BRIEF REVIEW

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High-Intensity Training in Football

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This article reviews the major physiological and performance effects of aerobic high-intensity and speed-endurance training in football, and provides insight on implementation of individual game-related physical training. Analysis and physiological measurements have revealed that modern football is highly energetically demanding, and the ability to perform repeated high-intensity work is of importance for the players. Furthermore, the most successful teams perform more high-intensity activities during a game when in possession of the ball. Hence, footballers need a high fitness level to cope with the physical demands of the game. Studies on football players have shown that 8 to 12 wk of aerobic high-intensity running training (>85% HR_{max}) leads to VO_{2max} enhancement (5% to 11%), increased running economy (3% to 7%), and lower blood lactate accumulation during submaximal exercise, as well as improvements in the yo-yo intermittent recovery (YYIR) test performance (13%). Similar adaptations are observed when performing aerobic high-intensity training with small-sided games. Speed-endurance training has a positive effect on football-specific endurance, as shown by the marked improvements in the YYIR test (22% to 28%) and the ability to perform repeated sprints (~2%). In conclusion, both aerobic and speed-endurance training can be used during the season to improve high-intensity intermittent exercise performance. The type and amount of training should be game related and specific to the technical, tactical, and physical demands imposed on each player.

Keywords: soccer, professional, performance, differences, intermittent exercise

A large number of studies have evaluated the physical demands of a football game and the effects of fitness training on football players.[1–6] This brief review focuses on aerobic high-intensity and speed-endurance training in football. First, the physiological requirements and energy demands of match play are discussed. Next, an overview of the effects of high-intensity training on physiological adaptations is presented followed by a discussion of these effects on footballers' performance. In the last section, we provide recommendations on how to use scientific information to implement individual game-related physical training.

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Physiological Requirements of Football Performance

Physical Demands in Football

Football is an intermittent sport characterized by ~1200 acyclical and unpredictable changes in activity (each every 3 to 5 s) involving, among others, 30 to 40 sprints,[1] more than 700 turns,[7] and 30 to 40 tackles and jumps.[1] In addition, the game requires other intense actions such as decelerations, kicking, dribbling, and tackling.[8] All these efforts exacerbate the physical strain imposed on the players and contribute to making football highly physiologically demanding.

Computerized time motion and semiautomatic video-based system analyses have revealed that top-class football players perform 2 to 3 km of high-intensity running (>15 km/h) and ~0.6 km of sprinting (>20 km/h).[1–3,9–11] Furthermore, these distances of running and sprinting are, respectively, 28% and 58% greater than those of moderate-level professional players.[1] In addition, the less successful teams exhibit greater decrements in the total sprint distance covered during the match,[1,3,11] suggesting that the ability to perform high-intensity activities throughout a game is very important.

Each playing position is characterized by its own activity profile and different tactical requirements in relation to the movement of the ball.[1,2] Central defenders cover less total distance and high-intensity running, while attackers complete more sprints and a greater portion of high-intensity activity when their own team is in possession of the ball than midfielders and defenders. For further and more-detailed information regarding the physical demands and match performance, the reader is referred to the following studies.[1–3,9–11]

During the second half of a match, the total distance and high-intensity running decline markedly,[1] with the amount of high-intensity running 20% to 40% lower in the last 15 min of the game compared with the initial 15-min period.[1,3,11] A greater decrement in running is observed when more activity is performed in the first half.[2] Furthermore, in the 5 min following the most demanding 5-min period of the game, the distance covered at high intensity is reduced by 6% to 12% compared with the game average.[1,3,11] Collectively, these results indicate that players experience fatigue toward the end of a match and temporarily during a game.[12] Accordingly, both single and repeated-sprint test performances are impaired after a high-intensity period during as well as at the end of the game.[13] Fatigue may also have a negative impact on passing precision,[14,15] with the less fit players showing a more pronounced deterioration in technical performance.[14] It appears that modern football is physically demanding and footballers need a high fitness level to cope with the energy demands of the game.

Energy Turnover in Football

To plan an appropriate training program, the energy requirements of the game must be understood. The physiological demands during a football match, when estimated by heart rate, correspond to ~70% of maximum oxygen uptake,[16] and suggest that the aerobic energy production is highly taxed and accounts for more than 90% of total energy consumption during a match.[8] Therefore, the capacity to perform intense exercise for prolonged periods of time should be specifically developed. This requirement can be accomplished by performing aerobic (high-intensity) training on regular basis. During a competitive match, a top-class player performs 150 to 250 intense actions,[1] reducing the concentration of muscle creatine phosphate, elevating levels of muscle lactate, and lowering muscle pH.[13] Thus, the anaerobic energy system is also heavily stimulated during many periods of the game. Therefore, it is important that players develop their ability to perform repeated maximal, or near maximal, efforts, which can be achieved through aerobic high intensity and speed-endurance training.

Physical Capacity of Top-Class Players

Top-class football players are characterized by moderate-to-high maximum oxygen uptake (VO_{2max}), that is 57 to 75 mL/kg/min.[17] However, due to the intermittent nature of the game, fitness-specific evaluations are more appropriate to accurately describe the physical capacity of the players. In this regard, performance in the yo-yo intermittent recovery (YYIR) test better reflects the ability to perform repeated intense exercise than VO_{2max} per se. Indeed, YYIR performance is well correlated with the amount of high-intensity running during a match.[18] In addition, YYIR tests provide more sensitive measures of changes in performance in sports of intermittent nature than VO_{2max}: performance in the YYIR test level 2 of Australian football players was 37% better than for the substitutes, whereas no differences were observed in VO_{2max} between starters and nonstarters.[19]

World-class players cover approximately 2400 m in the YYIR test level 1 and 1300 m in the YYIR test level 2,[20] which is 10% to 20% higher than moderate professional players.[20] Elite European top-league division players exhibit greater sprint and repeated sprint performances compared with amateur players.[21] For example, higher level players have both faster 6 × 40-m (20 + 20-m sprints with 180° turns separated by 20 s of passive recovery; professional 7.12 s vs. amateur 7.55 s) shuttle sprints, and single 20 + 20-m shuttle sprint (professional 6.88 s vs. amateur 7.08 s) performance than amateur players. The percent decrement during this repeated sprint test was smaller for top-class players compared with moderate professional and amateur players (3.3%, 5.1%, and 6.1%, respectively).

Physiological Adaptation to High-Intensity Training

Based on the contribution of the predominant energy system, high-intensity exercises can be divided into aerobic high-intensity and anaerobic (speed and speed-endurance) training, which represents the intensities below, close to, and above VO_{2max}, respectively.[22] This section provides an overview of the major physiological adaptations that occur in response to aerobic high-intensity and speed-endurance training and their relevance for football.

Aerobic high-intensity training elicits increases in cardiovascular parameters such as heart size,[23] blood flow capacity,[24] and artery distensibility.[25] These changes improve the capacity of the cardiovascular system to transport oxygen, resulting in faster muscle and pulmonary VO_2 kinetics[26,27] and higher VO_{2max}.[4,5,28] Thus, a greater amount of energy can be supplied aerobically, allowing a player to both sustain intense exercise for longer durations and also recover more rapidly between high-intensity phases of the game.

Anaerobic training involving speed-endurance drills increases the activity of some anaerobic enzymes, such as creatine kinase, phosphofructokinase, myokinase, and glycogen phosphorylase.[29] A higher rate of anaerobic energy turnover may improve the ability to produce power rapidly and continuously during short maximal bouts. A period of speed-endurance training increases the number of muscle membrane transport proteins involved in pH regulation, such as Na^+/H^+ exchanger isoform 1 (NHE1) and monocarboxylate transporters (MCT1 and MCT4),[30] and in some cases enhances muscle buffering capacity.[31] These changes may reduce the inhibitory effects of H^+ within the muscle cell and form part of the explanation for the improved performance during repeated intense exercises that are observed after a period of speed-endurance training. Anaerobic training also increases the expression of the Na^+,K^+ transport pump,[30,32] which, by reducing the contraction-induced net loss of K^+ from the working muscles, preserves the cell excitability and force development. This sequence of events should improve a player's ability to sustain very intense exercise for longer durations and perform high-intensity efforts more frequently during the game.

A large number of other muscular adaptations also occur with high-intensity training. For example, both aerobic high-intensity and speed-endurance training up-regulate several mitochondrial oxidative proteins and increase the muscle glycogen content[29]—the most important substrate for energy production in football.[16] The overall effect is pronounced changes in muscle metabolism with an increased fat oxidative capacity and reduced glycogenolysis, carbohydrate oxidation, and energy expenditure at a given exercise intensity.[29,33] These adaptations may be beneficial in football, where an improved capacity to use muscle triglycerides, blood free fatty acids, and glucose as substrates for oxidative metabolism could spare the limited muscle glycogen stores, thus allowing a player to exercise at a higher intensity toward the end of the game.

Muscle capillarization is also enhanced in response to speed-endurance training.[34] An enriched capillary network may lead to a shorter diffusion distance between capillaries and muscle fibers, and a larger area available for diffusion. Collectively, the enhanced capillarization may favor the release of compounds from muscle interstitium and delay fatigue development during intense exercise. In support of this contention, a higher capillary density is associated with performance improvements in an approximately 3-min exhaustive bout,[34] and related to muscle force maintenance (during and in recovery period) from short-term intense exercise.[35]

Effect of High-Intensity Training on the Performance and Adaptations of Football Players

Numerous studies have examined the effect of high-intensity training on performance and adaptations of football players (Tables 1, 2, and 3). A general finding is that aerobic and, in some cases, speed-endurance training increase VO_{2max} as well as lower blood lactate accumulation and oxygen uptake during submaximal work. In addition, periods of aerobic high-intensity and speed-endurance training

Table 1 Effects of aerobic high-intensity running training on physiological adaptation and performance in football players

Study	Level	n	Exercise Mode	Protocol	Intensity	Duration	Period	Physiological Adaptation	Performance Changes
Ferrari Bravo et al (2008)	Subelite	13	Running training	4 × 4 min, 3 min rest, 2 × wk	90–95% HRmax	8 wk	In season	↑6.6% VO2max* ↑3.7% VO2 RCP*	↑12.5% Yo-yo IR1* ↔Repeated sprint ability; 10-m sprint; SJ height and power; CMJ height and power
Helgerud et al (2001)	Junior elite	9	Running training	4 × 4 min, 3 min rest, 2 × wk	90–95% HRmax	8 wk	Preseason	↑10.8% VO2max* ↑21.6% speed LT* ↑15.9% VO2 LT* ↑6.7% RE* ↔1RM 90° squat	↑20.0% Total distance during a match* ↑100.0% Number of sprints during a match* ↑24.1% Number of involvements with the ball during a match* ↔10-m and 40-m sprint; CMJ height; kicking velocity; long pass accuracy
Impellizzeri et al (2006)	Junior elite	15	Running training	4 × 4 min, 3 min rest, 2 × wk	90–95% HRmax	12 wk	4 wk preseason + 8 wk in season	↑8.3% VO2max* ↑8.9% speed LT* ↑12.9% VO2 LT* ↑2.8% RE*	↑6.4% Total distance during a match* ↑22.8% High-intensity activity during a match* ↑14.3% Time to complete soccer-specific circuit*

(continued)

Table 1 ***(continued)***

Study	Level	n	Exercise Mode	Protocol	Intensity	Duration	Period	Physiological Adaptation	Performance Changes
Sporis et al (2008a)	Elite	11	Running drill training	4 × 4 min, 3 min rest, 3 × wk	90–95% HRmax	8 wk	Preseason	↑14.1% La peak*	↑2.2% 300-yard shuttle run test*
Sporis et al (2008b)	Junior elite	24	Running drill training	3 × 20 m; 3 × 40 m; 3 × 60 m; 2 min rest; 55–65% HRmax; 3 × wk	90–95% HRmax	13 wk	Preseason + in season	↑5.2% VO2max*	↑6.0% 200-m test* ↑4.2% 400-m test* ↑7.9% 800-m test* ↑6.7% 1200-m test* ↑7.3% 2400-m test*

HRmax, maximum heart rate; VO2max, maximum oxygen uptake; RE, running economy; RCP, respiratory compensation point; LT, lactate threshold; yo-yo IR1, yo-yo intermittent recovery test level 1; yo-yo IR2, yo-yo intermittent recovery test level 2; SJ, squat jump, CMJ, countermovement squat jump; La, lactate.

*Significantly different.

Table 2 Effects of aerobic high-intensity training performed as small-sided games or soccer ball dribbling on physiological adaptation and performance in football players

Study	Level	n	Exercise Mode	Protocol	Intensity	Duration	Period	Physiological Adaptation	Performance Changes
Chamari et al (2005)	Junior elite	18	Soccer ball dribbling around a track and small-sided games	4 × 4 min, 3 min rest, 2 × wk	90–95% HRmax	8 wk	In season	↑7.5% VO2max* ↑10.0% RE*	↑9.6% Distance covered in 10-min continuous test around a specific track*
Hill-Haas et al (2009)	Junior elite	10	Small-sided games	3–6 × 6–13 min, 1–2 min rest, 2 × wk	>80% HRmax	7 wk	Preseason	↔VO2max	↑17.0% Yo-yo IR1* ↔Repeated sprint ability; 5-m and 20-m sprint
Impellizzeri et al (2006)	Junior elite	14	Small-sided games	4 × 4 min, 3 min rest, 2 × wk	90–95% HRmax	12 wk	4 wk preseason + 8 wk in season	↑7.1% VO2max* ↑9.7% speed LT* ↑10.8% VO2 LT* ↑2.7% RE*	↑4.2% Total distance during a match* ↑25.5% High-intensity activity during a match* ↑15.8% Time to complete soccer-specific circuit*
Jensen et al (2007)	Elite	16	Small-sided games	30 min (2–4 min, 1–2 min rest), 1 × wk	Not specified	12 wk	In season	↑5.2% VO2max*	↑15.2% Yo-yo IR2* ↑20.8% Repeated sprint ability fatigue index* ↔30-m sprint
McMillan et al (2005)	Junior elite	11	Soccer ball dribbling around a track	4 × 4 min, 3 min rest, 2 × wk	90–95% HRmax	10 wk	End of season	↑9.4% VO2max* ↔RE ↔RFD during CMJ and SJ	↔10-m sprint ↑6.9% SJ height* ↑2.7% CMJ height*

HRmax, maximum heart rate; VO2max, maximum oxygen uptake; RE, running economy; RCP, respiratory compensation point; RFD, rate of force development; LT, lactate threshold; yo-yo IR1, yo-yo intermittent recovery test level 1; yo-yo IR2, yo-yo intermittent recovery test level 2; SJ, squat jump, CMJ, countermovement squat jump; La, lactate.

*Significantly different.

Table 3 Effects of repeated sprint and speed-endurance training on physiological adaptation and performance in football players

Study	Level	n	Type of Training	Protocol	Intensity	Duration	Period	Physiological Adaptation	Performance Changes
Dupont et al (2004)	Professional	22	Speed endurance and repeated sprint	2 × (12–15 × 15 s, 15 s rest), 1 × wk; 12–15 × (40 m. 30 s rest), 1 × wk	120% max aerobic speed All out	10 wk	In season	—	↑8.1% Max aerobic speed* ↑3.5% 40-m sprint*
Ferrari Bravo et al (2008)	Subelite	13	Repeated sprint	3 × (6 × 40m, 20s rest) / 3 min rest, 2 × wk	All out	8 wk	In season	↑5.0% VO2max* ↑2.9% VO2 RCP*	↑28.1% Yo-yo IR1* ↑2.1% Repeated sprint ability* ↔10-m sprint; SJ height and power, CMJ height and power
Hill-Haas et al (2009)	Junior elite	9	Speed endurance training	18–20 × 30–60 s 60–90 s rest, 1 × wk; 7 × 34 m, 35 s rest, 2–10 × 5–90 s, 15–90 s rest, 1 × wk or 30–35 × 10–20 m, 10–40 s rest, 1 × wk	90–95% HRmax All-out All-out	7 wk	Pre season	↔VO2max	↑22.0% Yo-yo IR1* ↔Repeated sprint ability; 5-m and 20-m sprint

VO2max, maximum oxygen uptake; yo-yo IR1, yo-yo intermittent recovery test level 1; SJ, squat jump, CMJ, countermovement squat jump; La, lactate.

*Significantly different.

result in performance improvements (~10 to 15%) during match play and/or football-related tests, such as the yo-yo intermittent recovery test and a repeated-sprint test.[18,36–38]

Aerobic High-Intensity Training

Effect of Training Without the Ball. In a series of studies, soccer players undertook 8 to 12 wk of aerobic high-intensity training consisting of 4 × 4-min running intervals (at an exercise intensity corresponding to 90 to 95% of HR_{max}) separated by 3 min of active recovery (60% to 70% of HR_{max}) performed twice a week.[4,5,28,39–41] Although the magnitude of changes varied considerably between the interventions, this type of training was effective in improving VO_{2max} (7% to 11%) and running economy (3% to 7%), as well as lowering the blood lactate accumulation during submaximal running (Table 1). The time to complete a soccer-specific circuit[4,28] and the distance covered in the YYIR test level 1[5] improved by 14 and 13%, respectively. In agreement, Sporis et al[40] showed that 13 wk of short intense running bouts combined with technical drills increased VO_{2max} (+5.2%) and performance time over several distances (between 200 and 2400 m).

Match running performance was also examined in some of these studies. For example, Impellizzeri et al[4] reported an increased total distance (6.4%) and high-intensity running (22.8%) covered during a game after the first 4 wk of aerobic high-intensity training. However, caution must be taken when interpreting game data because a number of factors influence performance during match play.[2] Since most of these studies were conducted during the early preseason period,[4,28] it is difficult to determine the independent effects of the high-intensity training beyond the normal adaptations associated with early preseason training. Furthermore, no additional physiological and performance improvements were observed when the training was extended for another 8 wk during the competitive season.[4]

Effect of Training with the Ball. The effect of performing high-intensity training through football-specific exercises, such as small-sided games, has also been examined.[4,6,39,42,43] A number of studies have shown that it is possible to achieve an elevated exercise intensity using the ball as demonstrated by elevated heart rates, marked blood lactate accumulations, and high rate of perceived exertions.[44,45] The main physiological changes and performance improvements are presented in Table 2.

In three studies, football players performed two weekly sessions of aerobic high-intensity training consisting of 4 × 4 min at 90% to 95% HR_{max} for 8 to 10 wk with 3 min of recovery either using small-sided games or soccer dribbling around a specific track.[4,6,42] Significant improvements in VO_{2max} (7% to 9%)[4,6] and running economy (3% to 10%) were observed irrespectively of whether the training was performed before, during, or immediately after the competitive season. Specifically, Impellizzeri et al[4] compared the effect of training with (using small-sided games) and without the ball and reported that both exercise modes were equally effective in improving a number of physiological measures (eg, VO_{2max}, velocity at the lactate threshold, running economy) and physical performance during a game (eg, total distance covered and number of high-intensity activities; Tables 1 and 2). Although the improvements observed in physical performance during the match (eg, sprint and high-intensity running) were not different between general and specific training, it cannot be ruled out that differences may have existed. Unfortunately, only one game was examined before and after the training period and technical aspects of the match (eg, quality of passes, involvement with the ball, and time at high-intensity spent with ball possession) were not evaluated. Such technical indices can discriminate between the most and the least successful teams[9] and may have been more positively influenced by small-sided games training. It is possible that the overall effect of training with small-sided games is greater for football-specific performance. This idea is supported by the work of Hill-Haas et al.[39] In this study, after 7 wk of preseason preparation involving two 20- to 40-min weekly sessions of small-sided games, junior elite football players improved their YYIR test level 1 performance by 17% despite unaltered VO_{2max} values. The training time spent above 90% of HRmax was ~40% less than that reported by Impellizzeri et al.[4] However, this argument requires further scientific evidence.

Football players do not always have the time to perform high-intensity training sessions twice per week, especially during the competitive period. Jensen et al[43] examined the effect of one in-season 30-min aerobic high-intensity training session and observed 15% improvements in the YYIR level 2 (from 850 to 950 m) and a 21% reduced decrement during a repeated sprint test after a 12-wk training intervention. Apparently, 30 min of aerobic high-intensity training performed once a week was sufficient to improve football-specific intermittent exercise performance in elite players during the competitive season. However, additional more-controlled studies are needed.

Speed-Endurance Training

Only a few studies have examined the effect of speed-endurance training on football players during the competitive season.[5,46] Dupont et al[46] demonstrated that 10 wk of training with short running bouts performed at high-intensity (between 120% of the maximal aerobic speed and maximal speed) were effective in improving maximal aerobic speed during a continuous incremental test. Ferrari Bravo et al[5] compared the effect of two sessions per week of repeated sprint training (three sets of six 40-m maximal shuttle sprints with 20 s of rest between sprints and 4 min between sets) versus aerobic high-intensity running training (4×4 min at 90% to 95% HR_{max}, 3 min of recovery) on YYIR and repeated-sprint performance. After the 8-wk training period, despite similar increases in VO_{2max} (~6%) and VO_2 at the respiratory compensation point (~6%), only the players who performed speed-endurance training improved the repeated-sprint ability (2%; Figure 1A). In addition, the speed-endurance training group had a significantly greater improvement in the YYIR test level 1 compared with the group performing aerobic high-intensity training (28.1% vs. 12.5%, respectively; Figure 1B). The latter finding is similar to the 22% YYIR test level 1 improvement observed after 7 wk of intense repeated sprint training during the preparation phase.[39] Thus, speed-endurance training has a positive effect on high-intensity intermittent exercise performance and elicits greater improvement in football-specific endurance. This outcome may be explained by the fact that this type of training taxes and induces adaptations in both aerobic and anaerobic metabolic pathways.[30,33,47] However,

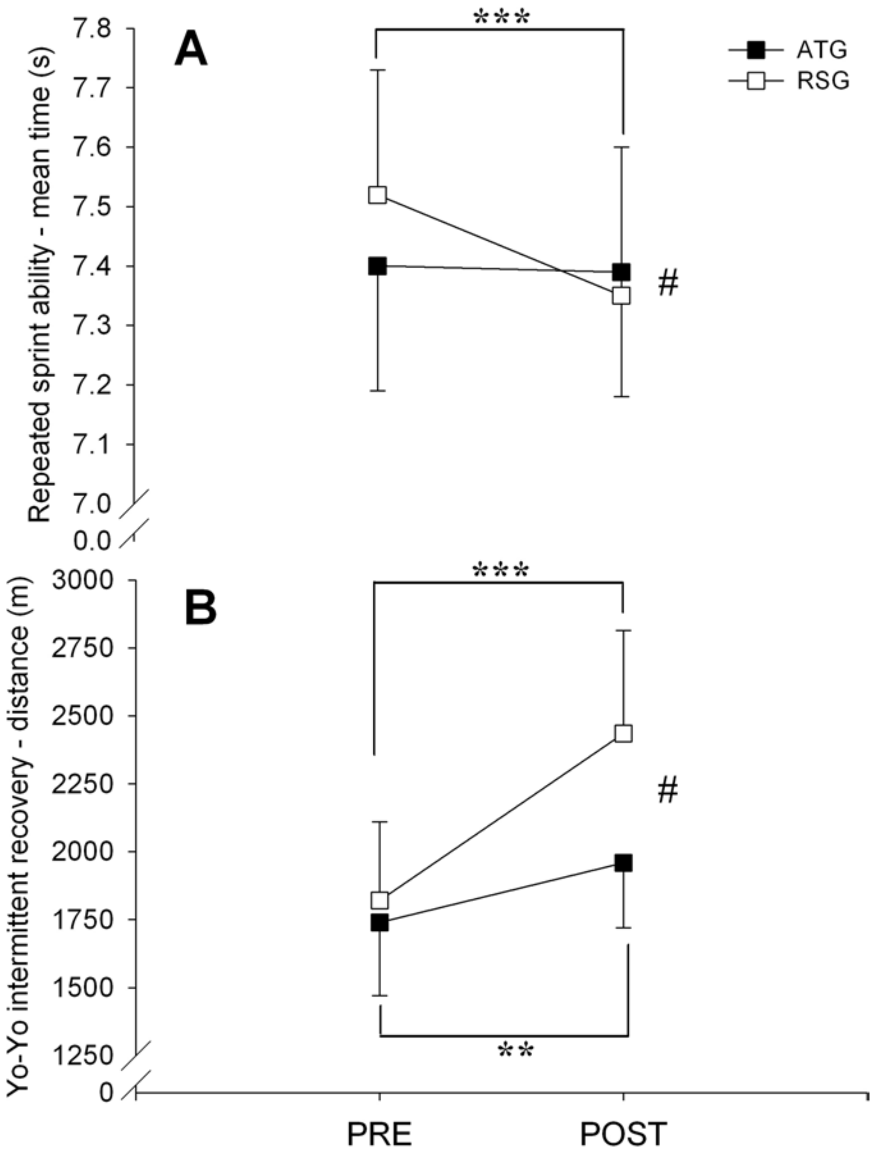

Figure 1 — Changes in the repeated-sprint ability test (panel A) and yo-yo intermittent recovery test level 1 (panel B) for aerobic running high-intensity training group (ATG) and repeated sprint training group (RSG) 5. $**P < .01$, $***P < .001$, $\#P < .01$; significant group $\times$ time interaction.

the effect of speed-endurance training on strength-related variables is less clear, with studies reporting either improved[46] or unchanged[5] single sprint and vertical jump performances.

Practical Applications

Aerobic high-intensity training has typically focused on enhancing VO_{2max}, utilizing training protocols that elicit high percentages of VO_{2max} that are sustainable for an extended period of time. However, the importance of VO_{2max} in football has been questioned.[20] Indeed, in a number of studies dealing with already trained individuals, improvements in specific performance tests were not associated with significant changes in VO_{2max}.[20,30,39] Nevertheless, even though useful in endurance events (eg, running, cycling), the limitations of performing continuous aerobic high-intensity training for football should be considered. Match analysis systems show that, during a game, players perform ~250 brief intense runs as well as many other demanding activities, including turning, tackling, jumping, kicking, and breaking.[1,7,8] Thus, both the characteristics and the intermittent nature of the game should be taken into account when designing training programs for football. As a consequence, we suggest that aerobic and speed-endurance training should be football related and preferably performed with the ball. There are several advantages associated with carrying out soccer-specific training compared with generic training activities. For example, the ability to change direction at high running speed is specifically related to the type of training performed.[48] Therefore, it is important that the training activities resemble those experienced during the game so that the groups of muscles engaged in football are trained, and the specific coordination abilities developed. This outcome can be achieved through small-sided games or football-related drills consisting of repeated exercise bouts involving changes of speed, direction, and specific movement patterns typical of those performed during match play.

The study by Ferrari Bravo et al[5] showed that a training protocol employing 4 × 4-min continuous running at 90% to 95% HR_{max} improved VO_{2max} but was less effective in enhancing football-specific performance (YYIR test) compared with repeated-sprint training. On the contrary, repeated sprint[5] and small-sided game training[39] were both very effective in improving YYIR performance. The physiological responses to continuous exercise are different from those to intermittent exercise, with the latter allowing higher prolonged metabolic stress with less marked fatigue. For example, the rise of the O_2 uptake is faster, the total utilization of O_2 bound to myoglobin is greater, and the fluctuations of muscle ATP and creatine phosphate are more pronounced when intense exercise is repeated.[49] In addition, substrate utilization and fiber type recruitment are different, with intermittent exercise activating both slow and fast twitch fibers, which would have been recruited only after prolonged submaximal continuous exercise.[49] These aspects are particularly relevant for team sports in which the ability to perform high-intensity intermittent exercise is essential.

Another advantage of performing specific high-intensity training in football is that the coordination, technical, and tactical skills are trained under fatiguing conditions closer to match play. For example, a study from the Italian *Serie A* league reported that players of the most successful teams cover a greater total distance (18%), including a higher proportion of high-intensity (16%) running in possession of the ball compared with players of less successful teams.[9] Thus, the players' ability to exercise at high-intensity when interacting with the ball may be an important determinant for success. In addition, studies have shown that forwards often receive the ball while sprinting or turning[50] and cover ~64% of their high-intensity running distance with ball possession.[2] Furthermore, the players' involvement with the ball, short passes, and successful short passes decrease between the first and the second half as well as after periods of very high-intensity exercise during matches.[9,14] These findings highlight the importance of increasing the players' contact with the ball during high-intensity training sessions. Technical and tactical training should be performed under conditions that replicate the physical demands of a competitive game.

When carrying out fitness training with the ball, it is fundamental to make sure that players are exercising at the desired intensity. Exercise intensity can be manipulated during small-sided games via modification of variables such as field dimension, number of players, the coach's verbal encouragement, and specific rules.[22] Rampinini et al[44] have shown that different combinations of these factors may lead to a variety of intensities resulting in ranges from ~84% of maximal heart rate (blood lactate concentration of ~3.4 mmol/L) during a six-a-side game on small pitch without coach encouragement, to ~91% of maximal heart rate (blood lactate concentration of ~6.5 mmol/L) during a three-a-side game on a larger pitch with coach encouragement. All this information suggests that small-sided games represent a valid aerobic training stimulus.

In modern football, players may be required to play up to ~50 games over a season, and it is important to maximize the limited time available for training. Under these circumstances, the match analysis data could be useful for examining the physical demands of match play and then designing specific game-related training drills based on the players' needs (ie, technical, tactical, and physical). For example, central defenders cover less total distance and perform less high-intensity running than players in other positions.[1–3,11] In contrast, the decline in high-intensity running with ball possession is greater for attackers and external midfielders,[11] most likely as a result of their increased high-intensity exercise and shorter recovery periods between intense bouts.[3] Furthermore, central midfielders complete a higher percentage of explosive sprints whereas attackers and full-backs perform more leading sprints.[11] Finally, although each tactical role is characterized by a typical activity profile, large individual variations in work profile are evident within the same playing position.[1] Thus, it is important that the type and the amount of high-intensity football training are specific to the competitive demands of match play.

Conclusions

High-level football is characterized by a high number of high-intensity exercise bouts. It is fundamental that players develop the ability to repeatedly perform intense exercise for long periods. This outcome can be achieved by conducting frequent sessions of aerobic high-intensity and speed-endurance training specific to the physical, movement, technical, and tactical demands of the game.

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