

Original Article

Comparison of two physical conditioning programs in improving aerobic endurance in moderately trained youth amateur soccer players during the preparation period

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Abstract:

Problem Statement: There are conflicting data regarding the optimal method in improving aerobic endurance in young soccer players **Approach:** A training intervention in moderately trained youth amateur soccer players. **Purpose:** To examine the effectiveness of two different physical conditioning programs in improving maximal oxygen uptake in moderately trained youth amateur soccer players. The first program was a traditional aerobic endurance training method (i.e involving mainly running), while the second program combined 50% of traditional aerobic endurance training with 50% of soccer specific aerobic training (i.e involving mainly training with the ball). Eighteen moderately trained youth soccer players from the same amateur were recruited and their maximal oxygen uptake was assessed using the 20-m shuttle run test. Subsequently players were randomly assigned into a control group (traditional aerobic training) and an experimental group (combined traditional aerobic training plus soccer specific aerobic training). Results were analyzed using two way analysis of variance with repeated measures on one factor (time). **Results:** Both training interventions were successful in improving maximal oxygen uptake ($p < 0.001$). However, there was no difference in maximal oxygen uptake between the two groups after the intervention. **Conclusions:** In conclusion, the present study demonstrated that a combined physical conditioning program is as effective as a traditional physical conditioning program in improving maximal oxygen uptake training in moderately trained youth soccer players during the preparation period, despite having approximately 50% less running volume.

Key words: small-sided games, ball possession games, preparatory season, extensive method, interval method, game form method

Introduction

Aerobic endurance is a critical performance attribute in modern soccer since it has been demonstrated that higher caliber teams have superior aerobic endurance characteristics compared to lower levels teams (Hoff & Helgerud, 2004; Wisløff, Helgerud, & Hoff, 1998). The gold standard in assessing aerobic endurance is maximal oxygen uptake (VO₂max) and it has been proposed that a higher VO₂max results in superior recovery of power output across repeated bouts of intense intermittent exercise (Tomlin & Wenger, 2001). Soccer involves periods of low intensity aerobic exercise interspersed with bouts of high intensity actions involving sprinting, jumping, tackling, accelerating, decelerating and changing of direction (Stolen, Chamari, Castagna, & Wisloff, 2005). Therefore, it has been postulated that high levels of VO₂max are beneficial in soccer because help to sustain a high work rate and assist in the recovery between the bouts of high-intensity actions (Stolen et al., 2005). In support of this it was previously shown that a preseason physical conditioning program involving high intensity running increased VO₂max by 11% in youth soccer players during the preparation period and resulted in 20% more distance covered in a match, 23% more time in possession of the ball, and a large increase (100%) in the number of sprints performed (Helgerud, Engen, Wisloff, & Hoff, 2001).

Consequently it appears that improving VO₂max during the preseason period is important in improving soccer performance. However, most of the physical conditioning programs aiming at improving maximal oxygen uptake in soccer players involved mainly traditional endurance training programs, that is running-based programs with minimum changes of direction and without involvement with the ball (Hoff & Helgerud, 2004, Helgerud et al., 2001). New trends in soccer training involve the development of combined physical conditioning programs that target both physical and technical/tactical aspects of the game mainly through the application of “small-sided games” (SSG), possession games and soccer-specific drills (SSD) (Bangsbo, 2003). According to Mayer and Mayer (2006) physical training in soccer should be combined with concurrent development of the

technical and tactical aspects of the game. It has been demonstrated that combined physical conditioning programs are at least equally effective as traditional physical conditioning programs in increasing VO₂max in young soccer players (Impellizzeri et al., 2006). However, coaches and sports scientists should keep in mind that the overall stimulus of the combined physical conditioning programs is determined by a number of factors such as technical ability of the players, number of participants, pitch dimensions, initial fitness levels, rules of the game and coach feedback (Little & Williams, 2006; Rampinini et al., 2007; Platt, Maxwell, Horn, Williams, & Reilly, 2001; Hill-Haas, Coutts, Rowsell, Dawson, 2008).

VO₂max can be determined either in the laboratory or in the field. While laboratory tests are accurate, they are expensive, time-consuming and require specially trained personnel. Therefore, amateur clubs may not have access to this type of VO₂max measurements. For this reason, sport scientists have developed field-based tests that accurately predict VO₂max and may serve as acceptable alternatives to assess this parameter when testing aerobic fitness in soccer players. Furthermore field-based tests have the added benefit of being time-efficient and do not require players to run on a treadmill. The most common field test for the assessment of VO₂max is the 20-Multistage Shuttle Fitness Test (MSFT). This test is being used by soccer clubs across all levels (Svensson & Drust, 2005). MSFT requires players to run back and forward for 20 meters at progressively increasing speeds. Previous research has demonstrated that the MSFT is highly accurate and repeatable when compared with the directly measured VO₂max in soccer players (Aziz, Mukherjee, Chia, & Teh, 2007; Aziz, Tan, & Teh, 2005; Kilding, Aziz, & Teh, 2006).

There are several studies in literature that report an increase of the VO₂max in soccer players using the traditional soccer training (Helgerud et al., 2001; Helgerud, Kemi, Hoff, 2003). There are also reports in the literature concerning investigations which studied the use of soccer specific aerobic training and found that it is beneficial for the increase of VO₂max (Little & Williams, 2006; Hill-Haas et al., 2008). But few studies investigated the differences between the two methods. For example Impellizzeri et al., 2005 found no statistical significant differences between traditional soccer training and specific soccer training in increase of VO₂max.

The purpose of the present study was to examine the effectiveness of two different physical conditioning programs in improving maximal oxygen uptake (VO₂max) in moderately trained youth amateur soccer players during the preparation period using the MSFT. Our hypothesis was that a combined physical conditioning program (50% running-based aerobic training and 50% soccer specific aerobic training) would be as efficient as a traditional physical conditioning program (100% running-based aerobic training) in improving VO₂max in moderately trained youth amateur soccer players during the preparation period.

Method

Participants

Nineteen youth amateur soccer players (average age: 16.3±0.8 years) volunteered to participate in the present study. Goalkeepers were excluded from the present investigation. All participants were given a short description of research and they were informed about the purpose of the study and the ethical aspects linked to the voluntary nature of their involvement. All study participants belonged to same amateur soccer club. All training sessions were supervised by the principal investigator of the present study. The players were required to participate in organized training sessions for at least four years and be injury free at least 2 months prior to the commencement of the study. Participants were informed not to participate in any other kind of physical training and that if they would miss 2 training units they would be excluded from the study. All the players participated in every scheduled training and there was no injury of any kind during the study period. The coaches of the club granted permission for the intervention to take place but were not informed regarding the research hypothesis. Players had their anthropometric characteristics and body fat recorded and their VO₂max measured at the field using the MSFT. Subsequently players were randomly assigned into two groups: a control group (CG) that performed a traditional physical conditioning program comprising of 17 training units of typical running-based aerobic endurance running and an experimental group (EG) that performed a combined physical conditioning program comprising of 17 training units of both typical running-based aerobic endurance running and soccer specific aerobic training. The intervention lasted for 5 weeks and players had their anthropometric characteristics and body fat recorded again and their VO₂max re-evaluated at the field using the MSFT. The study was approved by the Institutional Ethical Committee (University of Thessaly/DPESS) for use of Human subjects.

Procedures

All players performed the measurements between 8:30 and 10:00 am in a single day before and after a 5 week intervention period. All tests were conducted on the same natural grass ground at the beginning and end of the preparation period (July–August). The environmental temperature was 25 to 28 °C and the relative humidity ranged from 35 to 45% in both testing days. Body height, body mass and body fat were measured before testing. Prior to each test, players were allowed a 10-minute warm-up, which was identical for both tests. All players were verbally and equally encouraged in both tests.

Anthropometric characteristics: Subjects reported to the soccer ground at a fully hydrated state. Height and weight were measured using calibrated stadiometer and scale (Seca, Hamburg, Germany) in both occasions. Percent fat was assessed by the principal investigator using a skinfold calliper (Lange, Beta Technology, Santa Cruz, CA, USA) and was calculated based on previously published formula (Faulkner, 1968).

Multistage Shuttle Fitness Test: The MSFT was performed according to published guidelines (Ramsbottom, Brewer, & Williams, 1988). Prior to each test, players were allowed a 10-minute warm-up, which was identical for all trials. All players were verbally and equally encouraged in both tests. Players were required to run repeated 20-m shuttles in response to an audible signal (The National Coaching Foundation, United Kingdom) produced by a CD player. The speed at the first minute was 8.5 km/hour and was increased by 0.5 km/hour every minute. Players were required to complete as many levels and shuttles as possible. The test was terminated when the player was unable to follow the specific pace for 2 successive shuttles and/or he withdrew from the test because of exhaustion. VO_2max (in ml/min/kg) was assessed using the following equation: $31,025 + (3,238 \times T) - (3,248 \times A) + (0,1536 \times A \times T)$ where A is age of the athlete in years and T the velocity of the last completed stage. The coefficient of variation of MSRT has been reported between 2.2 and 2.8% in elite level soccer players (Hill-Haas et al., 2009, Aziz et al., 2005).

Training intervention: The training intervention was comprised by 17 training units that were applied over a 5 microcycle period (5 weeks). First and 2nd microcycle involved 4 training units, while the rest microcycle involved 3 training units. All microcycles involved an additional training unit that was devoted to tactical training and was the same for both groups. Furthermore during the 3rd, 4th and 5th microcycle, players participated in 3 friendly games (one at the end of every microcycle). The day after the friendly games was devoted to recovery training that was the same for all participants. During the training units of the intervention heart rate was continuously monitored using telemetry (Polar Sports Tester, Polar Electro OY, Kempele, Finland). Training intensities were prescribed according to the player's age-predicted maximum heart rate (HR). The 17 scheduled training units followed a similar pattern throughout the study period. Every training unit started with 15 minutes of warm-up and 10-15 minutes of dynamic stretching and calisthenics that were the same for both groups. Then the control group performed the aerobic running part of training for 15-30 minutes while at the same time the experimental group participated in small sided game, possession game or similar soccer specific drills. Both groups concluded the training sessions with 10 minutes of cool down. The training units were of 60-70 minutes total duration. The control group during the aerobic endurance running performed a variety of bouts (steady state aerobic, "threshold" running, intervals) ranging from 6 to 30 minutes with intensities between 70% to 90-95% of age-predicted maximum heart rate. At the same time the experimental group performed Small Sided Games, (SSG) or possession games in a variety of formats in order average bout intensity to range from 70% to 90-95% of age-predicted maximum heart rate. Out of the 17 training units, 9 of them were common for both groups (i.e the experimental group performed identical running as the control group). For the rest training units each group performed its assigned type of training. The control group had approximately 360 minutes of aerobic endurance running, while the experimental group devoted 190 minutes to aerobic running and 170 minutes to SSG, SSD or possession games. This resulted in 52.8% of total training volume (in minutes) being devoted to aerobic endurance running training and 47.2% of total training volume being devoted to soccer specific training for the experimental group.

Statistical analysis

Normal distribution of all data was checked using standard statistical procedures (Statistica 7.0, StatSoft, Tulsa, Oklahoma, USA). All variables were normally distributed. Based on our research hypothesis the dependent variable was VO_2max estimated using the MSRT. Independent variables were group with two between levels (control-experimental) and time with two within levels (pre-post). For the statistical analysis we used a 2-way ANOVA (group x time). For all comparisons the level of significance was set $\alpha < 0.05$. Data are presented as mean \pm SD unless stated otherwise.

In order to provide a measure of "meaningfulness" or "magnitude" of the treatment effect (i.e the training intervention) we report effect sizes (ES) for the changes in VO_2max in both groups (Batterham, & Hopkins, 2006; Rhea, 2004, Hopkins, 2002; Hopkins, 2003). In this regard the information obtained represents a standard unit for measuring and interpreting the changes that occurred in our groups. Furthermore while it allows for comparisons of different training methods within a single study, it also provides a method for comparing treatments in separate but related studies. In terms of ease of calculation, practicality, and application to practice, Cohen's d may be the preferred methods of ES calculation in the area of sports science (Rhea, 2004). ES of 0.1, 0.2, 0.5 and 0.8 are considered trivial, small, moderate and large respectively (Cohen, 1988).

Results

Body weight, body height and body fat did not differ significantly before and after the intervention for both groups ($F_{(1,16)} = .745$, $p = .401$, $\eta^2_p = .008$, $F_{(1,16)} = 0.07$, $p = 0.943$, $\eta^2_p = .065$, $\eta^2_p = .001$, and $F_{(1,16)} = .56$, $p = .887$, $\eta^2_p = .037$) respectively. Furthermore body weight, body height and body fat did not differ between groups

($F_{(1,16)}=.01$, $p=.917$, $\eta^2_p=.008$, $F_{(1,16)}=.356$, $p=.865$, $\eta^2_p=.015$, and $F_{(1,16)}=.021$, $p=.909$, $\eta^2_p=.006$) respectively. Anthropometric characteristics are presented in table 1.

Table 1. Anthropometric characteristics for both groups before and after the intervention

	HEIGHT (m)		WEIGHT (kg)		BODY FAT (%)	
	PRE	POST	PRE	POST	PRE	POST
Control group (n=9)	1.78±0.08	1.78±0.08	64.9±7.7	64.8±7.0	9.9±2.0	9.3±1.8
Experimental group (n=9)	1.77±0.05	1.77±0.05	65.4±8.5	65.1±7.8	9.5±2.0%	9.3±1.9

Regarding our research hypothesis, before the intervention VO_{2max} did not differ between groups ($F_{(1,16)}=.09$, $p=.943$, $\eta^2_p=.001$). After the intervention VO_{2max} increased significantly for both groups ($F_{(1,16)}=134.2$, $p<.001$, $\eta^2_p=.865$). However there was no time X group interaction, therefore VO_{2max} was not different between groups after the intervention ($F_{(1,16)}=.20$, $p=.657$, $\eta^2_p=.013$) (fig. 1).

For both groups Effect sizes (ES) presented a moderate increase in in VO_{2max} ; however the change was closer to large for the experimental group (ES=0.71) comparing to control group (ES=0.58).

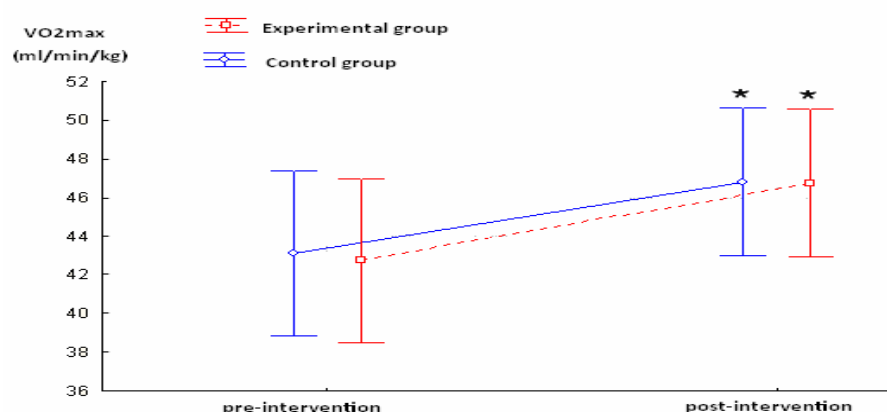


Fig. 1. Pre- and post-intervention VO_{2max} values for both groups.

* indicates significantly higher compared to pre-intervention values.

Discussion

In the present study we examined the effectiveness of two different physical conditioning programs in improving maximal oxygen uptake (VO_{2max}) in moderately trained youth amateur soccer players during the preparation period using a widely accepted field test such as the MSRT. Our hypothesis was that a combined physical conditioning program (50% running-based aerobic training and 50% soccer specific aerobic training) would be as efficient as a traditional physical conditioning program (100% running-based aerobic training) in improving VO_{2max} in moderately trained youth amateur soccer players during the preparation period.

The results of the present study confirmed our hypothesis. The training intervention resulted in increased VO_{2max} for both group compared to their initial values ($F=134.2$, $p<.001$). The combined physical conditioning program was as effective as the traditional physical conditioning program in increasing VO_{2max} since the groups did not differ in their VO_{2max} values following the intervention. Furthermore both groups started the intervention having similar VO_{2max} values (Graph 1). Collectively the results of the present study demonstrate that the application of an intervention that combines 50% of traditional aerobic endurance running with 50% soccer specific aerobic training with the ball is equally efficient with pure aerobic endurance running program in improving VO_{2max} in 15-16 years old amateur soccer players during the preparation period. In the present study VO_{2max} increased by $9.1\pm4.8\%$ and $9.7\pm3.6\%$ for the control and experimental group respectively after applying 17 training units within a 5 week period. This improvement is higher than the 7% that Impellizzeri et al., 2006 report in a similar intervention study, but less compared to 10% that has been reported by Helgerud et al., 2001.

In a previous study Impellizzeri et al., 2006 compared traditional with soccer specific aerobic endurance training and reported larger improvements in the group that trained with the traditional method. This observation led the researchers to conclude that the soccer specific may not be ideal in some cases. For example independent of player number or pitch dimensions, the status of the players may affect the intensity of the training (Impellizzeri et al., 2006). It has been previously reported that young players of lower technical ability may not be able to a tempo high enough during SSG or possession games or other types of soccer specific drills (poor passing, poor technique, more mistakes). Therefore in this case soccer specific aerobic endurance training may not be ideal (Castagna, Belardinelli, & Abt, 2005). Hoff and Helgerud, 2004 postulated that in order to effectively increase VO_{2max} one must attain high stroke volume for extensive periods of time without

interruptions that essentially decrease the “muscle pump” effect which is considered crucial in achieving high stroke volume (Mc Ardle, Katch, & Katch, 1996; Astrand & Rodahl, 1987). Thus, soccer specific aerobic endurance method has theoretical drawbacks since SSG or possession games is too difficult not to have any breaks at all—even for a few moments- (stop to return the ball or due to player injury) and thus there is a potential decrease of the “muscle pump” effect and in turn of the training stimulus. On the contrary, using traditional aerobic endurance running the coach can keep high intensity of exercise for the required time period a lot easier.

Furthermore it may be that not all SSG formats are indicated for creating a high intensity training stimulus. For example Stolen et al., 2005 directly measured VO_2max in the laboratory in 11 moderately trained young soccer players and then, using portable analyzers, measured oxygen uptake during 5 vs. 5 SSG on a 40m x 20m pitch and during high intensity interval running (15 sec near maximal sprint interspersed with 15 sec of active recovery for a total duration of 6 minutes). During SSG players attained $53\% \pm 12\%$ of their pre-determined VO_2max (along with $72\% \pm 9\%$ of their maximal heart rate), while the respective numbers during the interval running were $\sim 77\%$ and $\sim 96\%$. Thus the researchers concluded that SSG is not an effective training method due to its low training stimulus. However it should be pointed out that this study examined only one SSG format without altering number of participants or pitch dimensions. Nevertheless, coaches should keep in mind that certain SSG formats provide relatively low training stimulus and thus are not suitable for improving VO_2max .

Taken collectively the above findings led some coaches to conclude that traditional endurance training is a better choice when the target is to develop aerobic endurance. However the findings of the present study indicate that is not always the case. Even if the traditional method leads to superior results compared to a soccer specific method, the present study demonstrated that replacing 50% of the training volume of a traditional method with equal volume of soccer specific aerobic endurance training leads to no negative adaptations in terms of VO_2max development. Therefore it appears that traditional endurance training programs are not the only way to achieve increases in VO_2max . Simply by substituting half of the training units of a traditional program with soccer specific aerobic training units the coach will achieve similar improvements without the added monotony of ball absence during the training process (Mayer & Mayer, 2006).

Furthermore we should point out that based on our ES, the magnitudes of the improvements in VO_2max are considered “moderate” (0.59 for the control group and 0.71 for the experimental group) with a “large” effect requiring an ES of at least 0.8 (Cohen, 1988). Although marginal, we believe that from a practical point of view the effect of the combined physical conditioning program was a little bit stronger compared to that of the traditional physical conditional program. Furthermore when comparing the improvements in VO_2max observed in present study, they lie within the area of 7-10% which have previously been reported for soccer players of similar age training with either traditional running based or soccer specific methods (Impellizzeri et al., 2006; Helgerud et al., 2001).

Conclusions

Based on our findings we propose that coaches could easily substitute up to 50% of traditional aerobic endurance running-based training units with SSG, possession games or SSD without any negative effect on VO_2max development. In fact in this way with achieve a concurrent training of the technical aspects of the game. Other benefits of a combined physical conditioning program include a more positive attitude of the players towards this type of training, improvements of game-specific movements such as side-to-side, backwards and turning. However coaches should be aware of potential limitations during soccer specific aerobic training such that players availability will ultimately determine the SSG that can be applied (which may be not compatible with the desired training target in terms of intensity), while secondary parameters are GK availability and pitch dimensions.

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