

Effects of recreational soccer on physical fitness and health indices in sedentary healthy and unhealthy subjects

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ABSTRACT: Recreational soccer (RS) is becoming a popular alternative to the classical continuous exercise mode used for the improvement of cardiovascular and metabolic fitness in untrained people. The objective of this paper was to conduct a detailed systematic review of the literature, identifying the physiological responses to RS and the training effects of RS on aerobic fitness and health in untrained healthy individuals and clinical patients. PubMed, Google Scholar and ScienceDirect databases were searched using terms related to recreational soccer. Inclusion criteria were randomized controlled trials (RCT) that assessed acute physiological responses to RS or the training effects of RS on physical fitness and health in sedentary, untrained subjects of any age or health status. All studies were assessed for methodological quality using the PEDro scale. Thirty-five articles met the inclusion criteria; seven examined the acute response to RS, and 28 assessed training effects. Clear evidence was found that RS had positive effects on many health-related indices and variables, including VO_2 max (gains of 7-16%), blood pressure (reductions of 6-13 mmHg), body composition (decreased fat mass and improved indices of bone health), and metabolic and cardiac function. These positive effects were observed in both healthy individuals and clinical patients, irrespective of age or sex. Although this review provides clear evidence of the positive effects of RS on health, most studies had limitations of methodology (an average PEDro score < 6). Furthermore, many of the training studies were from a small number of research groups. Future studies should be extended to other countries and institutions to ensure generality of the results. Regular RS training leads to significant cardiovascular and muscular adaptations and gains of health both in sedentary individuals and clinical patients at all ages, suggesting that RS is a potentially highly motivational method to enhance population health.

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INTRODUCTION

Physical inactivity is a global public health problem that has contributed to the growing prevalence of obesity, diabetes mellitus, cardiovascular disease, hypertension, and stroke in modern societies [1,2]. Studies investigating the health benefits of regular physical activity have focused primarily on aerobic exercise, including treadmill or outdoor running and cycle ergometry, both as continuous and interval forms of training [3,4]. However, adherence to these modes of physical activity in the general population is relatively low, perhaps because such activities can be quite boring; often, as many as a half of participants cease to attend formal exercise classes after a few months. There is thus a need to find more enjoyable modes of training that elicit greater adherence by optimizing intrinsic motivation while offering health benefits that match those achieved by treadmill and

cycle ergometer programmes. In this context, recreational soccer (RS) is becoming a popular alternative for those seeking to improve their cardiovascular and metabolic fitness. Soccer practice is less structured than traditional fitness classes, but for many people it is more enjoyable and thus it has a greater potential to develop and sustain the intrinsic motivation of participants. RS games are usually conducted in a five-a-side, seven-a-side, or nine-a-side format on pitch dimensions with a width of 30–40 m and a length of 45–60 m [5,6]. Factors such as pitch size, the number of players, and training time and/or format can substantially modify exercise characteristics [7,8], but the potential effects of game manipulation have yet to be explored.

A growing body of research has highlighted health benefits from RS training in sedentary but otherwise healthy individuals [9,10], in

the obese [11] and in patients with various chronic conditions [12,13]. Both narrative and meta-analytic reviews [14,15] point to the conclusion that regular participation in RS can enhance both physical fitness and health status in untrained subjects. Bangsbo et al. [14] showed that small-sided RS games had marked positive effects on cardiovascular and metabolic function in untrained adult men, although they did not discuss research on the responses of women and children. A more recent meta-analysis [15] suggested that RS produced large improvements in maximal oxygen intake ($\dot{V}O_2\text{max}$) compared to other forms of training, regardless of the age, sex or health status of the participants. However, this meta-analysis included only studies that had made direct measurements of changes in $\dot{V}O_2\text{max}$.

Given the limitations of the aforementioned reviews and the fast appearance of publications on RS, the aim of the present review was to provide a systematic examination of potential factors affecting the intensity of RS, to determine acute physiological responses to such activity and to detail effects on aerobic performance and indices of health in both sedentary individuals and patients with various chronic clinical conditions..

MATERIALS AND METHODS

Search strategy. The search process followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for the conduct of systematic reviews [16]. The search covered three electronic databases (PubMed, Google Scholar, and ScienceDirect). Given the small number of articles relating to recreational soccer, no limits were placed on the search period. The terms “soccer”, “small-sided game”, “football”, “recreational”, “sedentary”, “physiological” and/or “health” were used either singly or combined in a systematic sequence. Manual searches were also made using reference lists from the recovered articles.

Study selection and inclusion criteria

Studies were included in the review if they met the following criteria: (1) Randomized studies assessing acute physiological responses to RS or the training effects of RS on physical fitness and health indices in sedentary, untrained, recreational subjects of any age or health status, including the obese, diabetic, and hypertensive individuals. (2) The outcomes were physiological (e.g., changes in heart rate, lactate or $\dot{V}O_2\text{max}$.) or improvements in indices of physical fitness and health (e.g., body composition, blood pressure, aerobic fitness, cardiac structure and function). (3) Studies involved controlled or matched-group training interventions of ≥ 4 weeks duration. (4) Articles were written in the English language and were published in peer-reviewed journals, using techniques of high reliability and validity. Conference proceedings and theses were excluded.

After the initial literature search and the screening of titles and abstracts from the 3 databases, a full text review of apparently relevant articles was made to ensure that they met the specified inclusion criteria (Figure 1).

Data extraction and quality assessment

Data from studies that met the inclusion criteria, including authors, year of publication, study subjects' characteristics, training programme (duration, frequency and intensity), outcome measures and the most important results, were extracted by one author, while the methodological quality and validity of the data were independently verified by two authors, with disagreements being resolved by discussion. The quality of the studies included was assessed formally using the PEDro scale [16]. This rates validity on a scale of 1-11 according to the following criteria: 1) Eligibility criteria specified. 2) Random allocation of subjects. 3) Concealed allocation of subjects. 4) Groups similar at baseline. 5) Subject blinding. 6) Therapist blinding. 7) Assessor blinding. 8) Less than 15% dropouts. 9) Intention-to-treat analysis. 10) Between-group statistical comparisons. 11) Point measures and variability of the data. Item 1 is not used in the scoring because it is related to external validity.

RESULTS

Study selection. Our search identified 605 potentially relevant articles. After a reading of abstracts and full text review, only 35 articles met the inclusion criteria. These studies are listed in table 1. Seven papers examined acute physiological responses to RS [7,8,17-21] and 28 reported effects of RS on physical fitness and indices of health. Of the latter, 18 articles focused on healthy subjects [5,6,9,10,22-35], 2 on overweight or obese children and adolescents [11,36], and 8 on effects in various clinical populations (i.e., diabetics, hypertensive, and patients with cancer) [12,13,37-42].

Study characteristics

Table 1. Studies that met the inclusion criteria included investigations of acute physiological responses to RS, and randomized controlled (RC) trials examining the effects of RS on indices of physical fitness

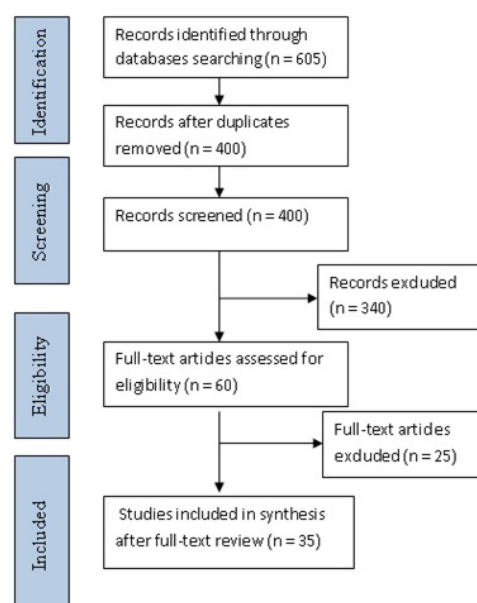


FIG. 1. PRISMA flow diagram of data search and study selection.

and health. The overall sample size for the 28 training trials was 1406 participants (768 female and 638 male); the 550 participants who undertook RS were compared with either a control group or subjects receiving alternative interventions (running or strength training). The training period ranged from 10 to 52 weeks, with most studies continuing over 12-15 weeks. The average frequency of training and the intensity of effort during RS were 2.9 ± 0.5 sessions per week and $81.4 \pm 3.0\%$ of HR max, respectively, with a mean session duration of 55 min. A variety of small-sided soccer games included 2 v. 2, 3 v. 3 and 7 v.7 formats.

TABLE 1. PEDro scores for the studies reviewed

Studies	PEDro item											Score
	1*	2	3	4	5	6	7	8	9	10	11	
Andersen et al. [41]	+	+	-	+	-	-	-	+	-	+	+	5
Andersen et al. [6]	+	+	-	+	-	-	-	+	+	+	+	5
Andersen et al. [32]	+	+	-	+	-	-	-	+	-	+	+	5
Andersen et al. [40]	+	+	+	+	-	-	-	+	+	+	+	7
Aslan [8]	+	+	-	+	-	-	-	+	+	+	+	6
Bangsbo et al. [31]	+	+	-	+	-	-	-	-	-	+	+	4
Barene et al. [46]	+	+	+	+	-	-	+	-	+	+	+	7
Barene et al. [29]	+	+	+	+	-	-	+	-	+	+	+	7
Bendixsen et al. [17]	+	+	+	+	-	-	-	+	+	+	+	7
Brito et al. [20]	+	+	-	+	-	-	-	+	+	+	+	6
Castagna et al. [18]	+	+	-	+	-	-	-	+	+	+	+	6
Connolly et al. [33]	+	+	-	+	-	-	-	-	-	+	+	5
Faude et al. [36]	+	+	-	+	-	-	-	-	-	+	+	4
Helge et al. [5]	+	+	-	+	-	-	+	-	-	+	+	5
Helge et al. [28]	+	+	-	+	-	-	-	+	-	+	+	5
Jakobsen et al. [35]	+	+	-	+	-	-	-	-	-	+	+	4
Knoepfli-Lenzin et al. [39]	+	+	-	+	-	-	-	+	-	+	+	5
Krustrup et al. [26]	+	+	-	+	-	-	-	+	+	+	+	6
Krustrup et al. [23]	+	+	-	+	-	-	-	+	-	+	+	5
Krustrup et al. [34]	+	+	-	+	-	-	-	+	-	+	+	5
Krustrup et al. [24]	+	+	-	+	-	-	-	+	-	+	+	5
Krustrup et al. [42]	+	+	-	+	-	-	-	+	+	+	+	6
Krustrup et al. [25]	+	+	-	+	-	-	-	+	-	+	+	5
Milanović et al. [10]	+	+	-	+	-	-	-	+	-	+	+	5
Milanović et al. [27]	+	+	-	+	-	-	-	+	-	+	+	5
Mohr et al. [12]	+	+	-	+	-	-	-	+	-	+	+	5
Mohr et al. [38]	+	+	-	+	-	-	-	+	+	+	+	6
Randers et al. [9]	+	+	-	+	-	-	-	+	+	+	+	6
Randers et al. [7]	+	+	-	+	-	-	-	+	+	+	+	6
Randers et al. [21]	+	+	-	+	-	-	-	+	+	+	+	6
Schmidt et al. [22]	+	+	+	+	-	-	-	+	+	+	+	7
Soussa et al. [37]	+	+	-	+	-	-	-	-	-	+	+	4
Toh et al. [19]	+	+	-	+	-	-	-	+	-	+	+	5
Uth et al. [13]	+	+	+	+	-	-	-	-	-	+	+	5
Vasconcellos et al. [11]	+	+	+	+	-	-	+	+	-	+	+	7

Note: * not included in scoring

Study outcomes

Detailed descriptions of study populations, training modes and volumes, and important outcomes are presented in Tables 2, 3, 4, and 5. Table 2 summarizes the acute physiological responses to different forms of RS. Table 3 shows gains in aerobic and muscular performance (i.e., jump height, sprint speed and muscular strength) after RS. Tables 4 and 5 indicate health benefits (favourable changes in body composition and bone health, reductions of systemic blood pressure, and metabolic and cardiac responses) in healthy, obese and clinical participants. There is clear evidence that RS training had positive effects on aerobic fitness, with 3-31% gains in $\dot{V}O_2\text{max.}$, 27-111% increases of intermittent endurance, gains in other measures of physical fitness (sprint speeds, jump heights and muscular strength), and favourable changes in many health-related indices including systemic blood pressure, bone turnover, metabolic factors, and cardiac function and structure. These various positive effects were observed in overweight and obese children and adolescents [11,36], in healthy men and women [22,27], and in hypertensive, diabetic, and cancer patients [12,13,37].

Methodological qualities of the included studies

The quality of the studies included in our analysis was relatively weak (Table 1). The mean PEDro score was 5.51/10 (range 4 to 7). However, all investigations were randomized controlled trials with an acceptable sample size. For practical reasons, most studies did not adopt a blinding design, but all studies made a between-group comparison.

DISCUSSION

Physiological responses and factors affecting the intensity of RS

As in elite soccer, physiological responses during RS have been assessed through measurements of heart rate and blood lactate, and by ratings of perceived exertion (RPE). Heart rate remains the most commonly used indirect but objective method of monitoring physiological stress [43]. In some small-sided soccer games, the HR increased to the same level as that observed during short-duration intermittent running [44]. The cardiovascular load during RS can exceed 80% of HRmax, and such intensities are similar to those observed in elite soccer games [21] (Table 2). For example, Castagna et al. [18] showed that the mean HR (% HR max) and the $\dot{V}O_2$ (% $\dot{V}O_2\text{peak}$) during 5 v. 5 indoor RS games were $83.5 \pm 5.4\%$ and $74.2 \pm 10.8\%$ of maximal values, respectively. The peak blood lactate concentrations and the time spent above 90% HRmax were also significantly higher ($p < 0.05$) during RS than during running training [23]. Moreover, in untrained men RS elicited a significantly higher mean HR (140 vs 100 beats \cdot min $^{-1}$) and a greater time spent above 90%HRmax (17 vs 0%), but a lower peak BL (7.2 ± 0.9 vs 10.5 ± 0.6 mmol \cdot L $^{-1}$) than strength training [32]. The above data suggest that RS elicits a high relative intensity of physical activity and that regular participation in such activity should have a substantial cardiovascular and metabolic impact on untrained subjects.

TABLE 2. Physiological responses during RS and other forms of training: Mean heart rates (HR) and blood lactate concentrations (BL).

Study Authors (years)	Participants Numbers/sex/ age (years)	RSSG format	Intensities	
			Mean HR(% HR max)	BL (mmol·L ⁻¹)
Aslan [8]	10/ M/ 31.7±7.6	5 v 5 : Small area	79.4 ± 3.7	-
		5 v 5 : Large area	81.7 ± 4.7	-
		7 v 7 : Small area	76.8 ± 4.4	-
		7 v 7 : Large area	78.7 ± 4.3	-
Bendiksen et al. [17]	93/(50 M, 43 F) / 8-9	Physical education program		
		A) RS	A) 76 ± 9%	A > C, D*
		B) Basketball	B) 77 ± 8%	B > C, D*
		C) Circuit training	C) 62 ± 1%	-
Brito et al. [20]	16/ M/22	Surface effects		
		A) Sand	A) 84.8 ± 1.5%	4.7 ± 0.6
		B) Turf	B) 87.8 ± 0.8%	B > C*
		C) Asphalt	C) 82.4 ± 1.3%	2.8 ± 0.3
Castagna et al. [18]	16/ M/ 16.8±1.5	5 v 5	83.5±5.4%	-
Randers et al. [7]	45/M/ (U10) with 22 RS players	A) 5 v 5 (30 x 40m)	A) 174 ± 10bpm	A > B*
		B) 8 v 8 (52.5 x 68m)	B) 168 ± 12bpm	-
	41/M/(U13) with 21 RS players	C) 8 v 8 (52.5 x 68m)	C) 170 ± 10bpm	-
		D) 11 v 11 (68 x 105m)	D) 171 ± 10bpm	-
Randers et al. [7]	12/ M/ 33.0 ± 6.4	RS: 4 x 12min (80 m ² per player)		
		A) 3 v 3	A) 84.1 ± 3.9	A=B=C
		B) 5 v 5	B) 84.5 ± 5.0	5.9 ± 2.4
		C) 7 v 7	C) 82.8 ± 5.1	5.5 ± 2.9
Toh et al. [19]	13/M/ 10.7 ± 1.2 overweight	RS (pitch area)		
		A) Badminton court (6.1 x 13.4 m)		-
		B) Volleyball court (9 x 18 m)	A < B*	-
		C) Basketball court (14.2 x 26.5m)	A < C*	-

Note: RS = Recreational soccer; HR = Heart rate; BL = Blood lactate; M = Male; F = Female; * = significant difference.

The intensity of RS can be manipulated by the modification of such variables as the number of players, the pitch area, the game format and its duration. Further, such manipulation is important in adjusting training prescriptions for health in untrained individuals. A few studies have examined factors affecting the intensity of RS exercise in untrained subjects. Aslan [8] demonstrated that cardiac responses were higher during 5-a-side than in 7-a-side games in recreational active males (the mean heart rates were 164.3 ± 11.9 and 161.2 ± 12.9 beats·min⁻¹ respectively). If a game is played with fewer players, there are more occasions when each participant is involved with the ball. Randers et al. [21] investigated the effect of number of players on the physiological effects of RS in young U10 recreational soccer players. Mean HR was greater during a 20-minute 5 v. 5 game (pitch size = 30 x 40 m) than in an 8 v. 8 game (pitch size = 52.5 x 68 m). The authors of this study concluded that the HR is high in youth RS, irrespective of the level of competition, and that playing with fewer players in a smaller pitch area had a relatively minor effect on the physical demands of the game. Toh et al. [19] assessed the effects of modifying the pitch area on the physiological responses and enjoyment of overweight boys during a 30 min RS

game. The mean HR was significantly lower in a badminton court (6.1 x 13.4 m) than in basketball (14.2 x 26.5 m) or volleyball (9 x 18 m) courts. The energy expenditure was similar when playing on the badminton and volleyball courts, but was lower on the basketball court, with no significant differences in enjoyment between the 3 settings.

Another factor affecting RS is the nature of the playing surface. Brito et al. [20] compared physiological responses on artificial turf, asphalt, and sand. The mean HR on all 3 surfaces was higher than 80% of HRmax, with averages of $84.8\% \pm 1.5$, $87.8\% \pm 0.8$ and $82.4\% \pm 1.3$ on sand, turf, and asphalt respectively. The difference of HR between turf and asphalt was statistically significant. BL was also significantly lower on asphalt than on sand (2.8 ± 0.3 vs. 4.7 ± 0.6 mmol·L⁻¹); and RPE was significantly lower on asphalt than on either turf or sand. Nevertheless, all 3 surfaces provided an adequate physiological stimulus to achieve substantial fitness and health benefits.

It appears that a decrease in the number of players and an increase in pitch area can be suitable approaches to increase the intensity of RS; however, further studies are needed to determine optimal formats for the training of various types of population.

TABLE 3. Effects of recreational small-sided game training on aerobic performance and physical fitness in healthy individuals and clinical patients.

Study	Participants	Training program:	Adaptations
Authors	N/sex/age (years) /health status	Duration (weeks) /volume (per week)/ session duration (min)/ intensity	(Intermittent endurance, $\dot{V}O_2$ max, submaximal HR (%HRmax), Balance, Physical fitness)
Andersen et al. [32]	26/ M /68.2 Healthy	16 weeks: 2 sessions x 1h/week A) RS 84% HR max B) ST 61% HR max C) Control -	Yo-Yo IE1 $\dot{V}O_2$ max Cycle time to exhaustion A) \uparrow 43%* A) \uparrow 15%* A) \uparrow 7%* B) NC B) NC B) NC C) NC C) NC C) NC
Bangsbo et al. [31]	53/ F/ 19–47/ Healthy	16 weeks: 2 sessions /week : A) RS 83% HR max B) RN 82% HR max C) Control -	Yo-Yo IE2 $\dot{V}O_2$ max A) \uparrow 37 \pm 6% A>B, C* A) \uparrow 15% A>B, C* B) \uparrow 26 \pm 6% B>C* B) \uparrow 10% B> C* C) NS C) \uparrow 3%
Barene et al. [30]	118/ F/ 45.8/ Healthy	40 weeks: 3 x 1h/week : A) RS 78.3% HR max B) Zumba 75% HR max C) Control -	$\dot{V}O_2$ max A) NS B) \uparrow 2.2 B>C* C) NS
Connolly et al. [33]	44/ F/39 \pm 6 / Healthy	16 weeks: 13.5min x 2/week : A) RS 159 bpm B) VT 92 bpm C) Control -	HRmax A) \downarrow 6% A>B, C* B) NS C) NS
Faude et al. [36]	14H/8F/10.8/ overweight	6 months training: 3 x 1h/week: A) RS 80% HR max B) STD 77% HR max	20m shuttle run test (min) Maximal power (w) A) \uparrow 50% A=B A) \uparrow 8,66% A=B B) \uparrow 44,8% B) \uparrow 7,2%
Helge et al. [5]	50/ F/36.5/ Healthy	14 weeks: 2 x 1h/week: A) RS 83% HR max B) RN 82% HR max C) Control -	Balance (number of falls) CMJ height CMJ peak power A) \downarrow 29.4%* A) \uparrow 6.3%* A) \uparrow 3% B) \downarrow 33.3%* B) \uparrow 6.8%* B) \uparrow 2.4% C) \downarrow 16.8% C) \downarrow 5% C) \downarrow 5.1%
Jakobsen et al. [35]	43/ M/21–45 / Healthy	12 weeks: 3 x 45min/week: A) RS NR B) RN 80% HR max C) INT >90% HR max D) Control -	Balance (CoP sway length) Balance (CoP sway area) A) \downarrow 18.2%* A) \downarrow 30.2%* B) \downarrow 14.6%* B) NC C) \downarrow 12.8%* C) \downarrow 23.4%* D) NC
Krustrup et al. [24]	38/ M/20–43/ Healthy	12 weeks: 2–3 x 1h/week: A) RS 82% HR max B) RN 82% HR max C) Control -	maximal hamstring strength $\dot{V}O_2$ max 30m sprint A) \uparrow 11%* A) \uparrow 13%* A) \uparrow 0.11s* B) NC B) \uparrow 6%* B) NC C) NC C) NC C) NC
Knoepfli-Lenzin et al. [39]	47 M (25–45) Mild hypertensive	12 weeks: 3 x 1h/week: A) RS B) RN C) Control	$\dot{V}O_2$ max Yo-Yo IRTL2 A) \uparrow 6.08%* A) \uparrow 27.8%* B) \uparrow 10.5%*\$ B) \uparrow 33.2%\$ C) NC C) NC
Milanović et al. [27]	69/M/33 / Healthy	12 weeks : 3 x 60min/ week A) RS B) Rn C) Control	$\dot{V}O_2$ max CMJ SJ A) \uparrow 24.2%* A) \uparrow 12.1%*\$ A) \uparrow 14.8%*\$ B) \uparrow 21.5%* B) \uparrow 3.0%* B) \uparrow 3.3%* C) \downarrow 5% C) \uparrow 0.2 C) \uparrow 0.3
Mohr et al. [12]	41/F/30–50/ Hypertensive	15 weeks: 3 \pm 0.1sessions / week. A) RS B) Control	Yo-Yo IE1 HR submax A) 111 \pm 18% * A) \downarrow 7.2 * B) NS B) NS
Randers et al. [9]	17/M/20–43 Healthy	12 weeks: 2.4 x 1h /week 54 weeks: 1.3 x 1h/week A) RS: 81–82% HRmax B) Control	30m sprint $\dot{V}O_2$ max (ml · kg ⁻¹ · min ⁻¹) Yo-Yo IR2 A) \uparrow 3.2%* A) \uparrow 3.1* A) \uparrow 49%* B) NC B) NC B) NC
Schmidt et al. [22]	26/ M/65–75/ Healthy	12 weeks: 2 x 1h/week: A) RS B) ST C) Control	$\dot{V}O_2$ max A) \uparrow 18%* B) NC C) NC
Vasconcellos et al. [11]	14H, 6F/12–17/ Obese	12 weeks: 3 x 60min/ week: A) RS B) Control	$\dot{V}O_2$ peak A) \uparrow 31.3%* B) \uparrow 5.3%

Note: RS= recreational soccer; ST = strength training; RN = running training; HR = heart rate; M = male F = female; Submax = submaximal; BL = Blood lactate; $\dot{V}O_2$ = oxygen uptake; NC= no significant change; \uparrow = improvement; \downarrow = decrease; *: significant differences from control.

TABLE 4. Health benefits after RS training in healthy participants: body composition, bone mineral density, blood pressure, metabolic and cardiac adaptations.

Study : Authors/Years	Participants : N/sex/Age(years)	Training:Type/ duration/volume/ intensity (Fc max)	Adaptations : Body composition, Blood pressure, metabolic and cardiac function			
Andersen et al. [6]	37/ F/36.5±8.2	16 weeks: 2 x 1h/week A) RS B) RN C) Control	Mean BP: A) ↓6% B) ↓3.7% C) NC	Right ventricular diameter A) ↑12%* B) ↑10%* C) NC	Peak systolic velocity A) ↑26%* B) ↑17%* C) NC	
Bangsbo et al. [31]	53/F/19– 47	16 weeks, 2 x 1h/week A) RS B) RN C) Control	Muscle enzymes CS A) ↑9% B) ↑12% C) NC	HAD A) ↑8% B) NC C) NC	Number of capillaries per fibre A) ↑18%* B) NC C) NC	
Barene et al. [30]	118/F/ 45.8	40 weeks: 0-12 week: 5 x 1h/ week 12-40 week: 2-3 x 1h/week. A) RS B) Zumba training C) Control	% fat A) ↓1.2%* B) ↓2.2% * C) NC	Total BMC (g) A) ↑39.3 * B) NC C) NC	Plasma osteocalcin (µg/l) A) ↑6.6* B) NC C) NC	Plasma leptin (µg/l) A) ↓6.6* B) NC C) NC
Connolly et al. [33]	44/ F/ 20-45	16 weeks : 2 x 13,5 min/week: A) RS B) Vibration training C) Control	BF (%): A) ↓ 1.7 ± 2.4% * B) NC C) NC	Decrease of PCR: A) ↓ 4 ± 8% B) NC C) NC		
Helge et al. [5]	65/ F/ 36.5	14 weeks: A) RS: 1.8 x 1h/week B) RN: 1.9 x 1h/week C) Control	Total v BMD in left tibia: A) ↑ 2.6%* B) ↑ 0.7%* C) NC	Total v BMD in right tibia: A) 2.1%* B) 1.1%* C) NC		
Helge et al. [28]	36/M/68.2	12 months: 2-3 x 40- 50min/week: A) RS B) RST C) Control	BMD in proximal femur A) ↑5.4%* B) NC C) NC	Plasma osteocalcin A) ↑46%* B) NC C) NC		
Krustrup et al. [24]	38/M/20-43	12 weeks: 2-3 x1h/ week: A) RS B) RN C) Control	muscle fibre area A) ↑15%* B) NC C) NC	number of capillaries per fibre A) ↑22%* B) ↑16%* C) NC		
Krustrup et al. [25]	36/M/20-43	12weeks: 2-3 x 1h/ week: A) RS B) RN C) Control	Fat mass A) ↓3.0%* B) ↓1.8%* C) NC	LDL-cholesterol A) ↓14.81%* B) NC C) NC		
Krustrup et al. [26]	97 (43M, 54F)/ 9–10	10 Weeks: 3 x 40 min/week : A) RS B) Control	left ventricular posterior wall diameter (mm) A) ↑ 0.4 ± 0.7 B) ↓ 0.1± 0.6		Global isovolumetric relaxationTime (ms) A) ↑3.8 ± 10.4 * B) ↓0.9 ± 6.6	
Randers et al. [9]	17/M/20-43	12 weeks: 2.4 x 1h/week 54 weeks: 1.3 x 1h/week A) RS: 81-82% HR _{max} B) Control	Mean fiber area A) ↑10%* B) NC	SBP (mmHg) A) ↓8* B) NC	Leg bone density A) ↑2%* B) NC	Leg bone mass A) ↑3.5%* B) NC

Note: RS = recreational soccer training; RN = running training; RST = resistance training; BP = blood pressure; BMD = bone mineral density; M = male; F = female; NC = Non-significant changes; ↑ = improvement; ↓ = decrease; LBM = lean body mass; BMC = Bone mineral content; LDL = low-density lipoprotein; HDL = High-density lipoprotein.



TABLE 5. Health benefits after RS training in overweight, obese, and clinical patients.

Study	Participants:N/sex/ age(years)/health status	Training: duration/volume/ intensity (Mean HR)	Adaptations: Body composition, blood pressure, metabolic and cardiac functions
Andersen et al. [41]	25/ M/ 31–54 Hypertensive	6 months: 2 x 1h/week: A) RS: 83% HRmax B) Control	Total Fat %: A) ↓5 ± 2% B) NC Mean BP A) ↓10* B) ↓5
Krustrup et al. [42]	33/ M/ 31–54 Hypertensive	6 months: 2 x 1h/week A) RS: (85% HRmax) B) Control	Total BMC A) NC B) NC LDL, HDL, CRP DBP A) ↓8 ± 6* B) ↓3 ± 3
Knoepfl-Lenzin et al. [39]	57/ M/ 20–45 Hypertensive	12 weeks: 3 x 1h/week A) RS: 79.9% HRmax B) RN: 79.4% HRmax C) Control	DBP (%) A) ↓10.3* B) ↓6.9% C) ↓4.7 Total cholesterol A) 5.2% B) NC C) NC Total fat mass (kg) A) ↓2 B) ↓1.6 C) NC
Mohr et al. [12]	41/ F/ 35–50 Hypertensive	15 weeks: 3 x 1h/week A) RS: 80.5%HRmax B) Control	Total BF%: A) ↓2.1 ± 0.7%* B) ↓0.5 ± 0.4% SBP A) ↓6 ± 2* B) ↓1 ± 2
Mohr et al. [38]	83/ F/ 45±6 Hypertensive	15 weeks: 3 x 1h/week A) RS B) HI swimming C) MI swimming D) Control	Plasma osteocalcin A) ↑37±15%* B) NC C) NC D) NC Femoral shaft BMD A) ↑1.7±1.9* B) NC C) NC D) NC Trochanter BMD A) ↑2.4 ± 2.9 %* B) NC C) NC D) NC
Sousa et al. [37]	44 (27 F, 17 M)/ 48–68 Diabetes mellitus (type 2)	12 weeks: 3 x 40 min/week A) RS 70-90% HRmax + diet B) diet only	Body fat (%) A) ↓2.4 ± 0.1%* B) ↓2.4 ± 0.1% Blood glucose (mmol/L) A) ↓1.1 ± 0.1 B) ↓1.1 ± 0.2 Cholesterol (mmol/l) A) ↓0.6 ± 0.2* B) NC Blood triglyceride (mmol/l) A) ↓0.4 ± 0.1* B) NC
Vasconcellos et al. [11]	30 (24M,6F)/ 12-17 Obese	12 weeks: 3 x 1h /week A) RS 84.5% HRmax B) Control	BMI (%) A) ↓2.3* B) ↑3.7* SBP A) ↓3.9* B) NC Total Cholesterol (mg/dl) A) ↓16.2 ± 5.8 B) NC Triglycerides (mg/dl) A) ↓20.5 ± 12.9 B) NC

Note: RS = recreational soccer training; RN = running training; BP = blood pressure; BMD = bone mineral density; M = male; F = female; NC = no significant change; ↑ = improvement; ↓ = decrease; LBM = lean body mass; BM = body mass; BMC = Bone mineral content; FM = Fat mass; BMI = body mass index;

Effects of RS on aerobic performance and physical fitness

Table 3 summarizes studies examining gains of aerobic and physical fitness with RS training. Positive effects of RS on intermittent endurance and $\dot{V}O_2\text{max}$ were found both in sedentary individuals and in patients with various clinical conditions. Gains of $\dot{V}O_2\text{max}$ ranged from 3 to 31% [9,11]. Bangsbo et al. [31] compared the effects of 16 weeks RS (twice weekly 1 h training sessions) with running training (RT) and a control group (CG) in healthy and initially untrained women. Performance was assessed before training, and after 4 and 16 weeks of study participation. Over the 16 weeks, $\dot{V}O_2\text{max}$ increased by 15% in RS and 10% in RT, whereas there was no significant change in the CG (3%). Further, the Yo-Yo intermittent endurance level 2 (Yo-Yo IE2) performance of the RS group relative to 4-week and initial score was augmented by $37 \pm 6\%$ and $21 \pm 4\%$ respectively ($P < 0.05$) relative to pre-training and 4-week values respectively, as compared with gains of $26 \pm 6\%$ and $20 \pm 6\%$ for RT, and no changes in the CG. Over the 16 weeks, the time to exhaustion in an incremental treadmill test increased by 21% and 17% for RS and RT, respectively ($P < 0.05$), compared with a change of only 4% in the CG. In obese adolescents (12-17 years), 12 weeks of RS again achieved a significant increase in $\dot{V}O_{2\text{peak}}$ ($7.9 \pm 2.8 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) compared with a matched control group [11]. Likewise, middle-aged hypertensive men and women who completed a period of RS showed significant improvements in $\dot{V}O_2\text{max}$ of 6.1% [39] and in intermittent endurance (from 30% to 111%) [6,12,31]. The mean HR during RS training was above 75% of HRmax [30,31] and the HR was above 90% of HRmax for 16.6% of the game [45], indicating the important stimulus to aerobic training during a typical RS game.

Other studies point to the beneficial effects of RS on various measures of physical fitness (jump height, muscle strength, sprint times and balancing ability). Significant and greater improvements in sprint time (0.11 s) and maximal strength (1.1%) were noted after RS compared with continuous running [24]. Furthermore, the jump performance of overweight boys and healthy untrained men showed significant gains ranging from 5% to 15% following periods of RS [9,27,36]. Likewise, postural balance as assessed by the flamingo test improved significantly (by about 45%) after RS [9,35]. It seems reasonable to attribute the enhanced physical fitness and balance to the intermittent high-intensity movements of soccer that include frequent accelerations, jumping and changes of direction.

Health benefits

Effects on body compositions

Regular participation in RS has positive effects on body composition in both healthy individuals and patients with clinical conditions (table 4 and 5). The observed benefits include reductions in fat mass and increases in lean body mass. A significant loss of body fat (1.2-1.7%) was observed in healthy untrained women after 16 to 40 weeks of RS [33,46]. Likewise, in healthy adult men fat mass was

significantly decreased (3%) and lean body mass was increased significantly (1.7 kg) after 12 weeks of RS [25].

Positive effects of RS on body composition have also been demonstrated in obese individuals and in various patient populations. Thus Vasconcellos et al. [11] showed that 12 weeks of thrice weekly RS led to a significant decrease of BMI (2.3%) and body fat (4.9%) in obese adolescents. Others noted significant decreases of fat mass (ranging from 2 to 5%) after 12-24 weeks of RS training in hypertensive patients [12,39,41]. Likewise, De Sousa et al. [37] found a significant increase in $\dot{V}O_2\text{max}$ after 12 weeks of combined football and dietary restriction, but not in the dietary restricted group. In addition, they found reductions in blood triglycerides, total cholesterol, and low-density lipoprotein only in the football and diet group after the 12-week intervention. This was associated with improvement in insulin sensitivity as shown by lower glucagon and homeostatic model assessment of insulin resistance. The positive changes in body composition reflect the intensive energy expenditures during typical training sessions; there is increased metabolism of fat not only during the period of exercise but also following training (as post-session lipolysis) [33].

Effects on bone mineral density

Bone strength and good postural balance make important contributions to a low frequency of falls and a reduced risk of skeletal fracture [47]. Total (13%) and leg (24%) bone mineral density (BMD) values were higher in elite female football players than untrained women [48]. Participation in RS also produces positive changes in bone health. Thus, in healthy premenopausal women, a 14-week period of RS caused a significant increase in total volumetric BMD in the left and right tibias ($2.6 \pm 2.3\%$ and $2.1 \pm 1.8\%$, respectively), coupled with significant increases in strength, and enhanced postural balance as assessed by the Flamingo test [5]. Furthermore, female hospital employees showed significant increases in plasma concentrations of osteocalcin and BMC over 12 weeks of RS [45], and healthy adult men had gains of leg bone density (2%) and leg bone mass (3.5%) after 64 weeks of RS [9]. Again, Helge et al. [28] showed that 12 months of RS caused significant increases in BMD in the proximal femur (5.4%) and in plasma osteocalcin concentrations (46%) of elderly men (average age 68 years), with no significant changes of these variables in a matched strength-training group. Among women suffering from mild hypertension, greater effects on markers of bone turnover were observed after 15 weeks of RS compared with after programmes of moderate or high-intensity swimming [38]. The positive effects on BMD, strength, and balance reflect the physical requirements of RS: intense movements in various directions, jumps, accelerations, decelerations, and rapid side-cutting movements, all of which cause mechanical impacts that stimulate bone calcification as well as enhancing vertical jumping ability and muscular strength [5]. RS appears to be an effective method for improving bone health, especially in untrained premenopausal women.

No study has yet investigated the effects of RS on BMD in untrained children or adolescents. However, some longitudinal studies of young soccer players show an association between soccer practice and high levels of BMC and BMD in the legs, lumbar spine, femoral neck and total hip in prepubescent soccer players [49,50]. Moreover, young soccer players show higher bone mass and hormonal concentrations than sedentary age-matched controls, especially around puberty [51]. Nevertheless, more research on the effects of RS on BMD is needed in untrained children and adolescents.

Effects on blood pressure

Exercise training has been recommended as an effective non-pharmacological, behavioural intervention to prevent and to treat hypertension. Studies focusing on BP responses to RS in healthy individuals have demonstrated positive effects. Krstrup et al. [23] reported that in premenopausal women both resting systolic blood pressure (SBP) and diastolic BP (DBP) were reduced significantly (by 7 ± 2 and 4 ± 1 mmHg, respectively) after 12 weeks of RS, whereas only SBP was reduced in a matched running group (6 ± 2 mmHg). Further, Randers et al. [9] found that regular participation in 64 weeks of RS significantly decreased the systolic blood pressure (8 mmHg) of healthy adult men.

In hypertensive patients, regular RS training caused significant and marked decreases in both systolic and diastolic BP levels. Mohr et al. [12] found significant decreases of 6 ± 2 and 12 ± 3 mmHg in the SBP and DBP of premenopausal women with mild hypertension after 15 weeks of RS. Similar results were observed for hypertensive men. Knoepfli-Lenzin et al. [39] found a significant decrease in systolic (7.5%) and diastolic (10.3%) blood pressures after 12 weeks of RS. Vasconcellos et al. [11] reported a reduction in systolic blood pressure (-5.0 ± 2.3 mmHg) after 12 weeks of an RS programme in obese adolescents.

The above-mentioned studies have consistently shown a clinically important reduction of BP after twice- or thrice-weekly RS training sessions, especially in hypertensive individuals. RS, performed under the supervision of the patient's physician, can thus be recommended for the prevention and treatment of hypertension.

Adaptations of metabolic and cardiac function

Bangsbo et al. [31] compared the effects of 16 weeks of RS with responses to a running programme in a sample of 65-year-old adult healthy women; they found significant increases of citrate synthase (CS) and 3-hydroxyacyl-CoA dehydrogenase (HAD) activity (9% and 8%, respectively) after 4 weeks of RS, with no further change in the next 12 weeks. Running training also increased CS by 12%, but it caused no significant change in HAD. The number of capillaries per fibre also increased by 18% after RS, but no change was observed after running training. Participation in a 12-week RS programme also led to a significant (14.8%) decrease in LDL cholesterol in healthy adult men [25]. Regular participation in 16 weeks of RS significantly decreased the plasma cholesterol concentrations

of hypertensive women by 0.4 ± 0.1 mmol·L⁻¹, without significant changes in LDL or HDL concentrations [12]. Regular RS also decreased the total cholesterol of hypertensive men by a significant 5.2% [39]. Combining RS (3 x 40 min per week) with dietary restriction for 12 weeks led to a significant decrease in blood glucose (1.1 mmol·L⁻¹), total cholesterol (0.6 mmol·L⁻¹), and triglyceride (0.4 mmol·L⁻¹) in patients with diabetes mellitus [37].

RS may also induce changes in cardiac function and structure. Andersen et al. [6] observed increases in left ventricular end-diastolic volume of 13% and 11% after 16 weeks of RS or running training, respectively. They noted a significantly greater decrease in isovolumetric relaxation time in RS compared to the running group (26% vs 14%, respectively), whereas left ventricular systolic and diastolic performance increased in both training groups. In children aged 9–10 years, as little as 10 weeks of RS (three 40 sessions·week⁻¹) resulted in significant improvements in left ventricular posterior wall diameter, interventricular septum thickness, and global isovolumetric relaxation time, as compared with a control group that maintained usual activities [26]. Furthermore, overweight children showed significant increases in left ventricular posterior wall diameter, right ventricular systolic function, and global isovolumetric relaxation time after 3 months of RS [36]. Thus, we may conclude that regular RS can elicit favourable metabolic and cardiac adaptations.

CONCLUSIONS

Conclusions and directions for future research. The prevalence of sedentary behaviour has continued to grow in recent decades, leading to increased cardiovascular morbidity and mortality, and there remains an urgent need for effective physical activity programmes with good compliance. In this regard, soccer merits increased attention. This review provides evidence that recreational soccer (RS), practised 2 to 3 times per week, yields important health benefits in both healthy and pathological subjects. The high intensities of effort reached during RS induce substantial positive adaptations in aerobic and physical fitness, blood pressure, bone mineral density, anthropometric characteristics, metabolic function, and cardiac structure and function, with the size of these gains matching or exceeding those obtained from alternative forms of training with low rates of compliance. RS allows participants to train at a health-targeted intensity with a low perception of exertion and a high level of enjoyment. Nevertheless, there remains a need for formal comparisons of compliance between RS and other training modalities such as running, cycle ergometry and other types of fitness class. Moreover, the exercise intensities reached during RS plainly can exceed those normally recommended for health promotion. Future epidemiological studies should thus look critically at the safety of RS, particularly in clinical populations. Data should be collected on acute cardiovascular and blood pressure responses to various forms of RS, and the risks of cardiovascular incidents and musculo-skeletal injuries (including concussion) should be compared between RS and alternative forms of training. Further, costs per participant should be assessed,

and related to both other formal exercise classes and informal walking, running and cycling programmes. More research is also needed to clarify the effects of changes in game format and duration on physiological responses to RS. Nevertheless, many of the health benefits presently observed with RS training compare favourably with those obtained by more conventional approaches to training, to the

point that slightly higher costs and possibly greater risks of injury may prove acceptable in a cost-benefit analysis.

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