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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

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ABSTRACT

Over the past 10 years, researchers have studied the effects of recreational football training as a health-promoting activity for participants across the lifespan. This has important public health implications as over 400 million people play football annually. Results from the first randomised controlled trial, published in the *BJSM* in January 2009, showed that football increased maximal oxygen uptake and muscle and bone mass, and lowered fat percentage and blood pressure, in untrained men, and since then more than 70 articles about football for health have been published, including publications in two supplements of the *Scandinavian Journal of Medicine and Science in Sports* in 2010 and 2014, prior to the FIFA World Cup tournaments in South Africa and Brazil. While studies of football training effects have also been performed in women and children, this article reviews the current evidence linking recreational football training with favourable effects in the prevention and treatment of disease in adult men.

THE PHYSIOLOGY OF RECREATIONAL FOOTBALL—WHY MIGHT TRAINING CONFER HEALTH BENEFITS?

Recreational football training conducted as small-sided games (4v4 to 6v6) has broad-ranging physiological effects, with more pronounced changes achieved than through recreational running, interval running and fitness training.[1–4] Its marked effect on the cardiovascular system may, in part, be a result of average heart rates being around 80% of maximal heart rate (HRmax) during training, with substantial time spent at 80–90% and above 90% HRmax during a 1 h training session, irrespective of age, fitness status and previous experience of football training (figure 1).

Notably, overweight men with type 2 diabetes mellitus (T2DM), 65–75-year-old men with no prior experience of football and men with prostate cancer, were all able to perform football training with much time spent above 80% HRmax.[5–7] These groups carried out the training at an intensity as high as lifelong-trained veteran (masters) football players.[8] Generally, the participants conducted more than 100 high-intensity runs and specific intense actions such as dribbles, shots, tackles, turns and jumps per training session. Importantly, despite the high heart rates during training, recreational football training had the lowest score in perceived exertion (3.9 of 10) in comparison with other activities such as jogging, interval running and fitness training.[9 10] This may be one reason why participants in the training studies usually found the game enjoyable and maintained their interest in football training even after the intervention study period was over.[11–13]

CARDIOVASCULAR EFFECTS OF RECREATIONAL FOOTBALL

Blood pressure and heart rate at rest

Many studies have shown that a period of recreational football training lowers blood pressure in normotensive untrained participants (table 1). Systolic blood pressure in middle-aged men was typically reduced by 7–8 mm Hg after a 3-month training period, higher than the 3–4 mm Hg reduction often seen with other types of exercise modalities with the same duration and frequency.[14] Also, diastolic pressure was lowered (5–7 mm Hg) significantly after a period of recreational football (table 1). It should be noted, however, that in some studies, blood pressure was not reduced by a period of football training, which may be due, in part, to the inclusion of healthy participants with low baseline values in these studies (table 1).

Recreational football training lowers blood pressure remarkably in patients with hypertension. Thus, football training twice a week for 24 weeks led to men's systolic blood pressure falling from 151 to 139 mm Hg, and diastolic pressure, from 92 to 84 mm Hg.[15] Three quarters of the participants reached systolic and diastolic blood pressure values below 140 and 90 mm Hg, respectively.

Football training also lowers blood pressure in patients with T2DM. Approximately 80% of patients with T2DM are hypertensive, which nearly doubles the risk of adverse cardiovascular events.[16] In patients with T2DM, systolic and diastolic blood pressure was reduced by 9 and 8 mm Hg, respectively, through 12 weeks of football training, with no further change in the following 12 weeks of football training.[17] These reductions in blood pressure are more pronounced than those reported for other exercise interventions with hypertensive and patients with T2DM, where reductions in resting mean blood pressure of 3–5 mm Hg are observed after 3 months of training and compares favourably with commonly used medication such as β-blockers.[18 19]

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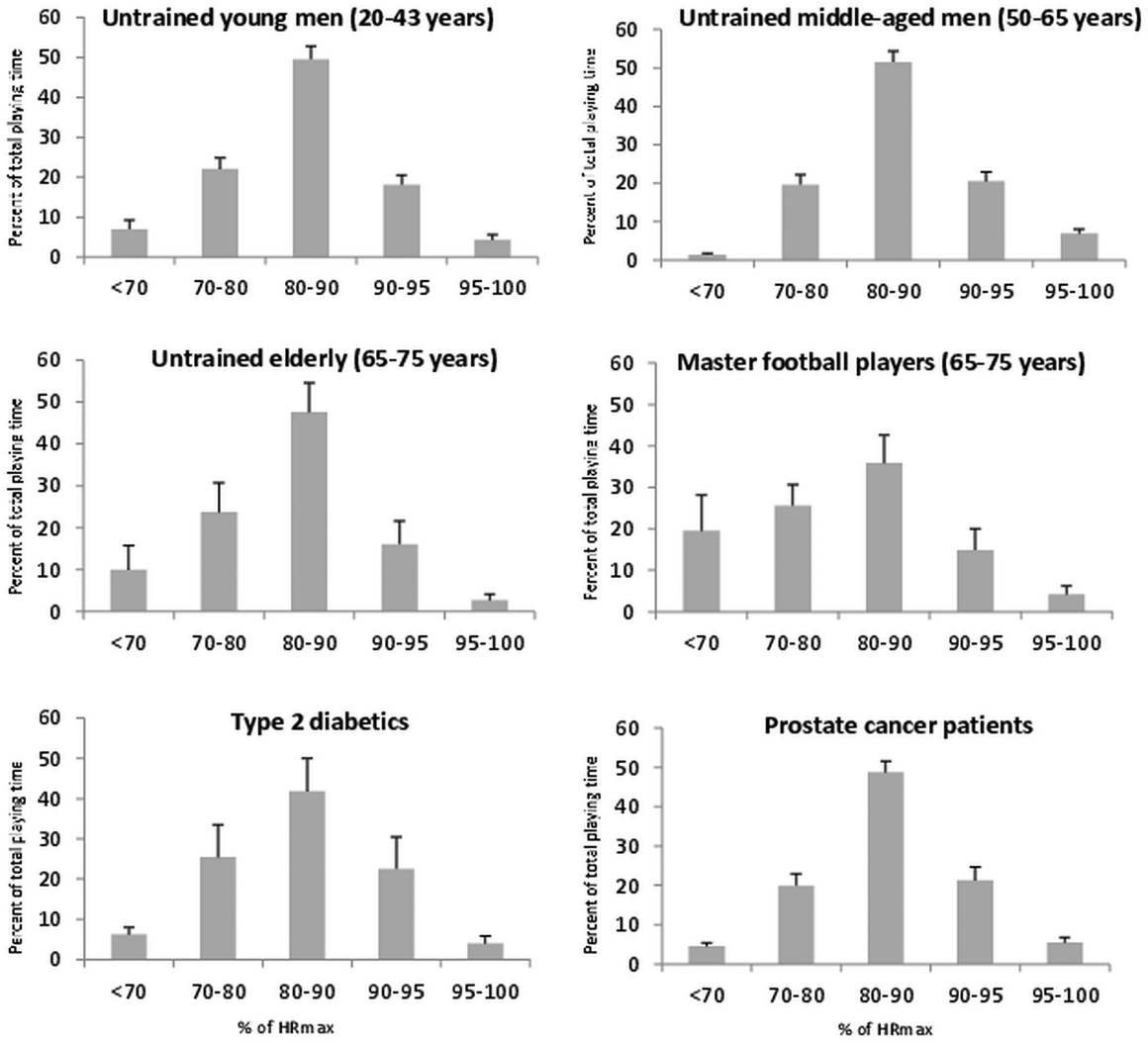

Figure 1 Heart rate distribution, expressed as a percentage of maximum heart rate, during football training consisting of small-sided games for various study groups. Data are presented as means±SEM. HRmax, maximal heart rate.

In addition, in a randomised study of prostate cancer, patients receiving androgen deprivation therapy (gonadotropin-releasing hormone agonists with or without anti-androgens), systolic and diastolic blood pressures were 3 mm Hg lower after 12 weeks of football training. This was, however, not significantly different from changes in the control group.[7] The lack of change in blood pressure observed in these patients, where approximately 50% received antihypertensive therapy and most had been treated for prostate cancer for more than 3 years, may have been due to bias associated with low blood pressures and optimal blood pressure control at baseline owing to long-term medical surveillance of cardiovascular risk factors associated with androgen deprivation therapy.[20]

The mechanisms behind the larger blood pressure reduction after a period of recreational football training compared with other training modalities are not clear. In almost all studies, heart rate at rest was markedly lowered (4–12 bpm) after a period of football training (table 1), probably mediated by an augmented stroke volume (see below) and modulation of the autonomous nervous system with an increase in parasympathetic activity.[21 22] It is unclear, however, whether cardiac output was reduced.

Vascular tone and total peripheral resistance may have been lowered by a reduced sympathetic drive accompanying the period of football training. Although physical exercise can improve endothelium-dependent vasodilation in large conduit arteries, the effects on microvascular endothelial function, a primary determinant of peripheral vascular resistance, are less clear.[23–25] Indeed, in four of the more recent football training studies of men with hypertension, T2DM or prostate cancer with androgen deprivation therapy and elderly male participants, there was no change in microvascular reactive hyperaemic index, a measure of microvascular endothelial function determined by peripheral arterial tonometry.[15 26]

On the other hand, a cross-sectional comparison of veteran football players and untrained elderly healthy men showed a higher reactive hyperaemic index in the football group, while arterial stiffness measured by the augmentation index was reduced by football training in middle-aged hypertensive men.[15 27] Furthermore, in men with T2DM, football training was associated with an increased number of capillaries around type I striated skeletal muscle fibres.[5] It is therefore possible that reduced arterial stiffness and an increased microvascular bed contribute to blood pressure-lowering effects, but the mechanisms by which football training may reduce arterial blood pressure more than other training modalities warrant further study. Altogether, the pronounced drops in blood pressure and resting heart rate observed in a range of studies are important markers of improved cardiovascular health profile in sedentary

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Table 1 Changes in cardiovascular variables in untrained men as a result of a period of recreational F training compared to R or inactive C

Study	Activity, target group, gender	Age (years)	Training intervention; Duration (weeks), intensity (%), frequency (per week), session duration (min)	VO_2max (mL/kg/min or %)	VO_2max (L/min or %)	HR sub-max (bpm)	HR rest (bpm)	BPsys rest, (mmHg)	BPdia rest, (mmHg)	MAP rest (mmHg)	RV systolic function, TAPSE (cm)	LV diastolic function, E/A ratio (%)	Arterial stiffness (AI) (%)
Krustrup *et al*[1 2 10]	F, UT, M,	29	12; 82%HRmax; 2.3; 60	13%↑*	11%↑*	20↓*†	6↓*	8↓*	5↓*	6↓*	–	–	–
	R, UT, M	31	12; 82%HRmax; 2.5; 60	8%↑*	7%↑*	21↓*†	6↓*	7↓*	5↓*	6↓*	–	–	–
	C, UT, M	31	No intervention	1%↓NS	1%↓NS	0↔NS	1↑NS	2↓NS	2↑NS	1↑NS	–	–	–
Randers *et al*[8 41]	F, UT, M	31	64; 82%HRmax; 1.3; 60	8%↑*	6%↑*	22↓*†	8↓*‡	8↓*‡	3↓NS	5↓*	–	–	–
	C, UT, M	32	No intervention	–	–	–	2↓NS	2↓NS	3↑NS	1↑NS	–	–	–
Schmidt *et al*[26]	F, UT, M	68	52; 82%HRmax; 1.7; 45–60	–	18%↑*‡	–	8↓*	NS	NS	NS	0.5↑*‡	25%↑*‡	–
	S, UT, M	69	52; 8–20RM; 1.9; 45–60	–	3%↑NS	–	2↓NS	NS	NS	NS	0.0↔NS	NS	–
	C, UT, M	67	No intervention	–	1%↑NS	–	2↓NS	NS	NS	NS	0.2 ↓NS	NS	–
Andersen *et al*[6]	F, UT, M	68	16; 84%HRmax; 1.6; 45–60	3.8↑*	–	8↓*	–	–	–	–	–	–	–
	S, UT, M	69	16; 8–20RM; 1.5; 45–60	0.8↑NS	–	9↓NS	–	–	–	–	–	–	–
	C, UT, M	67	No intervention	0.7↓NS		7↓NS							
Krustrup *et al*[15]	F, UT, M[a,]	46	24; 85%HRmax; 1.7; 60	8%↑*	–	12↓NS	8↓*	13↓*‡	8↓*‡	10↓*‡	–	–	7%↓*
	DAG, UT, M[a]	47	DA on CRF	3%↓NS	–	4↓NS	3↓NS	8↓*	3↓*	5↓*	–	–	↔NS
Andersen *et al*[6]	F, UT, M[a]	46	24; 83%HRmax; 1.7; 60	8%↑*	–	–	8↓*	–	–	10↓*‡	0.4↑*‡	34%↑*‡	–
	DAG, UT, M[a]	47	DA on CRF	2%↓NS	–	–	3↓NS	–	–	5↓*	NS	NS	–
Knoepfli-Lenzin *et al*[22]	F, UT, M[mh]	37	12; 80%HRmax; 2.4; 60	9%↑*	6%↑*	–	7↓*	11↓*	9↓*‡	10↓*†	–	–	–
	R, UT, M[mh]	36	12; 79%HRmax; 2.5; 60	12%↑*	11%↑*	–	9↓*	7↓*	6↓*	6↓*	–	–	–
	C, UT, M[mh]	38	No intervention	1%↑NS	1%↑NS	–	6↓*	7↓*	4↓*	6↓*	–	–	–
Schmidt *et al*[17]	F, UT, M[t]	51	24; 82%HRmax; 1.2; 60	12%↑*	11%↑*	–	6↓NS	9↓*	8↓*	8↓*	0.4↑*‡	18%*↑	0.1%↑NS
	C, UT, M[t]	49	No intervention	2%↑NS	2%↑NS	–	2↑NS	3↑NS	0↔NS	1↑NS	0.1↓NS	NS	0.6%↑NS
De Sousa *et al*[39]	F, UT, M[t]+W[t]	61	12; 83%HRmax; 3; 40; F+D	10%↑*‡	–	–	–	–	–	–	–	–	–
	C, UT, M[t]+W[t]	61	Diet group	3%↓ NS	–	–	–	–	–	–	–	–	–
Uth *et al*[37]	F, UT, M[p]	67	12; 85%HRmax; 2–3; 45–60	1.5↑*	–	–	–	–	–	–	–	–	–
	C, UT, M[p]	67	No intervention	0.3↑ NS	–	–	–	–	–	–	–	–	–
Faude *et al*[56]	F, UT, OCh	11	12; 80%HRmax; 4.5; 60	7%↓NS	5%↓NS	7↓*	–	–	–	–	–	–	–
	SP, UT, OCh	11	12; 77%HRmax; 4.5; 60	7%↓NS	3%↓NS	7↓*	–	–	–	–	–	–	–
Hansen *et al*[55]	F, UT, OCh	10	12; >80%HRmax; 4; 60–90	–	–	–	–	–	–	–	0.26↑*‡	NS	1.9%↑NS
	C, UT, OCh	11	No intervention	–	–	–	–	–	–	–	NS	NS	2.7%↓NS

Changes between pretraining and post-training intervention (unless otherwise stated).
*Significant difference from 0 weeks.
†Significant group difference compared to control.
‡Significant group difference.
a, hypertensive participants; AI, augmentation index; BPdia, diastolic blood pressure; BPsys, systolic blood pressure; C, controls; CRF, cardiovascular risk factors; DAG, doctor's advice group; E/A ratio, ratio of early (E) to late (A) ventricular filling velocities; F, football; F+D, football + diet group; HRmax, maximal heart rate; LV left ventricular; M, men; MAP, mean arterial pressure; mh, mildly hypertensive participants; NS, not significant; OC, overweight children; p, prostate cancer patients; R, running; RV, right ventricular; S, strength training; SP, standard physical activity; t, type 2 diabetics; TAPSE, tricuspid annular plane systolic excursion; UT, untrained; W, women.

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individuals. Resting heart rate is an independent risk factor for cardiovascular disease in healthy participants and in patients with established diseases, for example, T2DM and hypertension.[28–30]

Heart structure and function

Recreational football training has significant effects on myocardial structure and function at rest, as determined by comprehensive transthoracic echocardiography using tissue Doppler, speckle tracking and strain rate analyses (table 1). For example, there were considerable improvements in variables associated with left ventricular systolic and diastolic function, and right ventricular systolic function, after a period of football training in untrained middle-aged hypertensive men, men with T2DM and elderly men.[5 17 26] Left ventricular end-diastolic volume was also increased, which, in view of unaltered or increased left ventricular systolic function, suggests increased stroke volume. Interestingly, there were no changes in echocardiographic parameters after football training in patients with prostate cancer undergoing androgen deprivation therapy, raising the intriguing possibility that the latter may counteract the favourable effects of football training on the heart.[7]

Notably, several of the changes observed after football training, for example, enhanced diastolic function, have not been found in selected studies with other training modalities, for example, cycling, strength training, jogging and walking, suggesting that football may be a more powerful stimulus.[31–33] Interestingly, in participants with T2DM, high-intensity interval cycle training improved diastolic function much more than medium-intensity cycle training,[34] and it is likely that the underlying mechanisms are similar to the mechanisms behind the marked effects of football training, which includes numerous intense activity periods interspersed by periods with low-intensity activity.

Notwithstanding these considerations, subclinical cardiac systolic and diastolic dysfunction measured by these echocardiographic variables have been associated with increased mortality, and it remains to be determined whether the favourable changes demonstrated after football training, if maintained over time, can improve major end points such as myocardial infarction, stroke or death.[35 36]

Maximum oxygen uptake

Regular recreational football training increases maximum oxygen uptake (VO_2max) in previously untrained participants. Most studies have shown 7–15% increases in VO_2max after 12–24 weeks of training, which is comparable to or higher than observed in investigations with running and cycling (table 1). Even more pronounced effects were observed in 65–75-year-old men, that is, 16% and 18% increases in VO_2max after 16 and 54 weeks of football training, respectively, which may be related to the low baseline levels.[26]

In men with T2DM, VO_2max was also higher (11%) after 24 weeks of football training, and in hypertensive participants football training increased VO_2max by 8% after 3 months of training.[15 17] A smaller within-group increase of 4% was observed for a group of patients with cancer conducting 45–60 min football training sessions two to three times a week for 12 weeks, and no significant between-group effect was found.[37]

EFFECT OF RECREATIONAL FOOTBALL ON BLOOD LIPID PROFILE AND BODY COMPOSITION

Blood lipid profile

A typical finding, though not always significant, is that total plasma cholesterol and low-density lipoprotein (LDL) cholesterol are lower after a period of recreational football training (table 2). For example, in young and middle-aged men, training for 12 weeks led to a significant 15% decrease in LDL cholesterol and a non-significant 8% increase in high-density lipoprotein cholesterol levels.[1] In addition, LDL cholesterol levels were lower by 13% in young and middle-aged homeless men playing street football for 3×40 min for 12 weeks.[38] These changes may add to the aforementioned favourable cardiovascular effects of football training to reduce the risk of future cardiovascular diseases.[14] Also, patients with T2DM aged 48–68 years lowered

Table 2 Changes in blood lipids in untrained men as a result of a period of recreational F training compared to R or inactive C

Study	Activity, target group, gender	Age (years)	Training intervention; Duration (weeks), intensity (%), frequency (per week), session duration (min)	Total-Chol rest (mmol/l or %)	HDL-Chol rest (mmol/l or %)	LDL-Chol rest (mmol/l or %)
Krustrup *et al*[1]	F, UT, M	29	12; 82%HRmax; 2.3; 60	5%↓NS	8%↑NS	15%↓*†
	R, UT, M	31	12; 82%HRmax; 2.5; 60	7%↓NS	8%↑NS	4%↓NS
	C, UT, M	31	No intervention	0%↔NS	7%↑NS	0%↔NS
Randers *et al*[8 41]	F, UT, M	31	64; 82%HRmax; 1.3; 60	0%↔NS	8%↑NS	7%↓NS
	C, UT, M	32	No intervention	2%↑NS	0%↔NS	7%↑NS
Randers *et al*[38]	F, UT, Mh	36	12; 82%HRmax; 2.2; 60	0.1↓NS	0.0↔NS	0.4↓*NS†
	C, UT, Mh	43	No intervention	0.1↑NS	0.1↓NS	0.1↑NS
Krustrup *et al*[15]	F, UT, M[a]	46	24; 85%HRmax; 1.7; 60	–	8%↓NS	9%↓NS
	DAG, UT, M[a]	47	DA on CRF	–	9%↑NS	9%↑NS
Knoepfli-Lenzin *et al*[22]	F, UT, M[mh]	37	12; 80%HRmax; 2.4; 60	5%↓*	8%↑NS	3%↓NS
	R, UT, M[mh]	36	12; 79%HRmax; 2.5; 60	2%↓NS	0%↔NS	0↔NS
	C, UT, M[mh]	38	No intervention	4%↓NS	8%↑NS	3%↓NS
Schmidt *et al*[17]	F, UT, M[t]	51	24; 82%HRmax; 1.2; 60	5%↓NS	8%↑NS	11↑NS
	C, UT, M[t]	49	No intervention	8%↑NS	9%↑NS	9%↑NS
De Sousa *et al*[39]	F, UT, M[t]+W[t]	61	12; 83%HRmax; 3; 40; F+D	0.6↓*†	0↔NS	0.4↓*†
	C, UT, M[t]+W[t]	61	Diet group	0.4↑NS	0↔NS	0.3↑NS

Changes between pre and post training intervention (unless otherwise stated).
*Significant difference from 0 weeks.
†Significant group difference compared to control.
a, hypertensive participants; C, controls; Chol, cholesterol; CRF; cardiovascular risk factors; DAG, doctor's advice group; F, football; F+D, football+diet group; HDL, high-density lipoprotein; HRmax, maximal heart rate; LDL, low-density lipoprotein; M, men; mh, mildly hypertensive participants; NS, not significant; R, running; t, type 2 diabetics; Total-chol, total plasma cholesterol; UT, untrained; W, women.

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their total cholesterol and LDL cholesterol levels when combining 3×40 min football sessions a week for 12 weeks with a calorie-restricted diet.[39]

Body fat and lean body mass

Regular recreational football training influences body composition (table 3). Loss of body fat in middle-aged men was in the range of 1–3 kg following 3 months of training, corresponding to a reduction in fat percentage of 1–3%. Specifically, fat mass was lowered by 1.8 kg in young and middle-aged homeless men playing street football for 45 min, two to three times a week for 12 weeks, corresponding to a decrease in body fat percentage from 17.9% to 15.9%.[38]

In some studies, a period of recreational football training led to higher lean body mass. Total and leg muscle mass were elevated by 1.7 and 1.1 kg, respectively, after 12 weeks of two to three 60 min football training sessions per week.[1] A few studies have, however, not been able to demonstrate a significant effect of football training on lean body mass (table 3). The number and length of sprints, and the number of intense actions, depend on the number of players, the degree of man-to-man marking and the pitch size used for small-sided games.[8 40] Further studies are warranted to clarify whether the change in muscle mass is related to the way the training is conducted.

Also, marked effects of football training on body composition have been observed in patient groups (table 3). In middle-aged men with T2DM, total fat mass was 1.7 kg lower and android fat percentage reduced by 12.8% after 24 weeks of football training.[5] An even more pronounced response was found when another group of T2DM patients conducted 3×40 min football sessions per week for 12 weeks with a caloric-restricted diet, with a loss of fat mass of 3.4 kg.[39] Interestingly, a significant increase in muscle mass of 0.9 kg in patients with prostate cancer undergoing antiandrogen treatment was observed after two to three times weekly 45–60 min training sessions over 12 weeks, despite the minimal levels of testosterone in these patients.[37]

Bone mass and bone mineral density

Participation in small-sided football games also affects the skeleton (table 3). Thus, in 20–43-year-old sedentary men, lower extremity bone mineral content was elevated by 2% after 12 weeks of recreational football training twice a week and was maintained in the following 52 weeks with a reduced frequency to about once a week.[1 41] Football training also influenced elderly participants (65–75 years of age), with bone mineral density (BMD) in left and right proximal femur being, respectively, 1.1 and 1.0% higher after 4 months of training.[42] Continuing the training for another 8 months led to further marked improvements in the elderly, reaching increases in BMD of 3.8% and 5.4% in the right and left femoral neck, respectively, as well as increases of 2.4% and 2.9% in the left and right proximal femur, respectively[42] (table 3). These findings suggest that the osteogenic BMD response in elderly men is not lower, but rather slower, than in their younger counterparts.

The changes in the elderly are markedly higher than what has been observed in other intervention studies examining the skeletal effect of physical activity.[43–45] It is likely that the actions in the small-sided football games, with many changes in direction and speed,[46] augment BMD, since the osteogenic stimulus from exercise depends on the strain rate and magnitude induced by muscle contraction and ground reaction forces.[47–50]

Measurements of biochemical bone markers in the elderly suggested that the anabolic response was due to improved bone formation (table 3). Similarly, indication of anabolic effect in bone metabolism was seen in a study of homeless men, where trunk BMD was also elevated (1.0%) after 12 weeks of 2.2 football training sessions a week[46] (table 3). Together with the functional improvements in rapid muscle force and postural balance (see below), the higher BMD with regular participation in football training is likely to reduce the risk of fractures due to falling.[51 52]

MUSCLE ADAPTATIONS IN RECREATIONAL FOOTBALL

A few studies have measured changes in muscle oxidative enzymes as a result of a period of recreational football training (table 4). A 14% increase in the maximal activity of leg muscle citrate synthase (CS) occurred after 12 weeks of training, with no further increase during the following 54 weeks, with training frequency reduced from 2.3 to 1.3 times a week.[1 41] The change during the first 12 weeks was greater than that observed in a running group performing the same volume of training, suggesting that the intermittent nature of football training had a greater impact on the development of the muscle oxidative system. The maximal activity of 3-hydroxyacyl-CoA dehydrogenase (HAD) was non-significantly elevated by 5% and 16% after 12 and 64 weeks, respectively, of football training,[41] which may have been one reason for the elevated fat oxidation during exercise found after a period of football training.[53]

Surprisingly, there was no change in maximal activity of leg muscle CS and HAD in patients with T2DM after 12 and 24 weeks of football training, and the expression of CS was even significantly lowered after 24 week of training.[5] On the other hand, the training led to higher expression of muscle actin and Akt-2, as well as a tendency to a higher amount of the GLUT-4 protein. In addition, muscle capillarisation, expressed as number of capillaries per fibre, was increased by 22% in middle-aged men after 12 weeks of recreational football training,[1] which was similar to that observed in a running group performing a similar amount of training (table 4). Also, a group of patients with T2DM with an average age of around 50 years increased leg muscle capillarisation during a 24-week recreational football training period, albeit to a lesser degree than observed in the younger men.[5]

EFFECT OF RECREATIONAL FOOTBALL ON FUNCTIONAL CAPACITY

Regular recreational football training has a marked positive effect on the functional capacity of the participants (table 5). In addition to improvements in VO_2max (see above), middle-aged male participants, as well as school children, had 25–50% improved performance in Yo-Yo intermittent tests consisting of 2×20-m runs performed repeatedly at progressively increasing speeds and separated by either 5 seconds (Yo-Yo intermittent endurance test level 1 and 2; IE1 and IE2) or 10 s of rest (Yo-Yo intermittent recovery test level 1, IR1).[38 53 54 55] Also, elderly men had improved Yo-Yo IE1 performance (43%) after 16 weeks of football training, as well as better sit-to-stand (29%) performance.[6]

In some studies, maximal leg strength was higher after, rather than before, a period of recreational football training (table 5). In the study by Krustrup *et al*,[53] maximal hamstring power was increased by 11% in combination with a 0.11 s improvement in a 30 m sprint, after 12 weeks of training. Studies have observed that recreational football training led to an increase in countermovement jump performance for boys[56] and young men,[41] whereas others did not find any change for young[57] and elderly men.[6] Nevertheless, a consistent finding has been that

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Table 3 Changes in body composition in untrained men as a result of a period of recreational F training compared to R or inactive C

Study	Activity, target group, gender	Age (years)	Training programme; Duration (weeks), intensity (%), frequency (per week), session duration (min)	Total fat mass (kg)	Total fat percentage (%)	Lean body mass, whole body (kg)	Lean body mass, legs (kg)	Bone mineral density, left and right proximal femur (%)	Bone mineral density, left and right femoral neck (%)	Bone mineral density (legs) (%)	Bone mineral density, trunk (%)	Bone marker – osteocalcin (%)
Krustrup *et al*[1]	F, UT, M	29	12; 82%HRmax; 2.3; 60	2.7↓*†	2.9↓*†	1.7↑*†	1.1↑*†	–	–	–	–	–
	R, UT, M	31	12; 82%HRmax; 2.5; 60	1.7↓*	1.7↓*	0.6↑NS	0.6↑NS	–	–	–	–	–
	C, UT, M	31	No intervention	0.3↓NS	0.2↓NS	0.1↑NS	0.3↓NS	–	–	–	–	–
Randers *et al*[8 41]	F, UT, M	31	64; 82%HRmax; 1.3; 60	3.2↓*†	3.8↓*†	2.7↑*	1.1↑*†‡	–	–	2%↑*	–	–
	C, UT, M	32	No intervention	0.2↓NS	0.6↓NS	1.2↑*	0.2↑NS	–	–	1%↑NS	–	–
Helge *et al*[42]	F, UT, M	68	52; 82%HRmax; 1.7; 45–60	–	–	–	–	LL:2.4%↑* RL:2.9%↑*	LL:5.4%↑* RL:3.8%↑*	–	–	46%↑*†
	S, UT, M	69	52; 8–20RM; 1.9; 45–60	–	–	–	–	NS	NS	–	–	NS
	C, UT, M	67	No intervention	–	–	–	–	NS	NS	–	–	NS
Krustrup *et al*[15]	F, UT, M[a]	46	24; 85%HRmax; 1.7; 60	1.9↓NS	2.2↓NS	0.2↑NS	0.1↑NS	–	–	2.1%↑NS	–	–
	DAG, UT, M[a]	47	DA on CRF	0.9↓NS	1.0↓NS	0.2↑NS	0.0↔NS	–	–	0.0% NS	–	–
Knoepfli-Lenzin *et al*[22]	F, UT, M[mh]	37	12; 80%HRmax; 2.4; 60	2.0↓*	2.0↓*†	0.5↑NS	–	–	–	–	–	–
	R, UT, M[mh]	36	12; 79%HRmax; 2.5; 60	1.7↓*	1.4↓NS	0.0↔NS	–	–	–	–	–	–
	C, UT, M[mh]	38	No intervention	0.1↑NS	0.1↑NS	0.3↓NS	–	–	–	–	–	–
De Sousa *et al*[39]	F, UT, M[t]+W[t]	61	12; 83%HRmax; 3; 40; F+D	3.4↓*	2.4↓NS	0.2↓NS	–	–	–	–	–	–
	C, UT, M[t]+W[t]	61	Diet group	3.7↓*	2.4↓NS	1.0↓NS	–	–	–	–	–	–
Andersen *et al*[5]	F, UT, M[t]	51	24; 83%HRmax; 1.5; 60	1.7↓*	1.5↓*	0.7↑NS	0.5↑NS	–	–	NS	–	–
	C, UT, M[t]	49	No intervention	0.1↓NS	0.2↓NS	0.8↑NS	0.5↓*	–	–	NS	–	–
Helge *et al*[46]	F, UT, M[h]	36	12; 82%HRmax; 2.2; 60	1.8↓*	–	0.9↑*	–	–	–	–	1%↑*	27%↑*†
	C, UT, M[h]	43	No intervention	NS	–	NS	–	–	–	–	NS	NS
Uth *et al*[37]	F, UT, M[p]	67	12; 85%HRmax; 2–3; 45–60	1.3↓*	0.9↓*	0.9↑*†	–	–	–	–	–	–
	C, UT, M[p]	67	No intervention	0.3↓NS	0.0↔NS	0.1↑NS	–	–	–	–	–	–

Changes between pre and post training intervention (unless otherwise stated).
*Significant difference from 0 weeks.
†Significant group difference compared to control.
‡Significant group differences.
a, hypertensive subjects; C, controls; CRF, cardiovascular risk factors; DAG, doctor's advice group; F, football; F+D, football+diet group; h, homeless subjects; HRmax, maximal heart rate; LL, left leg; M, men; mh; mildly hypertensive subjects; NS, not significant; p, prostate cancer patients; R, running; RL, right leg; S, strength training; t, type 2 diabetics; UT, untrained; W, women

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Table 4 Changes in muscle enzymatic activity and capillarisation in untrained men as a result of a period of recreational F training compared to R or inactive C

Study	Activity, target group, gender	Age (years)	Training intervention; Duration (weeks), intensity (%), frequency (per week), session duration (min)	Capillarisation, cap per fibre (%)	CS activity (%)	HAD activity (%)
Krustrup *et al*[2 10 53]	F, UT, M	29	12; 82%HRmax; 2.3; 60	22%↑†	14%↑†	5%↑NS
	R, UT, M	31	12; 82%HRmax; 2.5; 60	16%↑	7%↑NS	5%↑NS
	C, UT, M	31	No intervention	5%↑NS	11%↓NS	11%↓NS
Randers *et al*[8 41]	F; UT; M	31	64; 82%HRmax; 1.3; 60	–	18%↑	16%↑NS
	C; UT; M	32	No intervention	–	–	–
Andersen *et al*[5]	F, UT, M[t]	51	24; 83%HRmax; 1.5; 60	7%↑	7%↓NS	5%↓NS
	C, UT, M[t]	49	No intervention	5%↓NS	9%↑NS	1%↑NS

Changes between pre and post training intervention (unless otherwise stated).
†Significant group difference compared to control.
CS, citrate synthase; C, controls; HAD, 3-hydroxyacyl-CoA dehydrogenase; HRmax, maximal heart rate; F, football; M, men; NS, not significant; R, running; t, type 2 diabetics; UT, untrained.

recreational football training improves balance (table 5), clearly suggesting that this training also ameliorates the participants' ability to coordinate movements and thereby potentially reduce accidental injuries in their everyday life.

SYNOPSIS

Recreational football training conducted as small-sided games (4v4 to 7v7) performed for 45–60 min up to three times a week promotes health. Such easy to do training resulted in reduced blood pressure, lowered resting heart rate, favourable adaptations in cardiac structure and function, improved blood lipid profile, elevated muscle mass, reduced fat mass and improved functional capacity. Most changes occurred within the first 3 months, with bone mass density developing further when the training was continued.

For patients with non-communicable diseases (NCDs), such as hypertension and T2DM, even greater effects have been observed on key variables, and the marked improvements of cardiac function and cardiorespiratory fitness are likely to reduce the high risk of cardiovascular diseases in these patient groups. Nevertheless, further studies should examine the value of increasing the volume of recreational football, including a higher frequency of training, and, ultimately, investigate long-term effects of football training on clinical end points and mortality.

PERSPECTIVES

Football is by far the most popular sport in the world, with more than 400 million active players, and it is now clear that recreational football promotes health. Thus, football is an attractive way of reducing the risk of increasing the number of individuals becoming overweight and developing NCDs, as well as treating those already affected.

Importantly, recreational football has been associated with positive psychosocial interactions, including increased social capital, improved quality of life, general well-being and motivational status.[11–13] The participants in these studies, irrespective of their background, age, weight and whether they are suffering from hypertension, diabetes or cancer, enjoyed playing. As such, football appeals to many and may improve the chances of long-term adherence for individuals who are not motivated to engage in individual exercise otherwise. As an example, a group of middle-aged men with T2DM, introduced to one another during a study, still play football together more than 2 years after the study finished.[5 13]

Despite these encouraging data, scale-up requires a considerable collaborative effort from volunteers, sports organisations and bodies responsible for health promotion, such as FIFA and the WHO. Indeed, FIFA has taken the first step, promoting information about the health benefits of recreational football and implementing projects around the world; the Danish Football Association has had great success with the Football Fitness concept, recruiting a high number of adults with no previous experience of football.[58]

PRACTICAL APPLICATIONS

The size of the pitch should be adjusted to the number of participants playing football, 80 m^2 per participant is recommended.[58] Standard football rules, except the offside rule, should be applied. The risk of injury when participating in small-sided football games must be addressed. Generally, in

What are the new findings?

- Recreational football training conducted as small-sided games has marked effects on the cardiovascular system with average heart rates being around 80% of maximal heart rate (HRmax) and substantial time is spent above 90%HRmax even for elderly and patient groups.
- Recreational football training has broad-ranging physiological effects. It lowers systolic and diastolic blood pressure by typically 7–8 and 5–7 mm Hg, respectively, and even more in hypertensive and patients with type II diabetes.
- Recreational football improves left and right ventricular function and increases VO_2max by 7–15% and even more in 65–75-year-old men.
- Recreational football also lowers body fat, total cholesterol and low-density lipoprotein cholesterol, and increases leg muscle mass and bone mineral content, as well as muscle oxidative enzymes and functional capacity.
- Recreational football training produces more pronounced broad-spectrum adaptations than training programmes solely focusing on continuous jogging, interval running or strength training.

Table 5 Changes in performance of untrained men as a result of a period of recreational F training compared to R or inactive C

Study	Activity, target group, gender	Age (years)	Training programme; Duration (weeks), intensity (%), frequency (per week), session duration (min)	Time to exhaustion, max work (s)	Counter-movement jump (%)	Sprint, 30 m (s)	Max leg strength (kg or %)	Yo-Yo IR1 (m)	Yo-Yo IE1/IE2 (m or %)	Postural balance, flamingo test (%)
Krustrup *et al*[2 10 53]	F, UT, M	29	12; 82%HRmax; 2.3; 60	102↑*	–	0.11↑*	11%↑*†‡	–	420↑*†‡	–
	R, UT, M	31	12; 82%HRmax; 2.5; 60	101↑*	–	0.01↓NS	1%↓NS	–	195↑*	–
	C, UT, M	31	No intervention	25↑*	–	–	2%↑NS	–	21↑NS	–
Randers *et al*[8 41]	F, UT, M	31	64; 82%HRmax; 1.3; 60	98↑*	5%↑*†	0.15↑*	–	–	382↑*	49%↑*
	C, UT, M	32	No intervention	–	0%↔NS	–	–	–	–	27%↑NS
Jakobsen *et al*[55]	F, UT, M	29	12; 82%HRmax; 2.3; 60	–	1%↓NS	–	0%↔NS	–	–	41%↑*†
	R, UT, M	31	12; 82%HRmax; 2.5; 60	–	1%↓NS	–	2%↓NS	–	–	38%↑*†
	C, UT, M	31	No intervention	–	3%↓NS	–	0%↔NS	–	–	11%↑NS
Andersen *et al*[6]	F, UT, M	68	16; 84%HRmax; 1.6; 45–60	53↑*†	NS	–	–	–	43%↑*†	–
	S, UT, M	69	16; 8–20RM; 1.5; 45–60	43↓NS	NS	–	–	–	8%↑NS	–
	C, UT, M	67	No intervention	58↓NS	NS	–	–	–	5%↓NS	–
Krustrup *et al*[15]	F, UT, M[a]	46	24; 85%HRmax; 1.7; 60	79↑NS	–	–	–	–	–	–
	DAG, UT, M[a]	47	DAG on CRF	19↑NS	–	–	–	–	–	–
Knoepfli-Lenzin *et al*[22]	F, UT, M[mh]	37	12; 80%HRmax; 2.4; 60	0.9↑*†§	–	–	–	–	144↑*	–
	R, UT, M[mh]	36	12; 79%HRmax; 2.5; 60	1.1↑*†§	–	–	–	–	168↑*†	–
	C, UT, M[mh]	38	No intervention	0.0↔NS§	–	–	–	–	50↑NS	–
Schmidt *et al*[17]	F, UT, M[t].	51	24; 82%HRmax; 1.2; 60	–	–	–	–	–	377↑*	–
	C, UT, M[t]	49	No intervention	–	–	–	–	–	52↑NS	–
Helge *et al*[46]	F, UT, M[h]	36	12; 82%HRmax; 2.2; 60	–	–	–	–	–	–	46%↑*
	C, UT, M[h]	43	No intervention	–	–	–	–	–	–	3%↓NS
Uth *et al*[37]	F, UT, M[p]	67	12; 85%HRmax; 2–3; 45–60	–	–	–	8.9↑*†	–	–	–
	C, UT, M[p]	67	No intervention	–	–	–	2.2↑NS	–	–	–
Faude *et al*[56]	F, UT, OCh	11	12; 80%HRmax; 4.5; 60	–	15%↑*	–	–	–	–	–
	SP, UT, OCh	11	12; 77%HRmax; 4.5; 60	–	14%↑*	–	–	–	–	–
Bendiksen *et al*[54]	F+H, UT, Ch	9	6; 76%HRmax; 2; 30	–	–	–	–	148↑*†	–	–
	C, UT, Ch	9	Low-intensity activities	–	–	–	–	106↓NS	–	–

Changes are between pre and post training intervention (unless otherwise stated).
*Significant difference from 0 weeks.
†Significant group difference compared to control.
‡Significant group differences.
§Maximal velocity (km/h).
¶Yo-Yo IR1 children.
a, hypertensive participants; C, children; C, controls; CRF, cardiovascular risk factors; DAG, doctor's advice group; F, football; F+H, football+hockey; h, homeless participants; HRmax, maximal heart rate; M, men; mh, mildly hypertensive participants; NS, not significant; OC, overweight children; p, prostate cancer patients; R, running; S, strength training; SP, standard physical activity; t, type 2 diabetics; UT, untrained.

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organised football, the number of injuries in training is one-fifth to one-tenth of that occurring during match play, at around eight injuries per 1000 h of training.[10 60] This corresponds to one injury every 1.2 years and one severe injury approximately every 13 years per participant, if training is performed for 1 h, twice a week.[10] The figures may be less for recreational football, as less than 5% of the participants sustained an injury that kept them away from training (Bangsbo *et al*, unpublished data). Most injuries occurred in the initial phase of the training period, emphasising that football training should be slowly introduced. Notably, the overall injury rate during recreational football training appears to be reduced with age, which may be due to a reduction in game intensity, speed and forceful contacts.

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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

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