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Research article

Effect of 8 Weeks Soccer Training on Health and Physical Performance in Untrained Women

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Abstract
This study aims to analyze the physiological, neuromuscular, and biochemical responses in untrained women after eight weeks of regular participation in small-sided soccer games compared to aerobic training. Twenty-seven healthy untrained women were divided into two groups [soccer group (SG = 17) and running group (RG = 10)]. Both groups trained three times per week for eight weeks. The variables measured in this study were maximal oxygen uptake (VO_2max), relative velocity at VO_2max (vVO_2max), peak velocity, relative intensity at lactate threshold (vLT), relative intensity at onset of blood lactate accumulation (vOBLA), peak force, total cholesterol, HDL, LDL, triglycerides, and cholesterol ratio (LDL/HDL). VO_2max, vLT, and vOBLA increased significantly in both groups (12.8 and 16.7%, 11.1 and 15.3%, 11.6 and 19.8%, in SG and RG respectively). However, knee extensors peak isometric strength and triglyceride levels, total cholesterol, LDL, and HDL did not differ after eight weeks of training in both groups. On the other hand, the LDL/HDL ratio significantly reduced in both groups. In conclusion, eight weeks of regular participation in small-sided soccer games was sufficient to increase aerobic performance and promote health benefits related to similar aerobic training in untrained adult women.

Key words: Soccer training, aerobic training, physical fitness, health, aerobic fitness.

Introduction

Many sports such as soccer, have received a growing interest from sports scientists and governments around the world as a popular option for promoting physical activity and health in children, youth, men, women and the elderly; including minorities (Hammami et al, 2016; Milanovic et al., 2015; Parnell et al., 2016). Soccer is a global phenomenon with approximately 270 million practitioners (FIFA, 2015), and can be used as a channel for promoting health and the prevention of chronic diseases caused by physical inactivity (Krustrup et al., 2010a). Whereas only 10% of people who play soccer are women (FIFA, 2015), many perceive that there is potential for the sport to grow in popularity among women (Krustrup et al., 2010a).

From this perspective, systematic soccer practice among untrained women can be an alternative and effective recreational mode to improve aerobic fitness, in comparison to traditional training such as running and cycling (Krustrup et al., 2010b). Soccer, unlike continuous modalities, is an intermittent sport that allows alternating intensity during its practice, in which many actions are performed with and without changes in direction (Jakobsen et al., 2011).

In addition, most decisive moments (i.e., sprints, dribbling, and jumps) are performed at high intensity, which consequently causes high musculoskeletal system demand (Stolen et al., 2005). These overloads can generate significant adaptations that would improve physical performance (Hoff and Helgerud, 2004) and mechanical properties in bone tissue (Helge et al., 2010; Robling et al., 2002).

Studies regarding small-sided soccer games (i.e., 5x5, 6x6, 7x7, and 8x8) have been proposed in order to evaluate the training effect on physical fitness and health levels (Knoepfli-Lenzin et al., 2010; Krustup et al., 2010c), muscle strength and power (Bangsbo et al., 2010; Sundstrup et al., 2010), mineral bone density (Helge et al., 2010; Pedersen et al., 2009), and biochemical adaptations (Andersen et al., 2010; Randers et al., 2010) in untrained subjects. Most of the studies comparing untrained individuals during aerobic training and soccer practice in small-sided games have used intervention periods higher than or equal to 12 weeks (Bangsbo et al., 2010; Helge et al., 2010; Knoepfli-Lenzin et al., 2010; Randers et al., 2010). However, some studies have compared skilled youth soccer players during small-sided games versus high-intensity intermittent training (Dellal et al., 2012) and generic fitness training (Hill-Hass et al., 2009) over six and seven-week periods, respectively. Results showed that the three types of training were equally effective and induced similar effects.

In this context, we hypothesized that small-sided soccer games performed in a short period of time may be similarly effective as treadmill aerobic exercise training for untrained subjects. To the best of our knowledge, there is no study relating the effects of two different training models (i.e., soccer and treadmill running) on aerobic functional indices (velocities at VO_2max, lactate threshold and OBLA), and neuromuscular and biochemical variables in untrained women. Besides that, few studies have used the blood lactate concentration to set the endurance training zones (intensity domains) during treadmill running.

The study aims to analyze the physiological,

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neuromuscular, and biochemical responses after eight weeks of regular participation in small-sided soccer games compared to aerobic training in untrained women.

Methods

Participants

Twenty-seven healthy untrained women were separated into two groups: soccer [SG (28.8 ± 3.6 years old)] and running group [RG (27.1 ± 4.7 years old)]. The participants were non-smokers, were not using any medication, and had not practiced regular physical activity for at least three months prior to interview. Prior to any testing all participants were familiarized with the experimental procedures and informed of the associated risks and benefits of participation. All participants signed an informed consent term in agreement with the Committee of Ethics in Research with Humans of the institution where this study was conducted (P2046, FR429396).

Experimental design

All participants were at a similar level of fitness prior to the start of the training program and were divided according to individual interest in each type of modality. Small-sided training sessions were conducted on an artificial grass soccer field and aerobic training on a treadmill. Three individuals in the SG had no previous experience with soccer and one participant from RG did not complete the study for personal reasons. The subjects were evaluated before and after the training intervention through laboratory tests (anthropometry and body composition, maximal incremental treadmill test, strength test, and blood samples test). There were no significant differences between the two groups in pre-intervention values for age, body mass, body fat percentage and maximal oxygen uptake (VO_2max).

Intervention training

The intervention training was performed three times per week for eight consecutive weeks without interruption. Only the subjects who participated in at least 80% of the training sessions were included in the study. Soccer sessions consisted of matches in a small-sided format of 7x7 or 8x8, with field dimensions of 55 m x 40 m. The running sessions were performed on a motorized treadmill (LT160 Movement, Brazil) using continuous and interval methods at low (lactate threshold - LT) and high intensity (onset of blood lactate accumulation - OBLA) (Heck et al., 1985). On Monday and Friday, RG exercised for 50 minutes, in which 25 minutes was divided into five sets of 5 minutes at an intensity corresponding to OBLA, with passive recovery periods of 1 minute. The initial and final 10 minutes were performed continuously at the intensity corresponding to LT. On Wednesday, RG trained continuously for 50 minutes at the intensity corresponding to LT (Figure 1). Individual work intensity was increased by 5% every two weeks for RG.

Tests and protocols

Anthropometry and body composition: Body mass and height were measured with an electronic scale (Toledo, Brazil) to the nearest 100 g and with a wall stadiometer (Sanny, Brazil) to the nearest 1 mm, respectively. Body mass and height were calculated using body mass index (BMI = body mass/height^2). All anthropometric measurements were obtained by a single evaluator anthropometrist, according to the protocols of the International Society for the Advancement of Kinanthropometry. The skinfolds of suprailiac regions, calf and subscapular were measured with a scientific skinfold caliper (Cescorf, Brazil). Body density and body fat percentage were estimated using the equation developed by Siri (1961).

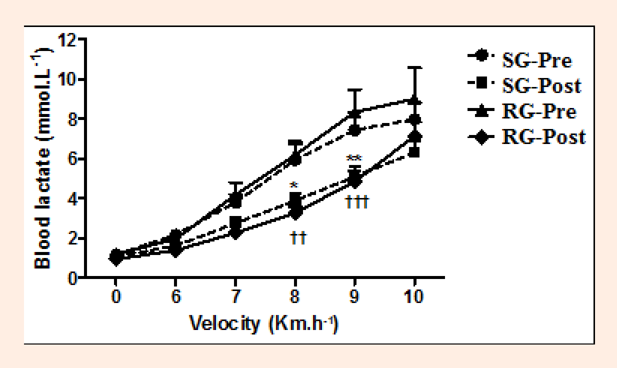

Figure 1. Blood lactate behavior for kinetics during incremental test. SG = soccer group, RG = running group, Pre = period before intervention and Post = period after intervention. Blood lactate is expressed as mmol·L^{-1} and presented as mean ± S.E.M. * $p < 0.05$ and ** $p < 0.01$ when compared pre and post in SG and †† $p < 0.01$ and ††† $p < 0.001$ in RG by two-way analysis of variance (ANOVA) followed by Bonferroni's multiple comparison test.

Incremental treadmill test: An incremental maximal running test was conducted on a motorized treadmill (Imbramed Millenium Super ATL, 10.200, Brazil). to determine VO_2max, velocity relative to VO_2max (vVO_2max), peak velocity (PV), velocity relative to LT (vLT), and OBLA (vOBLA) The treadmill was set at 1% gradient with an initial starting speed of 6.0 km·h^{-1}, which was subsequently increased by 1.0 km·h^{-1} every 3 minutes with 30-second intervals for blood sampling to obtain the subsequent blood lactate measurement. The test was performed until volitional exhaustion. All subjects were verbally encouraged to exert maximal effort during the test. Oxygen consumption (VO_2) was measured breath-by-breath using an automated open circuit gas analyzer (Quark PFT Ergo, Cosmed, Rome, Italy). Heart rate (HR) was measured throughout the test (Wireless HR monitor, Cosmed, Rome, Italy).

Determination of LT and OBLA: Between each stage of the incremental test, 25 μL of arterial blood was collected from the ear lobe to determine the lactate concentration ([La]) using an electrochemical analyzer (YSI 2700 STAT®, Yellow Springs, Ohio, EUA). LT was determined as the intensity corresponding to the fixed concentration of 2.0 mmol·L^{-1} and OBLA was determined by linear interpolation; adopting a fixed lactate concentration of 3.5 mmol·L^{-1} (Heck et al., 1985).

Strength test: Force was recorded from the right leg using a machine, which included a chair, during three knee extension isometric contractions (TRG Fitness, Brazil). A load cell (Primax, BTS model, Brazil), with measuring tension capacity of 200 kgf, was attached to the equipment in order to acquire the force signal using a four channel Miotool 200/400 system (Miotec Biomedical, Brazil). The knee angle was fixed for all subjects at 60º (0º = full extension). Subjects were asked to perform three 5-second maximal voluntary contraction trials, with a 2-minute rest. Subjects were strongly encouraged during the trial, and the best result was used for further analysis.

Biochemical analysis: The venous blood samples were collected in heparinized tubes after 12 hours of fasting. Plasma was separated from whole blood by centrifugation at 3000 rpm for 10 minutes and stored at -80°C for later analysis. The levels of total cholesterol (TCHO), high-density lipoprotein cholesterol (HDL), and triglycerides (TG) were determined by enzymatic assays using diagnostic kits and following the manufacturer's instructions (Labtest Diagnóstica, Lagoa Santa, Brazil). The level of low-density lipoprotein cholesterol (LDL) was calculated from the following equation: TCHO - (HDL + TG/5).

Statistical analyzes

Data are presented as mean ± standard deviation. Normality was assessed by the Shapiro Wilk test. When data were normally distributed, parametric statistics were used. However, when data were not normally distributed, we adopted the "logarithmic transformation of the data" procedure. The mixed model ANOVA was used to compare the variables before and after the intervention period for repeated measures. When the time effect was significant, data were subsequently analyzed using post-hoc Bonferroni. The effect size (ES) was calculated between each pair of measurements according to Cohen (1988). To classify the magnitude of ES the criteria established by the guidelines of Batterham and Hopkins (2006) was adopted: trivial (< 0.2), small (≥ 0.2 – 0.6), moderate (≥ 0.6 – 1.2), large (≥ 1.2 – 2.0), and very large (≥ 2.0). The statistical program SPSS (version 17.0 for Windows; SPSS, Inc., IL, Chicago, USA) and the significance level of 5% was used for all analyzes.

Results

No significant differences were observed for body mass, BMI, and %BF ($p > 0.05$) after the intervention period in both groups (Table 1).

Table 2 shows the absolute and normalized results of physiological variables (velocities at VO_2max, peak, LT, and OBLA) and peak force for both groups during pre- and post-intervention. There was a significant increase between pre- and post-intervention in SG and RG for VO_2max (12.8% and 16.7%), VO_2 at LT (37.7% and

Table 1. Mean (±SD) anthropometric characteristics of the subjects in both soccer and running groups before and after 8-week exercise intervention protocol (n = 27).

	Soccer Group			Running Group		
	Pre	Post	ES	Pre	Post	ES
BM (kg)	63.1 (9.5)	63.9 (9.6)	.1	55.2 (4.9)	55.6 (4.9)	.1
Height (cm)	1.65 (.06)	1.65 (.06)	.0	1.63 (.05)	1.63 (5.2)	.0
BMI (kg/m^2)	23.7 (2.9)	23.4 (2.8)	.1	20.7 (1.7)	20.9 (1.7)	.1
%BF (%)	27.2 (4.4)	27.4 (4.5)	.1	27.1 (4.3)	24.5 (4.7)	.1

BM = body mass; BMI = body mass index; %BF = percentage of body fat; ES = effect size.

Table 2. Mean (±SD) physiological responses, velocity at different training intensities and peak force in both soccer and running groups, before and after 8-week exercise intervention protocol.

	Soccer Group			Running Group		
	Pre	Post	ES	Pre	Post	ES
VO_2max (ml·kg^{-1}·min^{-1})	37.0 (6.4)	41.4 (6.0)*	.7	36.5 (6.2)	42.2 (5.5)*	1.0
VO_2@LT (ml·kg^{-1}·min^{-1})	20.6 (6.3)	28.4 (6.0)**	1.2	25.5 (4.4)	31.3 (4.7)**	1.3
VO_2@OBLA (ml·kg^{-1}·min^{-1})	27.2 (6.8)	34.7 (7.8)***	1.0	27.7 (6.5)	36.4 (5.3)***	1.5
%VO_2@LT (%)	59.7 (13.4)	68.3 (10.6	.7	70.1 (6.0)	74.3 (7.9)	.6
%VO_2@OBLA (%)	76.8 (9.3)	83.0 (12.9)*	.6	79.5 (9.9)	87.2 (8.6)*	.8
$[La]_{PEAK}$ (mmol·L^{-1})	10.3 (2.3)	9.8 (2.2)	-.2	9.5 (1.9)	8.5 (1.5)	-.5
HR_{MAX} (bpm)	189 (7)	186 (6)	-.9	193 (4.7)	189 (9)	-.3
HR_{LT} (bpm)	127 (23)	134 (14)	.4	128 (27)	136 (20)	.3
HR_{OBLA} (bpm)	164 (13)	164 (2)	.0	163 (15)	172 (12)	.7
%HR_{LT} (bpm)	67.3 (11.9)	70.5 (6.6)	.3	66.2 (13.6)	70.3 (9.9)	.4
%HR_{OBLA} (bpm)	85.7 (5.9)	85.7 (7.0)	.0	84.4 (7.0)	88.8 (5.4)	.7
vVO_2max (km·h^{-1})	10.6 (1.6)	11.4 (1.5)*	.5	9.2 (.9)	10.2 (.9)*	1.0
PV (km·h^{-1})	11.2 (1.7)	11.9 (1.6)*	.4	9.9 (.6)	11.5 (.6)*	2.3
vLT (km·h^{-1})	6.1 (.7)	6.7 (.9)**	.8	6.0 (.8)	7.0 (1.2)**	.9
vOBLA (km·h^{-1})	7.24 (1.1)	8.1 (1.5)**	.6	7.1 (1.1)	8.4 (1.1)**	1.2
Peak Force (kgf)	90.5 (15.5)	99.4 (21.1)	.3	68.2 (19.0)	74.7 (21.6)	0.3

VO_2max = maximal oxygen uptake; VO_2@LT = VO_2 at the lactate threshold; VO_2@OBLA = VO_2 at the onset of blood lactate accumulation; %VO_2@LT = percent of VO_2max at the lactate threshold; %VO_2@OBLA = percent of VO_2max at the onset of blood lactate accumulation; $[La]_{PEAK}$ = peak of lactate; HR_{MAX} = maximal heart rate; HR_{LT} = heart rate at the lactate threshold; HR_{OBLA}=heart rate at the onset of blood lactate accumulation; %HR_{LT} = percent of heart rate at the lactate threshold; %HR_{OBLA} = percent of heart rate at the onset of blood lactate accumulation; vVO_2max = velocity associated with VO_2max; PV = peak velocity; vLT = velocity at the lactate threshold; vOBLA = velocity at the onset of blood lactate accumulation; ES = effect size. * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$ to Intra-group comparison (pre vs. post); * $p < 0.05$ to † Inter-group comparison.

Table 3. Mean (±SD) biochemical parameters in both soccer and running groups before and after 8-week exercise intervention protocol (n = 27).

	Soccer Group			Running Group		
	Pre	Post	ES	Pre	Post	ES
TGL (mg/dL)	84.1 (23.8)	85.2 (33.4)	.0	74.9 (20.0)	69.98 (20.1)	-.3
TCHO (mg/dL)	184.3 (33.2)	190.4 (29.3)	.2	184.5 (16.5)	170.4 (17.9)	.8
HDL (mg/dL)	75.5 (11.6)	80.6 (18.3)	.3	67.0 (12.8)	72.5 (13.6)	.4
LDL (mg/dL)	91.9 (26.2)	91.9 (18.0)	.0	67.0 (12.8)	67.0 (12.8)	-1.1
LDL/HDL (mg/dL)	1.24 (.3)	1.19 (.4)*	-.1	1.59 (.5)	1.26 (.3)*	-.9

TGL = triglycerides; TCHO = total plasma cholesterol; HDL = high density lipoprotein; LDL = low density lipoprotein; ES = effect size.

22.7%) and OBLA (27.6 and 31.4%), percent of VO_2max at OBLA (8.1% and 9.7%), velocity associated with VO_2max (7.5% and 10.7%), peak velocity (6.2% and 16.2%), velocity at LT (9.8% and 16.7%) and at OBLA (12.5% and 18.3%). No differences were observed for the lactate peak, heart rate at LT and at OBLA (absolute and normalized), and peak force between pre- and post-intervention in both groups ($p > 0.05$).

The results regarding the biochemical variables are presented in Table 3. No significant differences were observed for TGL, TCHO, LDL, and HDL when comparing pre- and post-intervention in both groups. However, the LDL/HDL ratio declined significantly after the training period for both groups (4% and 20.7% in SG and RG, respectively, $p < 0.05$).

Discussion

The study aims to analyze the physiological, neuromuscular, and biochemical responses after eight weeks of regular participation in small-sided soccer games compared to aerobic training in untrained women. Our findings support the hypothesis that soccer practice performed in small-sided games during a short period of time may be similarly effective as aerobic exercise training on a treadmill for untrained women. Besides health benefits, it is worth noting that soccer has an important social and recreational aspect that allows a more pleasurable experience compared to traditional exercise (i.e., running) (Ottesen et al., 2010).

The positive adaptations observed for physiological (i.e., VO_2max, vVO_2max, PV, vOBLA, vLT, and blood lactate) and biochemical variables (i.e., LDL/HDL ratio) occurred earlier compared to most of the previous studies (Table 2). Improvements in VO_2max after eight weeks of regular training may be related to (i) the number of weekly sessions (3 times per week), (ii) exercise intensity in the heavy domain; which is often associated with OBLA (~ 90% HRmax) for both groups, and (iii) an increase in oxygen supply and oxygen utilization by the active muscles, followed by an increase in capillarity and mitochondrial density (Holloszy and Coyle, 1984). According to Caritá et al. (2013), when exercise is performed in heavy domain intensity it is more sensitive to changes determined by aerobic fitness level. When a high physiological adaptation level is expected, the adaptations seem to depend on the training specificity principle.

Furthermore, the training-induced improvement magnitudes in VO_2max, PV, LT, and OBLA seem to depend on factors such as stimulus (intensity, duration and frequency training program), initial fitness level, and individual genetic potential (Larsen and Jenkins, 2002). During the intervention period, intensity was monitored in both groups, but only controlled individually for RG using individual subject vLT and vOBLA. Both groups showed a similar improvement for VO_2max and the increasing percentage observed was higher than the value found in untrained men after 12 weeks (Andersen et al., 2010; Randers et al., 2010) and 16 months of soccer training (Krustup et al., 2010b). Moreover, our results are in line with improvements observed by Bangsbo et al. (2010) in a study involving healthy untrained premenopausal women after 16 weeks intervention.

The average HR during the training period was 86.9 and 82.2% of HRmax for SG and RG, respectively. Therefore, this suggests that the soccer practice performed in the small-sided games format (7x7 and 8x8) increased demand on the cardiovascular system similar to aerobic training running mode. In addition, HR average values for SG in the present study were higher compared to recreational soccer matches observed by Randers et al. (2010), in which the HR average remained at approximately 80% of HRmax. In the present study, positive effects observed after eight weeks may be related to the intensity performed during training period, which remained at the intensity relative to the heavy domain intensity (Caritá et al., 2013). The lowest percentage values of the HRmax observed for RG is due to intensity control, which ranged between LT and OBLA. On the other hand, the highest intensity observed for SG is possibly due to high displacement of the players on the soccer field. In the present study, the players had a larger area to cover (137 m^2 and 157 m^2 for 7x7 and 8x8, respectively) compared to the other study (125 m^2 and 150 m^2, for 4x4 and 5x5, respectively) (Randers et al., 2010).

In relation to the increase observed for vLT and vOBLA in both groups, we suggest that neuromuscular demand due to an increasing individual work intensity in running training and the highest displacement in the soccer pitch required a high intensity associated with peripheral factors that could induce an increase in these physiological parameters (Dubouchaud et al., 2000). Moreover, improvement observed in aerobic capacity may be related to mechanisms that control lactate metabolism, ability to produce and remove lactate at a given running speed (Messonnier et al., 2002) and peripheral factors (i.e., muscle fiber type, capillary density, and the number of mitochondria) (Creer et al., 2004). In addition, the highest capacity for lactate removal may be related to the increased lactate transporter isoforms MCT1 and MCT4 that appear susceptible to aerobic training (Dubouchaud et al., 2000). Another possible explanation for the increase observed in vLT and vOBLA is due to a possible increase in capillary density which occurred during the eight weeks of training in both groups (Messonnier et al., 2002). The vLL and vOBLA values of the present study are consistent with previous studies that have investigated these physiological parameters in professional soccer players (McMillan et al., 2005) and junior players (Impellizzeri et al., 2006), after 20 and 14 weeks of training, respectively.

No significant differences were observed for knee extensors peak strength. Our results corroborate previous findings, which evaluated isometric quadriceps strength after four and 16 months of soccer training in premenopausal women (Krustup et al., 2010b). According to the authors, during the first four months no difference was observed in isometric quadriceps strength; only after 16 months of training. It seems that the intervention period was a determining factor for the result of no change in peak strength in the present study. Probably a longer period (>4 months) of soccer practice is necessary, involving high-intensity muscle actions (i.e., accelerations, decelerations, changes of direction, and quick jumps) to promote neural factors that improve strength gains (Mohr et al., 2003; Pedersen et al., 2009).

Biochemical responses did not change significantly in both groups after the intervention period (Table 3). However, an interesting finding was that 8 weeks of intervention was enough to reduce LDL/HDL ratio in both groups. A high variable level is associated with increased risks of developing coronary heart disease (Lemieux et al., 2001). Our findings are consistent with previous studies that used longer intervention periods, in which 12 weeks of soccer training caused reduction in LDL and LDL/HDL ratio in untrained men (Krustup et al., 2009) and 16 weeks induced decrease LDL/HDL ratio in premenopausal women (Krustup et al., 2010c). Probably a longer intervention period is necessary to produce significant effects to this and other biochemical variables. Nevertheless, the results from the literature on aerobic exercise effects associated with plasma lipoprotein concentrations remain controversial (Durstine et al., 2001; Leon and Sanchez, 2001).

Thus, positive adaptations observed in the present study suggest that short-intervention periods of small-sided soccer games can cause significant changes in LDL/HDL ratio and consequently prevent coronary heart risk. On the other hand, it seems that the level improvements on these lipid variables are associated with a reduction in body mass and body fat percentage (Lemieux et al., 2001). In the present study, no significant changes in BM, BF%, and BMI (Table 1) were observed. Our results were similar to those observed previously with untrained subjects after six weeks of low volume sprint intervals and traditional endurance training (Burgomaster et al., 2008). However, when the recreational soccer practice intervention period was higher than 12 weeks, significant reduction in BM and BF% was observed (Knoepfli-Lenzin et al., 2010; Krustrup et al., 2010c).

Conclusions

In summary, eight weeks of regular participation in small-sided soccer games was enough to increase aerobic performance and promote health benefits related to similar aerobic training in untrained adult women. Furthermore, strength-level maintenance, body composition, and some biochemical variables were important for the overall health status of the subjects. Soccer practice in small-sided games, as a way to promote physical fitness and health in untrained women, can be best explored in the literature. Moreover, the practical importance of the present study is the possibility for soccer to be considered a popular sport played in a group and one that has the potential to be more pleasurable and effective among women as other traditional training modalities like running and cycling.

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The experiments comply with the current laws of the country in which they were performed. The authors have no conflict of interest to declare.

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Key points

- Regular participation in soccer small sided-games increase aerobic performance and promote health benefits related to similar aerobic training in untrained women.
- 8 weeks soccer training is enough to promote positive physiological and biochemical adaptations in untrained women.
- Soccer small sided-games have the potential to be more pleasurable and effective among women as other modalities as running and cycling.

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