained.

With regard to hormonal markers, only C concentration was sensitive to different volumes and intensities of training, since decreases were observed in the team that performed the hardest training (Team 1), and increases were found in the other team. Additionally, the negative correlation found between C changes and training volume supports this point and is in agreement with a relationship previously described (Chin & Evonuck, 1971; Viru & Smirnova, 1982). Studies on this subject have shown varying results, finding increases as well as decreases or no changes in C levels, although always in non-team sports players (Bonifazi et al., 1995; Bosco et al., 2000; Rowbottom et al., 1997; Tsai et al., 1991; Uusitalo et al., 1998; Vervoorn et al., 1991). The differences in training workloads applied in each sample could, to some extent, account for the diversity of these results. The training volume applied in Team 1 (approximately 3 hours per day of total training), could be enough to provoke C decreases. This pattern of variation, indicative of decreases in catabolic processes, can be interpreted as an adaptive response to the exercise applied. Another aspect to take into account is the increment in C levels shown by Team 2, which could be favored by the low levels shown prior to training.

Despite significant differences in C levels, the FTCR was not significantly affected by the different volume of training applied in both teams. In the present study, the previously found decrement in FTCR after a 5-month training period (Salvador et al., 2001) has not been replicated. The characteristics of the sample could be responsible for this divergence since participants in that latter study were men and women of different sports disciplines.

On the other hand, the nonsignificant variations of FT contrasts with the increases found in some studies (Rowbottom et al., 1997; Vervoorn et al., 1991) but is in agreement with the lack of changes found in long-term studies (Bonifazi et al., 1995; Tsai et al., 1991), and concretely with one of those that took FT measures after the same period of training (Guezennez, Leger, Lhoste, Aymonod, & Pesquies, 1986). Thus, it can be concluded that the duration of the training period should be considered as an important factor that moderates the T response to training. In accordance with testosterone results, LH levels did not present significant differences depending on the amount of training (Urhausen et al., 1995). As in this previous research, PRL levels did not significantly differ between either team, conveying the idea that the receptor sensitivity to LH was not importantly affected.

Mood was not sensitive to differences in training between teams, at least at doses or duration studied, which reflects a similar psychological adaptation to training in both basketball teams. The improvement observed in mood states for all subjects could be partially due to the fact that habitual practice of physical activity has positive psychological effects such as a reduction of negative mood and depression (Petruzzello & Tate, 1997). In fact, all participants showed an "iceberg profile," which is characteristic of well-adapted sports persons (Suay et al., 1998), their POMS-T scores being in the range proposed for them (Morgan, O'Connor, Ellickson, & Bradley, 1988). Furthermore, the social support and other aspects involved in sports activity, especially in team sports, could also contribute to these benefits. The mood scores indicate that subjects are not overtrained, showing a lack of unhealthy psychological signs in the TSs. Increases in fatigue and decreases in vigor have been described in early overreaching phases, and enhanced depression has been observed in later overtraining states (O'Connor, Morgan, & Raglin, 1991). In the present study, none of these scales have shown these profiles of variation.

Considering the POMS-T as well as the different scales, no significant correlations for C have been found in either TS. O'Connor et al. (1991) observed increases in C with a worsening in mood after 3 days of increased training in swimmers, although correlations between both were not calculated. In other sports settings such as competition, a lack of significant correlations between hormones and mood have also been found (González-Bono, Salvador, Ricarte, Serrano, & Arnedo, 2000; González-Bono, Salvador, Serrano, & Ricarte, 1999). In this study, C variations only correlated with depression changes, in agreement with studies analyzing psychological stress in healthy subjects

(Hubert, Möller, & Nieschlag, 1989) and in depressive patients (von Zerssen, Doerr, Emrich, Lund, & Pirke, 1987). Despite the fact that C variations were related to depression and associated with training volume simultaneously, non-significant relationships were found between mood scales and training. This picture of associations can suggest that mood changes after exercise can be mediated by levels of glucocorticoids, although this hypothesis strongly needs a more conservative testing than correlations, or be proved in a wider sample.

From an overall view, only C levels significantly varied in a different way between one team and the other in the present study. One point to consider in these results can be the lack of control group, and this leads to the extended problem of selecting an appropriate control group for professional sports persons. On the one hand, when sedentary individuals are considered as control group, they usually present different hormonal levels at rest that, in turn, can affect the hormonal response to the stimuli. On the other hand, studying sports persons involves the difficulty of exposing them to a deprivation of physical activity. In this study, we opted for a methodological strategy that consists in considering each participant as his own control with a conservative statistical test. However, the selection of an appropriate control group in this area remains a challenge for future research. Another aspect to take into account can be possible influences of performance on hormonal and/or psychological variables. This point supposes additional problems in the sports discipline considered in the present study. All the subjects were on the court a similar amount of time, although their individual scores highly depended on their court position (pivot, base, wing). Thus, scoring cannot be considered as a performance parameter. It is worth noting that the teams considered in this study finished as first and second of the category ranking. However, the accuracy of measurements of objective and subjective performance is an interesting point in this type of sports.

In summary, training significantly modified only C levels while mood was not sensitive to variations in training volume. These differences in timing and/or sensitivity between hormonal and psychological markers of training would favor divergences in conclusions among studies depending on the variables measured. This fact emphasizes the need for examining hormonal and psychological variables together from an integrative approach.

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