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Overtraining in Sport: Physiological, Psychological and Performance Effects of Participation in Division I Competitive Basketball

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Abstract. Overtraining has been one of the most popular topics in meetings and journals dealing with top-level sports. The problem has been well known for 70 years, but many specifics concerning overtraining are still very unclear. The purpose of this study was to examine the acute and chronic effects of a competitive basketball season on its respective players competing at the Division I level, and to determine if there were any global changes in performance, physiological or psychological variables which indicated some type of overtraining syndrome. Twenty female subjects were recruited for this study. Ten subjects were recruited from the Alzahra University Basketball team (BB) (21.2 ± 1.4 yrs), the other ten from the general student population (GEN) (21.0 ± 1.2 yrs). Participants were measured at preseason and 3 time points throughout the 12-week season to assess changes in performance, physiological and performance variables. Statistical analyses were performed by utilizing an ANOVA with repeated measures (level of significance was set at $p < 0.05$). Results indicated that many of the physiological, performance, and psychological variables examined during the duration of the study did not exhibit any significant changes. Relative peak power was the only performance variable in this study which elicited a significant group x time interaction ($p < 0.05$). However, observed changes in this variable indicated an increase across the season. A number of physiological variables demonstrated significant group x time interactions: lean body mass ($p < 0.05$), extra-cellular fluid ($p < 0.05$) and creatine kinase ($p < 0.05$). Psychometric testing revealed significant time effects discovered in feelings of fatigue ($p< 0.05$), feelings of being overtrained ($p < 0.05$), overwhelmed ($p < 0.05$) as well as feelings of being tired of university ($p < 0.001$) and never being able to get caught up ($p <0.05$). Our findings indicate that the stresses placed upon collegiate basketball players from a combination of their academic and athletic responsibilities indicate some perturbations in select variables which are indicative of overtraining syndrome (OTS). While OTS occurs in three phases (psychological, physiological, performance), negative changes in performance were not indicated. Physiologically, changes were elicited in a few variables, yet these variations remained within normal clinical ranges for this population.

Keywords: Overtraining, Basketball, performance, physiological or psychological variables

1. Introduction

Overtraining has for decades been one of the most popular topics in meetings and journals dealing with top-level sports (A. L. Uusitalo, 2001). The problem has been well known for 70 years (A. L. Uusitalo & Tahvanainen, K. Uusitalo, A., 1996; A. L. Uusitalo, 2001), but many specifics concerning overtraining are still very unclear. This ambiguity has lead researchers to try and determine specifically what happens to athletes when they begin to overtrain. Overtraining syndrome (OTS) is characterized by a sports-specific decrease in performance together with disturbances in mood state (Urhausen & Kindermann, 2002). OTS corresponds to a loss of adaptability resulting in a well-known symptomatology: deterioration in performance, difficulty training and an absence of motivation, behavioral disorders (irritability, melancholy), sleeping disorders, difficult recovery, an increased occurrence of muscular accidents, and higher sensitivity to infections (Lac & Maso, 2004). To determine and predict overtraining in athletes a myriad of biological markers have been propounded. Taken alone, none of them have an absolute significance (Lac & Maso, 2004). Biological markers are those which are physiological, biochemical, hormonal and immunological in nature (Lac & Maso, 2004). Questionnaires (physiological profiling, overtraining questionnaires, etc.) used

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to determine the states of mood are valuable and probably precious aids for the evaluation of the state of the current training cycle, when to taper, or the onset of overtraining (Lac & Maso, 2004). Additionally, cardiac control is used widely in athletes to adjust the intensity of training (Lac & Maso, 2004). In an overtrained athlete, resting heart rate and blood pressure are elevated, the adaptation of the heart rate to exercise is altered, and there are some anomalies on the ECG (S. L. Hooper, Mackinnon, Howard, Gordon, & Bachmann, 1995; Lac & Maso, 2004; Urhausen & Kindermann, 2002). These modifications constitute good indicators of fatigue. Overtraining syndrome is one of the most feared complications among competitive athletes and thus is of real interest in sports medicine and scientific research (Urhausen & Kindermann, 2002). Scientific data on overtrained athletes are extremely scarce. One of the most commonly cited papers in the area of overtraining and its mechanisms was by Barron et al. (1985). In this 1985 experiment, an insulin-induced hypoglycemic challenge was administered to assess hypothalamic-pituitary function in overtrained athletes (Barron et al., 1985). This event stimulates the release of ACTH, GH and prolactin. Athletes were also intravenously administered luteinising hormone-releasing hormone (LHRH) and thyrotropin-releasing hormone (TRH), which act at the level of the pituitary (Barron et al., 1985). Overtrained athletes had significant decreases in GH, ACTH and consequently cortisol responses in response to insulin administration, which returned to levels similar to that of asymptomatic runners following 4 weeks of rest (Barron et al., 1985). This suggests that there was impairment at the hypothalamic level. Responses of hormones released as a result of LHRH and TRH (i.e. thyroid-stimulating hormone, prolactin, luteinising hormone and follicle-stimulating hormone) were unchanged. This demonstrated that there was no evidence of pituitary dysfunction and hence the impairment was at the level of the hypothalamus. Additionally, this study examining the hypothalamic dysfunction in overtrained athletes was one of the first and only studies investigating possible mechanisms of overtraining; hormonal imbalance has since been cited by numerous authors as a mechanism of overtraining (Barron et al., 1985). While this research provided new and interesting information, subject numbers were very small and individual variation was high. Four overtrained athletes were investigated in total, with only two subjects given actrapid insulin alone. The prolactin responses of the subjects to this challenge ranged from <1 to 98 ng/min/mL. Additionally, subjects were reported to be recovered after a 4-week rest period. This suggests that the athletes were, indeed, overtrained; however, performance was not measured in this study at any time point. Although this study provides information on changes that may be associated with overtraining, the results are not entirely conclusive. Rowbottom et al. (1995) examined a combination of parameters in ten athletes from different sports who were diagnosed as overtrained. Within this study, athletes selfreported difficulty maintaining their training regimen and debilitating fatigue. In this case, debilitating fatigue was defined as fatigue which was not alleviated by rest or bedrest; however, performance could not be measured at baseline (Rowbottom et al., 1995). The investigators measured, resting hematological, biochemical and immunological measures and compared with established normal ranges. The only measured parameter that was significantly different to normal ranges was glutamine, indicating that in most hematological, biochemical and immunological aspects, these athletes were not different from normal controls. A recent study by Smith and Norris (2000) reported similar plasma glutamine levels in five athletes who were diagnosed as overtrained and athletes who responded normally to training and competition (Smith & Norris, 2000). While time taken to recover was not reported, it was stated that athletes took longer than 4 weeks to return to baseline training volume and intensity levels. In 2000, Hedelin Wiklund, Bjerle and Henriksson-Larsen reported increased HRV and decreased resting heart rate in an athlete who was suggested to be overtrained. The athlete reported accumulated fatigue and reduced performance; however, the change in performance was not reported and the type of exercise test employed was unclear. Compared with normally responding subjects examined during the same period, the overtrained subject exhibited an increase in high-frequency and total power in the lying position during intensified training, which decreased after recovery (Hedelin et al., 2000a). The increase in high-frequency power was suggested to be most likely the result of increased parasympathetic activity (Hedelin et al., 2000a). In other studies by Hedelin et al. (2000) in the same year, HRV did not seem to be affected by short-term overtraining (Hedelin et al., 2000; Hedelin, Wiklund, Bjerle, & Henriksson-Larsen, 2000b). According to Halson (Halson & Jeukendrup, 2004), it is not possible to conclusively comment on the similarities or differences between overreaching and overtraining because of the following reasons: 1. The lack of research in the overtraining area; 2. A lack of baseline measures as symptoms are often evident before a performance assessment can be made; and 3. The variation in methodologies and outcomes in experiments investigating overreaching. Rowbottom et al. (1995) indicate that the abnormalities seen in the variables which often indicate a state of fatigue induced by an increase in exercise are minimal (Rowbottom et al., 1995). This is congruent with overreaching research which has been conducted. Comparisons cannot be made between the maximal exercise responses in overreached athletes and those of overtrained athletes, as the information does not exist in overtrained athletes (Halson & Jeukendrup, 2004; S. L. Hooper et al., 1995). While comparisons cannot be made, the does seem to be slight similarities within hormonal changes indicating a possible link between the two, however, this is based on an extremely small amount of scientific literature relating to this topic. The purpose of this study was to examine the acute and chronic effects of a competitive basketball season on its respective players competing at the Division I level, and to determine if there were any global changes in performance, physiological or psychological variables which indicated some type of overtraining syndrome.

2. Method

2.1. Participants

Twenty female subjects between the ages of 18 and 23 were recruited to participate in this study. Ten of them were from the Alzahra University Basketball Team. Participants who were not members of the University Basketball Team were recreationally active members recruited from the general student population. Subjects were not allowed to participate in this study if they were pregnant, became pregnant, or had a desire for pregnancy. The participants were told the purpose of the research, the protocol to be followed, and the experimental procedures to be used.

2.2. Independent and Dependent Variables

The independent variable was the collegiate extra-curricular activities. Dependent variables evaluated included: anthropometric and physiological variables (body weight, height, body mass, body water, body composition, resting values for heart rate, blood pressure and electrocardiogram (ECG), and selected blood variables), performance variables (vertical jump, 20-yard sprint, anaerobic capacity), and psychological variables (Profile of Mood States [POMS], and a fatigue inventory index).

2.3. Assessment Schedule

There will be five testing sessions where data will be collected. The first testing session (T1) was the baseline data collection and was completed prior to the beginning of the competitive basketball season. T2 occurred two weeks later after the T1. T3 took place at week 8 of the season. T4 occurred at the end of season and T5 was planned to occur one week after the season testing date. After statistical analysis of performance variables indicating no significant group x time interactions, it was decided by the investigators that T5 was not necessary considering the statistical findings at the time that a significant effect would be observed at a time when training and competition load was reduced.

2.4. Statistical Analyses

Analysis of variance (ANOVA) for repeated measures univariate tests were used to analyze data. Data was considered statistically significant when the probability of type I error was 0.05 or less. If a significant group, treatment and/or interaction alpha level were observed, Tukey's honestly significantly different (HSD) post-hoc analyses were performed to determine where significance was obtained. After statistical analysis, evaluations of individual results were examined to determine if any individuals have elicited an overtrained response. Cohen's d was used as a measure of effect size, to determine proportional overlap between the two distributions where 0.2 will be considered a small-effect size, 0.5 and 0.8 will be considered a medium-effect and large effect respectively (Kirk, 1982). I felt that this evaluation was necessary from the fact that this study was underpowered due to the small number of subjects.

3. Results

3.1. Subjects Demographics

Table 1: Subject Demographics

Variable	BB Group (±SD)	GEN Group (±SD)	Group p-level
Age (yr)	21.2 (1.4)	21.0 (1.2)	0.894
Height (in)	68.1 (2.3)	53.0 (1.8)	0.471
Weight (kg)	66.4 (20.7)	57.3 (12.8)	0.074

Table 1 summarizes the mean age, height, and initial (T1) weight for each group. While no significant differences were found between groups prior to testing, a trend was observed in weight ($p = 0.063$), with the

BB group had a greater mean weight 70 ± 21.8 than the GEN group (58.3 ± 12.7).

3.2. Performance Variables

No statistically significant time effects, group x time interaction or group differences were seen in vertical jump, twenty yard dash, peak power or relative mean power. Other performance variables assessed via the Wingate cycle ergometer test showed significant group differences, with mean power (BB 535.54 ± 18.72, GEN 452.50 ± 53.37) and rate of fatigue (BB 42.35 ± 13.60, GEN 22.12 ± 16.65) demonstrating p-values of (p = 0.028) and (p = 0.046) respectively. While relative peak power did not indicate any significant time effect or group effect, a significant group x time interaction (p = 0.045) was demonstrated with mean differences from baseline T 4 means of 0.78 ± 0.53 for BB and 0.14 ± 0.64 for GEN. Tukey's HSD post hoc test did not reveal significance between means. The significant interaction observed with relative peak power, indicated an increase in with both groups over time, with the GEN group eliciting a greater increase in relative peak power. Due to these findings, there will be no significant changes found in performance variables as a result of a Division-I competitive basketball season is accepted.

3.3. Physiological Variables

Body Composition Values

Significant between group differences were seen in weight (BB 154.26 ± 5.26, GEN 129.61 ± 6.45, p = 0.008), lean body mass (LBM) (BB 46.12 ± 1.40, GEN 40.29 ± 1.70, p = 0.016), fat mass (BB 16.0 ± 1.1, GEN 11.3 ± 1.3, p = 0.012), fat free mass (FFM) (BB 48.20 ± 1.44, GEN 42.30 ± 1.80, p = 0.018), and percent body fat (BB 24.44 ± 0.99, GEN 21.02 ± 1.21, p = 0.043). These differences in body composition were expected, given the demographic makeup of the population used in this study. While there was no significant differences reported for bone mineral content (BMC), there was a between group trend reported (BB 2.14 ± 0.6, GEN 1.97 ± 0.7, p = 0.061). While no significant time differences were shown to exist, a group x time interaction was reported for LBM with baseline changes of -.560 ± 1.30 and .381± 0.71 for both BB and GEN groups respectively (p = 0.033). Post-Hoc analysis of this interaction revealed significant differences at all time points, with a mean of 45.6 ± 5.4 for the BB group at T 4, and 40.5 ± 4.4 for the GEN group at the same time point. Additionally, the BB group indicated a decrease in lean body mass over time with a decrease from 46.2 ± 5.4 at T 1 to a mean of 45.6 ± 5.0 at T4. This decrease in LBM is a typical response to a competitive season and in some cases may be a sign of overtraining. Intra-cellular fluid (ICF), and total body water (TBW) both maintained significant groups differences with reported means for ICF of 20.13 ± 0.59 for BB and 17.40 ± 0.73 for GEN, and TBW group means of 35.11 ± 1.08 for BB and 30.38 ± 1.32 for GEN. Extra-cellular fluid (ECF) demonstrated not only a significant group effects, but also a group x time interaction was indicated with changes of 0.069 ± 0.095 for BB groups and 0.160 ± 0.117 for GEN group from baseline values (p = 0.35). Post hoc analysis indicated significant differences between means at all time points, with the greatest significant difference seen at T 2 with mean values of 15.3 ± 2.2 for BB and 13.0 ± 0.8 for GEN. Cohen's d revealed a medium effect size for weight (d = 0.61) indicating that this variable may have reached significance if enough statistical power was achieved.

Cardiovascular and Hemodynamic Values

No statistically significant time effects or group x time interactions were seen in resting heart rate (resting HR), systolic blood pressure (BBP), or diastolic blood pressure (DBP) values. A statistical trend was revealed for heart rate between groups (p = 0.068) with T 1 mean HR values of 55.9 ± 6.3 and 59.8 ± 6.0 for BB and GEN groups, respectively. These mean differences were anticipated due to the increased physical training which the BB group participated in prior to the season. ECG analysis resulted in no significant time effect or group x time interaction in PR interval, QRS complex or QT interval. There was a significant group effect revealed for both PR (p = 0.019) and QT intervals (p = 0.001). While a significant group effect was discovered, all means fell within the normal clinical value range.

Red Blood Cell Count Values

No significant group, time, or group x time differences were found in red blood cell count (RBC) or hemoglobin. Statistical analysis did reveal a significant time effect for both hematocrit (BB 39.47 ± 0.45, GEN 41.93 ± 0.74) and mean corpuscular volume (MCV) (BB 87.58 ± .32, GEN 91.01 ± 0.72), which increased over the course of the study. A significant time effect was also indicated for mean corpuscular hemoglobin (MCH) (BB 30.83 ± 0.32, GEN 30.02 ± 0.30) and mean corpuscular hemoglobin concentration (MCHC) (BB 35.0 ± 0.12. GEN 32.96 ± 0.14), both of which decreased over the study duration. While a significant time effect was demonstrated, values for all four variables remained within normal clinical ranges.

A significant time effect trend also existed for the increase in RBC levels for both groups (BB 4.55 ± 0.086, GEN 4.59 ± 0.105, $p = 0.056$); although, these levels remained within normal clinical ranges.

Differential White Blood Cell Values

Statistical analysis revealed no significant group, time or groups x time differences in the following variables: white blood cell (WBC), neutrophils, lymphocytes, neutrophil:lymphocyte ratio, monocytes, basophils or eosinophils.

Serum Analysis

Statistical analysis did not reveal any time effect, group effect or group x time interaction for glucose, BUN, creatinine, BUN:creatinine, calcium and uric acid. Cohen's d revealed a medium effect size for both calcium ($d = 0.60$) and uric acid ($d = 0.60$) indicating that these variables may have reached significance if enough statistical power was achieved.

Lipid Panel Values

No significant interactions were established over time, group x time or group for triglycerides, total cholesterol, LDL cholesterol, or HDL cholesterol. Thus, based upon the previous data we accept hypothesis H2 stating that there would be no significant changes in the aforementioned physiological variables between groups.

Muscle damage and Serum Liver Function Markers

Statistical analysis revealed a significant group effect for lactate dehydrogenase (LDH) levels ($p = 0.001$). LDH means for BB and GEN groups were 135.5 ± 19.8 and 97.4 ± 14.3 respectively at baseline, and 123.5 ± 25.7 and 100.4 ± 22.3 at T 4. No significant time effect or group x time interactions were observed for this variable. A significant group x time interaction increase was for creatine kinase (CK) levels ($p = 0.002$). Mean changes from baseline for both groups were -4.81 ± 7.5 (BB), and 17.34 ± 9.2. Post hoc analysis revealed the difference occurred at the T 2 time point. While a significant difference was observed, it should be noted that CK levels did not exceed normal clinical values. This would indicate that the level of training was not significant enough to produce an extensive amount of muscle damage to elicit a considerable increase in CK levels. No significant group interaction or time effect was shown for CK. Liver function tests measured from serum exhibited no significant time or group effect, nor were any group x time interactions seen in alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP), or gamma glutamyl transpeptidase (GGT). AST however, did reveal a group x time trend ($p = 0.061$).

Hormonal Alterations

Statistical analysis revealed that there was no time effect or group effect or group x time interaction for interleukin-6 (IL-6), total testosterone (tTEST), or free testosterone (fTEST). Initially cortisol, total testosterone, free testosterone, interlukins-1, 6, 10, IGA-1 and TNF-α were proposed. However, since no significant differences were observed in IL-6 and the nutrophill:lymphocyte ratio, we felt it to be an unnecessary and cost prohibitive to examine IL-1, IL-10, IGA-1 and TNF-α based on the lack of effects observed in these variables.

3.4. Psychological Variables

Profile of Mood State (POMS)

No significant changes were indicated for five of the six dimensions measured by POMS. There was a significant time effect reported for fatigue ($p = 0.005$). Fatigue increased in the BB group with a baseline mean of 12.3 ± 3.7 to 18.5 ± 7.6 at the last time point. Additionally, the GEN group showed an increase of 11.1 ± 3.5 at baseline and a mean of 13.5 ± 3.9 at T 4. These increases in fatigue indicated that subjects within the BB and GEN groups demonstrated an increased feeling of fatigue as the study progressed. A large effect size was demonstrated ($d = 0.83$) in fatigue as well indicating that the likelihood of this variable showing significant group x time effects would have been high if statistical power were increased. A statistical time effect trend for anger and hostility was also reported ($p = 0.07$).

Fatigue Index

Of the fifteen questions asked, no group x time interaction was statistically determined. However, there was a group x time trend in "I am tired of school?" ($p = 0.081$). Groups effects were observed in with differences in feeling physically fatigued, with higher means reported in the BB group (4.1 ± 1.7 at T 1 and 5.2 ± 2.3 at T 5) compared to the GEN group (3.5 ± 1.6 at T 1 and 2.9 ± 1.0 at T 5). Similar observations were noted in feelings of fatigue in arms and shoulders with baseline reported means of 5.1 ± 3.0 and 2.5 ±

1.6 for BB and GEN groups respectively. Group difference seen in leg fatigue were greater in the BB group as the study progressed, with slight increases in means from T 1 to T 4 of 4.3 ± 1.4 to 5.1 ± 2.6 for the BB group. Leg fatigue in the GEN groups decreased slightly from 4.0 ± 1.9 at T 1 to 2.9 ± 1.5 at T 4. A group effect was also present for general tiredness. The BB group reported a higher mean of 4.3 ± 2.3 at T 1 when compared to the GEN group at 2.0 ± 1.1. The BB group maintained a higher feeling of general tiredness, leg fatigue, physical fatigue and tiredness in the arms and shoulders. These differences are expected since the BB group is most likely undergoing increased amounts of then the GEN group. Group effect trends existed for feelings of mental fatigue, and feelings of heart and lung fatigue. Calculation of effect size for mental fatigue indicated a medium-effect (d = 0.61). Significant time effects were seen in seven of the fifteen questions relating to fatigue. Both groups increased in over time with feelings of heart and lung fatigue with means changes of 2.45 ± 0.28 (BB) and 1.60 ± 0.34, general tiredness (BB 4.97 ± 0.48, GEN 3.10 ± .59), feelings of being overtrained (BB 6.03 ± 0.65, GEN 6.05 ± 0.80), feelings of being overwhelmed (BB 2.52 ± 0.35, GEN 1.53 ± 0.43), being tired of school (BB 7.60 ± 0.64, GEN 6.35 ± 0.78), and a felling of not getting caught up (BB 5.07 ± 0.58, GEN 3.43 ± 0.72). Feeling of physical strength decreased in both groups over time from 7.5 ± 2.2 and 6.5 ± 2.7. Also noted was a trend was seen in feelings of a stressful family life.

4. Discussion

How athletes respond to the stresses of preparation and competition is complex and is an area which is not completely understood. Placing enough stress on the athlete to provide a positive adaptation is critical, but knowing when increase volume and intensity and when to recover is challenging. Overtraining is a problem that has been well known for 70 years (A. L. Uusitalo & Tahvanainen, K. Uusitalo, A., 1996; A. L. Uusitalo, 2001). Overtraining corresponds to a loss of adaptability resulting in a wellknown symptomatology: deterioration in performance, difficulty training and an absence of motivation, behavioral disorders (irritability, melancholy), sleeping disorders, difficult recovery, an increased occurrence of muscular accidents and higher sensitivity to infections (Lac & Maso, 2004). To determine and predict overtraining in athletes a myriad of biological markers have been propounded. Taken alone, none of them have an absolute significance (Lac & Maso, 2004). Biological markers are those which are physiological, biochemical, hormonal and immunological in nature (Lac & Maso, 2004). While numerous studies have examined many of these markers individually (Angeli Minetto, Dovio, & Paccotti, 2004; Armstrong & VanHeest, 2002; Atlaoui et al., 2004; Barron et al., 1985; Berger et al., 1997; Costill et al., 1988; Fry et al., 1994; Gastmann & Lehmann, 1998; Hedelin, Wiklund, Bjerle, & Henriksson-Larsen, 2000a; Jeukendrup & Hesselink, 1994; Koutedakis & Sharp, 1998), to our knowledge this is the first study to examine the acute and chronic effects of a competitive basketball season on its respective players competing at the Division I level, and to determine if there are any collective, global changes in performance, physiological and psychological variables which may indicate some type of overtraining syndrome.

4.1. Performance Variations

Several studies in the past have been conducted to assess overreaching and overtraining in swimmers (Barr & Costill, 1992; Kirwan et al., 1988; Kreider et al., 1998) and a recent study examined physiological and performance changes in collegiate soccer players (Kraemer et al., 2004). Though there have been a number of studies focusing on the physiological (Ndon et al., 1992; Rajappan, O'Connell, & Sheridan, 2003; Rowbottom et al., 1995; Sharp & Koutedakis, 1992; L. L. Smith, 2000) and psychological (Morgan et al., 1987; Morgan et al., 1988; Morgan, 1994; O'Connor et al., 1989; Raglin, Morgan, & O'Connor, 1991) variations involved with athletic competition, yet it is very hard to examine performance during competition. The findings of this study indicated that relative peak power was the only aspect of performance which significantly changed over the duration of this investigation with increases reported in both groups. Vertical jump and 20-yard sprint times did not show any significant differences. This conclusion does not match that of Kraemer et al (2004), who reported significant changes in both of these variables over the course of a Big Ten soccer season (Kraemer et al., 2004). In their study, collegiate soccer payers who started revealed a -13.8% decrease in vertical jump and an increase of 4.3% in 20-yard sprint speed. We believe that nature and demands of both sports (soccer and basketball) are quite different and this may explain why vertical jump and 20 yard sprint times did not decrease. Also the variation in season training (volume and intensities of practice, competition and strength and conditioning) my also in part be responsible as well. These changes in vertical jumps and 20 yard sprint times may be exclusive to the training approach to collegiate soccer players. The training approach and decrements in performance has been documented in swimmers (Barr & Costill, 1992; Kreider et al., 1998), rowers (Kellmann & Gunther, 2000) and cyclists (Jeukendrup et al., 1992). It is important to remember that there has not been one definitive performance test which has been shown to indicate overtraining, thus any test performed may not be indicative of overall athletic performance (Lac & Maso, 2004).

4.2. Physiological Variations

A decrease in body weight and lean body mass has been reported as a marker of overtraining (Armstrong & VanHeest, 2002; Fry, Morton, & Keast, 1991; S. L. Hooper & Mackinnon, 1995; S. L. Hooper et al., 1995; Kreider et al., 1998; Lac & Maso, 2004; Lehmann, Foster, & Keul, 1993). The results of this study indicated similar findings with a significant drop of 1.3 ± 0.25% of lean body mass by basketball players throughout their competitive season. Since the relative amount of evidence indicating that basketball players exhibit signs of OTS is small, we believe that the decrease in LBM seen in the BB group may be a result of the decreased amount of training time in the weight room during the season. A medium-effect size was noted for body weight indicating the possibility of a significant drop in weight had enough statistical power been present. This drop in weight would most likely have been correlated with the decrease in lean body mass previously discussed. It is interesting that significant increases in relative peak power occurred across a season, and while not significant, there was an increase in vertical jump performance with the BB group which is another index of power. This would indicate that while LBM decreased, power and nervous system activation was maintained across the competitive season. While some studies have indicated changes in bone mineral content in (Stone et al., 1991) our results indicate no changes in BMC in basketball players. Another physiological variable examined in this study was resting heart rate and blood pressure. Changes in resting heart rate were not observed during this investigation. Our results indicated a mean resting HR of 55.9 ± 6.3 bpm at baseline and 54.5 ± 8.0 bpm at the conclusion of the season. The usefulness of maximal heart rate has been questioned due to the individual decrease of ~3 to 5 beats per minute (Urhausen & Kindermann, 2002). Regardless, the majority of the literature has indicated that resting heart rate changes do occur in overtrained athletes (Hedelin et al., 2000; Hedelin, Wiklund, Bjerle, & Henriksson-Larsen, 2000a; Hedelin, Wiklund, Bjerle, & Henriksson- Larsen, 2000b; L. L. Smith, 2000; A. L. Uusitalo et al., 2000). Others seem to be more conservative and have reported similar findings indicating no variation in resting heart rate (Urhausen, Gabriel, & Kindermann, 1998). Overall, the basketball players in this study expressed slightly lower mean resting HR values. These lower values are perhaps a result of the cardiovascular and hemodynamic adaptations from their conditioning program. The primary purpose of the immune system is to monitor the internal environment for the presence of foreign pathogens such as viruses, bacteria, and parasites, which could ultimately cause extreme harm, including death, to the organism (Smith, 2004). The immune system operates using specific immune cells, white blood cells (WBC), to survey the internal environment, and also receives support from additional immune-related systems (Smith, 2004). Overtrained athletes often anecdotally report an alteration in immune system function and the use of markers of immune function as a diagnostic test for overtraining has been suggested (Halson & Jeukendrup, 2004). The overtrained athlete displays numerous signs and symptoms suggestive of altered immune function. These include increased susceptibility to colds and allergies, increased incidence of upper respiratory tract infections (UTRI), and swollen lymph glands (Fry et al., 1991; Nieman & Pedersen, 1999), and tissue trauma (Smith, 2004). Whether immune function is seriously impaired in overtrained athletes is unknown as the scientific data are not available (Halson & Jeukendrup, 2004). This study revealed no significant perturbations with immune function in WBC count, basophil, eosinophil, or monocyte values assessed from whole blood. Furthermore, neutrophil and lymphocyte levels were not significantly altered, which is in agreement with Fry et al, (1994) indicating that neutrophil numbers have been reported to be unchanged in response to intensified training that resulted in a state of overreaching (Fry et al., 1994), and that overtraining and overreaching do not appear to significantly alter circulating lymphocyte number (Kreider et al., 1998). Importantly, neutrophil function has not been assessed in overreached athletes and, therefore the relative contribution of neutrophil cells to possible immune dysfunction in overreached athletes is unknown (Halson & Jeukendrup, 2004). Based upon present findings, results indicate that participation in a competitive basketball season does not initiate a negative effect on immune function and response. Hematological responses may be variable in athletes and not always related to decreased performance (Kreider et al., 1998). Red blood cell (RBC) indices are useful in the diagnosis of types of anemia (Rita Nanda, 2005). These indices include MCH (mean corpuscular hemoglobin), MCHC (mean corpuscular hemoglobin concentration, MCV (mean corpuscular volume) and hematocrit. Both groups elicited similar changes in aforementioned indices. MCV increased, in both BB and GEN groups as did hematocrit, while MCH and MCHC decreased in both groups. While variations did take place, all of the variables remained within normal clinical ranges. All other blood variables including liver enzymes and blood lipid values showed no variation outside of normal clinical values indicating that sufficient stress was not placed upon participants to elicit some change in hematological values. Increased levels of creatine kinase occur as a result of muscle damage, and has been measured and evaluated in sports as an outcome of muscular stress (Halson & Jeukendrup, 2004). The evaluation of CK levels in the blood, has been proposed to help diagnose OTS (L. L. Smith, 2004). CK activity mirrors the mechanical-muscular strain of the training in the preceding days and reacts to the intensity and volume of exercise (Urhausen & Kindermann, 2002), yet some believe that the reliance of this as an OTS marker is overestimated and believed not to confirm changes in overtrained athletes (Fry et al., 1992; Rowbottom et al., 1995; Urhausen, Gabriel, & Kindermann, 1998) . In fact, CK activity may only reflect the level of training activity following periods of intensified training and may be a reflection of training stress (Kreider et al., 1998). The results of this study indicated a significant change in CK levels with both groups with mean changes from baseline of -4.81 ± 7.5 (BB), and 17.34 ± 9.2. While these changes were significant, levels did remain within the normal referenced range for CK levels. The magnitude of this range was not sufficient enough to indicate an increased level of training. The CK results may be explained by the beliefs of some investigators who have indicated that some athletes are nonresponders and show only vary small increases in CK activity (Urhausen & Kindermann, 2002). In addition, after a single bout of eccentric exercise, a muscular adaptation lasting several weeks can occur (Clarkson & Tremblay, 1988), which may explain the decreased levels seen in the basketball population due to the fact that there was a significant amount of resistance training performed prior to season. Increased uric acid concentrations have consistently been found to remain elevated above resting levels 24 hours after exercise and longer in overtrained individuals (Kreider et al., 1998). While uric acid failed to show a significant increase, there was a medium-effect size reported indicating that something was occurring, however there was not enough statistical power to indicate significance of this variable. Another outcome of this study was to examine specific hormone and cytokine changes. Initially cortisol, total testosterone, free testosterone, interlukins-1, 6, 10, IGA-1 and TNF-α were proposed. However, since no significant differences were observed in IL-6 and the nutrophil:lymphocyte ratio, we felt it to be an unnecessary and not cost effective to examine IL-1, IL-10, IGA-1 and TNF-α. The results of this found no significant change in total or free testosterone levels. This conclusion did not support the results documented by Flynn et al.(1994) who observed decreased serum total and free testosterone levels concurrent with a decrease in performance following intensive training in runners and swimmers (Flynn et al., 1994). The investigators indicated that both serum total testosterone and free testosterone were significantly ($P < 0.05$) lower for the swimmers at T2 (TT 16.7 ± 2.5; FT 85.3 ± 8.5) compared to T1 (TT 30.3 ± 2.8; FT 130.2 +/- 20.9) (Flynn et al., 1994). This study failed to reproduce these effects, for total testosterone (T1 0.067 ± 0.042; T4 0.070 ± 0.034) and free testosterone (T1 1.6 ± 0.8; T4 1.5 ± 0.9) in the BB group. Since the documented response of both total and free testosterone concentrations in overreached athletes is contradictory (Halson & Jeukendrup, 2004), and given the fact that the goal of this study was not to produce an overtrained state, but rather observe basketball athletes across a season, the results indicated that there was not sufficient stress to elicit a change in total or free testosterone across a season. Interleukin-6 (IL-6) is a pro-inflammatory cytokine secreted by T cells and macrophages to stimulate immune response to trauma, especially burns or other tissue damage leading to inflammation (Febbraio & Pedersen, 2005). Recent research has also indicated that IL-6 possesses anti-inflammatory properties as well (Smith, 2004). It has been proposed that overtraining syndrome may be caused by excessive cytokine release during and following exercise causing a chronic inflammatory state and "cytokine sickness" (Robson, 2003). This sickness is a result of excessive training/competing with insufficient time for rest and recovery, results in some form of tissue trauma and associated chronic inflammation, with the resulting release of a group of molecules, cytokines (Smith, 2004). It is further proposed that increased blood cytokine levels are capable of accessing the central nervous system and stimulating specific brain areas, resulting in behaviors such as depression, loss of appetite, and sleep disturbances (Smith, 2004). The results of this study indicated no significant change in IL-6 levels for either group. While tissue trauma occurred in both groups through the duration of the study, the degree of trauma may not have been significant enough in all athletes eliciting a noteworthy change. Another consideration is that the times of the testing sessions were not associated with elevated levels of IL-6. There is also the notion that neither the stresses of a competitive division I basketball season nor the stresses of a recreationally active college female will develop significantly elevated levels of IL-6.

4.3. Psychological Variations

Another component of this study was to investigate psychological variables using three different measures to determine if any changes would occur as a result of a competitive basketball season. When stressors outweigh the individual's resiliency, that person begins to physically or psychologically deteriorate (Kreider et al., 1998). It has been reported that an impaired mood state and subjective complaints are considered as sensitive and early markers of OTS (Urhausen & Kindermann, 2002). The mood of a sportsperson can be successfully monitored using the Profile of Mood States (POMS) (Veale, 1991). The POMS consistently has been employed to measure the mood states associated with overtraining (Berger et al., 1997). The use of the POMS in this study revealed significant feelings of increased fatigue in both groups and a continual increase of fatigue in the BB group. Fatigue increased in the BB group with a baseline mean of 12.3 ± 3.7 to 18.5 ± 7.6 at the last time point. Additionally, the GEN group showed an increase of 11.1 ± 3.5 at baseline and a mean of 13.5 ± 3.9 at T 4. These changes translated to a 34% increase in fatigue for the BB group, and an 18% increase in fatigue for the GEN group. No other category (tension-anxiety, depression-dejection, vigor, or confusion-bewilderment) indicated a significant increase with the exception of anger, which revealed a statistical time effect trend indicating that both groups perceived greater amounts of fatigue in the later part of the study. Our results support those of Smith (2004), indicating that signs and symptoms of overtraining include psychological or behavioral changes including, constant fatigue, depression, and emotional instability (Smith, 2004). The investigators of this study feel that the reason for this continued increase in fatigue may be related to the cessation of the spring semester. Once the semester was complete, the BB group continued to train and practice longer to prepare for the post season, where the GEN group did not have any additional responsibilities once the semester was over. Results of the fatigue index revealed that initially, the BB group experienced increased feelings of physical fatigue, arms and shoulder fatigue, leg fatigue and general tiredness when compared to the GEN group. In our estimation, these group differences can be attributed to the increased amount volume and intensity the basketball team was undergoing prior to the start of the season. The demands of this weekly schedule would elicit these increases in perceived fatigue. Seven other factors were shown to increase over the course of the study for both groups. Heart and lung fatigue, general tiredness, feeling physically strong, feeling overwhelmed, feeling overtrained, tired of school and a feeling of never being able to get caught up. Understandably, with the increasing demands of athletics and academics, it would stand to reason that as a semester progresses a sensation of not being able to get caught up, being overwhelmed and becoming tired of school would increase, which in turn would lead the increased general tiredness. Along the same lines, general tiredness from the increase in stress would also explain the decreased feelings of physical strength, increased heart and lung fatigue. These results support the hypothesis that the deterioration of mood state usually starts well before the definitive drop in performance and parallels the increase in training load (Urhausen & Kindermann, 2002). While there were increased feelings of being overtrained reported, there was no clear reason why this variable increased in both groups. This study however, did reveal clear and evident signs of psychological distress much like other investigators in past studies (Fry et al., 1992; Halson et al., 2002; Jeukendrup et al., 1992; Morgan et al., 1987; Morgan et al., 1988; Morgan, 1994; O'Connor et al., 1989; O'Connor et al., 1996; Snyder et al., 1993; Urhausen, Gabriel, & Weiler et al., 1998; Veale, 1991).

5. Conclusion

We can conclude from our findings that the stresses placed upon collegiate basketball players from a combination of their academic and athletic responsibilities indicate some perturbations in select variables which are indicative of OTS. While OTS occurs in three phases (psychological, physiological, performance), negative changes in performance were not indicated. Physiologically, changes were elicited in a few variables, the variations reminded within normal clinical ranges for this demographic. Psychological changes indicated that basketball players demonstrated an increased negative effect on life events, yet mirrored their non-athletic counterparts in feelings of fatigue, and being tired of school. It is clear that more research in this area needs to be completed to determine the exact mechanisms and manifestations of overtraining and its effect on athletes at all levels.

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