

Aerobic and anaerobic capacity of professional soccer players in annual macrocycle

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Abstract

The aim of the study was to examine aerobic and anaerobic capacity changes of Greek professional soccer players in the beginning of the preparation (T1) and the competitive period (T2) as well as in the end of the first (T3) and the second round (T4). Twenty four male players aged 24.3 ± 4.3 years old participated in the study. The researchers examined anthropometric characteristics, aerobic and anaerobic capacity. Analysis of variance at the level .05 showed that VO₂max value significantly changed from T2 ($57.16 \pm 3.17 \text{ ml.kg}^{-1}.\text{min}^{-1}$) to T1 ($55.56 \pm 3.81 \text{ ml.kg}^{-1}.\text{min}^{-1}$) and T4 ($56.07 \pm 2.84 \text{ ml.kg}^{-1}.\text{min}^{-1}$) and from T3 ($57.96 \pm 2.8 \text{ ml.kg}^{-1}.\text{min}^{-1}$) to T1 ($55.56 \pm 3.81 \text{ ml.kg}^{-1}.\text{min}^{-1}$). Regarding 35m repeated sprints the results showed that they were significantly improved in T4 ($4.67 \pm 0.15 \text{ sec}$). The highest speed drop was observed in T1 ($13.2 \pm 3.44\%$) and the lowest speed drop was observed in T2 ($8.35 \pm 2.81\%$) compared to T3 and T4. The study suggests that coaches have to develop appropriate training programs so as to achieve the highest speed with the lowest percentage drop at crucial moments during the annual macrocycle. The ideal balance in aerobic and anaerobic workout is a crucial training component for higher performance.

Keywords: anaerobic capacity, aerobic capacity, annual macrocycle, soccer.

Introduction

Soccer is a demanding sport the performance of which is determined by physical, techno-tactical, psychological, and social parameters. Aerobic capacity is also a crucial factor for soccer success (Eklblom, 1986). Physiological requirements of the game demand a high aerobic and anaerobic capacity, muscle strength, speed, power, skills, coordination and flexibility for the improvement of performance and the injury prevention (Reilly, Howe & Hanchard, 2003). Intensities of the game are also extremely high. Average heart rates have been found to be around 85% of maximal values, and peak heart rates have been close to maximal (Bangsbo, Iaiia, & Krustup, 2007). Furthermore, midfielders cover about 10-12 km with a mean intensity 80-90% of heart rate max and 70-80% of VO₂max rates close to the anaerobic threshold (Casajus, 2001; Eklblom, 1986; Helgerud, Engen, Wisloff, & Hoff, 2001; Hoff, Wisloff, Engen, Kemi, & Helgerud, 2002).

During an elite soccer game players perform about 1000-1400 repeated movement actions (Bangsbo, 1993; Mohr, Krustup, & Bangsbo, 2003) with speed and pace changes and several changes of physical demands (Bangsbo & Krustup, 2008). Soccer players walk about 18-27 min (20-30% of game duration), run on a very low intensity for about 13-23 min (15-25% of game duration), run on a moderate intensity for about 9-13 min (10-15% of game duration), run on a high intensity for about 4-7 min (4-8% of game duration), walking backwards for about 8-12 km (Reilly & Doran, 2001). Aerobic capacity is an important factor that affects the final league ranking, the quality of the game and the covered distances (Hoff, 2005; Impellizzeri, Rampinini, & Marcora, 2005). Furthermore, it may improve performance indicators such as the time spent in high intensity, sprint number, and ball touches during a game. Researchers conclude that high aerobic capacity also improves the recovering of high intensity interval training that alternates with lower intensities during the game (Bangsbo, 1993; Svensson & Drust, 2005). Although aerobic metabolism is highlighted, the most decisive actions such as short distance sprints, jumps, tackling and duals are very crucial for the final result of a game. These 150-250 short but intense actions during a game show that anaerobic capacity plays a crucial role for the final performance (Bangsbo et al., 2007). It is obvious that the quality of high intensity actions develop elite professional players. Specifically, international players significantly differ from professional players as they cover about 28% in high intensity running (2.43 km vs 1.90 km) and 58% more sprints (650 m vs 410 m). Sprints constitute 1-11% of the total covered distance, corresponding to 0.5-3% of the actual play time. During game players perform a sprint every 90 sec that usually lasts for 2-4 sec. Moreover, it has been found that 30 m

sprints demand longer recovering period than the usual 10 to 15 m sprints. Thus, sprint resistance and anaerobic capacity are very important indicators of performance. Players are required to cope with these physical demands with the highest physical condition during the whole competitive season (Aziz, Newton, Tan, & Teh, 2006). Therefore continuous assessment, information and feedback regarding physical condition play a crucial role in the success of any team.

It is also known that anthropometric characteristics and body composition have a significant effect on performance (Bangsbo, 1993; Reilly, 2003; Reilly, Bangsbo, & Franks, 2000; Shephard 1999; Stølen, Chamari, Castagna, & Wisløff, 2005). Because all these parameters change throughout the annual macrocycle many studies examined their changes during a whole competitive period (Mukherjee & Chia, 2010; Ostojic, 2003). In addition, because soccer performance is related with speed resistance the researchers also focused in changes of aerobic capacity throughout a whole competitive period (Aziz, Tan, Teh, & Council, 2005; Caldwell & Peters, 2009; McMillan et al., 2005; Metaxas, Sendelides, Koutlianos, & Mandroukas, 2006; Mohr, Krstrup, & Bangsbo, 2003; Kalapotharakos, Ziogas, & Tokmakidis, 2011; Ostojic, 2003; Śliwowski et al., 2011).

However there was a research gap regarding the combination of aerobic and anaerobic capacity during a whole competitive period so as to reveal the interaction of these parameters. Therefore, the aim of this research was to examine the aerobic and anaerobic capacity of Greek professional footballers at selected periods during the annual training macrocycle.

Material and Methods

Participants

Twenty four Greek soccer players aged 24.3 ± 4.3 years old, with 180.3 ± 3.8 cm height, and 77.4 ± 6.1 kg weight participated in the current study. They played for teams which participated in Greek Super League the season 2013-2014. They were informed about the procedures, the risks and the benefits of the study before signing a consent form approved by the University Ethics Committee. The variables examined in the beginning of the preparation period (July-T1) and the competitive period (September-T2) as well as in the end of the first (December -T3) and the second round (May-T4) of competitive period.

Measurements

Anthropometric variables

The researchers used a weighing scale (Seca 710, U.K.) and a height cursor (Seca Leicester, U.K.) to measure the weight and height of the participants. The body weight was calculated to the nearest 0.01 kg while the participant could only wear shorts and a t-shirt. For the measurement of height the participants had to take off their shoes and take a full inhalation. The body fat percentage was measured by Harpenden skinfold caliper (Harpenden, U.K.). Specifically, four skinfolds were placed on the right side of each participant (biceps, triceps, subscapularis and iliacus muscle). The calculation of body fat percentage was done according to the equations of Durnin and Womersley (1974).

VO₂max

The participants began their trial on treadmill with a progressively increasing intensity from a speed close to 65% of their heart rate max (Technogym runrace 1200, Italy). Every five trials the researchers calibrated the speed on the treadmill by measuring time of 30 rotations of the belt so as to calculate the speed and compare the indications of instruments. The slope of the treadmill throughout the test was maintained zero as the speed was increased every minute for 0.5 km/h until the participants could not follow the ramp belt speed.

RAST Test (anaerobic field test)

The researchers measured the maximal speed of the players applied RAST test (Running Based Anaerobic Sprint Test). The test includes six maximal speed repeats of 35 m and break 10 sec between the repeats. It also gives information for maximum, moderate and minimum power as well as the fatigue. Before the assessment of speed the researchers recorded the weight of the players and then they started a 10 min warming up. The participants started their trials by the order 'go' while the 35 m distance was marked with cones. The opposite side was used for the following trial after every 10 seconds. It has been reported that the RAST-obtained anaerobic performance is significantly correlated to the Wingate test (Zacharogiannis, Paradisis, & Tziortzis, 2004; Zagatto, Beck, & Gobatto, 2009)

Statistical analysis

SPSS package 17.0 was used for the statistical analyses of the data. Analyses of variance (ANOVA) conducted for the assessment of significant statistical differences between groups with different means. The level of statistical significance was set at $p < .05$.

Results

Weight (Figure 1)

Players did not indicate any significant difference regarding their mean weight from T1 to T4 ($p > .05$). Specifically their mean weight was $77.44 \text{ kg} \pm 6.13$ (T1), $76.48 \text{ kg} \pm 6.02$ (T2), $76.38 \text{ kg} \pm 5.69$ (T3), and $76.41 \text{ kg} \pm 5.69$ (T4).

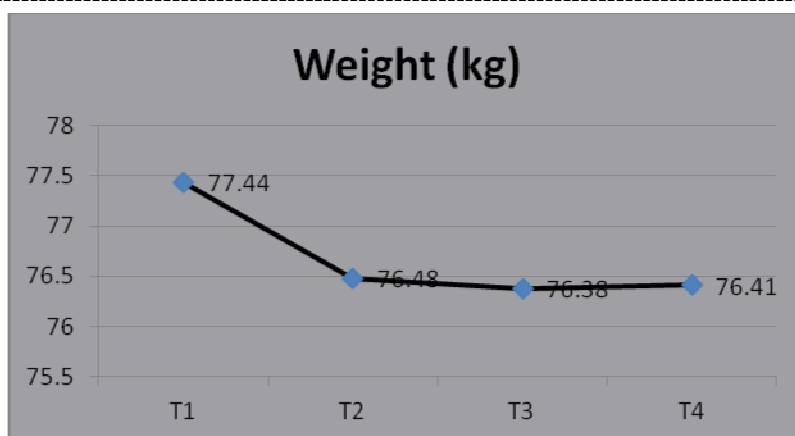


Figure 1: Players' weight during measurement periods

Body fat (Figure 2)

Body fat significantly changed between the measurements ($p < .05$). Specifically, body fat of T1 (10.33 ± 1.59) significantly changed compared to T2 (9.61 ± 1.67), T3 (9.32 ± 1.69) and T4 (9.41 ± 1.61) body fat.

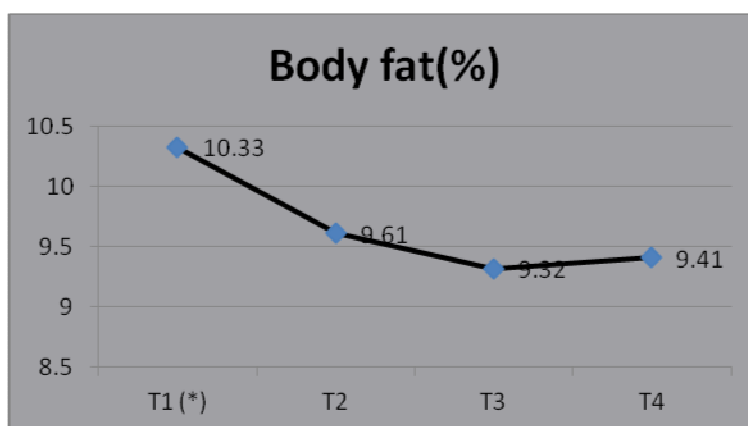


Figure 2: Players' body fat during measurement periods

* Significant difference between T1 and the measurements of T2, T3, and T4

VO2max (Figure 3)

The mean values of VO2max of T2 (57.16 ± 3.17) significantly differed ($p < .05$) from the VO2max of T1 (55.56 ± 3.81) and T4 (56.07 ± 2.84). VO2max of T3 (57.96 ± 2.8) also significantly differed ($p < .05$) from the VO2max of T1 (55.56 ± 3.81).

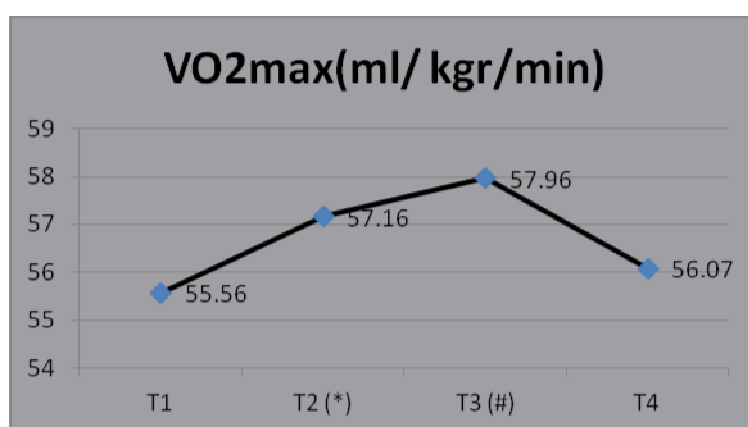


Figure 3: Players' VO2max during measurement periods

* Significant difference between T2 and T1 as well as between T2 and T4; # significant difference between T3 and T1

RAST TEST (Figure 4)

The mean values of 35 m speed which determined the anaerobic capacity significantly improved ($p < .05$) from T1 (4.73 ± 0.159 sec) to T4 (4.67 ± 0.151 sec); from T2 (4.77 ± 0.162 sec) to T4 (4.67 ± 0.151 sec); and from T3 (4.77 ± 0.156 sec) to T4 (4.67 ± 0.151 sec).

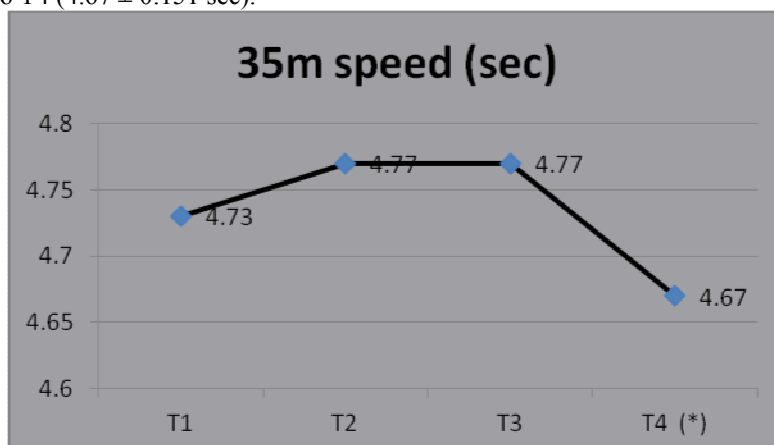


Figure 4: Players' 35 m speed during measurement periods

* Significant 35 m speed difference between T4 and the measurements of T1, T2, and T3.

Speed drop rate in the RAST test (Figure 5)

The mean values of speed drop rate were $13.2 \pm 3.44\%$, $8.35 \pm 2.81\%$, $9.6 \pm 2.94\%$ and $11.7 \pm 2.68\%$ for the measurements of T1, T2, T3 and T4 respectively. The speed drop rate was significantly higher in T1 than T2, T3 and T4 measurements ($p < .05$). Furthermore, the speed drop rate was significantly lower in T2 than T3 and T4 measurements ($p < .05$).

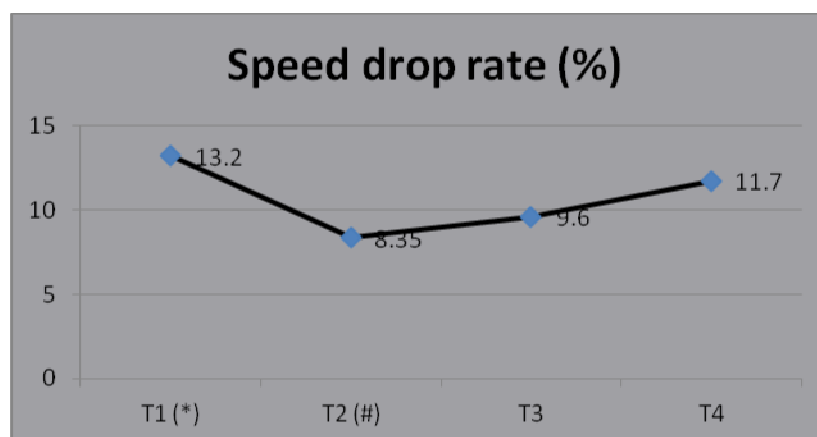


Figure 5: Players' speed drop rate during measurement periods.

* Significant speed drop rate difference between T1 and the measurements of T2, T3 and T4. # Significant speed drop rate difference between T2 and the measurements of T3 and T4.

Discussion

Anthropometric characteristics

The results of the current study did not show any significant difference between the measurements concerning the weight of the players. The findings confirm past results of Reilly & Thomas (1979) as well as Heller and colleagues (1992) who examined professional soccer players (Heller, Prochazka, Bunc, Dlouha, & Novotny, 1992). Specifically the current study showed that players' weight in the beginning of the preparation was 77.4 kg that was similar to past research (Casajus, 2001; Dellal et al., 2008; Hazir, 2010; Kalapotharakos, Strimpakos, Vithoulka, & Karvounidis, 2006; Metaxas, Sendelides, Koutlianos, & Mandroukas, 2006; Raven, Gettman, Pollock, & Cooper, 1976). As far as body fat percentage it has been found that high values cause a negative effect at sport performance (Meir, Newton, Curtis, Fardell, & Butler, 2001).

Reilly (1996) found that soccer players concentrate higher body fat during the transitional period which they lose during the preparation period. The current study confirmed this finding as players reduced their body fat after the preparation period (from 10.33% of T1 to 9.6% of T2). This reduction in the beginning of the competitive period is related to the positive changes in body composition that occurred by the high intensity training and the increased strength training of the preparation period (Mukhevjee & Chia, 2010). Similarly, other studies concluded that body fat percentage was significantly lower in the end of the competitive period (Ostojic, 2003).

Aerobic capacity

The current study showed a significant improvement of VO₂max in the end of the preparation period compared to the beginning of the preparation period (from 55.56 ml.kg⁻¹.min⁻¹ to 57.16 ml.kg⁻¹.min⁻¹) finding that confirmed past studies (Aziz, Newton, Tan, & Teh, 2006; Kalapotharakos, Ziogas, & Tokmakidis, 2011; McMillan et al., 2005; Metaxas, Sendelides, Koutlianos, & Mandroukas, 2006; Śliwowski et al., 2011). This finding is probably occurred by the abstinence from training during the transitional period (McMillan et al., 2005) and the oriented aerobic condition training of preparation period (Reilly & Thomas, 1979). Furthermore, VO₂max significantly reduced in the end of the competitive period finding that VO₂max and colleagues (2002) support (Mohr, Krstrup, & Bangsbo, 2002). In contrast, other studies suggest that VO₂max increased during the whole competitive period (Edwards, Clark, & Macfadyen, 2003). However they do not explain how this improvement is related to high performance in repeated sprints (quality and quantity of maximal speed during games) that determine the outcome of the game.

Anaerobic capacity

The mean speed significantly improved in the end of the competitive period whereas it remained stable before and after preparation period as well as in the middle of the competitive period. In contrast, Sienkiewicz and colleagues (2009) concluded that both mean and maximal speed significantly improved in the end of the preparation period compared to the beginning (Sienkiewicz-Dianzena, , Rusin, , & Stupnicki, 2009). It is probably explained by the different training programs that trainers applied in the preparation period. Although speed ability increased in the end of the competitive period, VO₂max was significantly reduced. This finding means that physiological mechanisms which determine speed and VO₂max are different (Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004). In our view the influence of speed and game activity on muscle enzyme activity and muscle coordination as well as the possible conversion of type IIA (fast twitch oxidative glycolytic) to type IIX (fast twitch glycolytic) muscle fibers because of the reduction of aerobic training in the end of the competitive period might explain this speed increase in the last measurement. Thus the ideal balance in aerobic and anaerobic workout is probably a crucial training component for higher performance. Furthermore the smallest percentage drop in speed was observed after the end of preparation, although it did not indicate the highest values. Probably this is due to the higher priority given to the improvement of aerobic capacity and the low priority of speed training. The findings of the current study agree to Ostojic's (2003) findings which suggest that Yugoslavian professional soccer players who participate in 1st division league achieved better 50 m speed time in the end of the competitive period. Similarly, semi-professional soccer players of 3rd division NCAA achieved better 10 m, 20 m, and 30 m speed time in the end of the competitive period (Magal, Smith, Dyer, & Hoffman, 2009). Even if the players perform high speed in the beginning of the competitive period, it might be improved as a result of the training and the games (Kraemer et al., 2004). A study applied to professional players of 1st division Singapore soccer league showed exactly the same results. They achieved better 20 m speed time in the end of the competitive period that probably occurred as a result of the training program which included repeated sprints of high intensity during the competitive period (Aziz, Newton, Tan, & Teh, 2006). Wisloff and colleagues (2004) suggest that a possible factor of this improvement is the higher performance of the explosive power of the legs the same measurement period. Furthermore, it is possible that the reduction of body fat in the competitive period positively affected the VO₂max and the speed time. It's already known that body fat is positively related to better performance in 5 m and 20 m speed (Aziz, Newton, Tan, & Teh, 2006) as well as in 50 m speed (Ostojic, 2003). In contrast Caldwell and Peters (2009) concluded that semiprofessional soccer players revealed worse 15 m speed in the middle of the competitive period compared to the beginning.

Conclusions

The current study highlights the problem of proper balance in the aerobic and anaerobic capacity training aimed to achieve the highest performance in annual training macrocycle. Trainers have to provide the appropriate training stimuli so as to maintain high the sprint endurance with the maximum speed throughout the whole season. Trainers have to take into consideration not only team stability and form, but also the participation of first team, substitution and reserve players. The current study suggests that trainers must measure physical skills of their players in combination with other variables (i.e. hematological, biochemical, psychological, and muscle damage indexes) so as to improve their feedback about how to peak players' performance during the competitive period.

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