

Original article

# Effects of soccer training on health-related physical fitness measures in male adolescents

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## Abstract

**Purpose:** The aims of this study were to (1) investigate the health-related physical fitness profile of untrained adolescent boys in comparison to adolescent soccer players, (2) determine the intensity and enjoyment of 6v6 and 4v4 small-sided games, and (3) evaluate the health-related effects of a short-period of soccer training in the untrained group.

**Methods:** Forty-one adolescent boys (untrained,  $n = 24$ : age =  $15.9 \pm 0.6$  years; trained,  $n = 17$ : age =  $15.7 \pm 0.7$  years) were recruited. For Purpose 1, the players ( $n = 17$ ) and the untrained ( $n = 24$ ) boys were tested for speed, jumping power, balance, flexibility, and aerobic capacity. After baseline testing, Purposes 2 and 3 were addressed by randomly assigning the untrained boys to either a soccer-training group (small-sided games, 2 sessions per week for 8 weeks) or to a control group, followed by identical retesting.

**Results:** At baseline, physical fitness was higher ( $p < 0.001$ ) in trained players than in untrained for aerobic fitness, sprinting, jumping power, and balance. Small-sided games using 6v6 or 4v4 elicited similar heart rate (HR) (mean:  $\sim 85\%$  peak heart rate,  $HR_{peak}$ ), rate of perceived exertion, and enjoyment responses. Over 8 weeks, the between-group analysis revealed that soccer training had a large beneficial effect on balance (45%) when compared with control group with unclear effects on other fitness parameters.

**Conclusion:** Adolescent soccer players had markedly higher physical fitness compared with untrained adolescents. Small-sided soccer games practiced by untrained adolescents elicited high exercise intensity. While 8 weeks of twice-weekly soccer training sessions induced significant improvement in balance, the short duration of the study was not sufficient to result in between-group differences in sprint and jump performance or aerobic fitness.

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**Keywords:** Enjoyment; Football; Heart rate; Small-sided games; Training

## 1. Introduction

A low level of physical fitness and life-style-related diseases during childhood and adolescence are associated with an increased risk of cardiovascular disease during adulthood.<sup>1</sup> Recent estimates suggest that many adolescents and children do not achieve the recommended level of physical activity<sup>2</sup> that is required to cause a reduction in the risk for

cardiovascular disease and physiological disorders during childhood and adolescence.<sup>3</sup>

Studies investigating the health-related physical fitness benefits of regular physical activity participation have focused primarily on aerobic exercise, including treadmill or outdoor running and cycle ergometry.<sup>4,5</sup> However, adherence to these modes of physical activity (e.g., continuous running) in the general population, and especially in adolescents, is relatively low, perhaps because such activities are perceived as isolating and boring.<sup>6</sup> There is, therefore, a need to find more enjoyable modes of training that elicit great adherence by optimizing intrinsic motivation while offering health benefits that match

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those accomplished by treadmill and cycle ergometry programs.<sup>7</sup> In this context, recreational soccer may be a popular alternative for those seeking to improve their cardiovascular, metabolic, and musculoskeletal fitness.<sup>8,9</sup>

A growing body of research has highlighted the health benefits of recreational soccer training in sedentary but otherwise healthy adults<sup>10,11</sup> and obese<sup>12</sup> or various patient populations.<sup>13,14</sup> Recent reviews<sup>15,16</sup> suggest that regular participation in recreational soccer can enhance both physical fitness and health status in untrained individuals. It has been shown for example, that a period of 12-24 weeks of soccer training caused a 7%-15% increase in the maximum amount of oxygen utilized ( $\text{VO}_{2\text{max}}$ ) in previously untrained participants.<sup>15</sup> Moreover, 12 weeks of soccer training in young and middle-aged men led to a significant decrease (15%) in low-density lipoprotein cholesterol.<sup>17</sup>

Only few studies have investigated the health effects of soccer-based training in adolescence.<sup>12,18</sup> In these studies, it was reported that obese adolescent boys improved a range of health markers, such as a reduction in body fat and blood pressure, an increase in high-density lipoprotein cholesterol, and  $\text{VO}_{2\text{max}}$  after 12 weeks of organized recreational soccer training. To the best of our knowledge, no data exist on the effects of recreational soccer in untrained normal-weight adolescents. Moreover, no data exist on the acute effects of different forms of small-sided games on perceived enjoyment for adolescent boys.

The aims of the present study were therefore to (1) investigate the health-related physical fitness profiles of untrained adolescents compared with adolescent soccer players, (2) determine the intensity and enjoyment responses to different forms of small-sided games for adolescent boys, and (3) investigate the effects on health-related fitness measures of a short-term (8 weeks) recreational soccer intervention performed with untrained boys.

## 2. Materials and methods

### 2.1. Participants

Twenty-four untrained post-pubertal adolescents (age:  $15.9 \pm 0.6$  years, years to and from peak height velocity [Y-PHV], see Section 2.2.4:  $0.2 \pm 0.9$ ) and 17 adolescent soccer players (age:  $15.7 \pm 0.7$  years, Y-PHV:  $0.8 \pm 0.8$ ) took part in the study. The baseline characteristics of the participants are presented in Table 1. To be included, participants had to be healthy, not suffering from any acute or chronic disease, and not receiving medical treatment. The trained boys had to have a minimum of 2 years of soccer training and competitions without any loss of time due to injury within 3 months preceding the study. The untrained boys had not been involved in regular physical activity for at least 2 years, but they participated in school physical education program (gymnastics, athletic sessions) for maximally 2 sessions of 1 h per week. All participants were fully informed of the risks and discomforts associated with the experimental procedures, and the children and their parents signed informed consent for their children to participate in the study. After baseline testing of all

Table 1  
Baseline characteristics of subjects.

	Untrained adolescents		Soccer players ( <i>n</i> = 17)
	Control group ( <i>n</i> = 12)	Intervention group ( <i>n</i> = 12)	
Age (year)	$15.8 \pm 0.7$	$15.9 \pm 0.4$	$15.7 \pm 0.7$
Y-PHV (year)	$0.5 \pm 0.7$	$0.3 \pm 0.7$	$0.8 \pm 0.8$
Body mass (kg)	$52.0 \pm 5.4$	$53.9 \pm 5.2$	$62.4 \pm 5.6$
Height (m)	$1.60 \pm 0.10$	$1.60 \pm 0.10$	$1.70 \pm 0.10$
BMI ( $\text{kg}/\text{m}^2$ )	$20.1 \pm 1.1$	$20.0 \pm 1.6$	$20.7 \pm 1.7$
BF (%)	$14.1 \pm 1.5$	$14.2 \pm 1.9$	$15.3 \pm 1.1$
LBM (kg)	$45.1 \pm 3.9$	$46.0 \pm 4.2$	$52.5 \pm 4.5$

Abbreviations: BF = body fat; BMI = body mass index; LBM = lean body mass; Y-PHV = years to and from peak height velocity.

participants, the untrained boys were randomly (using simple randomization: based on a single sequence of random assignments) allocated to either a soccer intervention group (ING) or a non-training control group (CON) and were retested after 8 weeks. The procedure and the study design are presented in Fig. 1. The protocol of the study conformed to the Declaration of Helsinki for human research, and the study was approved by the Ethical Committee of the Laboratory of Physiology, Faculty of Medicine of Sousse, Sousse, Tunisia.

### 2.2. Procedures

#### 2.2.1. Training intervention

The intervention group participated in 2 sessions of outdoor regular small-sided soccer per week over 8 weeks. Training usually took place on Wednesday and Friday afternoons. Each session was comprised of a short dynamic warm-up followed by 30-45 min of ordinary small-sided soccer drills (4v4 to 6v6). The small-sided games were played with varying rules and with goal keepers on an outdoor field with pitch size adjusted according to the number of players ( $30 \times 20$  m to  $50 \times 30$  m).<sup>19</sup>

#### 2.2.2. Measurements and testing

Perception of effort was evaluated using rate of perceived exertion (RPE) scores (10-point scale)<sup>20</sup> collected during the training period in all training sessions. Heart rates (HRs) (Polar S-810; Polar-Electro, Kempele, Finland) were collected during the last 2 weeks of training. Furthermore, we compared the physiological and perceptual responses and enjoyment between training sessions involving the 4v4 (with goalkeeper on a  $30 \times 20$  m pitch) or 6v6 (with goalkeeper on a  $50 \times 30$  m pitch) forms. A modified and validated Physical Activity Enjoyment Scale (PACES)<sup>21</sup> was completed after the 2 game formats. The PACES consisted of a 16-item questionnaire relating to different aspects of enjoyment and rated on a 5-point Likert-type scale.

#### 2.2.3. Anthropometric measures

Body composition, body mass, and height were measured under standard conditions. Body mass index (BMI) was

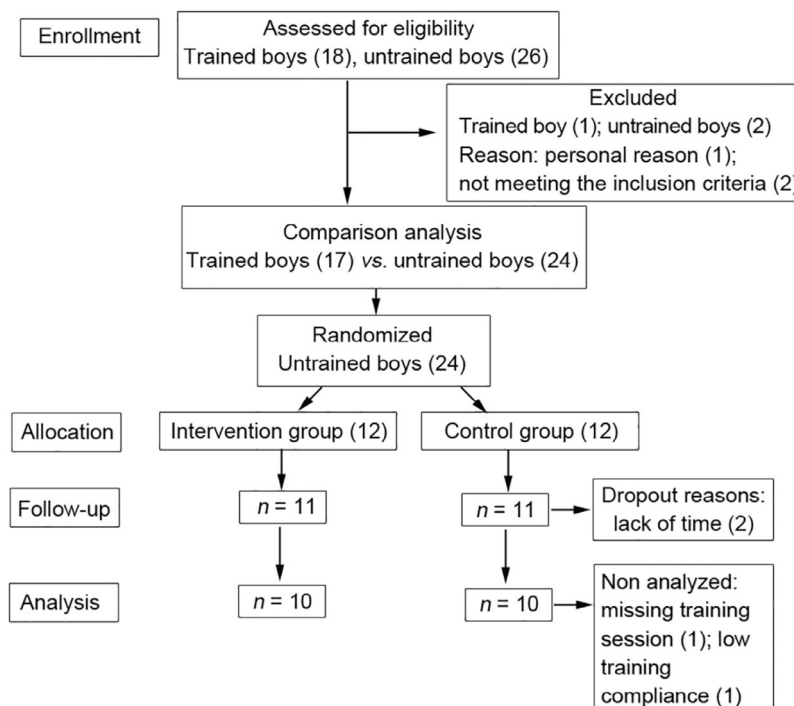


Fig. 1. Flow chart of study design, enrollment, randomization, and analysis.

assessed as weight in kilograms divided by height in meters squared. The 4 skinfolds (biceps, triceps, suprailiac, subscapular) were obtained by the same investigator using a Harpenden skinfold caliper (Lange, Cambridge, MA, USA). Skinfold thickness was then used to calculate body fat percentage using the techniques of Durnin and Womersley.<sup>22</sup> Lean body mass (LBM) was measured as the difference between body mass and fat mass.

#### 2.2.4. Maturity

For each participant, somatic maturity was estimated by predicting years from attainment of peak height velocity (Y-PHV), via a gender-specific equation that included anthropometric measures (weight, height, leg length, sitting height).<sup>23</sup>

#### 2.2.5. Health-related fitness testing

It has been reported that physical fitness represents a useful health marker in childhood and adolescence, which reinforces the need to include physical fitness testing in health monitoring systems.<sup>24</sup> All participants were familiar with the test protocols. All physical tests were performed under the same conditions and time of day and presented in a random manner after brief dynamic warm-up activities and included the evaluation of the aerobic fitness, sprint, flexibility, jump, and balance.

**2.2.5.1. Aerobic fitness.** Aerobic fitness was evaluated using the Yo-Yo intermittent recovery test (IRT) level 1.<sup>25</sup> The test consisted of repeated runs back and forth between markers placed 20 m apart at progressively increasing speeds controlled by an audio player. Participants recovered 10 s between every 40-m bout. The test was completed when the participant twice

failed to maintain the running pace or reached voluntary exhaustion. Participants wore HR monitors (Polar S-810; Polar-Electro) during testing to measure  $HR_{peak}$ . A recent study conducted by Póvoas and colleagues<sup>26</sup> demonstrated that Yo-Yo IRT performances and  $HR_{peak}$  are reliable for 9-16-year-old soccer players and non-athlete boys.

**2.2.5.2. Sprinting.** Sprint performance was evaluated with 10- and 20-m sprints. The subjects started in a standing position and performed 2 maximal 20-m sprints (with 10-m split time) using electronic timing gates (Brower Timing Systems, Salt Lake City, UT, USA; accuracy of 0.01 s).

**2.2.5.3. Flexibility.** The sit-and-reach test was used to evaluate flexibility. Using a static box with a tape measure, participants sat with their legs straight (extended) and their feet flat against the sit-and-reach device.<sup>27</sup> They exhaled and stretched forward as far as possible with one hand over the other and finger tips in line and held the endpoint for 2 s. This process was repeated twice and the better score was used for analysis.

**2.2.5.4. Jumping.** Jumping performance was evaluated using 2 different jumps. A countermovement jump (CMJ) was used to assess vertical jump height using an Optojump (Microgate, Bolzano, Italy). Participants were instructed to jump as high as possible while keeping their hands on their hips. Visual inspection was used to ensure that each landing was without any leg flexion. Horizontal jumping was assessed with the bilateral standing long jump (SLJ) using a metal tape measure.<sup>28</sup> Participants were instructed to jump as far as possible horizontally with 2 legs. Two repetitions were allowed for each jump and the best value was used for analysis.

**2.2.5.5. Postural balance.** Postural balance was assessed using the stork balance test.<sup>29</sup> Participants stood with hands on hips and the opposite foot against the inside of the supporting knee. Participants were instructed to raise the heel from the floor on the command and maintain balance for as long as possible. The trial ended if the heel touched the floor, the ball of the stance foot moved from its original position, or participants moved their hands from the hips. The test was performed twice and timed using a stop watch, with the better score used for analysis.

### 2.3. Statistical analyses

Statistical analyses were processed using SPSS Version 16.0 (SPSS Inc., Chicago, IL, USA). Data are expressed as mean  $\pm$  standard deviation (SD) and the level of significance was  $p < 0.05$ . The assumption of normality was verified using the Kolmogorov-Smirnov test. Test-retest reliability of the measures was assessed using the intraclass correlation coefficient (ICC) and the coefficient of variation (CV). For the Purposes 1 and 2, the difference between untrained and adolescent soccer players, and the difference between 3v3 and 6v6 were determined using independent Student's *t* tests and Cohen's *d* effect sizes.<sup>30</sup> For the intervention part (Purpose 3), data were assessed using ANCOVA with the baseline values and the somatic maturity (i.e., PHV) used as covariates to control for baseline imbalances between the control and intervention groups. Furthermore, analyses of between-group changes were processed using an approach based on the magnitudes of change called magnitude-based inferences (Hopkins, 2006).<sup>31</sup> Quantitative changes of beneficial or better vs. detrimental or poorer effects were assessed qualitatively as follows:  $< 1\%$ , almost certainly not;  $1\%$  to  $5\%$ , very unlikely;  $> 5\%$  to  $25\%$ , unlikely;  $> 25\%$  to  $75\%$ , possible;  $> 75\%$  to  $95\%$ , likely;  $> 95\%$  to  $99\%$ , very likely;  $> 99\%$ , almost certain. If the chance of having beneficial or better vs. detrimental or poorer performances were both  $> 5\%$ , the true difference between groups was assessed as unclear. The clinical inference was used, with the default probabilities for declaring an effect

clinically beneficial being  $< 0.5\%$  (most unlikely) for harm and  $> 25\%$  (possibly) for benefit. Cohen's *d* effect sizes were also calculated to determine the magnitude of the group differences in health-related physical fitness. Threshold values for Cohen's *d* statistics were  $< 0.25$ ,  $0.25-0.50$ ,  $\geq 0.50-1$ , and  $> 1$  for trivial, small, moderate, and large, respectively.<sup>30</sup>

## 3. Results

### 3.1. Purpose 1: untrained adolescents vs. adolescent soccer players

Table 1 shows the anthropometric and physical fitness characteristics of the trained and untrained groups. Differences in body composition and health-related physical fitness in adolescent soccer players vs. untrained group are presented in Table 2. For body composition, the trained adolescents had higher body mass (percentage of difference:  $18.1\%$ ,  $ES = 1.60$ ), height ( $6.8\%$ ,  $ES = 1.80$ ), and LBM ( $15.6\%$ ,  $ES = 1.54$ ) than the untrained adolescents. There was no significant difference in BMI or percentage of body fat (small effects). For physical fitness, the trained adolescents performed better at 20-m sprints ( $4.7\%$ ,  $ES = 1.00$ ), CMJ ( $13.9\%$ ,  $ES = 0.89$ ), SLJ ( $10.1\%$ ,  $ES = 0.95$ ), postural balance ( $59.6\%$ ,  $ES = 1.1$ ), and Yo-Yo IRT ( $57.4\%$ ,  $ES = 1.82$ ) than their counterparts. No significant difference was observed for the 10-m sprint performance and flexibility (small effect) (Table 2).

### 3.2. Purpose 2: training intensity, RPE, and enjoyment

For the intervention group, mean HR and RPE during training were  $140 \pm 14$  bpm and  $4.2 \pm 1.3$  AU (arbitrary unit), respectively. The mean HR obtained corresponded to  $84.6\% \pm 6.3\%$   $HR_{peak}$ . No significant differences (all  $p > 0.05$ ) in RPE, average HR, and PACES were found when comparing 4v4 and 6v6 forms) (Fig. 2).

Table 2  
Differences in body composition and health-related physical fitness in adolescent soccer players vs. untrained group.

	Untrained boys ( $n = 24$ )	Soccer players ( $n = 17$ )	Difference (%)	<i>p</i>	ES	Magnitude
Body mass (kg)	$52.9 \pm 6.4$	$62.4 \pm 5.6$	$18.1^*$	$< 0.001$	1.60	L
Height (m)	$1.60 \pm 0.10$	$1.70 \pm 0.10$	$6.8^*$	$< 0.001$	1.80	L
BMI	$20.0 \pm 1.6$	$20.7 \pm 1.7$	3.6	0.18	0.44	S
BF (%)	$14.2 \pm 1.9$	$15.3 \pm 1.1$	7.5	0.05	0.69	M
LBM (kg)	$45.4 \pm 4.8$	$52.5 \pm 4.5$	$15.6^*$	$< 0.001$	1.54	L
10 m sprint (s)	$1.9 \pm 0.2$	$1.9 \pm 0.1$	3.6	0.10	0.45	S
20 m sprint (s)	$3.4 \pm 0.2$	$3.2 \pm 0.1$	$4.7^*$	$< 0.001$	1.00	M
CMJ (cm)	$27.7 \pm 3.8$	$31.5 \pm 4.8$	$13.9^*$	0.01	0.89	M
SLJ (m)	$1.8 \pm 0.1$	$2.0 \pm 0.2$	$10.1^*$	0.01	0.95	M
Flexibility (cm)	$3.5 \pm 7.4$	$4.7 \pm 6.0$	37.2	0.50	0.20	T
Postural balance (s)	$4.7 \pm 1.2$	$7.5 \pm 3.3$	$59.6^*$	0.001	1.11	L
Yo-Yo IRT (m)	$662 \pm 157$	$1042 \pm 249$	$57.4^*$	$< 0.001$	1.82	L

\*  $p < 0.05$ , significant difference between the 2 groups.

Abbreviations: BF = body fat; BMI = body mass index; CMJ = counter movement jump; ES = effect size; IRT = intermittent recovery test; L = large; LBM = lean body mass; M = moderate; S = small; SLJ = standing long jump; T = trivial.

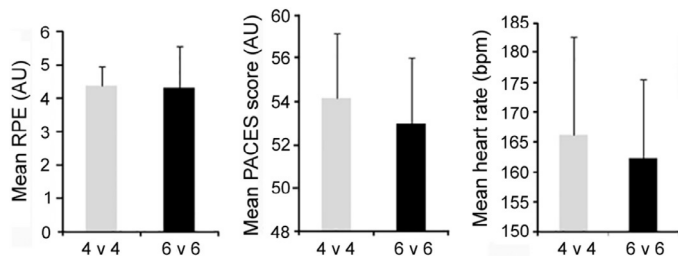


Fig. 2. Ratings of perceived exertion (RPE, arbitrary unit), Physical Activity Enjoyment Scale (PACES, arbitrary unit), and mean heart rate after completing the small-sided games of 4 v 4 ( $\times 3$ ) and 6 v 6 ( $\times 3$ ) with no significant differences (all  $p > 0.05$ ) between the 2 forms.

### 3.3. Purpose 3: effects of 8 weeks of recreational soccer training

Table 3 demonstrates the health-related physical fitness characteristics before the intervention and the percentage of change for each group and for the difference in changes between the groups. Over 8 weeks, the between-group analysis revealed that the ING had a large beneficial effect only on balance when compared with CON with unclear effects on other fitness parameters.

## 4. Discussion

The present study examined (1) the health-related physical fitness profiles of untrained adolescents in comparison to adolescent soccer players; (2) the effects of player number during small-sided games on HR, RPE, and enjoyment responses; and (3) the potential effects of short-term recreational soccer in a group of untrained adolescents. The main findings were that adolescent soccer players had markedly greater performances in almost all the health-related physical fitness measures as compared with untrained counterparts. Moreover, small-sided games using 6v6 or 4v4 elicited high and similar HR and enjoyment responses. Over a short-term intervention period, the *between group* analysis revealed that regular soccer

training had a large beneficial effect on balance when compared with control group, with unclear effects on other fitness parameters.

Health-related physical fitness refers to specific components of physical fitness, such as body composition, cardiorespiratory fitness, flexibility, and muscular fitness.<sup>32</sup> Today, health-related physical fitness is considered one of the most important health markers as well as a predictor of morbidity and mortality in relation to cardiovascular disease.<sup>24</sup> Moreover, Ortega and colleagues<sup>24</sup> demonstrated that physical fitness has already represented a useful health marker in childhood and adolescence, reinforcing the need to include health-related physical fitness testing in health monitoring systems dealing with youth. Thus far, however, the health-related physical fitness profiles of adolescent soccer players compared to untrained age-matched adolescents have been inconclusive. In the present study, we demonstrated that trained adolescents had significantly and markedly higher physical fitness levels compared with an untrained age-matched group. Major differences were seen in aerobic fitness, jump and sprint performance, as well as flexibility and balance. The finding that the trained adolescents were taller and had greater LBM than the untrained adolescents may in part explain the differences in strength-related fitness, such as jump and sprint performance, but not the differences in aerobic fitness and flexibility. These results support findings showing that 14-year old players who successfully audition for a select team were taller, heavier, leaner, and faster compared with players not selected.<sup>33</sup> The characteristics of soccer training, such as the intense actions and change of movement direction, and the high-intensity runs that occur during training and match play, may provide the main explanation for the high physical fitness level reported in adolescent soccer players. This finding suggests that regular soccer training should be encouraged in children and young inactive adolescents for improvements in health-related physical fitness.

Recently, recreational soccer has emerged as a feasible and efficacious strategy for increasing health-related fitness in

Table 3  
Outcome measures with effect statistics and qualitative inferences for within- and between-group comparisons.

	ING ( $n=10$ )			CON ( $n=10$ )			Group comparison (ING–CON)		ICC (95%CI)	CV (%)
	Pre (mean $\pm$ SD)	% $\Delta$	Qualitative inferences	Pre (mean $\pm$ SD)	% $\Delta$	Qualitative inferences	% Difference (90%CI)	Qualitative inferences		
10 m sprint (s)	1.9 $\pm$ 0.2	–3.7	S +ve*	1.9 $\pm$ 0.1	2.1	Un	–2.4 (–9.4 to 4.6)	Un	0.97 (0.91 to 0.99)	1
20 m sprint (s)	3.4 $\pm$ 0.2	–4.1	M +ve†	3.4 $\pm$ 0.1	0.9	Un	–2.8 (–6.7 to 1.1)	Un	0.92 (0.79 to 0.97)	2
CMJ (cm)	28.0 $\pm$ 3.6	1.7	Un	28.4 $\pm$ 4.8	–0.5	Un	1.1 (–5.3 to 7.5)	Un	0.76 (0.20 to 0.94)	4.3
Long jump (m)	1.8 $\pm$ 0.1	3.8	M +ve#	1.8 $\pm$ 0.1	3.1	Un	0.4 (–4.9 to 5.7)	Un	0.81 (0.58 to 0.92)	3.1
Flexibility (cm)	3.4 $\pm$ 9.0	17.1	Un	2.8 $\pm$ 7.6	3.9	Un	–5.4 (–66.3 to 55.4)	Un	0.96 (0.89 to 0.98)	2.3
Balance (s)	4.6 $\pm$ 1.4	17.0	S +ve#	4.3 $\pm$ 1.0	–26.1	M –ve#	44.8 (7.0 to 81.0)	L +ve#	0.50 (–0.90 to 0.87)	19.1
Yo-Yo IRT (m)	670 $\pm$ 140	30.9	L +ve†	630 $\pm$ 66	27.5	M +ve†	11.9 (–10.1 to 34.0)	Un	–	–

\* >25%–75%, possible.

# >75%–95%, likely.

† >95%–99.5%, very likely.

Abbreviations: CI = confidence interval; CMJ = counter movement jump; CON = control group; CV = coefficient of variation; ICC = intraclass correlation coefficient; ING = intervention group; IRT = intermittent recovery test; L = large; M = moderate; Pre = before intervention; S = small; SD = standard deviation; Un = unclear; +ve = positive effects compared with baseline or control group; –ve = negative effects compared with baseline or control group; % $\Delta$  = percent changes between initial and final measurement.

adult populations.<sup>34,35</sup> When we exposed untrained adolescents to short-term soccer-based training, there was a marked positive between-group effect on postural balance, but an unclear effect on 10-m sprint, 20-m sprint, CMJ, SLJ, flexibility, and Yo-Yo IRT performance when compared with controls (Table 3). The between-group effect on balance was highly significant despite poor reliability of the test (Table 3). For sprint and jump performance, the within-group analyses showed improvements similar or slightly lower than data reported in RCT studies for young adults and untrained adults<sup>17,34</sup> that included more participants and longer training periods (12-40 weeks) than the present study. Hence, the lack of between-group differences in most of the physical tests may be linked to sample size and to the short training period. The only study in which the effects of recreational soccer in adolescents were investigated showed that obese adolescents improve their health markers ( $\text{VO}_{2\text{max}}$ , body composition, blood pressure) after a 12 week recreational soccer program.<sup>12</sup> It has been reported that the positive effects of recreational soccer can be explained by the high exercise intensity achieved during training.<sup>36</sup> In the present study, the mean HR was 84.6% of  $\text{HR}_{\text{peak}}$ , a value that is comparable to that obtained in adult participants, where HR generally exceeded 80% of  $\text{HR}_{\text{max}}$ .<sup>35</sup> In addition to the high exercise intensity, recreational soccer represents an odd-impact physical activity that involves intense actions and movements in different directions. Further studies should explore the effectiveness of recreational soccer training on physical fitness in untrained adolescents over longer training periods and with a larger sample size.

Importantly, concomitantly to the high HR achieved during training, RPE scores were relatively low in comparison to other training forms, such as steady-state aerobic exercise on a cycle ergometer, or high-intensity resistance training performed at the same intensity.<sup>37</sup> This observation is similar to previous studies in untrained adults<sup>8</sup> and may be due to the high level of interest and motivation and the degree of enjoyment shown by the participants. This study was conducted in a country where soccer is the most popular sport (objective measure: higher number of licenses; subjective judgment: the time given to soccer in the media), and thus, the enjoyment of practicing a sport may be linked to its social importance. We also compared physiological and enjoyment responses to small-sided games with few players (4v4) versus more players (6v6). There were no significant differences in HR responses, RPE and enjoyment between the 2 forms. High-intensity interval training has also been shown to be a promising training protocol for increasing exercise enjoyment and promoting exercise adherence in sedentary young adults.<sup>38</sup> Thus, future research should compare the effects of recreational soccer with high-intensity interval training on health-related physical fitness and enjoyment in children and adolescents.

## 5. Conclusion

We showed that adolescent soccer players have superior health-related physical fitness profiles compared to an

untrained age-matched group. Small-sided soccer games practiced by untrained adolescents elicited high exercise intensity and enjoyment, with no differences between 6v6 and 4v4 forms. Moreover, 8 weeks of regular soccer training resulted in improved balance, whereas no other between-group differences were observed with short-term soccer training. Future studies with more participants and longer training periods are required to elucidate the effects of small-sided soccer in male adolescents.

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## Authors' contributions

AH conceived of the study design, carried out the data collection and analysis, interpreted the study results, and drafted the manuscript; MBR interpreted the study results and edited the manuscript; SK, MR carried out data collection and edited the manuscript; KC interpreted the study results and edited the manuscript; EB, ZT conceived of the study design, applied for funding, interpreted the study results, and edited the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

## Competing interests

The authors declare that they have no competing interests.

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