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ORIGINAL ARTICLE

Short-term street soccer improves fitness and cardiovascular health status of homeless men

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Abstract This study examined the effect of 12 weeks of small-sided street soccer (2.2 ± 0.7 sessions/week) and fitness center training (0.5 ± 0.2 sessions/week) on physical fitness and cardiovascular health profile for homeless men. Exercise capacity, maximal oxygen uptake (VO_{2max}), body composition (DXA scans), blood pressure (BP), and blood lipid profile were determined before and after the intervention period for 22 soccer-group subjects (SG) and 10 waiting list controls (CO). In addition, time-motion analyses, HR measurements, and pedometer recordings were performed during street soccer training and daily-life activities. During a 60 min 4 versus 4 street soccer session 182 ± 62 intense running bouts were performed; mean HR was 82 ± 4% HR_{max} and HR was >90% HR_{max} for 21 ± 12% (±SD) of total time. On a day without training the participants performed 10,733 ± 4,341 steps and HR was >80% HR_{max} for 2.4 ± 4.3 min. In SG, VO_{2max} was elevated ($p < 0.05$) from 36.7 ± 7.6 to 40.6 ± 8.6 ml/min/kg after 12 weeks and incremental cycle test performance was improved ($p < 0.05$) by 81 s (95% CI: 47–128 s). After 12 weeks, fat percentage (19.4 ± 8.5 to 17.5 ± 8.6%) and LDL cholesterol (3.2 ± 1.1 to 2.8 ± 0.8 mmol L^{-1}) were lowered ($p < 0.05$) in SG. The observed changes in SG were different ($p < 0.05$) from CO and no intra-group changes occurred for CO ($p > 0.05$). BP was unaltered after 12 weeks ($p > 0.05$), but diastolic BP was lowered for all SG subjects with pre-values >75 mmHg (83 ± 6 to 76 ± 6 mmHg, $n = 8$, $p < 0.05$). In conclusion, the exercise intensity is high during street soccer and regular street soccer training can be used as an effective activity to promote physical fitness and cardiovascular health status for homeless men.

Keywords Training intensity · Physical capacity · VO_{2max} · Cholesterol · Fat percentage · Muscle mass · Football

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Introduction

It is well documented that morbidity and mortality rates are higher for homeless and socially deprived men compared with the general population and that cardiovascular diseases are the leading cause of death (Barrow et al. 1999; Hwang et al. 1997). Several studies have investigated the cardiovascular risk profile in homeless and socially deprived individuals (Kim et al. 2008; Kubisova et al. 2007; Lee et al. 2005; Szerlip and Szerlip 2002). A high prevalence of hypertension and smoking among the homeless compared with the general population was found,

whereas the prevalence of hyperlipidemia, elevated BMI, and obesity were lower among the homeless. The elevated risk of health-related diseases and early death seen among the homeless may as well be due to misuse of alcohol and sedatives (Nielsen et al. 2011; Nordentoft and Wandall-Holm 2003).

The health profile and mortality from cardiovascular diseases are related to the activity level (Hu et al. 2005), and it is well documented that physical activity has a positive effect on several lifestyle-related diseases and cardiovascular risk factors (Pedersen and Saltin 2006). Knowledge about the physical activity level of homeless men is scarce, but in a Danish study approximately 70% of the homeless reported no participation in any form of physical activity (Pedersen et al. 2008).

Soccer is a popular team sport with more than 400 million active players worldwide and regular soccer training has been proven to be an effective health-promoting activity for untrained men aged 20–55 (Krustrup et al. 2009, 2010a, b). Following 12 weeks of small-sided soccer training maximal oxygen uptake, lean body mass and number of capillaries were increased, whereas systolic and diastolic blood pressure, resting heart rate, and LDL-cholesterol were reduced (Krustrup et al. 2009). Soccer has also been shown to contain positive motivational and social factors that may facilitate compliance (Elbe et al. 2010; Ottesen et al. 2010) and team sports like soccer may have a great potential for long-term health promotion for inactive homeless persons. In 2003 the first steps were taken to implement Street Soccer for Homeless worldwide with the introduction of the Homeless World Cup in Austria with 18 participating countries. Under the ambitious slogan "beating homelessness through football", this tournament has grown each year reaching 48 participating countries in Denmark in 2007 and a total of 64 participating countries in Brazil 2010. Since then, Street Soccer for Homeless has become a tool in the fight against physical inactivity and psycho-social problems for homeless, but scientific evidence is needed to understand the potential of this activity. Preliminary data collected from the Danish Homeless National team revealed high heart rates during 4 versus 4 street soccer training with mean and peak values of 84 and 98% of maximal heart rate and more than 30% of the total time above 90% of the maximal heart rate (Randers et al. 2010b). However, so far the activity profile and aerobic loading of street soccer have not been studied for homeless men with less soccer experience and skills and the physiological adaptations to a 12-week training program for homeless men is still to be investigated.

Therefore, the aim of this study was to examine how 12 weeks of street soccer training affects physical fitness and cardiovascular health profile for homeless men.

Methods

Design

The study was designed as a controlled training study. A total of 55 homeless men were recruited from shelters and unemployment offices in the Copenhagen area of which three-fifths ($n = 33$) was recruited for the training group and two-fifths ($n = 22$) were recruited for a waiting list control group. As a part of the agreement with the homeless organization the participants were not randomized. Figure 1 shows the trial profile. 27 training subjects and 18 control subjects showed up for the pre-testing, and 22 training subjects and 10 control subjects completed the full-intervention period and the post testing procedures. After the intervention period, 6 of the 10 waiting list control subjects took part in a 12-week training intervention. No differences were observed in pre-test scores among the drop-outs compared with the rest of the subjects.

Subjects

The street-soccer training group (SG) had mean age, body mass, BMI, fat percentage and maximal oxygen uptake of 37 ± 10 (±SD) years, 73.3 ± 16.7 kg, 22.9 ± 3.9 kg m^{-2}, 19.4 ± 8.5% and 36.7 ± 7.6 ml O_2 min^{-1} kg^{-1}, respectively, with corresponding values of 43 ± 9 years, 76.6 ± 15.6 kg, 24.1 ± 4.0 kg m^{-2}, 21.8 ± 7.9% and 33.7 ± 4.5 ml O_2 min^{-1} kg^{-1} for the control group (CO). Regular use of cigarettes, alcohol and cannabis was reported for 73, 36 and 64% of the SG and 70, 50 and 60% of the CO, respectively. 65% of the subjects were former alcoholics or drug users. The participants were fully informed of experimental procedures and possible discomfort associated with the study before giving their written informed consent to participate. The study was carried out in accordance with the guidelines contained in the Declaration of Helsinki and was approved by the local ethics committee of the Capital Region of Denmark.

Training intervention

The total number of training sessions was 32 ± 9 corresponding to an average of 2.8 ± 0.8 sessions per week over the 12 weeks intervention period. Three soccer training sessions were carried out per week with an attendance rate of 75% (2.2 ± 0.7 sessions per week). The street soccer training consisted of 4 versus 4 games on a 16 times 22 m asphalt pitch surrounded by 1.1 m high boards. The pitch and the rules were the official street soccer rules as used for the homeless world cup. All training sessions were supervised, and participants were verbally encouraged by the coach during each session. In the beginning of each soccer

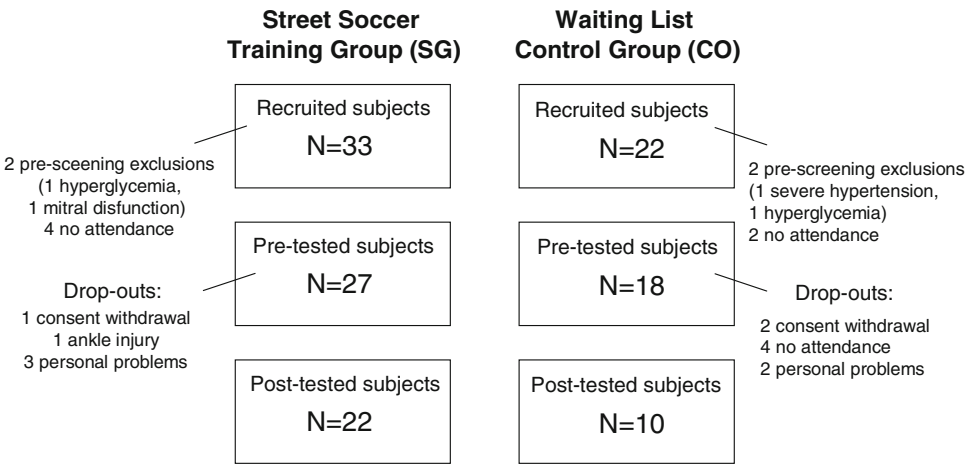

Fig. 1 Flow chart of the study participation. Fifty-five homeless men were recruited from shelters and unemployment offices in the Copenhagen area, i.e. 33 to the street soccer group (SG) and 22 for waiting list control group (CO). Pre-testing was performed of 27 and 18 SG and CO subjects, respectively, and 22 SG and 10 CO subjects completed the full intervention

training session, a 10 min warm-up was completed consisting of low-intensity running and dribbling exercises. Once every week, the participants were offered supervised training in a local fitness centre. The attendance rate was 54% (0.5 ± 0.2 sessions per week). The training consisted of 15 min of low-to-moderate intensity work out on a cycle ergometer or a cross-trainer. Moreover, five exercises of strength training (1 set with 10–12 repetitions, >15 RM) mainly for the upper body were completed.

Testing procedures

Before and after the training period, all participants completed a test battery in the laboratory. The participants showed up at 9 a.m. after an overnight fast. Moreover, the participants were not allowed to smoke 2 h before the tests. Blood samples were drawn for immediate measure for fasting lipoproteins, blood glucose and insulin according to standard procedures. After at least 20 min of rest in supine position, blood pressure was measured six times by an automatic upper left arm blood pressure monitor (OMRON-M7; OMRON; Illinois, USA) and a mean was calculated. Resting heart rate was calculated as the lowest average value over 1 min. Quadriceps muscle mass was estimated anthropometrically as described earlier (Krustrup et al. 2004). Whole body and regional fat mass as well as muscle mass was determined by DXA-scans (LUNAR, GE Medical Systems, Madison, Wisconsin, USA). After consuming a meal, the participants rested for at least 1.5 h before completing an incremental test to exhaustion on a cycle ergometer. Maximal oxygen uptake and ventilation were determined by pulmonary gas exchange measurements (MasterScreen CPX, Viasys Healthcare, St Paul, Minnesota, USA) and heart rate (Polar Team System, Polar Oy, Kempele, Finland) was measured during the test starting at 40 W with a 20 W increase every 2 min until exhaustion.

On a separate day, SG completed a Yo–Yo Intermittent Endurance level 1 test after a standardized warm-up. Heart rate belts were worn during the entire test. The warm-up consisted of continuously low-intensity running for 5 min followed by completion of the six first runs in the Yo–Yo IE1 test. After at least 5 min of rest the Yo–Yo IE1 test was completed to exhaustion (Krustrup et al. 2010b). The participants were verbally encouraged during the test.

Time-motion analysis

Nine of the participants were video filmed individually for later time-motion analysis. The digital video cameras (DCR-SX30, Sony, Tokyo, Japan) were positioned 5 m from the corner of the pitch at a height of about 1.5 m. The recordings were later replayed on a monitor for computerized coding of the activity pattern. The locomotor categories were adopted from previous studies and adjusted (Bangsbo et al. 1991; Randers et al. 2010a): standing (0–2 km h^{-1}), walking (2–6 km h^{-1}), jogging (6–9 km h^{-1}), low-speed running (9–13 km h^{-1}), moderate-speed running (13–16 km h^{-1}), high-speed running (16–19 km h^{-1}), sprinting (>19 km h^{-1}) and backward running. Maximal acceleration was counted as a sprint, although the speed did not reach maximum. The time for the player to pass premarkers in the pitch was used to estimate the speed for each activity of locomotion. High-intensity running was considered as the sum of moderate-speed running, high-speed running and sprinting. The number of in-fights/tackles and jumps/headers was also noted. All activities were expressed per 60 min playing time. Heart rate was recorded in 5 s intervals by short-range radio telemetry (Polar Team2 System, Kempele, Finland) and data were transferred to a computer using the Polar Team2 software (Polar, Kempele, Finland). Data are expressed in relation to individual maximal heart rate (HR_{max}). The individual HR_{max} was determined as the highest value reached during an

incremental cycle ergometer test to exhaustion or during the Yo–Yo IE1 test.

Daily activity level

To evaluate the daily activity level, nine participants wore Yamaxx pedometers (Yamaxx Digi-Walker model SW 701, Accusplit, US) for 2–4 days. Days with and without soccer training were represented in the analyses. Moreover, heart rate was recorded for 1–3 days without soccer training by the use of chest belts (Polar Team2 System).

Statistics

Two-way analysis of variance on repeated measures was applied to evaluate the time and group effects. When a significant interaction was detected, data were subsequently analyzed using a Student–Newman–Keuls post-hoc test. If no significant interaction effects were found, but a tendency towards significance was observed ($p < 0.10$), the effect size was calculated. The coefficient of variation (CV) was used as a measure of the intra-individual variation in steps per day measured with the pedometer and was calculated as the standard deviation of the difference between repeated measures divided by the mean and multiplied by 100 (Atkinson and Nevill 1998). A significance level of 0.05 was chosen. Data are presented as means ± SD or with 95% confidence intervals (95% CI).

Results

Heart rate and activity profile during training

The mean heart rate during 1 h of soccer training was 154 ± 12 b.p.m. corresponding to 82 ± 4% of HR_{max}. Peak HR reached 182 ± 14 b.p.m. corresponding to 97 ± 4% of HR_{max}. HR was above 90% of HR_{max} for 21 ± 12% of the training time and 80–90% of HR_{max} for 44 ± 16% of the training time (Fig. 2). During training in the fitness center, the mean HR was 133 ± 11 b.p.m. corresponding to 71 ± 3% of individual maximal HR. Peak HR during the training was 169 ± 8 b.p.m. corresponding to 90 ± 5% of HR_{max}. HR was above 90% of HR_{max} for 2 ± 5% of the training time and 80–90% of HR_{max} for 14 ± 8% of the training time (Fig. 2).

During 1 h of small-sided soccer games 1,623 ± 351 activity changes were observed which is an activity change every 2 s. A total of 182 ± 62 high-intensity runs were performed of which 29 ± 12 were sprints (Fig. 3). The high-intensity runs accounted for 6.0 ± 2.0% of the total playing time, whereas the players stood still or walked for 21.7 ± 5.5 and 43.8 ± 10.3% of the total playing time.

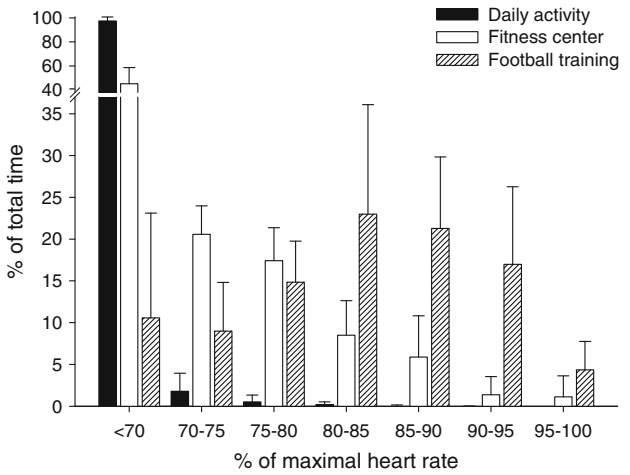

Fig. 2 Heart rate distribution, expressed in percentage of total time for soccer training, fitness center training and daily life activities for homeless men. Means ± SD are presented ($n = 9$)

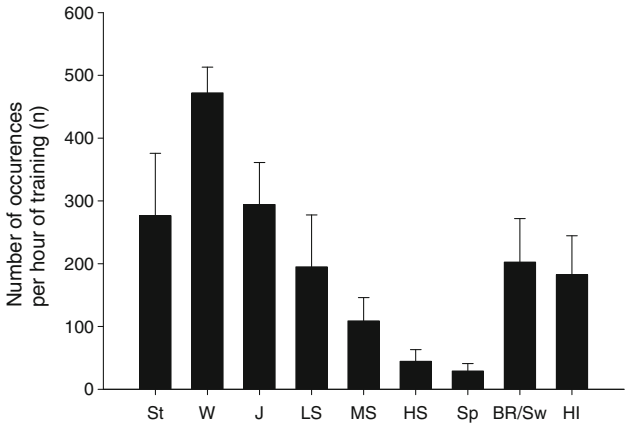

Fig. 3 Activity profile for homeless men during 1 h soccer training sessions, expressed as number of occurrences of standing (St), walking (W), jogging (J), low-speed running (LS), moderate-speed running (MS), high-speed running (HS), sprinting (Sp), backwards and sideways running (BR + Sw) as well as high-intensity running (HI) which is the sum of MS, HS and Sp. Means ± SD are presented ($n = 9$)

Backward and sideways running accounted for 8.6 ± 2.2% of the total playing time. The mean duration of the high-intensity runs was 1.2 ± 0.1 s, whereas the mean duration for walking was 3.4 ± 1.0 s. The number of tackles (with the feet) was 21 ± 8, whereas the number of in-fights/tackles with the body and jumps was 15 ± 6 and 1 ± 2, respectively. A total of 5,439 ± 3,094 steps were taken during a soccer training session.

Daily activity level

The mean HR during a normal day with no soccer training was 88 ± 10 b.p.m. corresponding to ~48 ± 7% of HR_{max}. The peak HR was 156 ± 10 bmp ~84 ± 8% of

HR_{max}. HR was below 70% of HR_{max} for 97 ± 3% of the total time, whereas it was above 80% of HR_{max} for only 0.2 ± 0.4% of total time, corresponding to 2.4 + 4.3 min. Pedometer measurements showed that the participants had 10,733 ± 4,341 (range: 3,769–17,567; CV = 35%) steps per day on days with no soccer training. The mean number of steps per day were 16,091 ± 5,149 (8,087–23,031; CV = 17%) on days which included soccer training.

Effect of training

Maximal oxygen uptake and ventilation

In SG, maximal oxygen uptake was elevated from 2.69 ± 0.47 to 2.95 ± 0.52 L O_2 min^{-1} (95% CI: 6.7 to 13.1%) after 12 weeks, which was significantly different ($p < 0.01$) from CO (2.58 ± 0.32 to 2.60 ± 0.35 L O_2 min^{-1}, 95% CI: −4.7 to 3.5%). After 12 weeks, maximal oxygen uptake expressed in relation to body weight was 3.9 mL O_2 min^{-1} kg^{-1} (95% CI: 2.4 to 5.3) higher in SG, which was different ($p < 0.01$) from CO (−0.3, 95% CI: −1.5 to 0.9 mL O_2 min^{-1} kg^{-1}; Fig. 4). In SG, peak ventilation rose from 124 ± 27 to 135 ± 21 L min^{-1} (95% CI: 6.7 to 17.8 L min^{-1}) over 12 weeks, which only tended ($p = 0.056$; effect size = 0.40) to be different from the change in CO (109 ± 17 to 110 ± 27 L min^{-1}, 95% CI: −8.1 to 10.1 L min^{-1}).

Changes in body composition

Total body mass and BMI were unaltered in SG and CO after 12 weeks (Table 1). In SG, total fat mass decreased by 1.7 kg (95% CI: −2.6 to −0.9 kg over 12 weeks, which

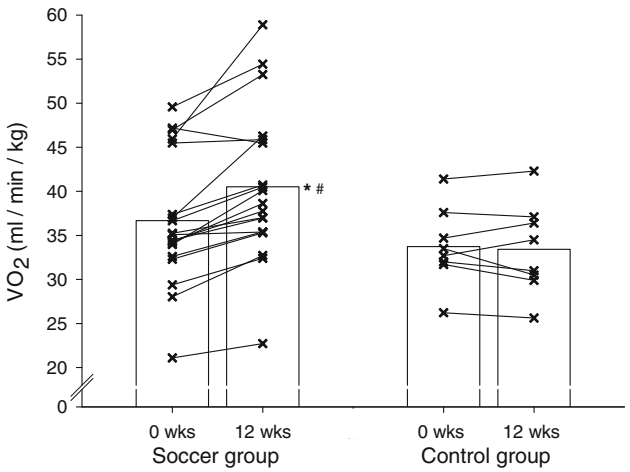

Fig. 4 Maximal oxygen uptake before and after 12 weeks of training (Soccer group, $n = 22$) or continuation of normal routines (Control group, $n = 8$). Means and individual values are presented. *Denotes significant difference from 0 weeks. #Denotes significant greater change in SG than CO

was significantly different ($p < 0.01$) from CO (0.6 kg, 95% CI: −0.9 to 2.0 kg). Accordingly, the observed changes in fat mass of the legs and upper body in SG (−0.5 kg, CI 95%, −0.8 to −0.2 kg; −1.1 kg, 95% CI: −1.6 to −0.5 kg, respectively) were different ($p < 0.01$) from CO (0.1 kg, 95% CI: −0.2 to 0.3 kg; 0.7 kg, 95% CI: −0.8 to 2.2 kg, respectively; Table 1). In SG, fat percentage was 2.0% point (95% CI: 1.0 to 3.0) lower after 12 weeks, which was different ($p < 0.05$) from CO (0.1% point, 95% CI: −1.0 to 1.3; Fig. 5). Both android and gynoid fat percentage were lowered ($p < 0.05$) to a higher extent in SG (−2.8% point, 95% CI; −4.3 to −1.3; −2.2% point, 95% CI: −3.3 to −1.1% point) than in CO (0.4% point, 95% CI; −0.8 to 1.5% point; 0.3% point, 95% CI: −0.9 to 1.5% point). The android:gynoid fat ratio remained unchanged in both groups (Table 1).

In SG, lean body mass increased by 1.0 (95% CI: 0.3 to 1.9) kg after 12 weeks, but this change was not significantly different from CO (0.4 ± 1.7 kg; 95% CI: −0.8 to 1.5; Table 1). No significant change was observed in quadriceps muscle mass (Table 1).

Blood lipoproteins and blood glucose

In SG, LDL-cholesterol was lowered by 0.4 mmol L^{-1} (95% CI: −0.7 to −0.2; 3.2 ± 1.1 to 2.8 ± 0.8 mmol L^{-1}) after 12 weeks, which was different ($p < 0.05$) from CO (3.2 ± 0.1 vs. 3.3 ± 0.8 mmol L^{-1}; Fig. 5). In SG, LDL-cholesterol decreased for all participants, except one, with pre-values above 2.5 mmol L^{-1} ($n = 13$; Fig. 5). HDL-cholesterol was unchanged both in SG (1.3 ± 0.4 to 1.3 ± 0.4 mmol L^{-1}) and CO (1.2 ± 0.1 to 1.1 ± 0.1 mmol L^{-1}). The HDL:LDL ratio increased by 0.06 (CI: 0.02 to 0.11) after 12 weeks in SG (0.43 ± 0.13 to 0.48 ± 0.19) which was different ($p < 0.05$) from CO (0.34 ± 0.11 vs. 0.33 ± 0.08). Total cholesterol was unchanged in both SG (4.8 ± 1.5 to 4.7 ± 0.9 mmol L^{-1}) and CO (5.1 ± 1.2 to 5.2 ± 1.1 mmol L^{-1}). Moreover, triglycerides were unchanged both in SG (1.29 ± 0.53 to 1.37 ± 0.65 mmol L^{-1}) and CO (1.44 ± 0.69 to 1.56 ± 0.86 mmol L^{-1}).

Blood glucose was unchanged in SG (4.9 ± 0.5 to 5.0 ± 0.6 mmol L^{-1}) and CO (5.0 ± 0.5 to 4.8 ± 0.6 mmol L^{-1}). Moreover, fasting insulin levels were unchanged in SG (36 ± 23 to 41 ± 27 pmol L^{-1}) as well as in CO (40 ± 19 to 51 ± 35 pmol L^{-1}).

Resting heart rate and blood pressure

In SG, resting heart rate decreased by 4 b.p.m. (65 ± 10 to 61 ± 9 b.p.m, 95% CI: −7 to 0) after 12 weeks, but this difference was not significantly different from CO (68 ± 15 to 71 ± 11 b.p.m, 95% CI −5 to 11, $p = 0.075$,

Table 1 Antropometric data, fat mass, fat percentage and lean body mass measured by DXA-scans for socially deprived men before and after 12 weeks of training (Soccer group, SG, $n = 22$) or continuation of normal routines (Control group, CO, $n = 10$)

	Soccer group		Control group	
	Pre	Post	Pre	Post
Height (m)	1.79 ± 0.09	1.79 ± 0.09	1.78 ± 0.06	1.78 ± 0.06
Weight (kg)	73.3 ± 16.7	72.6 ± 16.6	76.6 ± 15.6	77.2 ± 16.6
BMI (kg/m^2)	22.9 ± 3.9	22.6 ± 3.7	24.1 ± 4.0	24.3 ± 4.4
Fat mass (kg)	14.1 ± 7.1	12.4 ± 6.5*#	17.4 ± 8.8	18.0 ± 10.0
Fat mass—upper body (kg)	8.2 ± 4.7	7.1 ± 4.3*#	10.2 ± 5.8	11.0 ± 6.4
Fat mass—legs (kg)	4.3 ± 1.9	3.8 ± 1.8*#	5.2 ± 2.8	5.3 ± 3.0
Total fat percentage (%)	19.4 ± 8.5	17.5 ± 8.6*#	21.8 ± 7.9	21.9 ± 8.1
Android fat percentage (%)	25.3 ± 11.2	22.6 ± 10.6*#	29.3 ± 11.8	29.7 ± 11.5
Gynoid fat percentage (%)	21.9 ± 7.1	19.7 ± 7.1*#	25.7 ± 8.0	26.0 ± 7.6
Android:gynoid ratio	1.12 ± 0.28	1.11 ± 0.26	1.10 ± 0.24	1.10 ± 0.26
Lean body mass (kg)	56.2 ± 6.4	57.3 ± 5.6*	56.2 ± 8.6	56.6 ± 8.2
Quadriceps muscle mass—right leg (kg)	1.94 ± 0.34	1.99 ± 0.28	1.89 ± 0.41	1.89 ± 0.41
Quadriceps muscle mass—left leg (kg)	1.90 ± 0.28	1.94 ± 0.25	1.89 ± 0.47	1.89 ± 0.44

Data presented as means ± SD

* Denotes significant difference from Pre

\# Denotes significantly greater change in SG than CO

effect size = 0.63). Systolic, diastolic as well as mean arterial blood pressure was unchanged after 12 weeks in SG (116 ± 12 to 116 ± 11, 73 ± 9 to 71 ± 9 and 88 ± 10 to 86 ± 9 mmHg, respectively) and CO (119 ± 10 to 122 ± 17, 75 ± 8 to 76 ± 10, and 90 ± 8 to 91 ± 12 mmHg, respectively). In SG, all participants with diastolic pre-values above 75 mmHg had a decrement ($p < 0.001$) after 12 weeks (83 ± 6 to 76 ± 6 mmHg, $n = 8$).

Incremental cycle ergometer and Yo–Yo IE1 test

In SG, time to exhaustion was improved by 81 s (1,034 ± 218 to 1,116 ± 225 s, 95% CI: 47–128) s after 12 weeks, which was different ($p < 0.05$) from CO (928 ± 152 to 918 ± 137 s, 95% CI: −68 to 48). In SG, Yo–Yo IE1 test performance was improved ($p < 0.01$) by 45% over 12 weeks (1,335 ± 766 to 1,942 ± 1,180 m).

Discussion

The present study showed that homeless men, despite a high number of steps per day, have a very poor aerobic fitness and cardiovascular health profile. It was also shown that street soccer for homeless men included multiple repetitions of high-intensity running and elicited high heart rates. Another major finding of the present study was a, for homeless men, high attendance rate. Moreover, that street soccer and fitness center training for ~3 times per week for only 12 weeks period had marked effects on the cardiovascular risk profile due to an elevated maximal oxygen uptake and decreases in fat percentage and LDL-cholesterol and that this training regime resulted in significant improvements in endurance and intermittent exercise capacity.

Maximal oxygen uptake is a strong predictor of the risk of cardiovascular disease and early death (Erikssen et al. 1998; Keteyian et al. 2008). A 15% reduction in the risk of death with every 1 ml min^{-1} kg^{-1} increase in VO_{2max} has been found among patients with coronary heart disease (Keteyian et al. 2008). Moreover, Aspenes et al. (2011) found that every 5 ml min^{-1} kg^{-1} decrement in VO_{2max} corresponded to a ~56% higher prevalence of cardiovascular risk factors and it was suggested that a VO_{2max} of 44.2 ml min^{-1} kg^{-1} represents a threshold below which the cardiovascular risk profile is unfavorable. Thus, the improvement in VO_{2max} from 36.7 to 40.6 ml min^{-1} kg^{-1} with 12 weeks of soccer training observed for homeless men in this study is of high importance. The observation of similar peak respiratory exchange ratio (RER; 1.17 vs. 1.15) and peak heart rates (183 vs. 181 b.p.m.) in the ergometer test before and after the training period indicates that the change in maximal oxygen uptake was due to the training itself. Similar improvements in VO_{2max} have been found for 20- to 45-year-old normotensive men (Krustrup et al. 2009) and women (Bangsbo et al. 2010) as well as 30- to 55 year-old men with mild to moderate hypertension (Andersen et al. 2010) after 12–16 weeks of soccer training. The observed 10% increase in absolute values for VO_{2max} was accompanied by a ~8% increase in time to exhaustion and end power output in the incremental cycle exercise test. Moreover, the performance in an intermittent running test (Yo–Yo IE1) was improved by ~45%. Interestingly, large increases were observed in VO_{2max}, incremental test performance and Yo–Yo performance both for participants with low and medium pre-values. Together, these results demonstrate that small-sided soccer

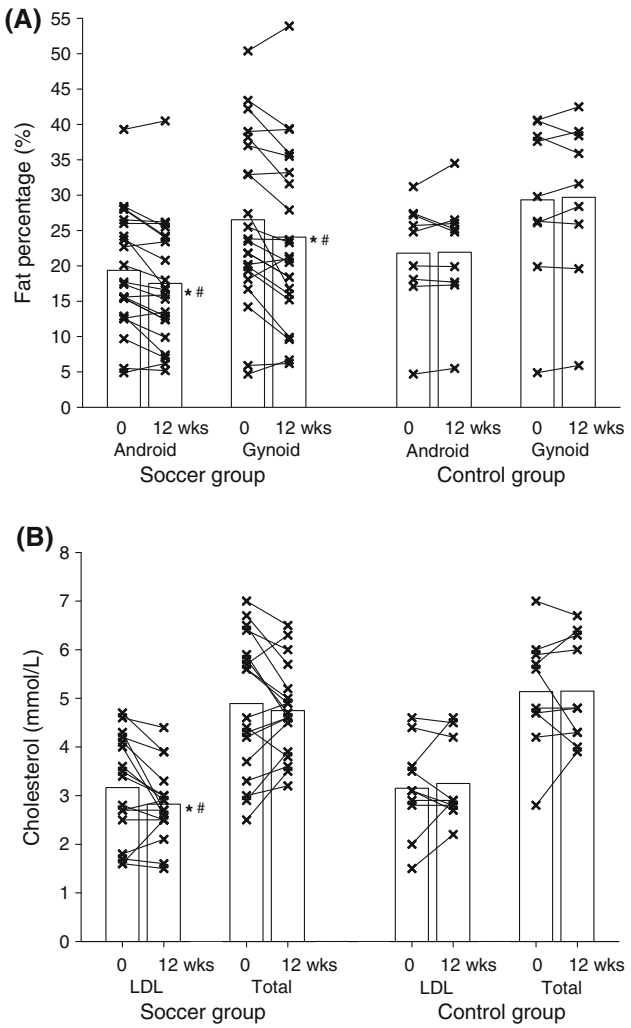

Fig. 5 Total and android fat percentage (**a**) as well as LDL and total cholesterol (**b**) before and after 12 weeks of training (Soccer group, SG, $n = 22$) or continuation of normal routines (Control group, CO, $n = 10$). Means and individual values are presented. *Denotes significant difference from 0 weeks. #Denotes significantly greater change in SG than CO

games have a good impact on the cardiovascular fitness and exercise capacity.

In the present study, we observed a decrease in fat mass of 1.6 kg after 12 weeks of training, which is similar to values obtained for pre-menopausal women but somewhat less than that for young and middle-aged men (2.1–3.0 kg; Krustrup et al. 2009, 2010c), a finding that might be explained by the heterogeneity of the subject group with regard to fat mass, overweight as well as underweight participants (see Fig. 5). The fat distribution and in particular the android fat percentage is more important to the cardiovascular risk profile than the total body fat (Walton et al. 1995; Wu et al. 1998). For the homeless men, we found a 2.5% point reduction in android fat percentage which is associated with a reduction in the cardiovascular risk profile (Wiklund et al. 2008), but we did not find any change in the android to gynoid fat ratio.

Since LDL-cholesterol is a strong predictor of cardiovascular diseases, a reduction is of great importance. Exercise training seldom results in a reduction in total cholesterol and LDL-cholesterol unless the body weight is reduced (Durstine et al. 2002; Leon and Sanchez 2001). One study has shown a reduction in LDL-cholesterol accompanied by a reduction in body weight following 12 weeks of soccer training for untrained men (Krustrup et al. 2009), whereas other soccer intervention studies have not seen a reduction in LDL-cholesterol (Andersen et al. 2010; Krustrup et al. 2010c). In the present study, body weight was unchanged but a ~6% reduction LDL-cholesterol was observed. A 1% reduction in LDL-cholesterol is associated with a 2–3% lower risk of coronary heart disease (Leon and Sanchez 2001). Moreover, for 12 of the 13 homeless men with LDL-cholesterol pre-values above 2.5 mmol L^{-1} and for 7 of 8 subjects with total cholesterol above 5 mmol L^{-1} a reduction was seen after 12 weeks of soccer training. Thus, in accordance with previous findings for untrained men (Krustrup et al. 2009) these results suggest that soccer has a favorable effect on the lipoprotein profile. No change was observed in blood pressure after 12 weeks of soccer training, which is in contrast to previous studies showing that soccer is effective in reducing the blood pressure following 12–16 weeks of soccer training in untrained normotensive men (Krustrup et al. 2009) and women (Krustrup et al. 2010c) as well as mild to moderate hypertensive men (Andersen et al. 2010; Knoepfli-Lenzin et al. 2010). However, although the mean diastolic blood pressure did not change, all eight participants with a pre-value above 75 mmHg had a decrement following the 12 weeks of soccer training. Moreover, 6 out of 9 with a pre-value in systolic blood pressure above 115 mmHg had a decrement. A meta-analysis encompassing one million adults showed a log-linear decrement in the risk of death from cardiovascular diseases with a decrease in systolic and diastolic blood pressure down to at least 115 and 75 mmHg, respectively (Lewington et al. 2002). A 20 mmHg decrease in systolic and 10 mmHg decrease in diastolic blood pressure is associated with a halving in the risk of death from cardiovascular diseases (Lewington et al. 2002). Thus, the reduction in systolic as well as diastolic blood pressure seen for the participants with elevated blood pressure prior to the soccer training intervention is of great importance and in accordance with our previous observations, that soccer has a good impact on blood pressure, especially for those participants with mild to moderate hypertension (Andersen et al. 2010; Krustrup et al. 2009, 2010c). When evaluating pre-post changes for subjects with poor pre-test values it should always be considered whether the findings are influenced by the regression

towards the mean phenomena (Nevill et al. 2004). In the present study we observed the most pronounced training effects in lipid profile and blood pressure for subjects with poor starting values and that the starting values for the subjects in the soccer group correlated with the absolute changes (e.g. total cholesterol, $r = -0.85$, $p < 0.01$), but the fact that the control subjects with poor starting values had no change in these variables supports the notion that the observed changes are related to the training regime. Even though BMI was unchanged after the training period an increase of ~1 kg in lean body mass was observed. This change was, however, not significantly different from the control group. A ~1 kg increase is also lower than observed after 12 weeks of soccer training for untrained men (1.7 kg) (Krustrup et al. 2009) and in contrast to a previous study by Krustrup et al. (2010b) no increase in quadriceps muscle mass was observed. Some (Darmon et al. 2001) but not all (Kubisova et al. 2008) studies have reported malnutrition in homeless men, and a questionnaire that was filled out by nine of subjects in the present study showed an average protein intake of 74% of recommended daily intake. However, further studies are required to establish whether diet-manipulation may lead to a more pronounced muscle hypertrophy after short-term training for the homeless. It is also to be investigated whether the pitch size influences the degree of hypertrophy after football training as more activity changes are performed during 4 versus 4 than during 7 versus 7 training (Randers et al. 2010b), but the peak running speeds are lower on smaller pitches potentially resulting in lower impact on the leg muscles during the decelerations and direction changes. The homeless men in this study covered ~10,700 steps per day without training. A value of 10,000 steps per day has gained popularity and has been associated with a healthy lifestyle but the value has also been questioned and seems insufficient for certain groups, e.g. children (Tudor-Locke and Bassett 2004). Lee et al. (2011) showed that following the guidelines for physical activity had no impact on the mortality if the cardiovascular fitness was poor, whereas a high cardiovascular fitness was associated with a low mortality independent of the adherence to physical activity. That fits well with our study showing that although more than 10,000 steps per day were covered, the heart rate was only above 70% of HR_{max} for 3% of the time and only above 80% of HR_{max} for 2–3 min per day outside training probably resulting in the poor cardiovascular fitness.

High-intensity interval training has been shown to be more effective in improving the maximal oxygen uptake than continuous moderate exercise (Nybo et al. 2010), and the intensity is an important factor for reversing risk factors of the metabolic syndrome (Tjonna et al. 2008). During the soccer training sessions mean heart rates were ~82% with heart rates above 80 and 90% of maximal heart rate for 66 and 21% of total time, respectively. Thus, the intensity was very high during the soccer training and a similar heart rate distribution has been observed for other groups (Randers et al. 2010b). Time-motion analyses revealed that a high number of brief intense actions were performed and several tackles, turns, accelerations, decelerations and in-fights contribute to the high stress on the cardiovascular system. It should be considered whether the biweekly 1 h fitness center training may have contributed significantly to the cardiovascular improvements observed in this study. First, the mean heart rate was ~70% of HR_{max} and HR was above 80% of HR_{max} for less than 10 min and previous studies have shown that recreational soccer is superior to moderate continuous running in improving cardiovascular fitness, lean body mass and some additional cardiovascular risk factors (Krustrup et al. 2009, 2010c). Second, the participants carried out four times as many street soccer training sessions than fitness training sessions (2.2 vs 0.5 sessions per week). Thus, it is likely that the positive effects seen in this study are mainly due by the street soccer training. However, in future studies examining training effects for homeless it would be preferable to examine the separate effects of soccer and fitness training. Another limitation of the present study is that the subjects were not randomized, even though we succeeded in recruiting subjects with similar psycho-social background and that no between-group differences were observed in pre-values for physical capacity and cardio-vascular health profile. Last, it should be emphazised that homeless men form a very heterogeneous subject group. In the present study a relatively small sample size was sufficient for the detection of inter-group differences in most of the main outcome variables, but for further investigations of the effects of soccer training for homeless for variables like muscle hypertrophy and resting heart rate, and examinations of the dose–response effects of soccer training for homeless a higher number of subjects is warranted. In summary, the present study showed that the impact on the cardiovascular system during small-sided soccer training for homeless men was high with heart rate above 90% of HR_{max} for more than 20% of the time, periods with near maximal heart rate and a high number of intense actions. Moreover, this study showed huge variation in various cardiovascular risk factors among a group of homeless men, and that the soccer training improved cardiovascular fitness and the lipoprotein profile and lowered the fat percentage. Thus, street soccer can be promoted as an intense physical activity for homeless men with marked and broad-spectrum effects on the cardiovascular health profile. Future studies are warranted to investigate the long-term physiological and psycho-social effects of street soccer participation.

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References

Andersen LJ, Randers MB, Westh K, Martone D, Hansen PR, Junge A, Dvorak J, Bangsbo J, Krustrup P (2010) Football as a treatment for hypertension in untrained 30–55 year-old men: a prospective randomized study. Scand J Med Sci Sports 20(Suppl 1):98–102

Aspenes ST, Nilsen TI, Skaug EA, Bertheussen GF, Ellingsen O, Vatten L, Wisløff U (2011) Peak oxygen uptake and cardiovascular risk factors in 4,631 healthy women and men. Med Sci Sports Exerc 43(8):1465–1473

Atkinson G, Nevill AM (1998) Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. Sports Med 26:217–238

Bangsbo J, Norregaard L, Thorso F (1991) Activity profile of competition soccer. Can J Sport Sci 16:110–116

Bangsbo J, Nielsen JJ, Mohr M, Randers MB, Krustrup BR, Brito J, Nybo L, Krustrup P (2010) Performance enhancements and muscular adaptations of a 16-week recreational football intervention for untrained women. Scand J Med Sci Sports 20(Suppl 1): 24–30

Barrow SM, Herman DB, Cordova P, Struening EL (1999) Mortality among homeless shelter residents in New York City. Am J Public Health 89:529–534

Darmon N, Coupel J, Deheeger M, Briend A (2001) Dietary inadequacies observed in homeless men visiting an emergency night shelter in Paris. Public Health Nutr 4:155–161

Durstine JL, Grandjean PW, Cox CA, Thompson PD (2002) Lipids, lipoproteins, and exercise. J Cardiopulm Rehabil 22:385–398

Elbe AM, Strahler K, Krustrup P, Wikman J, Stelter R (2010) Experiencing flow in different types of physical activity intervention programs: three randomized studies. Scand J Med Sci Sports 20(Suppl 1):111–117

Erikssen G, Liestol K, Bjornholt J, Thaulow E, Sandvik L, Erikssen J (1998) Changes in physical fitness and changes in mortality. Lancet 352:759–762

Hu G, Tuomilehto J, Silventoinen K, Barengo NC, Peltonen M, Jousilahti P (2005) The effects of physical activity and body mass index on cardiovascular, cancer and all-cause mortality among 47,212 middle-aged Finnish men and women. Int J Obes (Lond) 29:894–902

Hwang SW, Orav EJ, O'Connell JJ, Lebow JM, Brennan TA (1997) Causes of death in homeless adults in Boston. Ann Intern Med 126:625–628

Keteyian SJ, Brawner CA, Savage PD, Ehrman JK, Schairer J, Divine G, Aldred H, Ophaug K, Ades PA (2008) Peak aerobic capacity predicts prognosis in patients with coronary heart disease. Am Heart J 156:292–300

Kim DH, Daskalakis C, Plumb JD, Adams S, Brawer R, Orr N, Hawthorne K, Toto EC, Whellan DJ (2008) Modifiable cardiovascular risk factors among individuals in low socioeconomic communities and homeless shelters. Fam Community Health 31:269–280

Knoepfli-Lenzin C, Sennhauser C, Toigo M, Boutellier U, Bangsbo J, Krustrup P, Junge A, Dvorak J (2010) Effects of a 12 week intervention period with football and running for habitually active men with mild hypertension. Scand J Med Sci Sports 20(Suppl 1):72–79

Krustrup P, Soderlund K, Mohr M, Gonzalez-Alonso J, Bangsbo J (2004) Recruitment of fibre types and quadriceps muscle portions during repeated, intense knee-extensor exercise in humans. Pflugers Arch 449:56–65

Krustrup P, Nielsen JJ, Krustrup BR, Christensen JF, Pedersen H, Randers MB, Aagaard P, Petersen AM, Nybo L, Bangsbo J (2009) Recreational soccer is an effective health-promoting activity for untrained men. Br J Sports Med 43:825–831

Krustrup P, Aagaard P, Nybo L, Petersen J, Mohr M, Bangsbo J (2010a) Recreational football as a health promoting activity: a topical review. Scand J Med Sci Sports 20(Suppl 1):1–13

Krustrup P, Christensen JF, Randers MB, Pedersen H, Sundstrup E, Jakobsen MD, Krustrup BR, Nielsen JJ, Suetta C, Nybo L, Bangsbo J (2010b) Muscle adaptations and performance enhancements of soccer training for untrained men. Eur J Appl Physiol 108:1247–1258

Krustrup P, Hansen PR, Randers MB, Nybo L, Martone D, Andersen LJ, Bune LT, Junge A, Bangsbo J (2010c) Beneficial effects of recreational football on the cardiovascular risk profile in untrained premenopausal women. Scand J Med Sci Sports 20(Suppl 1):40–49

Kubisova D, Adamkova V, Lanska V, Dlouhy P, Rambouskova J, Andel M (2007) Higher prevalence of smoking and lower BMI, waist circumference, cholesterol and triacylglyceride levels in Prague's homeless compared to a majority of the Czech population. BMC Public Health 7:51

Kubisova D, Dlouhy P, Rambouskova J, Andel M (2008) Absence of protein-energy malnutrition in Prague homeless. Int J Public Health 53:57–63

Lee TC, Hanlon JG, Ben-David J, Booth GL, Cantor WJ, Connelly PW, Hwang SW (2005) Risk factors for cardiovascular disease in homeless adults. Circulation 111:2629–2635

Lee DC, Sui X, Ortega FB, Kim YS, Church TS, Winett RA, Ekelund U, Katzmarzyk PT, Blair SN (2011) Comparisons of leisure-time physical activity and cardiorespiratory fitness as predictors of all-cause mortality in men and women. Br J Sports Med 45(6):504–510

Leon AS, Sanchez OA (2001) Response of blood lipids to exercise training alone or combined with dietary intervention. Med Sci Sports Exerc 33:S502–S515

Lewington S, Clarke R, Qizilbash N, Peto R, Collins R (2002) Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 360:1903–1913

Nevill A, Holder R, Atkinson G, Copas J (2004) The dangers of reporting spurious regression to the mean. J Sports Sci 22(9):800–802

Nielsen S, Hjorthoj C, Erlangsen A, & Nordentoft M (2011). Psychiatric disorders and mortality among people in homeless shelters in Denmark: a nationwide register-based cohort study. Lancet doi:10.1016/S0140-6736(11)60885-4

Nordentoft M, Wandall-Holm N (2003) 10 year follow up study of mortality among users of hostels for homeless people in Copenhagen. BMJ 327:81

Nybo L, Sundstrup E, Jakobsen MD, Mohr M, Hornstrup T, Simonsen L, Bulow J, Randers MB, Nielsen JJ, Aagaard P, Krustrup P (2010) High-intensity training versus traditional exercise interventions for promoting health. Med Sci Sports Exerc 42:1951–1958

Ottesen L, Jeppesen RS, Krustrup BR (2010) The development of social capital through football and running: studying an intervention program for inactive women. Scand J Med Sci Sports 20(Suppl 1):118–131

Pedersen BK, Saltin B (2006) Evidence for prescribing exercise as therapy in chronic disease. Scand J Med Sci Sports 16(Suppl 1): 3–63

Pedersen P, Christensen AI, Hess U, & Curt T (2008). SUSY UDSAT—Sundhedsprofil for socialt udsatte i Danmark 2007 Rådet for Socialt Udsatte, Copenhagen

Randers MB, Mujika I, Hewitt A, Santisteban J, Bischoff R, Solano R, Zubillaga A, Peltola E, Krustrup P, Mohr M (2010a) Application of four different football match analysis systems: a comparative study. J Sports Sci 28:171–182

Randers MB, Nybo L, Petersen J, Nielsen JJ, Christiansen L, Bendiksen M, Brito J, Bangsbo J, Krustrup P (2010b) Activity profile and physiological response to football training for untrained males and females, elderly and youngsters: influence of the number of players. Scand J Med Sci Sports 20(Suppl 1):14–23

Szerlip MI, Szerlip HM (2002) Identification of cardiovascular risk factors in homeless adults. Am J Med Sci 324:243–246

Tjonna AE, Lee SJ, Rognmo O, Stolen TO, Bye A, Haram PM, Loennechen JP, Al-Share QY, Skogvoll E, Slordahl SA, Kemi OJ, Najjar SM, Wisloff U (2008) Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome: a pilot study. Circulation 118:346–354

Tudor-Locke C, Bassett DR Jr (2004) How many steps/day are enough? Preliminary pedometer indices for public health. Sports Med 34:1–8

Walton C, Lees B, Crook D, Worthington M, Godsland IF, Stevenson JC (1995) Body fat distribution, rather than overall adiposity, influences serum lipids and lipoproteins in healthy men independently of age. Am J Med 99:459–464

Wiklund P, Toss F, Weinehall L, Hallmans G, Franks PW, Nordstrom A, Nordstrom P (2008) Abdominal and gynoid fat mass are associated with cardiovascular risk factors in men and women. J Clin Endocrinol Metab 93:4360–4366

Wu CH, Yao WJ, Lu FH, Wu JS, Chang CJ (1998) Relationship between glycosylated hemoglobin, blood pressure, serum lipid profiles and body fat distribution in healthy Chinese. Atherosclerosis 137:157–165