Title: The effect of transition period on performance parameters in elite female soccer players.

Abstract

The purpose of this study was to examine the effect of a 4-week off-season period (transition period) on the anthropometric and performance parameters in elite female soccer players who participated in the UEFA women's Champions league. Eighteen female players (age 23.6±4.3 years) underwent testing at the end of the competitive period and right after the transition period. An incremental cardiopulmonary testing, body composition assessment and isokinetic testing at 60 °/sec were performed on both occasions. The cardiopulmonary exercise testing revealed that VO2max ($p=0.001$) and time on the treadmill ($p=0.000$) were significantly reduced after the transition period that included a 2 times/week exercise regimen. Furthermore, the quadriceps torque production at 60 °/s was significantly reduced for both the right ($p=0.013$) and left quadriceps ($p=0.004$) following the transition period. Finally, body weight ($p=0.001$) and body fat ($p=0.000$) significantly increased after 4 weeks of significantly reduced training volume. It is concluded that the transition period negatively affected the anthropometric and performance parameters of the female players. These data maybe informative for coaches and trainers as they demonstrate that despite the efforts to keep the players physically active the performance parameters decreased significantly.

Introduction

The number of female soccer players is without a doubt increasing worldwide [1]. Despite the growing popularity of women's soccer, no studies were identified that investigate the effect of transition period on the anthropometric and performance parameters. Most published literature available has examined those effects on male [2]rather than female players.

The entire soccer season can be divided into the pre-season, the competition and the transition periods. The duration of the transition period vary based on the division with the lower division teams having longer transition periods [3]. In addition to division, the transition period also depends on whether a team participates in the European leagues' qualification rounds [3]. However, regardless of their participation in international games, first division teams have a transition period of at least 4 weeks.

The transition period has been found to elicit moderately negative changes in body composition, sprint performance and muscle power in male soccer players [2]. Furthermore, decrements in maximal oxygen consumption (VO2max), time to exhaustion and intermittent running performance have been reported [2]. Nevertheless, although the decrease in VO2max is a well-documented result of the transition period, the length of the detraining period has been reported to play a role [3]. More specifically, it has been demonstrated that first division teams with a 2-week shorter transition period exhibit greater VO2max values compared to lower divisions [3]. It is possible that this shorter transition period prevents inactivity, thereby leading to smaller detraining effects [3].

Despite the fact that players are instructed to follow specific training protocols during the transition period, it is generally recognised that the training volume is significantly reduced during that time [4, 5]. It has been indicated that both short (< 4 weeks) and long-term (> 4 weeks) detraining result in a significant decline in VO2max, blood volume, cardiac output and stroke volume while heart rate increases [4,5].In addition to a decline in aerobic performance, a transition period was found to lead to an increase in body fat in the lower body in top level professional male soccer players [6].. Despite these early negative changes, it has been shown that muscular strength will only be affected if the detraining period is longer than 4 weeks.

Furthermore, a transition period of six weeks was found to lead to significant negative changes in squat jump, countermovement jump, sprint times and body composition in Greek professional soccer players [7]. It should be noted that the low intensity aerobic training that the players followed during that period was insufficient to prevent the rapid loss of exercise adaptations and optimal body composition parameters [7]. The increase in body fat during the transition period has been reported to negatively affect sprint times [9].

The detraining effects during the transition period may cause serious issues during the pre-season preparation phase, when players are exposed not only to several friendly games early in the pre-competition period but to high volumes of training sessions as well, in order to prepare for the competitive period. The increased training load during the pre-season phase can increase the odds of injury [10], especially for players who do not follow any training program during the transition period. The well documented evidence that female soccer players have higher incidence of knee injuries than males further reinforce on the importance of the transition period [11]. The importance of training status in female soccer players is further highlighted considering that a female field player covers on average a total distance of 10.2 km with high intensity running throughout a competitive game [12]. Finally, a study by Kraemer et al. (2004) underlines how critical the transition period is by indicating that the nature in which the players enter a season can have a significant effect on their performance during the season [13]. An inappropriate fitness level at the beginning of the season can result in entering the season with catabolic processes predominating which are manifested as decreases in strength, vertical jump and speed [13].

This study aimed to examine the effect of a 4-week transition period on body weight, body fat, VO2max and lower body strength in elite female players who participated in the UEFA women's Champions league. To the best of our knowledge no studies have examined the effect of the transition period on the anthropometric and performance parameters in elite female soccer players.

Materials and Methods

Participants

The study consisted of eighteen female elite soccer players (age 23.6 +/- 4.3 years, height 164.8+/-4.7 cm) that participated at the highest standard of the Cyprus's football league. Goalkeepers were excluded from the study as they do not participate in the same type of training sessions compared to the in-field players. To assess the hypothesis this observational study compared the body composition and performance parameters of the female players in late May (end of the competitive period) and early July (right after the transition period) between 8 am and 12 pm. All participants completed an informed consent form, after being briefed on the methods and procedures of the study. All of them had medical clearance before testing began and they were informed that their participation was completely voluntary. The study meets the ethical standards of the journal [14] and was approved by the University [redacted] ethics review board (reference number STEMH 541) and the [redacted] National Committee of Bioethics.

Study Design

Anthropometric testing and Body Composition

Age, height, weight and body fat were recorded prior to the testing. A wall stadiometer (Leicester height measure, Tanita, Japan) was used to measure participants' height which was recorded to the nearest centimeter. The body composition was determined using a leg to leg bioelectrical impedance analyser (BC418MA, Tanita, Japan). All participants were advised to abstain from any physical activity 24 hours prior to the measurements and were instructed to follow the standard BIA (bioelectrical impedance analysis) guidelines before the body composition measurements [15]. Players were measured wearing light clothing and bare feet after being instructed to empty their bladders. The same measurements were repeated right after the transition period.

Cardiopulmonary testing

Participants completed an incremental maximal cardiopulmonary testing on the treadmill (hp cosmos Quasar med, Nussdorf-Traunstein, Germany) at the end of the competitive period and after the transition period. The laboratory's temperature was set at 22+/- 1°C with the relative humidity at 50% during both testing sessions. The modified Heck protocol was used to measure VO2max values. During the test the inclination was kept at 3% for both the warm-up and exercise phase. The initial warm up speed was 4.8 km/h and increased by 1.2km/h every one minute. The exercise speed was 8.2km/h and increased by 1.2km/h every two minutes until the player reached exhaustion and could no longer continue. The recovery speed was 4.8km/h for 3 minutes with the inclination set at 0%. Heart rate was monitored throughout the test. The criteria for attaining VO2max were a plateau in VO2max despite an increase in workload, a respiratory exchange ratio (RER) greater than 1.05 and a heart rate that was within 10 to 12 beats of the age predicted maximum heart rate.

Lower body strength of quadriceps and hamstring muscles was assessed using the Human Norm and Rehabilitation system (CSMI Med & Solution, USA). Before the testing, the participants were instructed to warm up for 10 minutes on a cycle ergometer (Monark 894, Vansbro, Sweden). The test was initiated after the positioning of the participants on the isokinetic device. The players were in a sitting position with their thigh at an angle of 85 ° to the trunk while the axis of rotation of the dynamometer was aligned with the lateral epicondyle of the knee joint. The range of motion at the knee joint was 100 degrees. The thigh, ankle and upper body were fixed using straps. Following the familiarization training the players performed 3 repetitions at 60 °/sec to determine the peak concentric torque of both the quadriceps and hamstring muscles.

Training Protocol

The players followed a 2 times/week training regimen in order to maintain their fitness level (table 4) during the 4-week transition period. The program was monitored by the fitness coach for 14 of the players while 4 international players were instructed to follow the same training protocol. The program was conducted in the afternoon and lasted for 60 minutes.

Statistical Analyses

SPSS V22 (SPSS Inc, Chicago, IL, USA) was used for the statistical analysis. Brown & Forsythe's and Shapiro-Wilk tests were utilized to verify normality assumptions. A dependent t-test was utilised to compare VO2max, anthropometric and lower body strength measurements at the end of the competitive period and following the transition period. Cohen's *d* was calculated to determine the effect size. Means and standard deviations were reported for all the parameters. The level of significance was set at $p<0.01$.

Results

The body composition results can be found on table 1. The body composition measurements revealed that body weight increased from 58.3± 6.5 to 59.4±5.8 ($d=0.2$, $p=0.001$) while body fat increased from 19.8±3.5 to 21.5±3.1 ($d=0.5$, $p=0.000$) after a 4-week transition period. Furthermore, the isokinetic testing revealed that the quadriceps torque was significantly reduced after the transition period while the hamstring torque remained unchanged (table 2). The concentric isokinetic values at 60°/sec for healthy active females were reported to range between 135.4 to 174.8 Nm and 67.7 to 85.8 Nm for quadriceps and hamstring muscles respectively [16]. The right quadriceps torque production at 60

°/s was reduced from 137.6± 25 to 130.4± 20.4 (d=0.3, p=0.013) while for the left quadriceps torque production was reduced from 140.5± 27.4 to 134.2± 28.5 (d=0.2, p=0.004). The concentric hamstring torques that were exhibited by the female soccer players were above the normal values before as well as after the transition period. The cardiopulmonary testing on the treadmill revealed that the VO2max values were significantly lower following the transition period (table 3). In addition to the significant reduction in VO2max (d=0.5, p=0.001) values the total time on the treadmill was significantly reduced (d=0.65, P=0.000) (table 3). It should be noted that all the effect sizes for the tests with significant differences ranged from 0.2 (small effect) to 0.6 (medium effect).

Discussion

The primary purpose of this study was to determine the effect of a 4-week transition period on body weight, body fat, VO2max and lower body strength in elite female players who participate in the UEFA women's Champions league. The results of our study revealed significant increases in body weight and body fat which are in agreement with several studies [6, 7, 8]. Researchers [6] demonstrated that a 6-week detraining period resulted in a rapid loss of the optimal body composition status even though players followed a low intensity aerobic training during that period. A similar study,[8] indicated that despite the fact that the transition period may result in negative changes in body composition, these changes are smaller (less body weight and body fat gain) for the players who follow a training regimen compared to those who do not. The increases in body weight and body fat during the detraining period may have a significant negative effect on sprint performance [17]. Body weight and body fat are essential components of fitness for soccer, as excessive adipose tissue acts as dead weight, especially in sports in which the body mass needs to be lifted several times against gravity [18].

The detraining effects in our study are extended to lower body strength parameters. At the end of the competitive period, the quadriceps torque measurements exhibited by the female soccer players were within normal ranges [16], while after the transition period, they fell below normal values. In a review of 27 studies, mean decreases of 14.5% and 0.4% were identified in strength and power across mean detraining periods of 7.2 ± 5.8 and 7.6 ± 5.1 weeks, respectively [27]. Furthermore, it was demonstrated that strength levels can be maintained for up to 3 weeks of detraining, but decay rates will rise thereafter (between 5-16 weeks) [27]. In another study (2013)[26], force production was found to decline slowly with a parallel decrease in EMG activity. In the same study, it was concluded that strength performance in general can be maintained for up to 4 weeks of inactivity, while eccentric force, sport-specific power and recently acquired isokinetic strength may significantly decline in highly trained athletes.

Strength in the lower limbs is vital in soccer, as players must generate high forces for kicking, tackling, turning and jumping[18]. Several investigators reported a significant relationship between leg strength and kick performance in male soccer players [19, 20], in addition to the high correlation between peak muscle torque and angular velocity in female soccer players [21]. While having a high lower body strength alone does not necessarily result in successful soccer performance, a reduced lower body strength and improper balance between hamstrings and quadriceps strength may increase the risk of injury in soccer [22].

The effect of detraining is also extended to parameters related to endurance. The cardiopulmonary testing in our study revealed that the VO2max values were significantly lower following the transition period. In addition to the reduction in VO2max values, the total time on the treadmill was significantly reduced. These reductions may compromise performance during the pre-season training phase. As indicated, the nature in which the players enter a season can have a significant effect on their performance throughout the season [13]. Furthermore, it has been demonstrated that recently acquired VO2max gains are completely lost after 4 weeks of insufficient training stimulus [23]. These changes are associated with reductions in stroke volume, maximal cardiac output, cardiac dimensions and ventilatory efficiency [24]. Research indicated that the VO2max of semi-professional football players was found to be significantly reduced after 8 weeks of detraining [17]. Furthermore, VO_2 at anaerobic threshold was reported to be significantly higher at mid-season, with pre-season values being the lowest [25].

From a metabolic perspective, several studies have shown significant changes in oxidative enzymes as a result of detraining. Researchers indicated that the improvements observed on VO2max and glycolytic enzymes as a result of a 10-week training were reversed after 7 weeks of detraining [26]. Similar results were presented in a different study (1987) [27] that reported a reduction in glycolytic enzymes after 7 weeks of detraining. A more recent study [28] indicated that even a short period of detraining can reverse training-induced angiogenic remodelling in the plantaris and soleus muscles of rats. These changes in oxidative activity as well as the shifting of muscle fibre type could increase fatigue during the demanding pre-season training period. On the contrary, it has been suggested that a short period of tapering (about 2 weeks) where the training volume is reduced by 41-60% is an optimal strategy to maximise performance gains [29].

Practical Applications

Considering that maximising performance is the most important goal for coaches and athletes, there seems to be a need for the development of strictly controlled training programs during the off-season period for the female soccer players. Replacing complete rest or gym based programs with a marked reduction in the training load (tapering) when the off-season is longer than 4 weeks should also be considered. Furthermore, the injury prevention program proposed by the Fédération Internationale de Football Association (FIFA) [30, 31] may be utilised as a detraining prevention program. Future research should focus on testing the players throughout the year while keeping records of their training load as well as energy and macronutrient intake in order for the results to be more robust.

Conclusion

This is the first study to examine the effects of a 4-week transition period on performance parameters in professional female soccer players. It is concluded that despite the 2 times/week gym training program that the players followed, body fat and body weight increased.. Furthermore, quadriceps torque production was negatively affected, while hamstring torques remained the same as after the competitive period. Finally, VO2max and running time on the treadmill were also negatively affected after the significantly reduced training volume.

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