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ORIGINAL ARTICLE

Implementing intelligent physical exercise training at the workplace: health effects among office workers—a randomized controlled trial

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Abstract
Purpose The aim was to assess 1-year cardiovascular health effects of Intelligent Physical Exercise Training, IPET.
Methods Office workers from six companies were randomized 1:1 to a training group, TG ($N = 194$) or a control group, CG ($N = 195$). TG received 1-h supervised high intensity IPET every week within working hours for 1 year, and was recommended to perform 30-min of moderate intensity physical activity 6 days a week during leisure. The training program was based on baseline health check measures of cardiorespiratory fitness (CRF), body composition, blood pressure, blood profile, and musculoskeletal health.
Results There were no baseline differences between groups. CRF assessed as VO_{2max} in absolute values and relative to body weight was (mean ± SD): 3.0 ± 0.8 l/min and 35.4 ± 10.9 ml/min/kg for females, 3.9 ± 1.0 l/min and 37.9 ± 11.79 ml/min/kg for males. Intention to treat analysis demonstrated a significant almost 5 % increase in VO_{2max} in TG compared with CG. A per protocol analysis of those with an adherence of ≥70 % demonstrated a significant increase in CRF of more than 10 % compared with CG, and a significant reduction in systolic blood pressure (−5.3 ± 13.7 mm Hg) compared with CG.
Conclusion High intensity IPET combined with the recommendations of moderate intensity physical activity demonstrated significant clinical relevant improvements in CRF and systolic blood pressure. This underlines the effectiveness of health promotion by implementing physical exercise training at the workplace.

Keywords Cardiorespiratory fitness · Systolic blood pressure · Maximal oxygen uptake

Abbreviations

ANCOVA	Analysis of covariance
CG	Control group
CRF	Cardiorespiratory fitness
IPET	Intelligent physical exercise training
HDL	High density lipoprotein
HR	Heart rate
LDL	Low density lipoprotein
RPE	Rate of perceived exertion
1RM	One repetition maximum
TG	Training group
TG ≥ 70 %	Participants in the training group with an adherence of minimum 70 %
VO_{2max}	Maximal oxygen uptake

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Introduction

The workplace is recognized as an ideal setting for implementing health enhancing physical exercise training, as it provides an opportunity to reach a large and diverse population and engage individuals who might not otherwise have time and/or who face other obstacles to participate in physical exercise training (Kuoppala et al. 2008; Proper et al. 2003). In addition, the World Health Organization (WHO) has emphasized the workplace as a specially prioritized arena for public health promotion, and has implied an almost ethical obligation for a commitment from the workplace (Luttmann et al. 2003). Recent reviews on workplace health promotion presents evidence with regard to increased levels of physical activity (Proper et al. 2003), improvements in CRF (Conn et al. 2009), health risk indicators (Conn et al. 2009; Groeneveld et al. 2010), musculoskeletal pain (Proper et al. 2003), presenteeism (Cancelliere et al. 2011; Rongen et al. 2013), reduced sickness absence (Kuoppala et al. 2008; Rongen et al. 2013), and job stress (Conn et al. 2009). However, results are not consistent and the effect sizes are small to moderate due to the large heterogeneity and low quality of the included studies. The authors advocate for more high quality studies (Conn et al. 2009; Proper et al. 2003; Rongen et al. 2013).

Regular physical activity of moderate to vigorous intensity has proven to increase CRF and provides important and wide-ranging health benefits, i.e., reduced risk of hypertension, type-2 diabetes, metabolic syndrome, cardiovascular diseases, and all-cause mortality (Archer and Blair 2011; Lavie et al. 2015; Lollgen et al. 2009; Pedersen and Saltin 2015). Despite an abundance of evidence supporting the favorable health effects of physical activity, most adults remain physically inactive (Blair 2009; Garber et al. 2011). A greater emphasis on promoting physical activity through worksite physical exercise training interventions could have an important impact on reducing risk factors, life style diseases, and all-cause mortality. This is especially valid for workers with inactive job categories, such as office work.

Recent meta-analyses of the effectiveness of workplace health promotion programs demonstrated that effectiveness was partly determined by intervention characteristics (Conn et al. 2009; Rongen et al. 2013). Larger effect sizes were found when the intervention took place during paid working hours, had employee interventionists (Conn et al. 2009), and when the intervention offered weekly contact (Rongen et al. 2013). In line with this, we have in previous studies started to develop a physical activity concept of IPET. For each employee at the workplace, we designed individually tailored physical exercise training by balancing the occupational exposure with the individual health risk indicators, for references see (Sjogaard et al. 2014). The training regimen combined various forms of physical exercise training to improve CRF, individual health risk indicators, and musculoskeletal health (Sjogaard et al. 2014).

The aim of the present study was to individually tailor IPET to office workers and assess one-year health effects on CRF, and other health related outcomes.

Methods

Study design

The study was a 2 years parallel group, examiner-blinded, randomized controlled trial with an IPET based TG and a CG conducted in accordance with the CONSORT statement (Schulz et al. 2010). The primary end-point was 1 year, during the first year the training at the workplace was supervised every week and in addition self-training for 30-min, 6 days a week, was recommended. Therefore, CRF was hypothesized to increase during the first year. During the second year, the aim was to maintain the increase in CRF and training supervision was given only once a month. The present paper reports 1-year intervention effects.

The protocol for this study was presented in detail on recruitment and measures (Sjogaard et al. 2014). In short: six companies agreed to be part of the present study and comprised two private companies, two public municipalities and two national boards, located across Denmark. The enrolment was sequential in six strata from May 2011 to March 2012, with baseline, 1 year, and 2 years follow-up measures. Participants were assigned with an arbitrary ID number and randomized individually within each stratum following baseline measures using a random number computer algorithm. Due to the content of the physical exercise training intervention, participants, and the instructors supervising the IPET intervention were not blinded to group allocation. The examiners performing the health checks were blinded to participants' group assignment, and at follow-up testing, the participants were informed not to tell the examiners what group they were allocated to. All test personnel and investigators involved in data treatment were blinded to the randomization.

All participants were informed about the purpose and content of the project and gave written informed consent to participate in the study, which was conformed to The Declaration of Helsinki, and was approved by the Local Ethical Committee of Southern Denmark (S-20110051). The study was qualified for registration in ClinicalTrials.gov (NCT01366950).

Subjects

Eligible participants were employed as office worker working at least 25 h a week. Exclusion criteria were pregnancy and severe musculoskeletal disorders or other severe health issues such as cardiovascular diseases (e.g., chest pain during physical exercise, myocardial infarction and stroke), symptomatic herniated disc or severe disorder of the spine, postoperative condition or history of severe trauma. In total, 1341 office workers were invited to participate, 395 accepted the invitation and were assessed for eligibility. Eight were excluded due to pregnancy, and a total of 387 participants were randomized to either a TG ($N = 193$) or a CG ($N = 194$) (Fig. 1).

Health check

All participants underwent a health check after replying to an internet-based questionnaire including questions on musculoskeletal disorders (Kuorinka et al. 1987) at baseline and follow-up after one and 2 years of intervention. Measurements included: estimation of CRF, body composition, isometric muscle strength, balance test, core and neck/shoulder stability, blood pressure, and blood profile. All participants were individually notified of the results after the health check (Sjogaard et al. 2014).

Intervention

The training intervention offered to TG only was based on the theoretical framework of IPET described previously (Sjogaard et al. 2014). In short, the exercise training program was performed during working hours, at or nearby the working place, and the training was implemented in

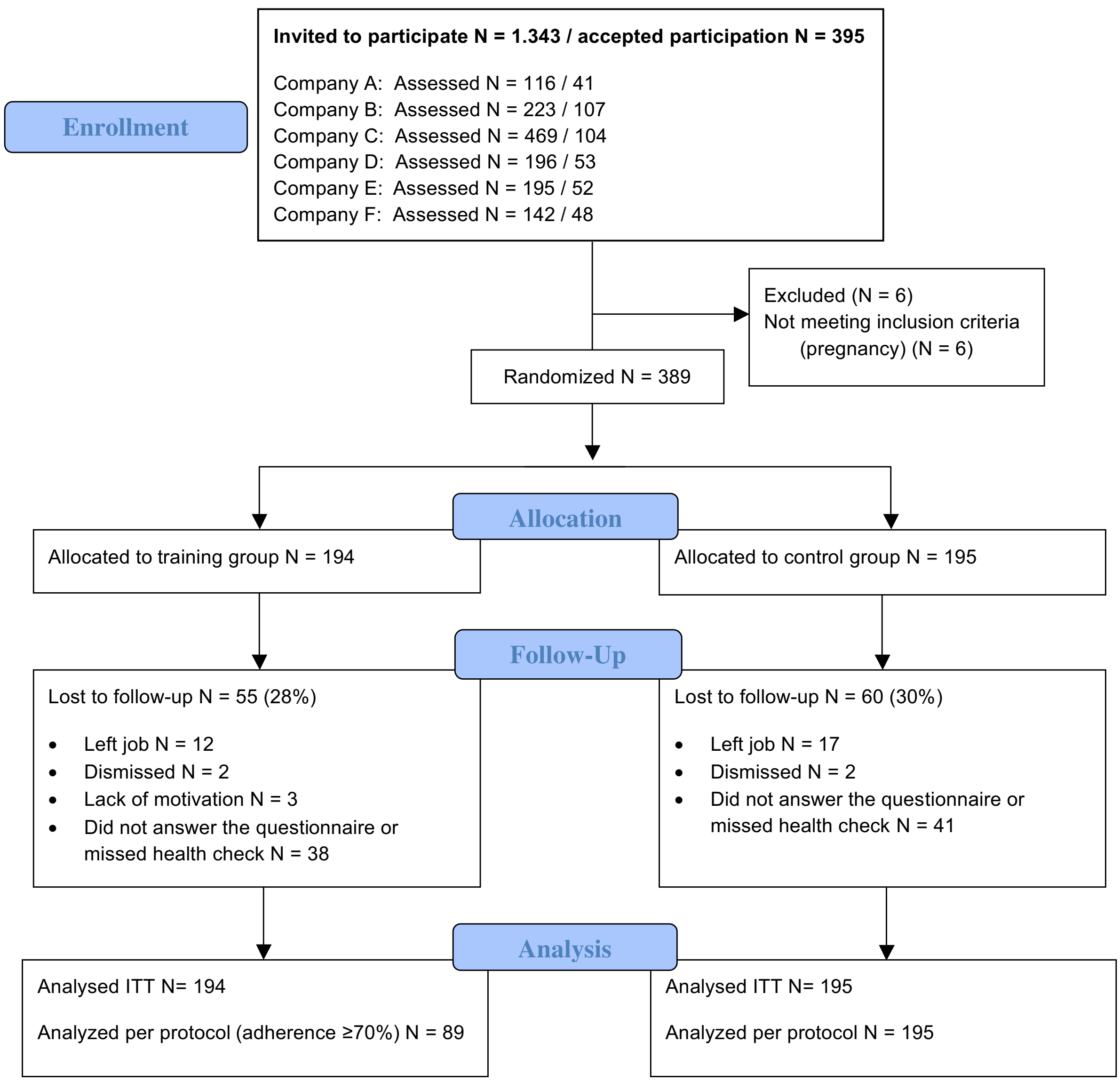

Fig. 1 Flow-chart (updated from Sjogaard et al. 2014)

cooperation with the employer. The training program lasted 1 h a week for 2 years, the first year was fully supervised and in the second year, monthly supervision of a weekly training session was provided. Each participant in TG received an individually tailored training program based on outcome measures of the baseline health check. For each measure cut-off points were identified to allocate individual training duration and intensity within cardio-, strength- and/or functional training (Sjogaard et al. 2014), following the guidelines from the American College of Sports Medicine (Garber et al. 2011), as well as specific strength training exercises for the neck and shoulder region (Andersen et al. 2008). For each training session, 10 min were given for getting to and from the training area, and 20 min were allocated to cardio-respiratory fitness training due to office workers sedentary working condition. Hereafter, each participant trained for 30-min his or her specific exercises according to the individual training program provided. In total, 32 individual training programs were developed, where nine of those covered more than 85 % of the participants' needs, most of which included neck/shoulder strength training and cardio training. Exercises for cardio-respiratory training were chosen by the employee after receiving guidance from their instructor. These exercises were at vigorous intensity and could be running, rowing, ball games etc. The selected strength training exercises were for the major muscle groups: one for the shoulders, three for the abdomen-back and one for the chest muscles. The targeted intensity for strength training was 60–80 % of 1RM, with three sets of eight repetitions. For specific neck and shoulder training, the exercises shrugs, lateral raise and reverse flies were allocated. Participants were asked to lift to their pain limits or as heavy as possible for eight repetitions in three sets while using proper technical execution. The functional training exercises were selected from nine different exercises: five for balance training and four for body core training. Throughout the training session, training intensity was kept high, targeting 77–95 % of heart rate maximum (HR max) corresponding to a rate of perceived exertion (RPE) of 14–17 on the Borg scale 6–20 (Wilson and Jones 1989). The instructors supervising the training sessions were instructed to record RPE values after each training session and to measure 1RM when the training intervention started, as well as to progress training and keeping the participants motivated throughout intervention.

In addition to the workplace intervention, participants in TG were encouraged to engage in moderate physical activity (64–76 % HR max, RPE 12–13) 6 days a week during leisure or a minimum of 3 h per week. Health ambassadors were appointed for every 10–15 employees by the company's middle managers among employees participating in the training but not being included in randomized TG (Sjogaard et al. 2014). The health ambassadors were key persons to motivate colleagues to become and sustain physically active during the course of the research project.

The CG received no workplace training or other information regarding recommended leisure time physical activity but was encouraged to maintain their lifestyle as usual.

Adherence

Attendance to the weekly training sessions at the workplace for the TG was recorded by the instructor and applied to calculate adherence, defined as the number of attended training sessions out of possible training sessions within the 1-year intervention. The number of possible training sessions varied across companies (34–37) because there were days, where training was not possible for some of the companies, and public holidays also affected the number of possible training session. For a per protocol analysis, we defined an inclusion criterion for TG of an adherence in the training sessions performed at the workplace of $\geq$ 70 % (Church et al. 2010). All participants in CG were included in the per protocol analysis.

Adherence to leisure time physical activity—as recommended for the TG only—was self-assessed by a representative sub-sample of 133 participants in TG and 134 participants in CG, using two questions: (1) 'How many days in a week have you within the last month spent 30 min or more of physical activity?' Possible answers were categories from 0 to 7 days a week; and (2) 'How much time have you on average spent on the following activities the past year? Also include transportation to and from work and other activities.' Possible answers were within three activity categories of light intensity, moderate intensity, and vigorous intensity: more than 4 h per week, 2–4 h per week, less than 2 h per week, or no such activity.

Measurements

All measurements at baseline were performed before the randomization and repeated after 1 and 2 years. The primary outcome was CRF expressed VO_{2max} in absolute values as l/min and relative to body weight as ml/min/kg, and secondary outcomes were body composition, blood pressure and blood lipid profile.

Maximal oxygen uptake

Maximal oxygen uptake was estimated from the relation between sub-maximal workload and stable heart rate obtained in Åstrand one-point sub-maximal test on a bicycle and subsequently using the Åstrand nomogram (Astrand and Ryhming 1954). CRF was corrected also for age according to Åstrand (Astrand 1960). The test procedure started with a load of 60 W for females and 90 W for males on a 1.0 kg, 60 rpm Monark bicycle (Monark 874E, Monarch Exercise AB, Sweden). After the first 2 min, the load was adjusted based on the measured heart rate. If the heart rate was below 120 beats per minute (BPM) during the first 2 min, 0.5 kg was added; further weight was added at 3 and 4 min if needed to attain a stable heart between 120 and 170 BPM. When the heart rate was recorded as stable for 1 min, the test was terminated. The duration of each test was approximately 7–10 min. The post-intervention test was performed following the same protocol regarding pedal rate and weights added to the bicycle (i.e., with the same external workload and duration at each incremental load as in the pre-randomization test). Heart rate was thus the only parameter that could differ between the pre- and post-intervention tests. Although, if a steady state between 120 and 170 BMP was not reached with the same protocol, additional weight was added until steady state was reached.

Blood pressure

After 5–10 min seated rest, blood pressure, BP, was measured on the right arm with an electronic blood pressure device (OMRON M7) and taken three consecutive times with no breaks. The mean of the two lowest measurements were applied (Appleyard 1989).

Blood profile

Fasting blood samples was analyzed by standard methods (enzymatic colorimetric method) for fasting blood glucose, triglycerides, low density lipoprotein (LDL) and high density lipoprotein (HDL), at the hospitals in the region where the companies were located.

Body composition

Height was measured using an altimeter, to the nearest half centimeter. Body mass, body mass index, fat percentages and muscle mass was calculated by a bio impedance device (Tanita TBF 300). Participants wear light clothing (1 kg adjustment).

Statistical analysis

The statistical analyses were based on an intention to treat approach using SPSS version 22. Missing values in either baseline or follow-up measurements were substituted with data carried forward or backward. When measurements had missing values in both baseline and post measurements, these was replaced by means of all existing values for the particular variable.

Differences in baseline characteristics were examined by either a Chi square test or independent *t* test depending on type of data. Analyzes of intervention effects for primary and secondary outcomes were done using analysis of covariance (ANCOVA). Per protocol analysis was performed for those participants in the TG who had an adherence of minimum 70 % (TG $\geq$ 70 %) and including all participants in CG. To detect a 5 % improvement in CRF on a group level, with a SD of 20 %, an alpha level of 5 %, and a power of 80 %, the Douglas Altman's nomogram showed a requirement of approximately 128 participants in each group for a one-tailed sample size calculation (O'Hara 2008). With an estimated dropout of 30 % the research project sought to recruit around 400 participants. Baseline characteristics and absolute change from pre- to post-intervention are presented as group mean and SD. For the analysis of covariance, group mean change is presented as adjusted means and SE with 95 % CI. The questions for leisure time physical activity were analyzed by calculating the delta values and ranking each participant into one of three categories: 'positive development', i.e., they spent more time/days on physical activity at follow-up compared with baseline; 'no development', i.e., they answered in the same category at baseline and follow-up, and 'negative development', i.e., they spent less time on physical activity at follow-up compared with baseline. We applied a Chi square test to analyze the difference between TG and CG. For all analyzes, a two-tailed significance level of 0.05 was considered statistically significant.

Results

Study population

There were no baseline differences between TG and CG with regard to demographics or primary and secondary outcomes (Table 1). Females accounted for 74 %; on average the participants were 44 ± 10 years old, had a height of 1.71 ± 0.09 m, a weight of 74.2 ± 16.6 kg, a BMI of 25.4 ± 5.1 kg/m^2 and a fat percentage of 31.9 ± 7.9 % for females and 21.2 ± 6.0 % for males. Absolute and relative VO_{2max} were on average 3.0 ± 0.8 l/min and 35.4 ± 10.9 ml/min/kg for females and 3.9 ± 1.0 l/min and 37.9 ± 11.8 ml/min/kg for males. The final average load used in the bicycle tests at baseline was 130.3 ± 43.2 W, and average steady HR was 146.0 ± 12.4 BPM, with no difference between TG and CG.

For the per protocol analysis, 89 participants had an adherence of minimum 70 % (TG $\geq$ 70 %). They differed at baseline from those in TG who had an adherence <70 %. With no sex difference, TG $\geq$ 70 % had a significantly lower absolute VO_{2max} (3.1 ± 0.9 vs 3.4 ± 1.1 l/min) as well as relative VO_{2max} (34.4 ± 9.8 vs 37.9 ± 12.2 ml/min/kg). In addition, the LDL cholesterol level was significantly higher

Table 1 Baseline characteristics for TG and CG

	TG $N = 193$		CG $N = 194$		
	Mean	SD	Mean	SD	p value
Age (years)	44	11	45	10	0.22
Height (m)	1.71	0.09	1.70	0.09	0.47
Weight (kg)	74.1	16.1	74.2	17.1	0.95
Fat (%)	28.9	8.9	29.3	8.7	0.64
BMI (kg/m^2)	25.3	5.0	25.5	5.2	0.80
Absolute VO_{2max} (l/min)	3.3	1.0	3.3	0.9	0.97
Relative VO_{2max} (ml/min/kg)	36.3	11.3	35.8	11.1	0.71
Load (Watt)	130.4	45.8	130.2	43.2	0.95
HR steady (bpm)	145.7	13.5	146.4	12.0	0.61
Systolic BP (mm Hg)	124	17	124	16	0.67
Diastolic BP (mm Hg)	81	11	82	10	0.57
LDL (mmol/l)	2.9	0.8	3.0	0.8	0.32
HDL (mmol/l)	1.7	0.5	1.6	0.4	0.63
Triglyceride (mmol/l)	1.1	0.8	1.1	0.5	0.68
Total cholesterol (mmol/l)	5.1	1.0	5.1	1.0	0.89
Blood glucose (mmol/l)	5.3	0.9	5.2	1.1	0.85

Data are mean ± SD for TG and CG

in those with a high adherence compared with those with an adherence below 70 % (3.1 ± 0.9 vs 2.8 ± 0.8 mmol/l), as well as the HDL cholesterol level was significantly lower (1.6 ± 0.5 vs 1.7 vs 0.5 mmol/l). There were no baseline differences between TG ≥70 % and CG.

There were no baseline differences between TG and CG with regard to the number of days being physically active. Both TG and CG reported 3 days per week as median. Also, no differences were found with regard to time spent on light, moderate or vigorous intensity. The majority in each group reported spending 2–4 h per week on light intensity (approx. 40 % of the participants) and less than 2 h per week on moderate intensity (approx. 45 % of the participants). For vigorous intensity approx. 17 % reported to engage in such activities.

Intervention effects

Of the 387 randomized participants, a total of 105 (30 %) were lost to follow-up, similar percentage for TG and CG. No adverse training effects were reported neither during training at work nor leisure. The overall average adherence for TG was 56 ± 29.2 % corresponding to 29.2 training sessions. There was no difference across companies with a range of 36–63 %, nor was there a significant difference between sex with an adherence of 54 ± 29.7 % for females and 61 ± 27.3 % for males. Mean RPE during exercise training at the worksite for the participants in the TG was 15.5 (min. 10; max. 18).

The intention to treat analysis showed statistically significant and different changes between TG and CG. Delta mean and adjusted mean differences are shown in Table 2. TG had a significantly higher increase in absolute VO_{2max} compared with CG, with a mean percentage increase of 8.2 ± 21.5 vs 3.5 ± 18.7 %. Relative VO_{2max} increased significantly more in TG compared with CG with a mean

Table 2 Delta (post–pre intervention) mean values for TG and CG

	TG $N = 193$		CG $N = 194$		Difference TG–CG				
	Delta mean	SD	Delta mean	SD	Adjusted mean	SE	95 % CI		p value
Weight (kg)	−0.49	3.32*	0.08	2.97	−0.57	0.32	−1.193	0.056	0.07
Fat (%)	−0.03	2.60	0.06	1.93	−0.11	0.23	−0.563	0.347	0.64
BMI (kg/m^2)	−0.22	1.09*	0.03	1.06	−0.26	0.11	−0.468	−0.042	0.02§
Absolute VO_{2max} (l/min)	0.18	0.61*	0.05	0.55	0.13	0.06	0.023	0.238	0.02§
Relative VO_{2max} (ml/min/kg)	1.46	6.57*	0.18	6.40	1.37	0.61	0.159	2.573	0.03§
Systolic BP (mm Hg)	−3.35	12.51*	−1.54	13.09	−2.04	1.18	−4.367	0.289	0.09
Diastolic BP (mm Hg)	−2.78	7.83*	−2.26	6.22*	−0.65	0.68	−1.991	0.693	0.34
LDL (mmol/l)	−0.01	0.53	−0.02	0.41	−0.01	0.05	−0.097	0.083	0.88
HDL (mmol/l)	−0.01	0.21	0.01	0.19	−0.01	0.02	−0.052	0.026	0.53
Triglyceride (mmol/l)	0.03	0.34	−0.02	0.44	0.06	0.04	−0.021	0.131	0.15
Total cholesterol (mmol/l)	−0.09	0.66	−0.09	0.47*	−0.01	0.05	−0.112	0.097	0.89
Blood glucose (mmol/l)	−0.12	0.77*	−0.11	0.58*	−0.01	0.06	−0.121	0.108	0.91

Adjusted mean difference (ANCOVA) between TG and CG with adjustment for the variable's pre intervention value

Data are mean ± SD for TG and CG and adjusted mean ± SE with 95 % CI

* Significant within group changes

§ Significant difference between TG and CG

Table 3 Delta (post–pre intervention) mean values for TG ≥ 70 % and CG

	TG ≥ 70 % *N* = 89		CG *N* = 194		Difference TG ≥ 70 % – CG				
	Delta mean	SD	Delta mean	SD	Adjusted mean	SE	95 % CI		*p* value
Weight (kg)	−0.95	3.44*	0.76	2.97	−1.02	0.40	−1.803	−0.231	0.01§
Fat (%)	−0.40	2.81	0.06	1.93	−0.48	0.29	−1.039	0.085	0.96
BMI (kg/m^2)	−0.39	1.15*	0.03	1.06	−0.42	0.14	−0.695	−0.148	0.03§
Absolute VO_{2max} (l/min)	0.43	0.58*	0.05	0.55	0.34	0.07	0.208	0.474	<0.01§
Relative VO_{2max} (ml/min/kg)	4.21	6.44*	0.18	6.39	3.76	0.79	2.215	5.306	<0.01§
Systolic BP (mm Hg)	−5.35	13.73*	−1.54	13.09	−3.16	1.55	−6.223	−0.103	0.04§
Diastolic BP (mm Hg)	−3.78	9.37*	−2.26	6.22*	−1.37	0.90	−3.149	0.405	0.13
LDL (mmol/l)	−0.09	0.56	−0.02	0.41	−0.06	0.06	−0.169	0.049	0.28
HDL (mmol/l)	−0.01	0.20	0.00	0.19	−0.02	0.02	−0.067	0.027	0.41
Triglyceride (mmol/l)	0.01	0.36	−0.02	0.44	0.05	0.05	−0.148	0.055	0.37
Total cholesterol (mmol/l)	−0.19	0.70*	−0.09	0.47*	−0.80	0.06	−0.208	0.046	0.21
Blood glucose (mmol/l)	−0.12	0.99	−0.11	0.58*	0.00	0.08	−0.149	0.153	0.97

Adjusted mean difference (ANCOVA) between TG ≥ 70 % and CG with adjustment for the variable's pre intervention value

Data are mean ± SD for TG ≥ 70 % and CG and adjusted mean ± SE with 95 % CI

* Significant within group changes

§ Significant difference between TG ≥ 70 % and CG

percentage increase of 6.8 ± 20.2 vs 2.5 ± 18.8 %. There was no difference between TG and CG with regard to secondary outcomes, except for BMI that for TG decreased significantly more compared to CG (Table 2). No sex differences were present for primary or secondary outcomes.

In the per protocol analysis, comparing TG ≥ 70 % with CG, absolute delta mean and adjusted mean differences are shown in Table 3. TG ≥ 70 % had a significantly higher increase in absolute VO_{2max} compared with CG, with a mean percentage increase of 16.7 ± 22.9 %. Relative VO_{2max} increased significantly more in TG ≥ 70 % compared with CG with a mean percentage increase of 14.4 ± 20.4 %. Further, TG ≥ 70 % had a significantly larger reduction in systolic blood pressure compared with CG, with a mean percentage reduction of 3.6 ± 10.7 vs 0.8 ± 10.1 %. In addition, TG ≥ 70 % had a mean percentage decrease in weight and BMI, which was significant compared with CG (Table 3).

Additionally, within group, changes occurred in the intention to treat analysis, showing that TG reduced systolic blood pressure significantly from pre- to post-intervention with a mean percentage of 2.1 ± 9.9 %, diastolic blood pressure with a mean percentage of 3.0 ± 9.1 %, as well as blood glucose with a mean percentage of 1.3 ± 11.4 %. In addition, CG reduced diastolic blood pressure with a mean percentage of 2.6 ± 7.5 %, and total cholesterol with a mean percentage of 1.2 ± 9.4 %. There were no sex differences with regard to primary or secondary outcomes.

At follow-up there was a significant difference between TG and CG regarding the proportion of participants changing the number of active days per week. TG showed a higher proportion of participants who achieved a positive development (TG: 60 % vs CG: 50 %), and a lower proportion of participants who achieved a negative development (TG: 16 % vs CG: 43 %). For time spent on light and moderate intensity, there was no between group difference in the proportion of participants who had a positive or negative development. For vigorous intensity, TG compared with CG increased significantly the proportion of participants achieving a positive development: 32 % in TG and 18 % in CG.

Discussion

The major finding of this study was significantly increased CRF among office workers after 1 year of workplace health promotion including increased levels of physical activity. The magnitude of increase in CRF obtained by TG compared with CG was almost 5 % in the intention to treat analysis and more than 10 % in the per protocol analysis. Furthermore, the per protocol analysis demonstrated a significant decrease in systolic blood pressure of 2.8 % which was significant compared with CG. The physical activity accounting for this encompassed IPET for 1 h a week and in addition self-training 30-min, 6 days a week was recommended.

The increase in estimated CRF is likely to provide a clinical relevant decreased risk for metabolic and cardiovascular diseases. A meta-analysis observed that a 1-MET (equal to 3.5 ml/min/kg) increase in CRF was associated with a

13 % reduction in all-cause mortality and a 15 % reduction in coronary heart/cardiovascular morbidity and mortality (Kodama et al. 2009). In the present study, participants with an adherence of ≥70 % demonstrated an increase in CRF of 4.2 ml/min/kg corresponding to a MET increase of 1.2. In a study of Danish office workers conducted in 2005–2006, a similar increase in CRF was observed with all-round exercise training performed 1 h a week for 1 year (Pedersen et al. 2009). Other studies among white-collar workers have, even after 8 weeks, been able to demonstrate significant increases in CRF with pedometer-based walking and stair climbing (Butler et al. 2015; Kennedy et al. 2007). In contrast to our study, the baseline values were much lower than in our study (below 30 ml/min/kg), providing a greater potential for improvement. Among blue-collar workers two recent Danish studies have been conducted presenting clinical relevant increases in CRF—7.3 % among cleaners (Korshoj et al. 2015) and 12.5 % among constructions workers (Gram et al. 2012). Common to those studies were also the low baseline values (below 30 ml/min/kg), which are associated with an increased risk for metabolic and cardiovascular diseases compared to values above 30 ml/min/kg (Blair et al. 1989).

A recent scientific statement from the American Heart Association supports workplace interventions with an incentive to enhance physical activity. In addition, authors found moderate evidence of the effects of improving awareness and attitudes about physical activity through educational campaigns, and that labeling and information about physical activity in public areas and better sports facilities may be beneficial in promoting more physical activity. However, in general the effects are modest and authors advocate for more research to translate evidence into action (Mozaffarian et al. 2012). In the present study we implemented a combination of 1 weekly hour of supervised vigorous physical exercise training during work hours and recommendations of 30-min moderate physical activity 6 days a week. Self-reports demonstrated a significant difference between TG and CG on the proportion of participants increasing their physical activity including their time spent on vigorous intensity with the training intervention.

Vigorous intensity has been associated with higher physiological benefits compared with moderate intensity, i.e., peak VO_{2max}, positive adaptations in cardiac structure and function, and cardiac biomarkers (Archer and Blair 2011; Lollgen et al. 2009; Swain 2005; Swain and Franklin 2006). However, as the literature on vigorous intensity in clinical cardiovascular research is sparse, the recommendations of more vigorous intensity exercise must be made with caution (Lavie et al. 2015). A combination of moderate and high intensities is in accordance with the recommendations from the American College of Sports Medicine (Garber et al. 2011).

Per protocol analysis demonstrated a significant reduction in systolic blood pressure of 5.3 mm Hg which was significant compared with CG. Such reduction is of clinical relevance as evidence suggests that systolic blood pressure has greater significance than diastolic blood pressure for cardiovascular risk (Rapsomaniki et al. 2014). Reductions of 10 mm Hg in systolic blood pressure would, in the long term, be associated with about 40 % lower risk of stroke death and about 30 % lower risk of death from ischaemic heart disease or other cardiovascular causes throughout middle age (Lewington et al. 2002). Even a 2 mm Hg reduction in systolic blood pressure would result in about 10 % lower stroke mortality and about 7 % lower mortality from ischaemic heart disease or other cardiovascular causes (Lewington et al. 2002). Despite blood pressure levels did not exceed 140/90 mm Hg in our study, producing persistent reductions in normotensive individuals would also avoid premature deaths and disabling strokes (Lewington et al. 2002). This is also supported by Rapsomaniki et al., who found that for all ages, the lowest risk for cardiovascular diseases was in individuals with systolic blood pressure of 90–114 mm Hg and diastolic blood pressure of 60–74 mm Hg (Rapsomaniki et al. 2014). Other studies conducted at the workplace have also demonstrated significant improvements in blood pressure among white-collar workers (Butler et al. 2015; McEachan et al. 2011; Pedersen et al. 2009) and blue-collar workers (Christensen et al. 2012), countering previous reviews' no evidence for an effect of worksite physical activity programs on blood pressure (Groeneveld et al. 2010; Proper et al. 2003).

An important finding is the proportion of participants with an adherence of ≥70 %, who had a significantly lower CRF at baseline compared with participants with an adherence <70 %, as well as poorer LDL and HDL levels. This indicates that individually tailored IPET was successful in motivating those who had a high need for engaging in physical exercise training. This also contradicts a study among university employees offering occupational wellness programs. The study found that individuals who were categorized as physically inactive were less likely to participate in the offered wellness programs compared with those categorized as physically active (Birdee et al. 2013). In addition, individuals categorized as physically inactive reported a higher prevalence of cardiovascular diseases and fair or poor health (Birdee et al. 2013).

A strength of this study was the high external validity due to mean age and gender distribution of the participants being similar to office workers in the Danish workforce and the companies being located in different parts of Denmark with both private and public sectors being represented. This study also had a rigid RCT design considered to be the golden standard in health research. In addition we were able to demonstrate clinical relevant health effects with the intention to treat analysis despite a lost to follow-up of 27 % and a conservative imputation (carry forward or backwards). A limitation of our study was the low acceptance rate of roughly 30 % among the invited employees, and unfortunately we do not know the characteristics of those who did not accept participation. Also, the low adherence of 56 % must be considered as a limitation, although, other studies among white-collar workers report adherence as low as 35 % (Blangsted et al. 2008) and 39 % (Dalager et al. 2015), the latter for only a twelve-week intervention period. This calls for increased attention on the recruitment procedures for workplace health promotion programs and strategies to make sustainable programs and participation (Rongen et al. 2014). This is also in agreement with a recent study demonstrating that even with high use of resources—time, money and organizational involvement—workplace health promotion programs face challenges with the ability to recruit participants and make sustained participation (Leyk et al. 2014).

In conclusion, this study demonstrated that 1 hour of supervised individually tailored physical exercise training integrated in the workday every week and recommendations of 30-min of moderate physical activity for 6 days a week had several health enhancing effects. Clinical relevant improvements were demonstrated in CRF and systolic blood pressure, which is of vital importance and underlines the effectiveness of health promotion implementing physical exercise training interventions at the workplace.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interests

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