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Effects of a 12-week intervention period with football and running for habitually active men with mild hypertension

C. Knoepfli-Lenzin[1,2], C. Sennhauser[1], M. Toigo[1,2,3], U. Boutellier[1,2], J. Bangsbo[4], P. Krustrup[4], A. Junge[5], J. Dvorak[5]

[1]Exercise Physiology, Institute of Human Movement Sciences, ETH Zurich, Zurich, Switzerland, [2]Institute of Physiology and Zurich Center for Integrative Human Physiology (ZIHP), University of Zurich, Zurich, Switzerland, [3]exersciences GmbH, Zurich, Switzerland, [4]Department of Exercise and Sport Sciences, University of Copenhagen, Copenhagen, Denmark, [5]FIFA – Medical Assessment and Research Centre (F-MARC), Zurich, Switzerland
Corresponding author: Claudia Knoepfli-Lenzin, Exercise Physiology, Institute of Human Movement Sciences, ETH Zurich, Winterthurerstr. 190, Zurich, Switzerland. Tel: 41 44 635 50 06, Fax: 41 44 635 68 63, E-mail: knoepfli@physiol.uzh.ch

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The present study examined the effect of football (F, $n = 15$) training on the health profile of habitually active 25–45-year-old men with mild hypertension and compared it with running (R, $n = 15$) training and no additional activity (controls, C, $n = 17$). The participants in F and R completed a 1-h training session 2.4 times/week for 12 weeks. Systolic and diastolic blood pressure decreased in all groups but the decrease in diastolic blood pressure in F (-9 ± 5 ($\pm$ SD) mmHg) was higher than that in C (-4 ± 6 mmHg). F was as effective as R in decreasing body mass (-1.6 ± 1.8 vs -1.5 ± 2.1 kg) and total fat mass (-2.0 ± 1.5 vs -1.6 ± 1.5 kg) and in increasing supine heart rate variability, whereas no changes were detected for C. Maximal stroke volume improved in F (+13.1%) as well as in R (+10.1%) compared with C (-4.9%). Total cholesterol decreased in F (5.8 ± 1.2 to 5.5 ± 0.9 mmol/L) but was not altered in R and C. We conclude that football training, consisting of high-intensity intermittent exercise, results in positive effects on blood pressure, body composition, stroke volume and supine heart rate variability, and elicits at least the same cardiovascular health benefits as continuous running exercise in habitually active men with mild hypertension.

Physical inactivity is recognized as one of the biggest public health problems of the 21st century (Blair, 2009). Often, overweight, hypertension, elevated blood lipids, type 2 diabetes, impaired autonomic regulation and other health-threatening diseases are a result of or occur in combination with inactivity. The American College of Sports Medicine states that physical activity is a cornerstone in the prevention and treatment of mild hypertension (Pescatello et al., 2004). Studies have shown that endurance exercise ameliorates the lipid profile and reduces visceral fat mass (Slentz et al., 2005, 2007). Also, autonomic control, e.g. reflected in heart rate variability (HRV), changes from a dominant sympathetic to a more parasympathetic activity with training (Carter et al., 2003). For obese individuals, this change is important because sympathetic nervous activity plays a role in the etiology of increased blood pressure (Davy & Hall, 2004). In addition, abdominal obesity, particularly the amount of visceral fat, is associated with an increased risk of metabolic and cardiovascular disease (Snijder et al., 2006). These few mentioned and other studies predominantly rely on endurance exercise for gaining health benefits.

Endurance exercise – such as running and cycling – needs a considerable time to expend a relevant amount of energy and many persons experience it as boring. Therefore, these people can hardly be motivated to exercise, resulting in a reduced compliance with regular training activity. Recently, high-intensity or intermittent training has also been shown to improve aerobic fitness and metabolism (Rodas et al., 2000; Coyle, 2005; Gibala & McGee, 2008). Therefore, this exercise modality (e.g. in the form of ball games) may represent a promising alternative for people otherwise not inclined towards conventional endurance exercise. Accordingly, Krustrup et al. (2009) investigated whether football training is as effective as running training in healthy untrained men. Obviously, for scientific purposes, training time and mean training intensity had to be similar. The main difference between running and football was that the intensity varied with football training, bringing the subjects several times close to their maximal performance (Krustrup et al., 2009). The health benefits of both training groups consisted of a reduction in blood pressure and fat mass as well as an increase in maximal oxygen consumption and the duration of an intermittent endurance performance. The football group (F) even reduced LDL-cholesterol and increased total muscle, while these beneficial adaptations were not present in the running group (R).

Following these promising results, we aimed at investigating football vs running training effects in persons with mild hypertension and the possible metabolic risk factors like elevated body mass index ($>25\,\mathrm{kg/m^2}$) and high blood lipid concentrations. In addition to the measurements of Krustrup et al. (2009), the adaptation of stroke volume and HRV was also examined.

Methods

Participants

This study enrolled 57 untrained male non-smokers. Inclusion criteria were as follows: Age: 20–45 years, systolic blood pressure: 120–150 mmHg, diastolic blood pressure: 80–95 mmHg, fasting blood glucose concentration: <7 mmol/L, and glycohemoglobin: <6 mmol/L. Exclusion criteria were the intake of medicaments or drugs, and abnormalities in the electrocardiogram (ECG). Participants were informed about the study and the experimental procedures before they signed an informed consent. The Ethics Committee of the ETH Zurich approved the study. Fifteen participants in F (age: 37 ± 4 years, BMI: $26 \pm 3\,\mathrm{kg/m^2}$), 15 in R (age: 36 ± 5 years, BMI: $26 \pm 3\,\mathrm{kg/m^2}$), and 17 in the control group (C: age: 38 ± 5 years, BMI: $27 \pm 3\,\mathrm{kg/m^2}$) completed the study. Five participants (F: 1, R: 1, C: 3) withdrew from the study because of lack of time, while five participants withdrew because of injuries (F: 2, related to the study; R: 3, not related to the study).

Study design

Participants were randomly assigned either to a training group (F: $n = 15$, R: $n = 15$) or to a control group (C: $n = 17$). F trained for 12 weeks on a small-sided football field while R completed 12 week of constant running at 80% maximal heart rate. During the intervention phase, the subjects of C continued their sedentary lifestyle. Before and after the training period, the participants performed the following tests in a randomized order on separate days with at least a 48-h recovery time between tests: a DXA scan, an incremental treadmill test, an incremental ergometer test and an intermittent Yo-Yo running test. Resting blood pressure was measured in a sitting position before the first of the just mentioned tests and a blood sample was taken for the determination of the overnight fasting blood lipids. Participants were instructed to comply with the following pre-test conditions: no intensive trainings 24 h before a test, no training on the testing day and to abstain from beverages containing caffeine 2 h before each test. Post-tests were performed at least 2 days after the last training session and within 3 week.

Measurements and protocols

Blood pressure

Blood pressure was measured with Cardioplus 500 (miostar, Migros, Switzerland) according to the WHO Guide to Physical Measurements (Chronic diseases and health promotion surveillance, http://www.who.int/chp/steps/manual/en/index3.html) in a sitting position in the first pre- and post-test.

Blood analyses

A venous blood sample of 10 mL was taken from the v. brachialis in the morning after an overnight fast to determine blood lipids and blood glucose concentrations in the first pre- and post-test. Blood lipids were analyzed by a professional laboratory (Medica, Zurich, Switzerland; enzymatical color test from Roche, Basel, Switzerland). Additional blood samples were obtained from an earlobe and blood glucose concentration was analyzed enzymatically amperometrically with BIOSEN C_line Sport® (EKF-diagnostic, Barleben, Germany).

Incremental exercise test on a treadmill

Before each treadmill test, resting heart rate and HRV were recorded in a supine position for 10 min, followed by an additional 5-min measurement in a standing position. Afterwards, a ramp protocol was performed on a Quasar treadmill (HP-Cosmos, Traunstein, Germany) until volitional exhaustion. The test started with a speed of 6 km/h and an inclination of 1°. Speed was increased by 0.2 km/h every 15 s. Oxygen consumption was recorded continuously with an Oxycon Pro (Viasys Healthcare, Würzburg, Germany). Also, heart rate was measured continuously during the 15 min at rest and during the treadmill test with a t6 monitor (Suunto, Vantaa, Finland). Maximal oxygen consumption and maximal heart rate were determined as the highest value during 30 and 10 s, respectively. Maximal treadmill speed was rounded to 0.1 km/h.

HRV at rest was analyzed from min 6 to 10 while supine and from min 11 to 15 while standing. HRV was edited by visual inspection and erroneous beats (e.g. movement artefacts or missing beats) were excluded from the recordings (on average 0.15 ± 0.27% of all heart beats). In the standing position, HRV of six participants (F: 2; R: 3; C: 1) could not be analyzed due to too many artifacts. Time domain indices of HRV, square root of the mean of the sum of squares of differences between adjacent RR intervals (RMSSD), and number of pairs of adjacent intervals differing by more than 50 ms divided by the total number of intervals (pNN50) were calculated. Short time variability (SD1) was evaluated by means of a point-caré plot (Tulppo et al., 1996).

Incremental exercise test on a cycle ergometer

An incremental exercise test was performed on a cycle ergometer (Ergoline 800, Ergonometriesysteme, Bitz, Germany). In participants older than 35 years, a physician supervised the ECG (AT-102, Schiller, Baar, Switzerland) during the test. Stroke volume measurements were performed using an Innocor™ unit (Innovision, Odense, Denmark). Innocor™ uses an oxygen-enriched mixture of an inert soluble gas (0.5% N_2O) to calculate blood flow and an inert insoluble gas (0.1% SF_6) to determine volumes. We assessed cardiac output measurements as described previously and divided it by heart rate to obtain stroke volume (Fontana et al., 2009). Briefly, all participants practiced the rebreathing technique with ambient air while sitting on the ergometer. Immediately after practicing, we measured stroke volume at rest in the same sitting position. Subsequently, the participants rested for another 2 min on the ergometer before they started pedalling at 70 W at a freely chosen pedalling rate (≥ 70/min; Kohler & Boutellier, 2005), which they then held constant throughout all the tests. Power was increased by 30 W every 2 min until volitional exhaustion. We determined stroke volume at rest and at maximal exercise, i.e. immediately before volitional exhaustion.

Intermittent Yo-Yo running test

A Yo-Yo intermittent endurance level 2 test (IE2) was performed on an indoor field and consisted of repeated blocks of 2 × 20 m running bouts, followed by a recovery phase lasting 5 s. Speed was increased according to Bangsbo (1995). Running pace was given by an acoustic signal. Blocks were repeated until volitional exhaustion, i.e. until the participants were not able to follow the given pace anymore for a second time. Before the test, participants warmed up by jogging for 5 min and they performed 1 test trial of 2 × 20 m with the lowest test speed. The total running distance was noted.

Dual-energy X-ray absorptiometry (DXA)

Before the DXA measurement, we assessed body mass with a SECA (model 761) weighting scale (Polymed, Glattbrugg, Switzerland) and body height with a SECA (model 206) wall tape (Polymed). Subsequently, we determined waist and hip circumference using a measuring tape, and calculated the waist-to-hip ratio. All physical measurements were performed according to the WHO Guide to Physical Measurements (Chronic diseases and health promotion surveillance, http://www.who.int/chp/steps/manual/en/index3.html). Total body DXA measurements were performed with a Lunar iDXA™ (GE Healthcare, Madison, WI, USA) according to the manufacturer's specifications. The appropriate scan mode was chosen to adjust the X-ray attenuation for the thickness of each participant. For our experiments, all scans were conducted in the standard (13–25 cm) mode, which requires ~ 6 min of scan time with an effective radiation dose of 4.7 μSv (manufacturer's technical data). Scan analysis was performed using GE encore software version 11.40.004. Total body fat and lean mass, % fat (tissue), as well as segmental (abdominal and gluteofemoral regions) fat and lean mass were used for subsequent analyses. The abdominal ("android") region of interest (ROI) was defined by the manufacturer's software as follows: lower boundary at the pelvis cut and upper boundary above the pelvis cut by 20% of the distance between the pelvis and neck cuts; lateral boundaries are the arm cuts. The gluteofemoral ("gynoid") ROI was defined by the manufacturer's software as follows: upper boundary below the pelvis cut line by 1.5 times the height of the android ROI and gynoid ROI height equal to two times the height of the android ROI, lateral boundaries are the outer leg cuts.

Training interventions

The subjects were requested to train 3 times/week, each training session lasting 1 h. All participants were instructed to record their training activity and heart rate was evaluated for each person in respect of training duration, average heart rate and relative distribution of heart rate (categories: <75%, 75–85% and >85% maximal heart rate). Effectively, participants carried out 2.4 ± 0.2 training sessions/week in F and 2.5 ± 0.3 training sessions/week in R. The training sessions lasted 59 ± 2 min and 58 ± 3 min in F and R, respectively. There was no difference in the mean weekly training frequency and duration between the two training groups. When a participant did not train for >7 days due to illness or injury, his training period was extended by the corresponding period of time. C maintained their sedentary lifestyle.

F trained either outdoor on a natural or an artificial grass field or indoor in a gym, depending on the weather conditions (e.g. snow on the ground). Training started with a warm-up of 10 min with non-fatiguing skill exercises, followed by a small-sided game with 3 vs 3, 4 vs 4 or 5 vs 5 players for a total game duration of 50 min. All training sessions were supervised by an investigator with the help of on-line heart rate monitoring in order to ensure that the heart rate of the participants was above the 65% maximal heart rate. R trained with a running speed corresponding to 80% maximal heart rate (± 4 bpm). Participants recorded the heart rate of each running session with a monitor (S610i, Polar Electro, Kempele, Finland). The participants were advised to start the training with a 10-min warm-up before increasing the running speed to the target heart rate, which was then held constant for 50 min. Running heart rates were regularly controlled in our laboratory.

Later, heart rates of F and R were analyzed in detail. The mean training intensity amounted to 79.9 ± 4.5% maximal heart rate in F and 79.4 ± 1.3% in R. There was no difference in the mean training intensity between the two training groups. The distribution of relative heart rate (categories: <75%, 75–85% and >85% maximal heart rate) differed at all three intensities between F and R (Fig. 1).

Statistical analysis

We performed statistical analyses using SPSS 16.0 software (SPSS, Chicago, Illinois, USA). First, normality of data was examined by a *Q–Q* plot. The univariate general linear model (ANOVA) was applied to detect significant differences between groups over time. To localize between-groups effects, the *post hoc* test of Bonferroni's was used. Parameter estimates displayed significant differences within group pre and post intervention. Data are presented as mean ± SD. The level of significance was set at $P < 0.05$.

Results

Blood pressure

Systolic and diastolic blood pressures were reduced within all groups after the intervention period (F: − 7.5% and − 10.3%; R: − 5.9% and − 6.9%; C: − 6.0%

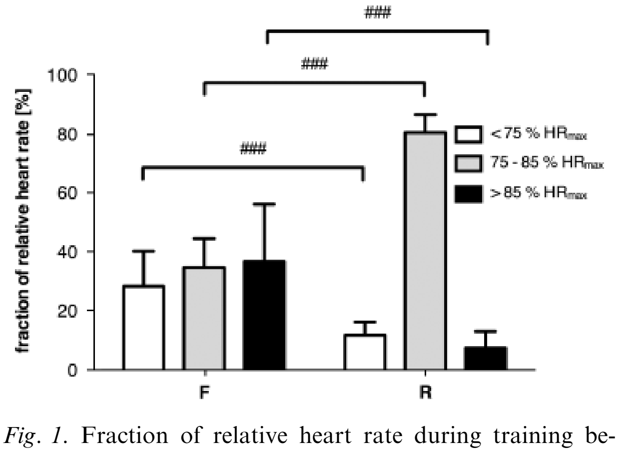

Fig. 1. Fraction of relative heart rate during training belonging to three intensity classifications in the football (F) and running group (R). % HR_{max}, % maximal heart rate, F: $n = 15$, R: $n = 15$; means ± SD are given; $^{\#}$significant difference between groups over time; $^{\#\#\#}P < 0.001$.

and −4.7%), while F but not R reduced diastolic blood pressure significantly after the intervention compared with C (Fig. 2). Reduction in the calculated mean arterial pressure was similar in F (− 10 ± 7 mmHg), R (− 6 ± 8 mmHg) and C (− 6 ± 7 mmHg).

Resting heart rate and heart rate variability

Heart rate measured at rest in a supine position decreased by −10.3% in F, −12.9% in R and −8.1% in C (Table 1). In the standing position, the reduction was −5.9% in F and −10.3% R, while no change was observed for C (−1.1%). No differences in HRV between groups were found over time (Fig. 3 and Table 1). Supine RMSSD was elevated in F and R after the training intervention (Fig. 3). pNN50 and SD1 increased within F and R while supine (Table 1) but not while standing. No changes were detected in C.

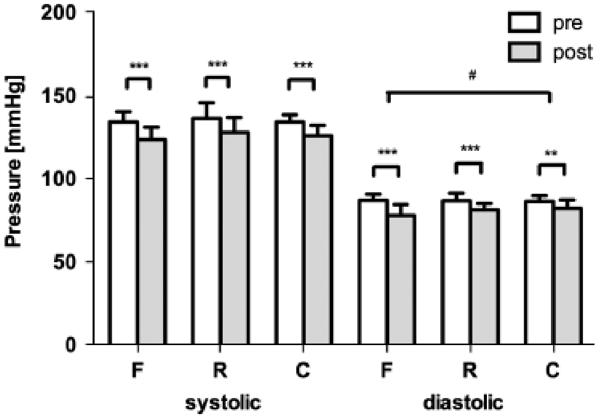

Fig. 2. Systolic and diastolic blood pressure before (pre) and after (post) intervention in the football (F), running (R) and control (C) group. F: $n = 15$; R: $n = 15$; C: $n = 17$; means ± SD are given; #significant difference between groups over time; $^{\#}P < 0.05$, *significantly different from before intervention; $^{**}P < 0.01$, $^{***}P < 0.001$.

Body mass and body composition

Both training groups showed a reduction in body mass and total fat mass during training (Table 2). In F, the absolute and relative fat mass as well as the android fat mass were lower after the intervention compared with C (Table 2, Fig. 4). In F and in R, the gynoid fat mass was reduced compared with C (Fig. 4). Moreover, F ameliorated waist circumference and the waist-to-hip ratio after intervention (Table 2) and showed a tendency ($P = 0.080$) toward an increased lean body mass. C showed no changes concerning body mass and body composition.

Blood lipids

Total cholesterol (F −5.2%) and the ratio of total cholesterol to HDL-cholesterol (F −10.4% and C −6.8%) were reduced after the training period, whereas R showed no changes in blood lipids (Table 3).

Cardiovascular performance

Resting stroke volume was unchanged in all three groups (Fig. 5). Maximal stroke volume during cycling was enhanced in F and R compared with C after the training period (Fig. 5). Within groups, maximal stroke volume was elevated in F (+13.1%) and R (+10.1%), whereas C (−4.9%) showed no change after training.

Maximal oxygen consumption expressed per unit of body mass increased more in F and R compared with C (Table 4). In F, the increase of maximal oxygen consumption reached almost statistical significance ($P = 0.051$) in comparison with C, while it was elevated in R (Table 4). Absolute and relative maximal oxygen consumption increased in F and R but not in C. Also, the maximal treadmill speed increased more in F and R than in C, and it was elevated in F as well as in R but not in C after the

Table 1. Resting heart rate and heart rate variability before (pre) and after (post) intervention while 5 min supine and 5 min standing in the football (F), running (R) and control (C) group

	Football		Running		Control	
	Pre	Post	Pre	Post	Pre	Post
HR supine (bpm)	68 ± 12	61 ± 8**	70 ± 7	61 ± 5***	74 ± 8	68 ± 8*
HR standing (bpm)	85 ± 12	80 ± 13*	87 ± 8	78 ± 10***	87 ± 10	86 ± 8
pNN50 supine (%)	11 ± 12	19 ± 14*	11 ± 13	18 ± 13*	7 ± 12	11 ± 13
pNN50 standing (%)	5 ± 8	8 ± 14	2 ± 3	3 ± 2	3 ± 5	2 ± 3
SD1 supine	23 ± 13	28 ± 12*	21 ± 12	28 ± 11**	18 ± 13	23 ± 12
SD1 standing	14 ± 9	17 ± 13	13 ± 6	14 ± 5	12 ± 7	13 ± 5

Significantly different from before intervention:
$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

pNN50, number of pairs of adjacent intervals differing by >50 ms divided by the total number of intervals; SD1, short-term variability in point-caré plot; supine: F: $n = 15$; R: $n = 15$; C: $n = 17$; standing: F: $n = 14$; R: $n = 12$; C: $n = 15$. Means ± SD are given.

intervention. The enhancement in Yo-Yo running distance in R was higher compared with C (Table 4). Within groups, F and R improved Yo-Yo running distance after training, while in C Yo-Yo running distance remained unchanged.

Discussion

This study showed that a 12-week football training program had positive effects on the health profile in habitually active men exhibiting mild hypertension. Diastolic blood pressure in F was lowered compared with the control group and the decrease in blood pressure was paralleled by an increased HRV as measured in the supine position. The decrease in total cholesterol and the ratio of total cholesterol to HDL-cholesterol in F was associated with decreases in body mass, total body and segmental fat mass, as well as improved indices of cardiovascular fitness, such as maximal stroke volume and maximal oxygen consumption. Most, but not all of these improvements in F were also achieved in R. Besides a decrease in blood pressure and the ratio of total cholesterol to HDL-cholesterol, no other changes occurred in C. As the total training time commitment, weekly training frequency and average heart rate during training sessions were similar for F and R, comparisons of training effects between F and R are meaningful.

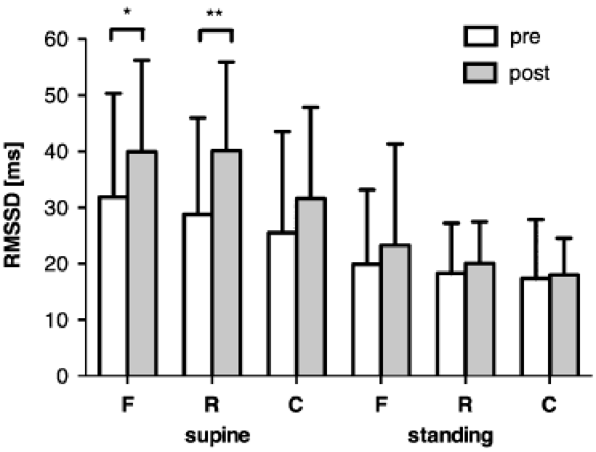

Fig. 3. RMSSD before (pre) and after (post) intervention during 5 min while supine and 5 min while standing in the football (F), running (R) and control (C) group. RMSSD, square root of the mean of the sum of squares of differences between adjacent RR intervals; supine F: $n=15$; R: $n=15$; C: $n=17$; standing F: $n=14$; R: $n=12$; C: $n=15$; means ± SD are given; *significantly different from before intervention; $^{*}P<0.05$, $^{**}P<0.01$.

Blood pressure, heart rate, and heart rate variability

We found that diastolic blood pressure decreased in all groups, but F showed a more marked decrease than C, whereas no difference was observed between R and C. In all three groups, systolic blood pressure and resting heart rate in the supine position were significantly reduced, without any difference between groups. This might indicate that the participants were less anxious about the procedures during the post-intervention measurements. Nonetheless, the study shows that the football group showed pronounced changes in blood pressure that appear to be related to the training itself, which is supported by the fact that the football and running groups showed significant increases in HRV in contrast to the control group.

It is well established that blood pressure is reduced with aerobic training for hypertensive participants (Fagard & Cornelissen, 2007), and it has been proposed to be linked to a reduction in the sympathetic tone. Our HRV results support this notion because parasympathetic activity increased when measured in the supine but not in the standing position. The increase of parasympathetic activity after training is associated with an improved vagal modulation, and therefore a reduction of cardiovascular mortality (Malik, 1996). Changing the position from supine to standing induces a shift from a dominant parasympathetic to a more sympathetic activity (Aubert et al.,

Table 2. Body mass and body composition before (pre) and after (post) intervention in the football (F), running (R) and control (C) group

	Football		Running		Control	
	Pre	Post	Pre	Post	Pre	Post
Body mass (kg)	82.1 ± 8.7	80.5 ± 8.9**	87.3 ± 9.4	85.7 ± 8.9*	88.3 ± 13.5	88.1 ± 13.4
Waist (cm)	94.0 ± 7.7	90.7 ± 8.3**	94.5 ± 8.1	93.2 ± 8.1	97.0 ± 11.1	96.6 ± 10.1
w/h ratio	0.92 ± 0.06	0.90 ± 0.06*	0.91 ± 0.04	0.90 ± 0.05	0.92 ± 0.06	0.93 ± 0.05
Total fat mass (kg)	23.2 ± 4.8	21.2 ± 4.6***##	25.2 ± 5.7	23.5 ± 5.5**	25.8 ± 9.3	25.9 ± 9.5
Relative fat mass (%)	29.2 ± 4.3	27.2 ± 4.3***##	29.7 ± 4.1	28.3 ± 4.3	29.7 ± 7.1	29.8 ± 7.3
Total lean mass (kg)	55.7 ± 5.6	56.2 ± 5.9	58.9 ± 4.9	58.9 ± 4.6	59.3 ± 6.4	59.0 ± 6.3

Significant difference between groups over time: $^{\#\#}P<0.01$.

Significantly different from before intervention: $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$.

w/h ratio, waist-to-hip ratio; F: $n=15$; R: $n=15$; C: $n=17$; means ± SD are given.

2003). Therefore, we suggest that the training effects on the reduction of blood pressure were rather mediated by an increase in parasympathetic activity than a reduction in sympathetic activity. In summary, the improved autonomic regulation, shown as a reduced heart rate, an increased HRV and lowered blood pressures, achieved in both F and R, is likely to have important health benefits.

Body composition and blood lipids

Body mass, as well as total, android and gynoid fat masses were reduced within both training groups, whereas no changes were observed for the control group. The observed change in the total fat mass over 12 weeks was 2.0 kg for the football group, which was slightly less than the 2.7 kg reduction observed over a similar duration in the study by Krustrup et al. (2009). In comparison with the control group, only F had a greater total and android fat mass loss and it was furthermore observed that waist circumference and waist-to-hip ratio decreased for F but not for R and C. The reduction of waist circumference, waist-to-hip ratio and android fat mass is of particular interest, because a reduction of this cardiovascular risk factors is associated with a more favorable metabolic profile (Snijder et al., 2006). Our results indicate that the intermittent exercise and brisk, multi-dimensional movements, which occur during football training, may promote abdominal fat loss. In association with these changes in fat mass, some, but not all, of the borderline blood lipid concentrations (Leon & Sanchez, 2001) were changed in the football group. Thus, total cholesterol and the ratio of total cholesterol to HDL-cholesterol were reduced in F, whereas no changes were observed in R. Although it has been reported that about 30 min (4 times/week during 9 week) of continuous high-intensity training (blood lactate concentration >4 mmol/L) can affect blood lipids negatively (Aellen et al., 1993), the present study and the study by Krustrup et al. (2009) suggest that the intensity peaks

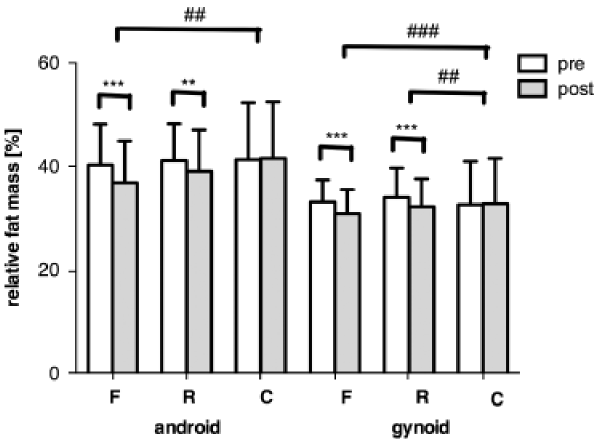

Fig. 4. Android and gynoid fat mass before (pre) and after (post) intervention in the football (F), running (R) and control (C) group. F: $n=15$, R: $n=14$, C: $n=17$; means ± SD are given; $^{\#}$Denotes significant difference between groups over time; $^{\#\#}P<0.01$, $^{\#\#\#}P<0.001$, *significantly different from before intervention; $^{**}P<0.01$, $^{***}P<0.001$.

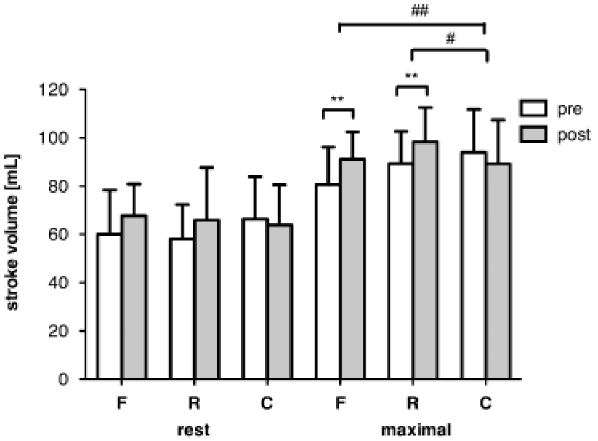

Fig. 5. Resting and maximal stroke volume before (pre) and after (post) intervention in the football (F), running (R) and control (C) group. F: $n=15$; R: $n=15$; C: $n=15$; means ± SD are given; $^{\#}$Denotes significant difference between groups over time; $^{\#}P<0.05$, $^{\#\#}P<0.01$, *significantly different from before intervention; $^{**}P<0.01$.

Table 3. Blood lipids before (pre) and after (post) intervention in the football (F), running (R) and control (C) group

	Football		Running		Control	
	Pre	Post	Pre	Post	Pre	Post
Total-C (mmol/L)	5.8 ± 1.2	5.5 ± 0.9*	5.3 ± 0.9	5.2 ± 0.8	5.5 ± 1.1	5.3 ± 1.1
HDL-C (mmol/L)	1.3 ± 0.4	1.4 ± 0.3	1.3 ± 0.3	1.3 ± 0.4	1.3 ± 0.3	1.4 ± 0.4
LDL-C (mmol/L)	3.8 ± 1.1	3.7 ± 0.9	3.3 ± 0.8	3.3 ± 0.7	3.5 ± 0.8	3.4 ± 0.9
Total-C/HDL-C	4.8 ± 1.6	4.3 ± 1.3**	4.3 ± 1.2	4.2 ± 1.4	4.4 ± 1.3	4.1 ± 1.2*

Significantly different from before intervention:

$^{*}P<0.05$, $^{**}P<0.01$.

C, cholesterol; HDL-C, high-density-lipoprotein-cholesterol; LDL-C, low-density-lipoprotein-cholesterol; total-C/HDL-C, ratio of total cholesterol to high-density-lipoprotein-cholesterol; F: $n=15$; R: $n=15$; C: $n=17$; means ± SD are given.

Table 4. Treadmill and intermittent Yo-Yo running test before (pre) and after (post) intervention in the football (F), running (R) and control (C) group

	Football		Running		Control	
	Pre	Post	Pre	Post	Pre	Post
VO_{2max} (L/min)	3.78 ± 0.53	$4.01 \pm 0.42^{**}$	3.90 ± 0.35	$4.31 \pm 0.32^{***\#\#\#}$	3.83 ± 0.56	3.85 ± 0.51
Rel. VO_{2max} (mL/kg/min)	46.1 ± 4.8	$50.1 \pm 4.1^{***\#}$	45.2 ± 4.7	$50.7 \pm 5.2^{***\#\#\#}$	43.7 ± 5.6	44.1 ± 5.8
V_{max} (km/h)	13.5 ± 1.3	$14.4 \pm 1.3^{***\#\#}$	13.8 ± 1.2	$14.9 \pm 1.2^{***\#\#\#}$	13.1 ± 1.3	13.1 ± 1.5
Yo-Yo IE2 test (m)	517 ± 151	$661 \pm 195^{***}$	506 ± 131	$674 \pm 209^{***\#}$	435 ± 119	485 ± 159

Significant difference between groups over time: $^{\#}P<0.05$, $^{\#\#}P<0.01$, $^{\#\#\#}P<0.001$.

Significantly different from before intervention: $^{**}P<0.01$, $^{***}P<0.001$.

VO_{2max}, maximal oxygen consumption; Rel, relative; V_{max}, treadmill speed at the end of the test; F: $n=15$; R: $n=15$; C: $n=17$; means ± SD are given.

achieved in F did not hinder a positive effect on the blood lipid profile. In further support of this notion, Slentz et al. (2007) demonstrated that HDL-cholesterol was increased after long-lasting training with vigorous-intensity bouts.

Maximal stroke volume, maximal oxygen consumption, and intermittent Yo-Yo running

In the present study, we found an increase in the maximal stroke volume and maximal oxygen consumption for F (13% and 9%) and R (10% and 12%) in comparison with C, where no changes occurred (−5% and 0%). In contrast to the findings of Helgerud et al. (2007), F did not improve maximal oxygen consumption to a greater extent than R and the observed change in maximal oxygen uptake for F was slightly lower than the observed increases for males (13%) and females (15%) after 12 and 16 weeks of recreation football training, respectively (Bangsbo et al., 2009; Krustrup et al., 2009). This observation is not due to differences in training intensity as the mean heart rate and time in the high-intensity training zone were similar between studies, but it may well be due to the higher initial training status of the subjects in the present study (VO_2max of 46 vs 39 and 33 mL/min/kg in Bangsbo et al., 2009; Krustrup et al., 2009, respectively). It is noteworthy that similar increases were observed in stroke volume and maximal oxygen consumption, underlining that the whole body maximal oxygen uptake is primarily determined by cardiac output (e.g. Levine, 2008). As expected, absolute and relative maximal oxygen consumption, peak treadmill test speed and Yo-Yo IE2 running distance (Table 4) increased significantly within the two training groups but not in C.

Conclusions

We conclude that football training provides at least the same cardiovascular and metabolic health benefits as continuous submaximal endurance exercise, such as running training, in habitually active mildly hypertensive persons.

Key words: blood pressure, blood lipids, stroke volume, heart rate variability, intermittent training, endurance training, soccer.

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