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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_2max (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 ($\dot{V}O_2max$) 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 $\dot{V}O_2max$.

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 $\dot{V}O_2max$.) 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.

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

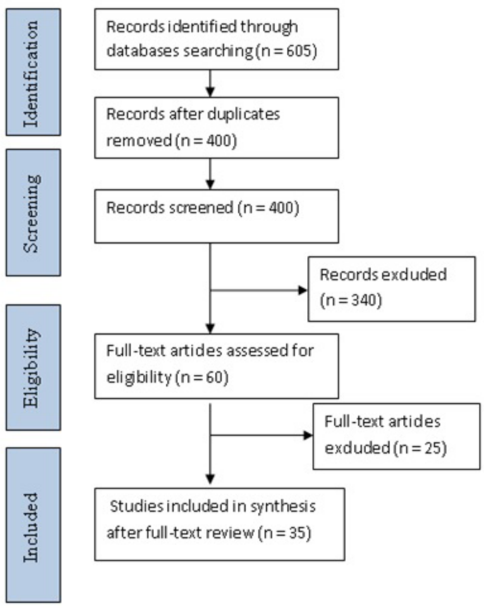

FIG. 1. PRISMA flow diagram of data search and study selection.

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 ± 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											
	1*	2	3	4	5	6	7	8	9	10	11	Score
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 el. [46]	+	+	+	+	-	-	+	-	+	+	+	7
Barene et al. [29]	+	+	+	+	-	-	+	-	+	+	+	7
Bendiksen 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
Milanoviĉ et al. [10]	+	+	-	+	-	-	-	+	-	+	+	5
Milanoviĉ 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 $\dot{V}O_2$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 $\dot{V}O_2$ (%$\dot{V}O_2$peak) during 5 v. 5 indoor RS games were 83.5 ± 5.4% and 74.2 ± 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 · 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 · 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	Participants		Intensities	
Authors (years)	Numbers/sex/ age (years)	RSSG format	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%	-
		D) Walking	D) 57 ± 5%	-
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*	4.2 ± 0.6
		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	5.9 ± 2.9 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% ± 1.5, 87.8% ± 0.8 and 82.4% ± 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 Authors	Participants N/sex/age (years) /health status	Training program: Duration (weeks) /volume (per week)/ session duration (min)/ intensity		Adaptations (Intermittent endurence, $\dot{V}O_2$max, submaximal HR (%HRmax), Balance, Physical fitness)		
Andersen et al. [32]	26/ M /68.2 Healthy	16 weeks: 2 sessions x 1h/week		Yo-Yo IE1	$\dot{V}O_2$max	Cycle time to exhaution
		A) RS	84% HR max	A)↑43%*	A) ↑15%*	A) ↑7%*
		B) ST	61% HR max	B) NC	B) NC	B) NC
		C) Control	-	C) NC	C) NC	C) NC
Bangsbo et al. [31]	53/ F/ 19–47/ Healthy	16 weeks: 2 sessions /week :		Yo-Yo IE2	$\dot{V}O_2$max	
		A) RS	83% HR max	A) ↑37±6% A>B, C*	A) ↑15% A>B, C*	
		B) RN	82% HR max	B) ↑26 ± 6% B>C*	B) ↑10% B> C*	
		C) Control	-	C) NS	C) ↑3%	
Barene et al. [30]	118/ F/ 45.8/ Healthy	40 weeks: 3 x 1h/week :		$\dot{V}O_2$max		
		A) RS	78.3% HR max	A) NS		
		B) Zumba	75% HR max	B) ↑2.2 B>C*		
		C) Control	-	C) NS		
Connolly et al. [33]	44/ F/39 ± 6 / Healthy	16 weeks: 13.5min x 2/week :		HRmax		
		A) RS	159 bpm	A) ↓6% A>B, C*		
		B) VT	92 bpm	B) NS		
		C) Control	-	C) NS		
Faude et al. [36]	14H/8F/10.8/ overweight	6 months training: 3 x 1h/week:		20m shuttle run test (min)	Maximal power (w)	
		A) RS	80% HR max	A) ↑50% A=B	A) ↑8,66% A=B	
		B) STD	77% HR max	B) ↑44,8%	B) ↑7,2%	
Helge et al. [5]	50/ F/36.5/ Healthy	14 weeks: 2 x 1h/week:		Balance (number of falls)	CMJ height	CMJ peak power
		A) RS	83% HR max	A) ↓29.4%*	A) ↑6.3%*	A) ↑3%
		B) RN	82% HR max	B) ↓33.3%*	B) ↑6.8%*	B) ↑2.4%
		C) Control	-	C) ↓16.8%	C) ↓5%	C) ↓5.1%
Jakobsen et al. [35]	43/ M/21-45 / Healthy	12 weeks: 3 x 45min/week:		Balance (CoP sway length)	Balance (CoP sway area)	
		A) RS	NR	A) ↓18.2%*	A) ↓30.2%*	
		B) RN	80% HR max	B) ↓14.6%*	B) NC	
		C) INT	>90% HR max	C) ↓12.8%*	C) ↓23.4%*	
		D) Control	-	D) NC	D) NC	
Krustrup et al. [24]	38/ M/20-43/ Healthy	12 weeks: 2-3 x 1h/week:		maximal hamstring strength	$\dot{V}O_2$max	30m sprint
		A) RS	82% HR max	A) ↑11%*	A)↑13%*	A) ↑0.11s*
		B) RN	82% HR max	B) NC	B) ↑6%*	B) NC
		C) Control	-	C) NC	C) NC	C) NC
Knoepfli-Lenzin et al. [39]	47 M (25-45) Mild hypertensive	12 weeks: 3 x 1h/week:		$\dot{V}O_2$max	Yo-Yo IRTL2	
		A) RS		A) ↑6.08%*	A) ↑27.8%*	
		B) RN		B) ↑10.5%*$	B) ↑33.2*$	
		C) Control		C) NC	C) NC	
Milanović et al. [27]	69/M/33 / Healthy	12 weeks : 3 x 60min/ week		$\dot{V}O_2$max	CMJ	SJ
		A) RS		A) ↑24.2%*	A) ↑12.1%*$	A)↑14.8%*$
		B) Rn		B)↑21.5%*	B) ↑3.0%*	B) ↑3.3%*
		C) Control		C) ↓5%	C) ↑0.2	C) ↑0.3
Mohr et al. [12]	41/F/30-50/ Hypertensive	15 weeks: 3± 0.1sessions / week.		Yo-Yo IE1	HR submax	
		A) RS		A) 111 ± 18% *	A) ↓7.2 *	
		B) Control		B) NS	B) NS	
Randers et al. [9]	17/M/20-43 Healthy	12 weeks: 2.4 x 1h /week		30m sprint	$\dot{V}O_2$max (ml·kg^{-1}·min^{-1})	Yo-Yo IR2
		54 weeks: 1.3 x 1h/week				
		A) RS: 81-82% HRmax		A) ↑3.2%*	A) ↑3.1*	A) ↑49%*
		B) Control		B) NC	B) NC	B) NC
Schmidt et al. [22]	26/ M/65-75/ Healthy	12 weeks: 2 x 1h/week:		$\dot{V}O_2$max		
		A) RS		A) ↑18%*		
		B) ST		B) NC		
		C) Control		C) NC		
Vasconcellos et al. [11]	14H, 6F/12-17/ Obese	12 weeks: 3 x 60min/ week:		$\dot{V}O_2$peak		
		A) RS		A) ↑31.3%*		
		B) Control		B) ↑5.3%		

Note: RS= recreational soccer; ST = strength training; RN = running training; HR = heart rate; M = male F = female; Submax = submaximal; BL = Blood lactate; VO_2 = oxygen uptake; NC: no significant change; ↑ = improvement; ↓ = 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	Mean BP:	Right ventricular diameter	Peak systolic velocity	
		A) RS	A) ↓6%	A) ↑12%*	A) ↑26%*	
		B) RN	B) ↓3.7%	B) ↑10%*	B) ↑17%*	
		C) Control	C) NC	C) NC	C) NC	
Bangsbo et al. [31]	53/F/19– 47	16 weeks, 2 x 1h/week	Muscle enzymes		Number of capillaries per fibre	
			CS	HAD		
		A) RS	A) ↑9%	A) ↑8%	A) ↑18%*	
		B) RN	B) ↑12%	B) NC	B) NC	
		C) Control	C) NC	C) 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.	% fat	Total BMC (g)	Plasma osteocalcin (µg/l)	Plasma leptin (µg/l)
		A) RS	A) ↓1.2%*	A) ↑39.3 *	A) ↑6.6*	A) ↓6.6*
		B) Zumba training	B) ↓2.2% *	B) NC	B) NC	B) NC
		C) Control	C) NC	C) NC	C) NC	C) NC
Connolly et al. [33]	44/ F/ 20-45	16 weeks : 2 x 13,5 min/week:	BF (%):	Decrease of PCr:		
		A) RS	A) ↓ 1.7 ± 2.4% *	A) ↓ 4 ± 8%		
		B) Vibration training	B) NC	B) NC		
		C) Control	B) NC	B) NC		
Helge et al. [5]	65/ F/ 36.5	14 weeks:	Total v BMD in left tibia:	Total v BMD in right tibia:		
		A) RS: 1.8 x 1h/week	A) ↑ 2.6%*	A) 2.1%*		
		B) RN: 1.9 x 1h/week	B) ↑ 0.7%*	B) 1.1%*		
		C) Control	C) NC	C) NC		
Helge et al. [28]	36/M/68.2	12 months: 2-3 x 40-50min/week:	BMD in proximal femur	Plasma osteocalcin		
		A) RS	A) ↑5.4%*	A) ↑46%*		
		B) RST	B) NC	B) NC		
		C) Control	C) NC	C) NC		
Krustrup et al. [24]	38/M/20-43	12 weeks: 2-3 x1h/ week:	muscle fibre area	number of capillaries per fibre		
		A) RS	A) ↑15%*	A) ↑22%*		
		B) RN	B) NC	B) ↑16%*		
		C) Control	C) NC	C) NC		
Krustrup et al. [25]	36/M/20-43	12weeks: 2-3 x 1h/ week:	Fat mass	LDL-cholesterol		
		A) RS	A) ↓3.0%*	A) ↓14.81%*		
		B) RN	B) ↓1.8%*	B) NC		
		C) Control	C) NC	C) NC		
Krustrup et al. [26]	97 (43M, 54F)/ 9–10	10 Weeks: 3 x 40 min/week :	left ventricular posterior wall diameter (mm)		Global isovolumetric relaxationTime (ms)	
		A) RS	A) ↑ 0.4 ± 0.7		A) ↑3.8 ± 10.4 *	
		B) Control	B) ↓ 0.1± 0.6		B) ↓0.9 ± 6.6	
Randers et al. [9]	17/M/20-43	12 weeks: 2.4 x 1h/week	Mean fiber area	SBP (mmHg)	Leg bone density	Leg bone mass
		54 weeks: 1.3 x 1h/week				
		A) RS: 81-82% HR_{max}	A) ↑10%*	A) ↓8*	A) ↑2%*	A) ↑3.5%*
		B) Control	B) NC	B) NC	B)NC	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:	Total Fat %:	Mean BP			
		A) RS: 83% HRmax	A) ↓5 ± 2%	A) ↓10 *			
		B) Control	B) NC	B) ↓5			
Krustrup et al. [42]	33/ M /31–54 Hypertensive	6 months: 2 x 1h/week	Total BMC	DBP		LDL, HDL, CRP	
		A) RS: (85% HRmax)	A) NC	A) ↓8 ± 6*		A) NC	
		B) Control	B) NC	B) ↓ 3 ±3		B) NC	
Knoepfli-Lenzin et al. [39]	57/M/ 20-45 Hypertensive	12 weeks: 3 x 1h/week	DBP (%)	SBP (%)	Total cholesterol	Total fat mass (kg)	
		A) RS: 79.9% HRmax	A) ↓10.3*	A) ↓7.5%	A) 5.2%	A) ↓2	
		B) RN: 79.4% HRmax	B) ↓6.9%	B) ↓ 5.9%	B) NC	B) ↓1.6	
		C) Control	C) ↓4.7	C) ↓6%	C) NC	C) NC	
Mohr et al. [12]	41/ F/ 35–50 Hypertensive	15weeks: 3 x 1h/week	Total BF%:	DBP	SBP	Total cholesterol (mmol/l)	
		A) RS: 80.5%HRmax	A) ↓2.1 ± 0.7% *	A) ↓12 ± 3*	A) ↓6 ± 2 *	A) ↓0.4 ± 0.1	
		B) Control	B) ↓0.5 ± 0.4%	B) ↓1 ± 1	B) ↓1 ± 2	B) ↓0.1 ± 0.2	
Mohr et al. [38]	83/F/45±6 Hypertensive	15 weeks: 3 x 1h/week	Plasma osteocalcin	Leg BMC	Femoral shaft BMD	Trochanter BMD	
		A) RS	A) ↑37±15%*	A) ↑3.1±4.5 %*	A) ↑1.7±1.9 *	A)↑2.4 ±2.9 %*	
		B) HI swimming	B) NC	B) NC	B) NC	B) NC	
		C) MI swimming	C) NC	C) NC	C) NC	C) NC	
		D) Control	D) NC	D) NC	D) 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	Body fat (%)	Blood glucose (mmol/L)	Cholesterol (mmol/l)	Blood triglyceride (mmol/l)	
		A) RS 70-90% HRmax + diet	A) ↓2.4 ± 0.1%*	A) ↓1.1 ± 0.1	A) ↓ 0.6 ± 0.2*	A) ↓0.4 ± 0.1*	
		B) diet only	B) ↓2.4 ± 0.1%	B) ↓1.1± 0.2	B) NC	B) NC	
Vasconcellos et al. [11]	30 (24M,6F)/ 12-17 Obese	12 weeks: 3 x 1h /week	BMI (%)	Fat (%)	SBP	Total Cholesterol (mg/dl)	Triglycerides (mg/dl)
		A) RS 84.5% HRmax	A) ↓2.3*	A)↓4.9*	A) ↓3.9*	A) ↓16.2 ± 5.8	A)↓20.5 ±12.9
		B) Control	B) ↑3.7*	B) ↓0.8	B) NC	B) NC	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 $\dot{V}O_2$max were found both in sedentary individuals and in patients with various clinical conditions. Gains of $\dot{V}O_2$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, $\dot{V}O_2$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 ± 6% and 21 ± 4% respectively ($P<0.05$) relative to pre-training and 4-week values respectively, as compared with gains of 26 ± 6% and 20 ± 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 $\dot{V}O_2$peak (7.9 ± 2.8 ml · kg^{-1} · 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 $\dot{V}O_2$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 $\dot{V}O_2$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 ± 2.3% and 2.1 ± 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. Krustrup 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 $mmol \cdot L^{-1}$, 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 $mmol \cdot l^{-1}$), total cholesterol (0.6 $mmol \cdot l^{-1}$), and triglyceride (0.4 $mmol \cdot l^{-1}$) 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 $\cdot$ $week^{-1}$) 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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REFERENCES

1. Lee I-M, Skerrett PJ. Physical activity and all-cause mortality: what is the dose-response relation? Med Sci Sports Exerc. 2001;33(6; SUPP):S459-S471.
2. Mokdad AH, Bowman BA, Ford ES, Vinicor F, Marks JS, Koplan JP. The continuing epidemics of obesity and diabetes in the United States. JAMA. 2001;286(10):1195-200.
3. Nybo L, Pedersen K, Christensen B, Aagaard P, Brandt N, Kiens B. Impact of carbohydrate supplementation during endurance training on glycogen storage and performance. Acta physiologica. 2009;197(2):117-27.
4. Duvivier BM, Schaper NC, Bremers MA, van Crombrugge G, Menheere PP, Kars M, Savelberg HH. Minimal intensity physical activity (standing and walking) of longer duration improves insulin action and plasma lipids more than shorter periods of moderate to vigorous exercise (cycling) in sedentary subjects when energy expenditure is comparable. PLoS One. 2013;8(2):e55542.
5. Helge EW, Aagaard P, Jakobsen MD, Sundstrup E, Randers MB, Karlsson MK, Krustrup P. Recreational football training decreases risk factors for bone fractures in untrained premenopausal women. Scand J Med Sci Sports. 2010;20(s1):31-9.
6. Andersen LJ, Hansen PR, Søgaard P, Madsen JK, Bech J, Krustrup P. Improvement of systolic and diastolic heart function after physical training in sedentary women. Scand J Med Sci sports. 2010;20(s1):50-7.
7. Randers M, Nielsen JJ, Bangsbo J, Krustrup P. Physiological response and activity profile in recreational small sided football: No effect of the number of players. Scand J Med Sci Sports. 2014;24(S1):130-7.
8. Aslan A. Cardiovascular responses, perceived exertion and technical actions during small-sided recreational soccer: Effects of pitch size and number of players. J Hum Kinet. 2013;38:95-105.
9. Randers MB, Nielsen JJ, Krustrup BR, Sundstrup E, Jakobsen MD, Nybo L, Dvorak J, Bangsbo J, Krustrup P. Positive performance and health effects of a football training program over 12 weeks can be maintained over a 1 year period with reduced training frequency. Scand J Med Sci Sports. 2010;20(s1):80-9.
10. Milanović Z, Pantelić S, Kostić R, Trajković N, Sporiš G. Soccer vs. running training effects in young adult men: which programme is more effective in improvement of body composition? Randomized controlled trial. Biol Sport. 2015(32):301-5.
11. Vasconcellos F, Seabra A, Cunha F, Montenegro R, Penha J, Bouskela E, Nogueira Neto JF, Collett-Solberg P, Farinatti P. Health markers in obese adolescents improved by a 12-week recreational soccer program: a randomised controlled trial. J Sports Sci. 2015:1-12.
12. Mohr M, Lindenskov A, Holm P, Nielsen H, Mortensen J, Weihe P, Krustrup P. Football training improves cardiovascular health profile in sedentary, premenopausal hypertensive women. Scand J Med Sci Sports. 2014;24(S1):36-42.
13. Uth J, Hornstrup T, Schmidt JF, Christensen J, Frandsen C, Christensen KB, Helge EW, Brasso K, Rørth M, Midtgaard J. Football training improves lean body mass in men with prostate cancer undergoing androgen deprivation therapy. Scand J Med Sci Sports. 2014;24(S1):105-12.
14. Bangsbo J, Hansen PR, Dvorak J, Krustrup P. Recreational football for disease prevention and treatment in untrained men: a narrative review examining cardiovascular health, lipid profile, body composition, muscle strength and functional capacity. Br J Sports Med. 2015;49(9):568-76.
15. Milanović Z, Pantelić S, Čović N, Sporiš G, Krustrup P. Is Recreational Soccer Effective for Improving VO2max? A Systematic Review and Meta-Analysis. Sports Med. 2015;45(9):1339-53.
16. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. Phys Ther. 2003;83(8):713-21.
17. Bendiksen M, Williams CA, Hornstrup T, Clausen H, Kloppenborg J, Shumikhin D, Brito J, Horton J, Barene S, Jackman SR. Heart rate response and fitness effects of various types of physical education for 8-to 9-year-old schoolchildren. Eur J Sport Sci. 2014;14(8):861-9.
18. Castagna C, Belardinelli R, Impellizzeri FM, Abt GA, Coutts AJ, D'Ottavio S. Cardiovascular responses during recreational 5-a-side indoor-soccer. J Sci Med Sport. 2007;10(2):89-95. doi: http://dx.doi.org/10.1016/j.jsams.2006.05.010.
19. Toh SH, Guelfi KJ, Wong P, Fournier PA. Energy expenditure and enjoyment of small-sided soccer games in overweight boys. Hum Mov Sci. 2011;30(3):636-47.
20. Brito J, Krustrup P, Rebelo A. The influence of the playing surface on the exercise intensity of small-sided recreational soccer games. Hum Mov Sci. 2012;31(4):946-56. doi: http://dx.doi.org/10.1016/j.humov.2011.08.011.
21. Randers M, Andersen TB, Rasmussen L, Larsen MN, Krustrup P. Effect of game format on heart rate, activity profile, and player involvement in elite and recreational youth players. Scand J Med Sci Sports. 2014;24(S1):17-26.
22. Schmidt JF, Hansen PR, Andersen T, Andersen L, Hornstrup T, Krustrup P, Bangsbo J. Cardiovascular adaptations to 4 and 12 months of football or strength training in 65 to 75 year old untrained men. Scand J Med Sci Sports. 2014;24(S1):86-97.
23. Krustrup P, Hansen PR, Andersen LJ, Jakobsen MD, Sundstrup E, Randers MB, Christiansen L, Helge EW, Pedersen MT, Søgaard P. Long term musculoskeletal and cardiac health effects of recreational football and running for premenopausal women. Scand J Med Sci Sports. 2010;20(s1):58-71.
24. Krustrup P, Christensen JF, Randers MB, Pedersen H, Sundstrup E, Jakobsen MD, Krustrup BR, Nielsen JJ, Suetta C, Nybo L. Muscle adaptations and performance enhancements of soccer training for untrained men. Eur J Appl Physiol. 2010;108(6):1247-58.
25. Krustrup P, Nielsen JJ, Krustrup BR, Christensen JF, Pedersen H, Randers MB, Aagaard P, Petersen AM, Nybo L, Bangsbo J. Recreational soccer is an effective health-promoting activity for untrained men. Br J Sports Med. 2009;43(11):825-31. doi: 10.1136/bjsm.2008.053124. PubMed PMID: 19098116.
26. Krustrup P, Hansen PR, Nielsen CM, Larsen MN, Randers M, Manniche V,

Hansen L, Dvorak J, Bangsbo J. Structural and functional cardiac adaptations to a 10 week school based football intervention for 9–10 year old children. Scand J Med Sci Sports. 2014;24(S1):4-9.
27. Milanović Z, Pantelić S, Sporiš G, Mohr M, Krustrup P. Health-related physical fitness in healthy untrained men: Effects on VO 2 max, jump performance and flexibility of soccer and moderate-intensity continuous running. PLoS One. 2015;10(8):e0135319.
28. Helge EW, Andersen T, Schmidt JF, Jørgensen NR, Hornstrup T, Krustrup P, Bangsbo J. Recreational football improves bone mineral density and bone turnover marker profile in elderly men. Scand J Med Sci Sports. 2014;24(S1):98-104.
29. Barene S, Krustrup P, Jackman S, Brekke O, Holtermann A. Do soccer and Zumba exercise improve fitness and indicators of health among female hospital employees? A 12 week RCT. Scand J Med Sci Sports. 2014;24(6):990-9.
30. Barene S, Krustrup P, Brekke OL, Holtermann A. Soccer and Zumba as health-promoting activities among female hospital employees: a 40-weeks cluster randomised intervention study. J Sports Sci. 2014;32(16):1539-49.
31. Bangsbo J, Nielsen JJ, Mohr M, Randers MB, Krustrup BR, Brito J, Nybo L, Krustrup P. Performance enhancements and muscular adaptations of a 16 week recreational football intervention for untrained women. Scand J Med Sci Sports. 2010;20(s1):24-30.
32. Andersen T, Schmidt JF, Nielsen JJ, Randers M, Sundstrup E, Jakobsen MD, Andersen LL, Suetta C, Aagaard P, Bangsbo J. Effect of football or strength training on functional ability and physical performance in untrained old men. Scand J Med Sci Sports. 2014;24(S1):76-85.
33. Connolly LJ, Scott S, Mohr M, Ermidis G, Julian R, Bangsbo J, Jackman SR, Bowtell JL, Davies RC, Hopkins SJ, Seymour R, Knapp KM, Krustrup P, Fulford J. Effects of small-volume soccer and vibration training on body composition, aerobic fitness, and muscular PCr kinetics for inactive women aged 20–45. J Sport Health Sci. 2014;3(4):284-92. doi: http://dx.doi.org/10.1016/j.jshs.2014.07.003.
34. Krustrup P, Hansen P, Randers MB, Nybo L, Martone D, Andersen LJ, Bune L, Junge A, Bangsbo J. Beneficial effects of recreational football on the cardiovascular risk profile in untrained premenopausal women. Scand J Med Sci Sports. 2010;20(s1):40-9.
35. Jakobsen MD, Sundstrup E, Krustrup P, Aagaard P. The effect of recreational soccer training and running on postural balance in untrained men. Eur J Appl Physiol. 2011;111(3):521-30.
36. Faude O, Kerper O, Multhaupt M, Winter C, Beziel K, Junge A, Meyer T. Football to tackle overweight in children. Scand J Med Sci Sports. 2010;20(s1):103-10.
37. Sousa M, Fukui R, Krustrup P, Pereira R, Silva P, Rodrigues A, Andrade J, Hernandez A, Silva M. Positive effects of football on fitness, lipid profile, and insulin resistance in Brazilian patients with type 2 diabetes. Scand J Med Sci Sports. 2014;24(S1):57-65.
38. Mohr M, Helge EW, Petersen LF, Lindenskov A, Weihe P, Mortensen J, Jørgensen NR, Krustrup P. Effects of soccer vs swim training on bone formation in sedentary middle-aged women. Eur J Appl Physiol. 2015:1-9.
39. Knoepfli Lenzin C, Sennhauser C, Toigo M, Boutellier U, Bangsbo J, Krustrup P, Junge A, Dvorak J. Effects of a 12 week intervention period with football and running for habitually active men with mild hypertension. Scand J Med Sci Sports. 2010;20(s1):72-9.
40. Andersen LJ, Randers M, Hansen PR, Hornstrup T, Schmidt JF, Dvorak J, Søgaard P, Krustrup P, Bangsbo J. Structural and functional cardiac adaptations to 6 months of football training in untrained hypertensive men. Scand J Med Sci Sports. 2014;24(S1):27-35.
41. Andersen LJ, Randers MB, Westh K, Martone D, Hansen P, Junge A, Dvorak J, Bangsbo J, Krustrup P. Football as a treatment for hypertension in untrained 30–55 year old men: a prospective randomized study. Scand J Med Sci Sports. 2010;20(s1):98-102.
42. Krustrup P, Randers MB, Andersen LJ, Jackman SR, Bangsbo J, Hansen PR. Soccer improves fitness and attenuates cardiovascular risk factors in hypertensive men. Med Sci Sports Exerc. 2013;45(3):553-60.
43. Hill-Haas SV, Dawson B, Impellizzeri FM, Coutts AJ. Physiology of small-sided games training in football. Sports med. 2011;41(3):199-220.
44. Dellal A, Chamari K, Pintus A, Girard O, Cotte T, Keller D. Heart rate responses during small-sided games and short intermittent running training in elite soccer players: a comparative study. J Strength Cond Res. 2008;22(5):1449-57.
45. Barene S, Krustrup P, Jackman SR, Brekke OL, Holtermann A. Do soccer and Zumba exercise improve fitness and indicators of health among female hospital employees? A 12-week RCT. Scand J Med Sci Sports. 2014;24(6):990-9. doi: 10.1111/sms.12138. PubMed PMID: 24151956.
46. Barene S, Krustrup P, Brekke OL, Holtermann A. Soccer and Zumba as health-promoting activities among female hospital employees: a 40-weeks cluster randomised intervention study. J Sports Sci. 2014;32(16):1539-49. doi: 10.1080/02640414.2014.906043. PubMed PMID: 24720526.
47. Karlsson M. Has exercise an antifracture efficacy in women? Scand J Med Sci Sports. 2004;14(1):2-15.
48. Jackman SR, Scott S, Randers MB, Ørntoft C, Blackwell J, Zar A, Helge EW, Mohr M, Krustrup P. Musculoskeletal health profile for elite female footballers versus untrained young women before and after 16 weeks of football training. J Sports Sci. 2013;31(13):1468-74.
49. Vicente-Rodriguez G, Ara I, Perez-Gomez J, Serrano-Sanchez JA, Dorado C, Calbet JA. High femoral bone mineral density accretion in prepubertal soccer players. Med Sci Sports Exerc. 2004;36:1789-95.
50. Zouch M, Zribi A, Alexandre C, Chaari H, Frere D, Tabka Z, Vico L. Soccer Increases Bone Mass in Prepubescent Boys During Growth: A 3-Yr Longitudinal Study. J Clin Densitom. 2015;18(2):179-86. doi: http://dx.doi.org/10.1016/j.jocd.2014.10.004.
51. Nebigh A, Rebai H, Elloumi M, Bahlous A, Zouch M, Zaouali M, Alexandre C, Sellami S, Tabka Z. Bone mineral density of young boy soccer players at different pubertal stages: relationships with hormonal concentration. Joint Bone Spine. 2009;76(1):63-9.