Monitoring Training Load, Recovery-Stress State, Immune-Endocrine Responses, and Physical Performance in Elite Female Basketball Players During a Periodized Training Program

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Abstract

Nunes, JA, Moreira, A, Crewther, BT, Nosaka, K, Viveiros, L, and Aoki, MS. Monitoring training load, recovery-stress state, immune-endocrine responses, and physical performance in elite female basketball players during a periodized training program. *J Strength Cond Res* 28(10): 2973–2980, 2014—This study investigated the effect of a periodized training program on internal training load (ITL), recovery-stress state, immune-endocrine responses, and physical performance in 19 elite female basketball players. The participants were monitored across a 12-week period before an international championship, which included 2 overloading and tapering phases. The first overloading phase (fourth to sixth week) was followed by a 1-week tapering, and the second overloading phase (eighth to 10th week) was followed by a 2-week tapering. ITL (session rating of perceived exertion method) and recovery-stress state (RESTQ-76 Sport questionnaire) were assessed weekly and bi-weekly, respectively. Pretraining and posttraining assessments included measures of salivary IgA, testosterone and cortisol concentrations, strength, jumping power, running endurance, and agility. Internal training load increased across all weeks from 2 to 11 ($p \leq 0.05$). After the first tapering period (week 7), a further increase in ITL was observed during the second overloading phase ($p \leq 0.05$). After the second tapering period, a decrease in ITL was detected ($p \leq 0.05$). A disturbance in athlete stress-recovery state was noted during the second overloading period ($p \leq 0.05$), before returning to baseline level in end of the second tapering period. The training program led to significant improvements in the physical performance parameters evaluated. The salivary measures did not change despite the fluctuations in ITL. In conclusion, a periodized training program evoked changes in ITL in elite female basketball players, which appeared to influence their recovery-stress state. The training plan was effective in preparing participants for competition, as indicated by improvements in recovery-stress state and physical performance after tapering.

Key Words female athletes, periodization, saliva, cortisol, testosterone, IgA

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Introduction

For elite athletes, the overall aim of the training process is to induce positive psychophysiological adaptations that, in turn, may create optimal conditions to enhance sport-specific performance during actual competition (36). Improvements in the physical capabilities of athletes (e.g., strength, power, endurance, agility) are particularly important, and these outcomes are the likely result of adaptive changes occurring on cellular and molecular levels (19). To maximize training adaptations and physical performance, conditioning staff typically manipulate 1 or more training variables (e.g., training volume, load intensity) across the precompetition period, often referred to as periodization (14,19,20).

A common periodization approach involves an overloading phase designed to maximize the training stimulus, followed by a tapering period (whereby training volume is reduced) to allow the activated systems to recover and subsequently adapt (19,20,30). Studies have confirmed the effectiveness of periodized programs involving a single overloading and tapering phase (4,7,9,14); however, few studies have described the training stimulus within this process and the responses of different adaptive systems (e.g., hormonal, immune, neural) (7,15). This information is important for assessing the effectiveness of a training program, which will also allow adjustments to be made if necessary to ensure that the training stimulus and adaptations are maximized.

Surprisingly, little is known about the efficacy of prescribing dual overloading and tapering phases leading into international competition, which better reflects the actual training procedures employed by many elite athletes. Among the few studies in team sport athletes, Bangsbo et al. (1) described the preparation program of the Danish National soccer team for the 2004 European Championship, which involved 2 periodization phases each lasting 9 days. The players were assessed using the Yo-Yo intermittent endurance test to verify training adaptation based on submaximal heart rate (HR) change. These authors demonstrated an elevated exercise-induced HR response from the beginning of the preparation to the end of the first phase, and a decline in the HR response after a reduction in total training volume (1). As submaximal, HR has been used as a marker of training adaptation, the increased HR response during the overloading period is suggestive of a fatigued state. Conversely, the attenuated HR response after tapering (with reduced training volume) suggests a positive adaptive state that could be attributed to a decrease in sympathetic activity (5).

In another study, Ferret and Cotte (12) examined the preparation of the French National Football team leading into the 1998 and 2002 FIFA world cups. The French team won the world cup in 1998 and was eliminated during the pool stages of the 2002 tournament. According to these authors, the main difference between 1998 and 2002 teams, which could help to explain such extreme results, was the fact that the 1998 team had enough time to develop the necessary athletic qualities by using 2 training phases followed by a 2-week tapering phase (12). In contrast, most of the players in the 2002 team started their preparation with the French team in a highly fatigue state resulting from the competitive season with their respective club teams; therefore, the staff members could not carry out appropriate training before the world cup (12).

Despite these reports on team sports, there is still a paucity of information on the effectiveness of overloading and tapering phases in team-sport athletes using the dual periodization model. Moreover, no study has described the training stimulus imposed by 2 periods of progressive overloading and tapering in elite female athletes preparing for an international championship. A better understanding of the training stimulus and adaptations occurring during progressive loading and tapering periods, especially during periods of intense physiological and psychological stress (i.e., precompetition), would improve training assessment, training load prescription, and the management of elite female athletes.

The study aim was to describe the training stimulus imposed on elite female basketball players during 2 overloading and tapering phases before a major international competition and the effects on internal training load (ITL), recovery-stress state, immune and hormonal status, and physical performance. It was hypothesized that the ITL and the recovery-stress state of the participants would increase in line with periods of overloading (i.e., greater training volume) and decrease during a tapering phase (i.e., reduced training volume). In addition, it was expected that the periodized training program would lead to positive changes in all physical performance outcomes.

Methods

Experimental Approach to the Problem

Nineteen elite female basketball players on the Brazilian National Team were monitored over a 12-week period before an international championship (Fédération Internationale de Basketball [FIBA] Americas Championship). In the first 3 weeks of training, the athletes completed a moderate-intensity training program with the aim to prepare the athletes for the subsequent overloading period. The athletes did not participate in any speed-agility training sessions at this time, and the intensity of endurance and strength training were moderate. The first overloading period was 3 weeks in duration (weeks 4–6), followed by a 1-week tapering phase (week 7). The second overloading period was 3 weeks in duration (weeks 8–10), followed by a 2-week tapering phase (weeks 11 and 12). Internal training load and recovery stress-state were assessed weekly and bi-weekly, respectively. Pretraining and posttraining program measures of salivary IgA, testosterone (T), and cortisol (C) concentrations were obtained, and repetition maximum (RM) strength, jumping power, running endurance, and agility were assessed.

Subjects

Nineteen elite female basketball players volunteered to participate in this study with a mean (±*SD*) age, height, body mass, and $\dot{V}O_2max$ of 26 ± 5 years, 181.8 ± 7.2 cm, 75.6 ± 12.6 kg, and 57 ± 12 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively. The players were members of the Brazilian National Team preparing for the FIBA Americas Championship and were considered to be highly trained with 14 ± 4 years of basketball training experience. Before the study commenced, each player provided written informed consent in accordance with the requirements of the local ethics committee.

Training Periodization

In the first 3 weeks of training, endurance and strength development were prioritized (Table 1). To achieve this goal, the athletes completed 3 endurance sessions per week at a moderate intensity, in the afternoon, alternating with technical and tactical sessions. All of the endurance sessions were conducted in a continuous fashion (20–40 minutes of steady state running) and, from week 4–6, an interval-type training approach was employed. The endurance sessions were

Table 1. Description of physical training completed during the 12-week period.

	Week 1–3	Week 4–6	Week 7	Week 8–10	Week 11–12
RT					
No. of sets	24–18	18	18	18	18
Repetitions perset	12–6	10–6	6	6	3–6
Goal intensity (%)	70–85	30–50	30	30	30
Rest period (min)	2–3	3	3	3	3
Sessionsper week	4	4	2	3	2
ET					
Goal intensity	Moderate	Moderate to high	High		
Work-to-rest ratio		1:1/2 to 1:1	1:2		
Work-to-rest ratio (s)		60″:30″ to 40″:40″	40″:80″ to 30″:60″		
Distance (km)	~6–5	~6–5	~4		
Sessionsper week	3	3	1		
SAT					
Goal intensity				All out	All out
Work-to-rest ratio				1:2–1:3	1:3
Work-to-rest ratio (s)				15″:30″ to 5″:15″	10″:30″ to 5″:15″
Distance (km)				~2–1	~2–1
Sessionsper week				3	1

RT = resistance training; ET = endurance training; SAT = speed-agility training.

performed on a basketball court. The participants also completed 4 resistance-training sessions per week, in the morning, during the first 6 weeks including the first overloading training phase (weeks 4–6). The training goals for these sessions were hypertrophy and strength development from week 1–3, with maximal power emphasized in weeks 4, 5, and 6. The first tapering week (week 7) was completed in a step-tapering format involving an immediate decrease in training volume (50% of the preceding week) (31). Training frequency was also reduced by half.

The second overloading phase (weeks 8–10) focused on speed, agility, and power development. Moreover, the technical and tactical sessions were performed at a greater intensity compared with the first overloading phase. With the aim to develop sport-specific fitness, 2 training sessions that simulated the physiological demands of competitive basketball games were conducted each week. Three resistance-training sessions were also completed in the mornings alternating with the speed and agility workouts. The second tapering phase during weeks 11 and 12 was again performed using a step-tapering approach (31). In the second tapering phase, greater emphasis was given to the technical and tactical components (5 sessions per week). Overall, the athletes exercised on a daily basis throughout the experimental period, with 1 full days rest on each week during the tapering phase.

Weekly Internal Training Load

Internal training load was calculated using an established method developed by Foster (13) that required each athlete to provide a rating of perceived exertion (RPE; CR-10 scale) for each session. To do this, participants were asked a simple question 30 minutes after training; "How was your workout?" An ITL was calculated by multiplying the session RPE score (indicator of global intensity) by training duration (in minutes). Data from all training sessions were combined to provide an absolute ITL score for each week of training. The session RPE method has been shown to be a valid method for monitoring training load in soccer players (18,21).

Recovery-Stress State

The Recovery-Stress Questionnaire for Athletes (RESTQ-76) is a psychometric tool developed to identify the magnitude in which athletes are physically or mentally stressed and their current state related to recovery (22). RESTQ-76 is composed by General Stress and Recovery scales along with Sport-specific Stress and Recovery scales (22). The General Stress component includes 12 scales which measure general stress, emotional stress, social stress, performance aspects, "physical complaints," basic aspects of recovery, sleep quality, and "success" outside sport (22). The 7 Sport-specific Stress items focus on aspects of recovery related to sport, including "disturbed breaks," "burnout/emotional exhaustion," "fitness/injury," "fitness/being in shape," "burnout/personal accomplishment," "self-efficacy," and "self-regulation" (22). The athletes rated each item on a 7-point Likert scale according to how often the subject has participated in various activities during the last 3 days. Total stress state was calculated as the sum of the subscale scores representing stress (Σ10 stress subscales), and total recovery state was assessed by the sum of the subscale scores representing recovery (Σ9 recovery subscales). As proposed in a previous study (9), a general indicator of recovery-stress state could be calculated by subtracting the total recovery state score from the total stress state score. The questionnaire was completed 6 times (at the end of every 2-week block) before the first training session of the day. The test-retest reliability of RESTQ-76 Sport has been previously reported ($r = 0.51$–0.81) (22).

Pretesting and Posttesting Measures

The study participants were tested at baseline (before the commencement of the periodization program) and after the 12-week training program for physical strength, agility, endurance, and power. Testing was completed over 2 sessions (morning and afternoon) after 2 days of complete rest from previous exercise. The order of testing was as follows: 1RM bench press, squat jump (SJ) power, and T-test ability were all assessed in the morning. In the afternoon, 8RM squat and Yo-Yo endurance were assessed. The order of testing was designed by the coaching staff to minimize any residual effects of fatigue between test exercises using the same muscle groups. Within the constraints of elite sport, it was not possible to randomize these exercises or to perform only 1 assessment each day. Trained exercise professionals were always present during testing to monitor exercise testing technique and protocols, and to provide verbal support.

Strength Testing

Strength testing was performed using standard procedures (23,34). After an initial warm-up using self-selected lighter loads and moderate repetitions (not more than 10 submaximal repetitions), participants were tested for their 1RM bench press and 8RM squat. For the 1RM bench press, a single repetition to failure protocol was used, in which the load increased across 3–4 attempts (separated by 3 minutes rest) until the participant was unable to complete the required repetitions using a proper technique. The selected loads for the 8RM squats were based on the previous lifts used by each athlete during their habitual strength training programs. The participants were familiar with this exercise, and the testing protocols so no more than 2 attempts were needed to determine their 8RM lift. The test-retest reliability of the 1RM bench press and 8RM squat assessments were determined 1 week before the study began using a subsample of 10 athletes who participated in the present investigation, and a set of values taken during pretesting (i.e., second day of the first week of the periodized program). The reliability between tests was high (Bench press ICC = 0.96; Squat ICC = 0.98).

Agility T-Test

The 40-m agility T-test was administered using a validated protocol, (32) and although the distance was adapted slightly, the test characteristics remained the same. Four cones were set out in a diamond shape and labeled A, B, C, and D. Each subject began with both feet behind a starting point (A) and, after an audio signal, they then sprinted 10 m forward to point B, touched the cone and shuffled 5 m to the left and touched cone C. After that, the athlete shuffled 10 m to the right and touched cone D and then 5 m to the left, back to point B. Then, the player ran backward passing the finish line at point A. Two electronic time sensors (Photo-cell system; CEFISE, Nova Odessa, SP, Brazil) were set 0.75 m above the floor and positioned 3 m apart facing each other on either sides of the starting line. The clock started and stopped when the players passed the electronic sensors. The reliability of the agility T-test has been reported as very high (ICC = 0.98) (32).

Yo-Yo Intermittent Endurance Test

The Yo-Yo intermittent recovery test, level 2, was performed as previously described (6,24). Briefly, subjects ran outdoors on a flat surface between 2 markers set at a 20-m distance apart. Starting at the first marker, they ran to the 20-m marker on an audio cue from a compact disc player, before turning and running back toward the first marker, which they had to reach by the next signal. The time between the cues would decrease every minute and thereby require each subject to adjust their running speed (i.e., faster) over time. Failure to reach the marker by the signal meant the person had to stop the test. The total distance covered (in meters) was recorded. A high test-retest reliability was reported for this test in a sample composed by trained individuals ($n = 16$) and elite soccer players ($n = 13$) (coefficient of variation [CV] = 9.6%) (24).

Squat Jump Test

Squat jump testing was performed using an established method (25). After 10 minutes of jogging and stretching, 3 jumps were performed on a jump mat (Ergojump Jump Pro 2.0; CEFISE) connected to a computer. The SJ was performed as a concentric only movement (i.e., no sinking down before the vertical jump) with hand placement on the hips to remove the effects of arm swing. Two-minute rest periods were provided between trials. Maximal jump height (in centimeters) was estimated and the best trial used for analysis. Jump mat technology provides valid measures of jump height compared with a criterion system ($r = 0.97$) (26), and pilot testing for this study indicated that the jump mat system also provides reliable measures (CV $<$ 4.0%; ICC = 0.95).

Salivary Hormone and Immune Markers

Saliva samples were collected at rest 1 day before training commenced and 1 day after the completion of the 12-week training program. The timing of sample collection was the same on each day (0730, 0930, 1200, and 1800 hours) to account for diurnal variation. The first saliva sample was taken immediately after the athletes woke up (overnight fasting). At 0800, the athletes received a standardized breakfast (CHO 1 $g \cdot kg^{-1}$, PRO 0.3 $g \cdot kg^{-1}$). Therefore, the last meal before 0930 was taken 90 minutes before the second saliva sample. Subjects also abstained from food and caffeine products for at least 90 minutes before the third and fourth samples. Initially, subjects were required to rinse out

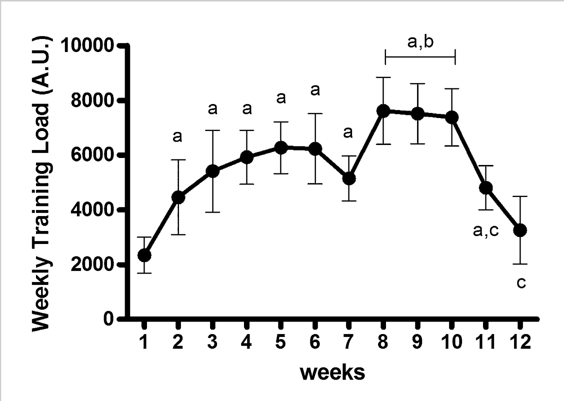

Figure 1. Weekly training load of elite female basketball players during 12 weeks of periodized training (mean ± *SD*). [a]Significantly different from week 1; [b]Significantly different from week 7; [c]Significantly different from weeks 8, 9, and 10.

their mouths with distilled water to clean the oral cavity. The subjects were in a seated position, with eyes open, head tilted slightly forward, and making minimal orofacial movement. Unstimulated saliva was collected into sterile 15-ml tubes over a 5-minute period and stored at −80° C until assay. Testosterone, C, and IgA concentrations were each determined in duplicate using an enzyme-linked immunoassay (Salimetrics, State College, PA, USA) and the manufacturer's instructions. The average intra-assay CV was 5.2, 4.5, and 3.8% for salivary C, T, and IgA, respectively.

Statistical Analyses

The assumption of normality and homoscedasticity was verified using the Shapiro-Wilk and Levene tests. A 1-way analysis of variance with repeated measures was used to examine the weekly changes in ITL and the biweekly changes in recovery-stress state across the 12-week training period. When a significant effect was identified, the post hoc Tukey honesty test was used to locate the differences. Paired *t*-tests were used to compare the IgA, hormonal and performance responses pretraining and posttraining. The level of significance was set at $p \leq 0.05$.

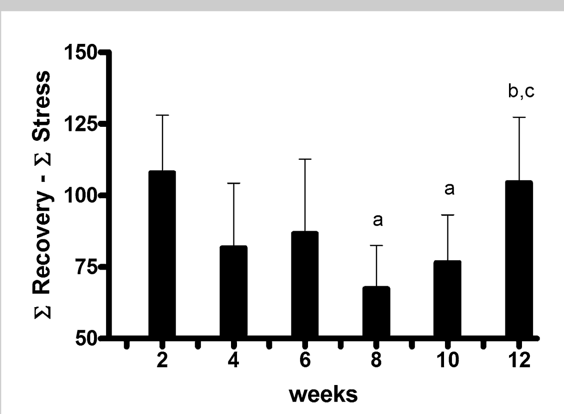

Figure 2. Recovery-stress responses of elite female basketball players during 12 weeks of periodized training (mean ± *SD*). [a]Significantly different from week 2; [b]Significantly different from week 8; [c]Significantly different from week 10.

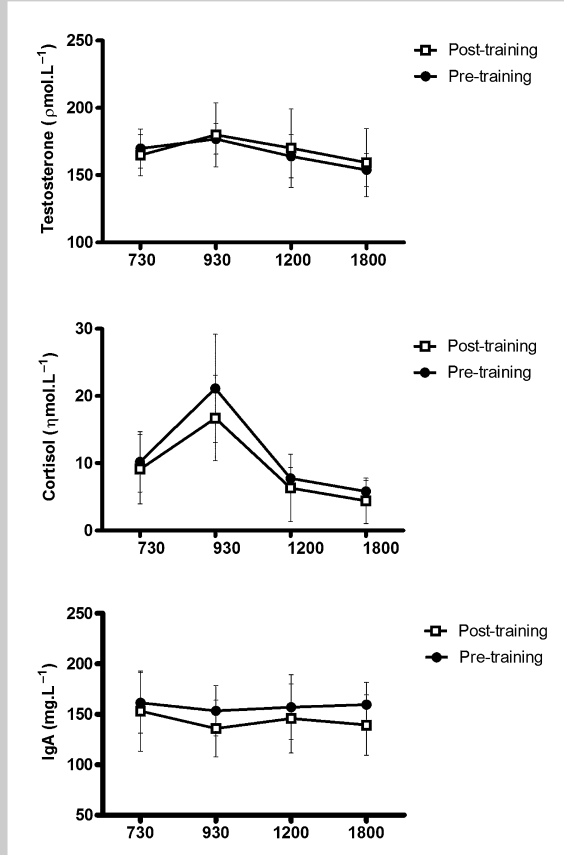

Figure 3. Salivary testosterone (A), cortisol (B), and IgA (C) concentrations of elite female basketball players pretraining and posttraining (mean ± *SD*).

Results

Compared with week 1, ITL increased significantly across all weeks from 2 to 11 (Figure 1, $p \leq 0.05$). After the first tapering period (week 7), a significant increase in ITL was observed during weeks 8, 9, and 10 from that observed in week 7. The second overloading phase (weeks 8, 9, and 10) was followed by a 2-week tapering period (weeks 11 and 12), at which time ITL decreased significantly ($p \leq 0.05$). A significant disturbance in the stress-recovery state (expressed by the sum of recovery subscales − sum of stress subscales) was noted in weeks 8 and 10 when compared with week 2 ($p \leq 0.05$; Figure 2). In week 12, the reported stress-recovery state was significantly higher than weeks 8 and 10, before returning to the baseline score.

Table 2. One repetition maximum bench press, 8RM squat, SJ, T-test, and Yo-Yo test performance of elite basketball female players pretraining and posttraining (mean ± *SD*).*

	Pretraining	Posttraining
1RM bench press (kg)	59.6 ± 5.2	66.0 ± 5.4†
8RM squat (kg)	75.3 ± 8.0	81.0 ± 7.6†
SJ (cm)	35.9 ± 4.4	39.4 ± 3.9†
T-test (s)	9.20 ± 0.34	9.05 ± 0.40†
Yo-Yo (m)	527 ± 146	576 ± 134†

*1RM = 1 repetition maximum; SJ = squat jump.
†Significantly different from pretraining $p \leq 0.05$.

No significant change in salivary T (Figures 3A) and C (Figure 3B) concentrations was seen from pretraining to posttraining across the 4 sampling points taken ($p > 0.05$). Similar to the hormonal parameters, no significant change in salivary IgA concentration was seen at any time point ($p > 0.05$; Figure 3C).

A significant improvement ($p \leq 0.05$; Table 2) in bench press 1RM and squat 8RM strength, and SJ height was identified from pretraining to posttraining. Sprinting time and distance covered during the respective agility T-test and Yo-Yo test were also improved after training ($p \leq 0.05$; Table 2).

Discussion

This study provides insight into the training stimulus imposed by a standard periodization plan used in elite sport and the effects on different physiological systems and physical performance in female athletes preparing for an international basketball competition. The periodized training program, which involved 2 overloading and tapering phases, was closely mapped by changes in training stimulus (ITL) leading to a improved physical performance and a lowered stress-recovery state. However, no changes in the hormonal and immune measures were observed in response to the periodized training program.

Supporting the study's initial hypothesis, the ITL responses of participants were aligned with the preprogramed overloading and tapering phases. This suggests that session RPE is a useful method for monitoring changes in external training loads in elite female basketball players. This is novel information as the majority of sport studies have been conducted on male athletes and in other team sports. For example, the session RPE method was considered a useful and valid method for monitoring training load in soccer players (18). Indeed, Jeong et al. (21) demonstrated that session RPE is useful to quantify training loads of a periodized program in professional soccer players, reporting much higher ITL in the preseason than in season, which reflected the higher volume of training performed during preseason. Coutts et al. (7,8) also highlighted the sensitivity of this method for monitoring ITL during intensified training and tapering in rugby players.

To date, few studies on team sport athletes have described the training stimulus and adaptations from a periodization plan involving 2 loading and tapering phases. Bangsbo et al. (1) described the preparation of the Danish National soccer team for the 2004 European Championship. The preparation lasted 18 days divided into 2 periods of equal duration, with training volume reduced in the second (tapering) phase. Although no reports on physical fitness were made, the team did qualify for the quarterfinals of the tournament which suggests, albeit speculatively, that physical performance may have benefited from this periodized training approach.

Studies that have examined the effects of a single overloading and tapering phase concur with the current findings. Coutts et al. (7) examined the effect of deliberate pre-season overreaching and tapering on muscle strength, power, endurance, and biochemical responses in semi-professional rugby players. After the tapering phase, the authors (7) observed increase in the multistage fitness test, vertical jump, 3RM squat, 3RM bench press, chin-up and 10 m sprint test. These results confirm that a tapering phase, following a period of intense training, can assist athletes' physical preparation. A significant change was also demonstrated in the plasma measures of the T to C ratio, glutamate, the glutamine to glutamate ratio, and creatine kinase after the overloading period (7), highlighting their use as possible markers of training status. However, it appears that indices of performance such as vertical jump, strength and mainly multistage fitness testing (7–9), along with time to exhaustion tests (17), should be the primary criteria for the correct diagnosis of an overreached state. The overloading and tapering parameters used in this work provided an effective training strategy leading into the basketball competition. Indeed, it is important to mention that the Brazilian national team won the following competition (FIBA Americas Championship). Optimizing the physical abilities of an athlete or team pre-competition, particularly for a major international tournament (characterized by a short duration), might be decisive in determining the outcomes of subsequent competition when the physical expression of speed, power, strength and/or endurance are key predictors of sport-specific performance.

The observed improvement in strength, SJ and running performance (endurance and agility) need to be highlighted in context. Basketball is an intermittent activity characterized by high-frequency, high-intensity actions and changes of directions over short distances (3,27). For instance, there are several actions (with or without the ball) of short sprints, abrupt stops, fast changes in direction, movements evolving acceleration in distinct duration and direction, as well as different types of vertical jumps all using explosive contractions (3,11,27). Success in basketball could be, at least in part, related to one's capacity to perform these actions well and thus, might be associated with vertical jump ability and running agility (2,10). These data reinforce the need to implement sport-specific measures to assess the physical state of an athlete prior to competition. Future studies are needed to verify if improvements in physical performance are related to a better performance during a competitive match.

The recovery-stress state of the team was impaired in weeks 8 and 10 compared with the baseline and, at week 12, there was a reported improvement in this state compared with weeks 8 and 10. The training weeks 8, 9, and 10 constituted the second deliberate overloading phase, followed by 2 tapering weeks. The accumulated effects from the first overloading phase, in addition to the second overloading phase, possibly affected the recovery capacities of the athletes while elevating total stress. Coutts et al. (9) showed an impaired recovery-stress state in male triathletes with an increase in ITL, but this outcome improved after a tapering period. The authors (9) also confirmed that the RESTQ-76 Sport questionnaire may provide a practical tool for recognizing overreaching in its early stages. Overall, the current findings suggest that a 2-week tapering period is sufficient (when employing a step tapering approach) for the restoration of psychological measures which, in turn, seem to be associated with concomitant improvement in physical performance.

The periodized training plan did not influence the baseline measures of salivary T and C concentrations, which is consistent with the findings of previous studies (7,29). Coutts et al. (7), for instance, demonstrated that the changes in plasma C and T measures were not correlated to the changes in training load or performance in the monitored athletes. Coutts et al. (7,8) also pointed out that biochemical parameters should not be used as an early maker of overreaching in a practical training environment. In addition, Moreira et al. (29) demonstrated that despite the existence of a large variation in ITL during a 4-week period of Futsal training, there was no significant change in resting salivary C concentration. In this study, it may be that more discrete hormonal changes occurred, but were not evident from the sampling schedule employed in the present study, being a pretesting to posttesting design. The lack of change in T and C concentrations may also reflect the fact that both measures returned to baseline (i.e., pretraining values) in line with the prescribed training loads.

The lack of change in salivary IgA is also consistent with previous research (33,35,38). Robson-Ansley et al. (33) reported no change in IgA concentration and secretion rate after 4 weeks of intense training. A recent study (35) also reported no alteration in salivary IgA after a 21-day intense training in 8 trained male cyclists. The results presented herein suggest that 2 phases of overloading training followed by appropriate periods of tapering does not negatively affect mucosal immunity and the stress level of elite female basketball players. However, the absence of any salivary IgA changes in this study could be attributed to the frequency of saliva sampling. Gleeson et al. (16) and Moreira et al. (28) both suggested that a more frequent saliva sampling protocol is needed to identify temporal changes in this mucosal immune parameter, especially during periods of intensified training and competition that are likely to be accompanied by greater physiological and psychological stressors.

The study limitations include the lack of control data and the sampling procedures employed. As previously mentioned by Stone et al. (37), the pretest posttest control design is the most common approach for academically based research; however, employing such a design in the elite sporting environment is almost impossible because of logistical constraints. The study's sample consisted of 19 female elite athletes (who were selected to compose the National Basketball Team) and, as a result, it is virtually impossible to find a similar group to establish a reasonable comparison. It is also important to acknowledge the absence of saliva samples collected immediately after the overloading phases, because of operational limitations. Still, the study results are unique in that female athletes of the highest level were monitored, the training procedures were not modified in any way to aid this investigation, and the monitoring period was of extreme relevance to the study population (i.e., before the major international competition).

In conclusion, the periodized training plan implemented in this study promoted improvement in the all-round physical performance capacity of elite basketball female athletes leading into a major international competition. The observed changes in ITL and, to a lesser extent, recovery-stress state mirrored the prescribed fluctuations in external TL from the 2 overloading and tapering phases.

Practical Applications

This study confirms that the periodization plan implemented can improve the physical performance capacity of elite female basketball players before a major international competition. Specific information on the training content and loading parameters (Table 1) may be used by coaches or trainers involved in comparable sports or athletes to guide their training and management practices before competition. It also appears that the Session RPE and REST-Q can provide useful information for monitoring both ITL and stress state in an elite athlete group. These psychometric tools offer a low-cost strategy to monitor training to ensure that proper loads and recovery periods are implemented, thus maximizing the dose-responses of the training stimulus and its adaptive outcomes.

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