Original Paper DOI: https://doi.org/10.5114/biolsport.2021.100361

# Fitness improvements of young soccer players after high volume or small sided games interventions

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**ABSTRACT:** The main goal was to determine anaerobic and aerobic improvement of young soccer players after six-week high volume (HVT) or small sided games (SSG) training intervention. One hundred and one highly trained youth soccer players (16.2 ± 1.3 years) were divided into SSG (n = 51) and HVT groups (n = 50) and according to age into an under sixteen subgroup (U16), under seventeen subgroup (U17), and under nineteen subgroup (U19). The performance was assessed by Yo-Yo intermittent test, Repeated sprint ability test (RSA), and K-test before and after both training interventions. For U16 the SSG group recorded significant improvements in the K-test (0.64 ± 0.56 s; p = .04) and RSA (0.15 ± 0.43 s; p = .01). For U19 the SSG group recorded the same improvements, in the K-test (0.43 ± 0.57 s; p = .007), RSA (0.21 ± 0.22 s; p = .048), and Yo-Yo test (127.25 ± 17.87; p = .049). HVT improved aerobic performance when the Yo-Yo test was significantly better after intervention at U17 (199.00 ± 111.83 m; p = .030), U19 (88.40 ± 66.38 m; p = .049). In total, the HVT group spent 621 min (56.45 ± 5.01 min) of aerobic training and the Small sided game group spent 291 min (26.45 ± 8.61 min) of small sided games focused on aerobic performance. This study showed that both SSG and HVT training interventions were effective for aerobic improvement for the U19 category, but not for younger players. SSG was identified to be more appropriate to fitness development of soccer players.

**CITATION:** Karel Hůlka, Matej Strniště. Fitness improvements of young soccer players after high volume or small sided games interventions. Biol Sport. 2021;38(4):573–578.

Received: 2020-06-15; Reviewed: 2020-08-26; Re-submitted: 2020-09-11; Accepted: 2020-10-19; Published: 2020-12-31.

**Key words:**
Repeated sprint ability
Agility
Intermittent exercise
Skill-based training

## INTRODUCTION

Soccer is a team contact sport where youth players (aged from 16 to 19 years) cover 8–9 km during a game [1] and approximately 20–22% of the distance is performed as high- and very high-intensity running (speed from 13.0 to 18.0 km·h$^{-1}$) and sprinting [1]. A soccer match imposes great physiological demands on both aerobic and anaerobic energy systems. Players performing at the elite or sub-elite level are required to maintain high-intensity activity during the whole game and to do that certain levels of physical capacities are critical for such performance [2].

The importance of individual physical capacities may differ according to players' role (forwards, defenders, midfielders) on the field [3] but repeated sprint ability, speed, explosive power and aerobic capacity are widely reported as significant discriminants that affect the players' performance on the field [1, 4]. Thus, specific conditioning concepts gained more attention in the last decade and a new approach in the form of small sided games (SSG) has become popular for sport coaches and specialists especially due to its ability to develop aerobic capacity at the same time with technical and tactical elements [5, 6].

SSG are considered to be an appropriate tool for developing specific conditioning in team sport players because of their ability to replicate the game requirements [7, 8], which is supported by Bompa and Buzzichelli [9], who stated that the best training results are achieved through the exercise that corresponds with the competitive demands. However, SSG has several factors (number of players, pitch size, coach encouragement, rules, etc.) that are reported to affect the intensity of the game, and coaches should be aware of these effects and plan the training session according to the training objectives [10].

SSG are reported to reach intensities of 90–95% $HR_{max}$ [11] which correspond to the intensity that is considered functional in improving aerobic fitness in soccer players and to intensities during a game (80–90% $HR_{max}$) [12]. Such sport-specific conditioning may provide similar or even greater increase in key qualities for soccer players than traditional conditioning drills [6, 10, 13].

The research interest about SSG training is connected with application to the training of youth. Studies are mainly focused on physical and physiological responses of various types of rules changes [14, 15, 16] or ball type [17]. Only two studies were concentrated on the effect of SSG training intervention physical performance. Lupo et al. [18] compared the influence of the SSG and running technique intervention on the agility of youth players. The influence of SSG intervention on aerobic performance was measured by Praca, Sousa and Greco [19].

The main goal of the study was to determine the difference of anaerobic capacity, aerobic capacity and agility improvements of young soccer players after six-week high volume and small sided games training intervention. We hypothesized that SSG training intervention leads to similar fitness improvements as HVT training intervention.

## MATERIALS AND METHODS

### *Subjects*

A total of 101 soccer players took part in this study. Thirty-five players played in the category of U16 (mean ± standard deviation [SD]: age = 15.1 ± 0.3 years, weight = 69.8 ± 2.9 kg, height = 175.8 ± 4.8 cm), thirty-four players played in the category of U17 (age = 15.9 ± 0.3 years, weight = 73.6 ± 2.2 kg, height = 180.1 ± 3.6 cm), and thirty-two players played in the category of U19 (age = 17.5 ± 0.5 years, weight = 71.4 ± 6.4 kg, height = 180.2 ± 2.7 cm) in the highest Czech national leagues. All participants had several years of experience in soccer and had more than 5 team sessions per week and one match. Participation was voluntary and players could withdraw from the study at any time. Prior to data collection, the aims and objectives of the present study were clarified to all participants and all of them and their parents provided written informed consent. The research design was approved by the institutional ethical committee (14/2020). All players were instructed to maintain normal daily food and water intake during the research. The experiments were performed in accordance with the ethical standards of the Declaration of Helsinki and the participants signed an informed consent form.

### *Study design*

A randomized parallel matched-group design was used. The training intervention lasted 6 weeks and consisted of one-week pre-testing, 4 weeks of training intervention and one week of post-testing. All sessions were performed during the pre-season (June-July 2018). Detailed periodization of this 6-week interventions is shown in Table 1.

Players were randomly assigned to one of the groups – the High volume training group (HVT; n = 50) or the Small sided games group (SSG; n = 51). The random allocation to one of the groups was performed by tossing a coin. The anthropometric characteristics of divided groups are shown in Table 2. Both training programs and individual training sessions are presented in Table 3. The practices focused on aerobic training consisted of 25 min warm-up, 25 min of football skills and tactical training, and the rest of the practice sessions consisted of aerobic intervention followed by 10 min cool-down. To reduce the effect of the two training protocols, the other training variables (technical, tactical, etc.) were identical for both groups.

**TABLE 1.** Six week training program.

| Week | | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|---|
| 1 | Mor | Free | Free | Free | Free | Free | Day off | Day off |
| | after | aerobic run 20 min | Day off | Testing K-test, RSA | Day off | Testing yo-yo | | |
| 2 | mor | free | free | free | free | free | free | Day off |
| | after | SkillsT & cond (STA, CO, S) | TactT, AERO | TactT& cond (Sta, A, S,CO) | TactT, AERO | TactT& cond (Sta, A, S,CO) | Fmatch | |
| 3 | mor | free | free | free | free | free | free | Day off |
| | after | AERO & cond (STA, CO, S) | SkillsT & TactT | SkillsT & AERO | TactT& cond (Sta, A, S, CO) | TactT, AERO | Fmatch | |
| 4 | mor | Free | cond (Sta, A, S,CO) | Free | Free | cond (Sta, A, S,CO) | Fmatch | Day off |
| | after | SkillsT & cond (STA, CO, S) | SkillsT & AERO | TactT | TactT, AERO | TacT & SkillsT | Free | |
| 5 | mor | Free | cond (Sta, A, S,CO) | Free | Free | cond (Sta, A, S,CO) | Fmatch | Day off |
| | after | SkillsT & AERO | Skills & cond (STA, CO, S) | TactT & AERO | TactT, SkillsT | TacT & AERO | Free | |
| 6 | mor | Free | Free | Day off | Free | Free | Free | Day off |
| | after | SkillsT & cond (STA, CO) | Testing K-test, RSA | | Testing yo-yo | SkillsT & TactT | Fmatch | |

Notes: mor = morning; after = afternoon; Cond = Conditioning; Aero = Aerobic training; TactT = Tactical training; Sta = dynamic stability; CO = Core training; A = Agility Training; S = Strength training; SkillsT = Skills training.

**TABLE 2.** Characteristics of players included to the research

| | N | age | height (cm) | weight (kg) |
|---|---|---|---|---|
| U16 HVT | 17 | 15.2 ± 0.3 | 176.6 ± 5.1 | 69.6 ± 3.0 |
| U16 SSG | 17 | 15.1 ± 0.3 | 175.4 ± 5.0 | 69.8 ± 2.7 |
| U17 HVT | 17 | 16.0 ± 0.4 | 181.1 ± 3.2 | 74.1 ± 2.7 |
| U17 SSG | 17 | 15.9 ± 0.3 | 179.8 ± 4.0 | 72.1 ± 2.6 |
| U19 HVT | 16 | 17.5 ± 0.6 | 181.2 ± 3.6 | 70.8 ± 5.1 |
| U19 SSG | 17 | 17.4 ± 0.5 | 180.1 ± 2.4 | 71.7 ± 6.9 |

Notes: N-number of participants; HVT-High volume training intervention; SSG – Small sided games training intervention

**TABLE 3.** Detailed plan of practices focused on aerobic performance.

| | SSG | Time (min) | HVT | Time (min) |
|---|---|---|---|---|
| 1 | 6x6 min run + 3 min break | 51 | 6x6 min run + 3 min break | 51 |
| 2 | 3v3, 3x 3min; 4v4, 2x 4min, 2min rest | 17 | 4x12min Fartlek+2min break | 54 |
| 3 | 4v4 5x4 min, 2min rest | 20 | 2x30 min Fartlek+5 min break | 65 |
| 4 | 3v3 4x3min; 4v4 2x5min, 2min rest | 22 | 4x12min Fartlek +2min break | 54 |
| 5 | 4v4 6x4 min, 2min rest | 24 | 3x15 min Fartlek +3 min break | 51 |
| 6 | 3v3 4x3min; 4v4 2x5min, 1min rest | 22 | 2x25 min Fartlek +5 min break | 55 |
| 7 | 4v4 6x4 min, 1min rest | 24 | Continuous run of 8.9 km | 60 |
| 8 | 3v3 5x3min; 4v4 3x4min, 2min rest | 27 | 5x10 min Fartlek + 1 min break | 55 |
| 9 | 4v4 5x6 min, 1min rest | 30 | 3x15min Fartlek+3 min break | 51 |
| 10 | 3v3 8x3min, 1min rest | 24 | Continuous run of 8.9 km | 60 |
| 11 | 4v4 5x6 min, 1min rest | 30 | 2x30 min Fartlek + 5 min break | 65 |
| **Mean ± SD** | | 26.45 ± 8.61 | | 56.45 ± 5.01 |

Notes: SSG- programme of SSG group; HVT – programme of HVT group;

*Testing protocols*

Three tests were separated 24 h from each other and performed before and after training intervention. Tests were aimed at assessing players' aerobic capacity (Yo-Yo intermittent recovery test level 2), anaerobic capacity (RSA) and agility improvement (K-test). All testing sessions were performed at the same time of day to avoid a circadian effect. Every testing session started with standardized warm-up and dynamic stretching. Also, participants were familiarized with all testing protocols prior to training sessions.

*K-test*

The K-test was performed to assess speed and agility (Figure 1). The time was measured by electronic timing gates (0.01 s precision; PR1aW, Alge-Timing GmbH, Austria). Every player completed three attempts with 10 min recovery. The best time was taken. The distance between cones 1–2 and 1–5 was 4.5 m. The distance between cones 2–3 and 5–4 was 3 m. The player started from the run-up start

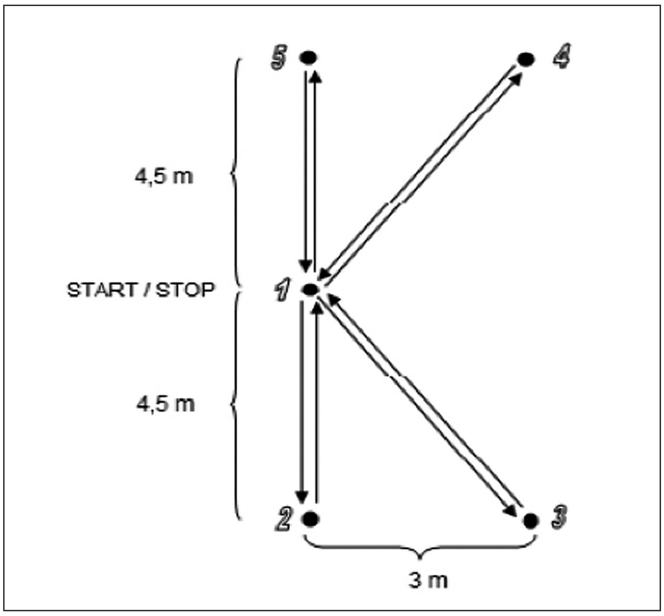


**FIG. 1.**

position on his own. The test was performed outdoors on a grass pitch and running lanes were marked by cones. The K-test was validated and applied with 0.10 s standard error of measurement [20].

### *Repeated sprint ability test (RSA)*

The RSA test was applied to determine the level of repeated sprint ability of players [21]. The RSA test consisted of 6 repetitions of maximal 2x15-m shuttle sprints with 14 s passive standing recovery. Three seconds before starting each sprint, subjects were asked to assume the ready position and await the start signal [21]. The player started from the run-up start position. The time was measured by electronic timing gates (PR1aW, Alge-Timing GmbH, Austria) with one hundredth of a second accuracy. The test was performed outdoors on a grass pitch and running lanes were marked by cones. The test was shown to be reliable and valid [22]. For our purpose Sprint decrement (%Sdec) was calculated as follows [20]:

$$\%Sdec = \text{total time} \cdot \text{ideal time}^{-1} \cdot 100,$$

where the ideal time is 6 times the best sprint time.

### *Yo-Yo intermittent recovery test level 2*

Aerobic performance of participants was assessed by the Yo-Yo intermittent level 2 (YYIRT2) test [23]. The YYIRT2 consists of two 20-m runs performed at increasing speeds controlled by audio bleeps. There is 10 s of active recovery (consisting of 2x5 m of jogging) after each running bout. The test was stopped when the participants were not able to make it to start in time for the second time and the distance covered was recorded as a final result [23]. The test was performed outdoors on a grass pitch and running lanes were marked by cones.

### *Data analysis*

Statistical analysis was performed using the data analysis software system Statistica (13.0 version, StatSoft, Inc., Tulsa, USA). All results are expressed as mean ± SD. The prerequisites of normality and homogeneity of variance were verified using the Kolmogorov-Smirnov and Lilliefors test respectively. One-way ANOVA of repeated measures was used to determine the significance of differences between measurement sessions ($p \leq 0.05$). Effect size (Cohen's d) was calculated to determine the practical difference between the SSG training programme and the High-volume training programme. Effect size values of 0 to 0.19, 0.20 to 0.49, 0.50 to 0.79, and 0.8 and above were considered to represent trivial, small, medium, and large differences, respectively [24].

## RESULTS

The results of all tests before and after both program interventions are shown in Table 4. For the U16 category the SSG intervention group recorded significant improvements in the K-test (0.64 ± 0.56 s; $p = .04$) and RSA test performance (0.15 ± 0.43 s; $p = .01$). For the U19 category the SSG intervention recorded similar improvements as in U16, thus in the K-test (0.43 ± 0.57 s; $p = .007$) and RSA test performance (0.21 ± 0.22 s; $p = .048$); moreover they improved in the Yo-Yo test (127.25 ± 17.87; $p = .049$). High volume training

**TABLE 4.** The results of training interventions

| | SSG | | | | HVT | | | |
|---|---|---|---|---|---|---|---|---|
| | pre | post | p | d | pre | post | p | d |
| **U16** | | | | | | | | |
| K-test (s) | 11.51 ± 0.54 | 10.87 ± 0.76* | .04 | 1.41 | 11.74 ± 0.64 | 11.30 ± 0.65 | .10 | 0.53 |
| RSA (s) | 6.21 ± 0.06 | 6.11 ± 0.06* | .01 | 1.14 | 6.17 ± 0.17 | 5.99 ± 0.14 | .08 | 1.09 |
| YO-YO (m) | 517.74 ± 151.70 | 637.09 ± 144.21 | .18 | 1.80 | 530.52 ± 237.00 | 680.15 ± 140.00 | .08 | 0.46 |
| **U17** | | | | | | | | |
| K-test (s) | 11.42 ± 0.98 | 11.19 ± 1.07 | .51 | 0.21 | 11.25 ± 0.52 | 11.09 ± 0.78 | .66 | 0.14 |
| RSA (s) | 5.92 ± 0.28 | 5.82 ± 0.47 | .39 | 0.29 | 5.87 ± 0.11 | 5.82 ± 0.16 | .91 | 0.10 |
| YO-YO (m) | 555.78 ± 156.57 | 602.11 ± 169.61 | .40 | 0.28 | 538.00 ± 177.42 | 740.12 ± 226.47* | .03 | 0.77 |
| **U19** | | | | | | | | |
| K-test (s) | 11.42 ± 0.72 | 10.84 ± 0.58* | .007 | 0.93 | 11.32 ± 0.79 | 10.97 ± 0.67 | .12 | 0.53 |
| RSA (s) | 5.88 ± 0.41 | 5.64 ± 0.35* | .048 | 0.67 | 5.89 ± 0.60 | 5.71 ± 0.32 | .67 | 0.14 |
| YO-YO (m) | 645.88 ± 95.98 | 772.35 ± 91.88* | .049 | 0.64 | 678 ± 99.61 | 766.40 ± 125.89* | .049 | 1.37 |

Notes: pre- Values before intervention; post- values after intervention; *-significant differences at p = .05; RSA-Repeated sprint ability test; Yo-Yo – Yo-Yo intermittent recovery test level 2; d- effect size intervention improved the aerobic indicator when Yo-Yo test performance was significantly better after intervention in the U17 (199.00 ± 111.83 m; p = .030) and U19 category (88.40 ± 66.38 m; p = .049).

In total, the high HVT group spent 621 min (56.45 ± 5.01 min) of aerobic training and the SSG group spent 291 min (26.45 ± 8.61 min) of small sided games focused on aerobic performance.

## DISCUSSION

The main goal of the study was to determine the difference of anaerobic and aerobic improvement of young players after six-week high volume or small sided games training intervention. According to our results SSG intervention has the potential to develop repeated sprint ability of players, aerobic performance, and agility at the same time, in contrast with HVT intervention, where aerobic performance was developed only. But the extent of development seems to be dependent on the age of players. These results are consistent with the findings of previous studies that have investigated changes in athletic performance after SSG training interventions.

Aerobic performance is traditionally an important component of physical training in soccer [25]. Aerobic training can improve some aspects of soccer performance, including distance covered, time spent at high intensity, number of sprints and touches of the ball during a match [26]. Furthermore, high aerobic fitness appears to improve recovery during high-intensity intermittent exercise, typical of soccer performance and training [27, 28]. Nowadays the view to improve aerobic and anaerobic capacity is changed because of time efficiency of training. This change was brought about by increasing the number of matches during the season. That is why the fusion of aerobic training and technical-tactical training or skill-based training is necessary. Researchers started to measure differences in fitness performance between these types of training and traditional training. In our study we found a significant improvement of aerobic performance in the U19 category after SSG intervention. Significant differences were found by [29] after a nine-week training programme of rugby players. According to Owen, Wong del, Paul and Dellal [30] four-week SSG training can improve fitness characteristics of players. Similar findings were made by Hill-Haas et al. [32] after a 7-week preseason training period of SSG led to significantly improved Yo-Yo intermittent recovery and by Seitz et al. [8] after an eight-week SSG training intervention. The reason for nonsignificant differences in our study in the U16 and U17 categories may be related to the lower intensity of SSG training because of the lower technical and tactical level of players, as was suggested by Hill-Haas et al. [32]. According to McMillan, Helgerud, Macdonald and Hoff [33] optimal aerobic adaptations are possible if cardiac output remains elevated for sustained periods during soccer training, and for exercise intensities of > 90% of peak heart rate. Thus SSG should be modified to be appropriate to their level.

We found significant improvements in repeated sprint ability of players after SSG training intervention. Similar findings were reported by Owen et al. [30], Buchheit et al. [34] and Seitz and Rivière [35]. It is likely that the type of SSG undertaken by the players produced an efficient training stimulus that induced improvement in RSA [35]. After SSG training intervention, a very important result for soccer players was significant improvement in agility and thus change of direction speed improvement. We consider insufficient improvement of agility and RSA and lower training time for technical and tactical preparation to be a crucial deficiency of HVT intervention for suitable fitness preparation of soccer players in contrast with SSG intervention.

SSG intervention seems to be effective to develop the agility, but probably an age (or technical) limit exists. While technically able players can improve agility during SSG, small players (not technically equipped) should prefer running intervention [18]. This approach is similar to aerobic performance development by SSG intervention. Moreover, SSG intervention enables coaches to enhance time spent by replicating movement and tactical demands similar to competitive match play [32]. Last but not least, an advantage of SSG training intervention is that it is thought to increase player compliance and motivation, since it is perceived to be sport specific [36]. Hence the players can develop decision making, skills under pressure and fatigue, and specific conditioning at the same time. This fact can lead to gaining more time for injury prevention training or regeneration of players.

As a limit of the study we consider that the results indicate the trends in junior categories only and cannot be generalized to other age categories. The biological age of participants was not taken into account at the same time. The future research should determine the age limit from which it is appropriate to apply the SSG training intervention.

## CONCLUSIONS

The present study showed that both elected SSG and HVT training interventions were equally effective for aerobic improvement for the U19 category, but not for younger players. Younger players need to use simpler SSG. However, SSG training intervention was identified to be more appropriate to fitness development due to several reasons. The first is concurrent development of aerobic, anaerobic fitness and agility performance, which leads to time efficiency of the fitness programme. The second one is concurrent development of specific fitness, decision making, and skills under pressure and fatigue. The last reason is higher motivation of the players to do the fitness programme.

**Acknowledgments**

This study was supported by Palacký University grant IGA_FTK_2020_002.

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