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Effects of Workplace Physical Exercise Intervention on the Physical Perceived and Measured Physical Functioning among Office Workers - A Cluster Randomized Controlled Cross-Over Design

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Abstract

Purpose: The main aim of the present study was to investigate the effects of a workplace exercise intervention on physical functioning. Dose of the exercise and other physical activity outside the intervention were controlled for. The other aims were to determine the physical strain of training and determine training force as a percentage of work time (OPA), leisure time (LTPA) and time spent on all activities (AT).

Methods: The study was a cluster randomized controlled trial (CRT) with each department as the unit of randomization (n=36, n=19, n=15, n=25). The cross-over design consisted of one 15-week intervention period of resistance training (30% 1RM) and training guidance, and another period of the same length with no training or guidance. The subjects (n=90) were office workers [mean age 45.7 (SD 8.5) years]. Percentage body fat was measured using bioelectrical impedance, spinal flexibility with goniometer and a cervical measurement system, muscular strength with a 5RM test and a hand grip test. Subjective physical condition was assessed by questionnaire and physical activity by questionnaire and diary. The statistical analysis was based on linear mixed models.

Results: The active component of the intervention, light resistance training, significantly increased both subjective physical condition (p=0.015) and upper extremity extension strength (p= 0.001). Intervention had no effect on percentage body fat, spinal flexibility, hand grip strength or lower extremity strength. The estimated increase in subjective physical condition during the 15-week period was 4 units (95% CI 1-7) or 6% and in upper extremity extension strength 1.3 kg (95% CI 0.5- 2.1) or 4%. Relative physical strain, measured as percentage of maximal oxygen consumption, was 33.7%. Training force was 1.12 metabolic equivalent hours per week, representing 2.0% OPA, 5.9% of LTPA and 1.2% of AT.

Conclusion: Light resistance training during the working day had a positive effect on the office workers` subjective physical condition and strength of upper extremities. Controlling for training dose and other physical activity outside the intervention and confounding factors provides for a better specificity and understanding of the dose-response and effectiveness of exercise intervention on physical functioning among office workers.

Keywords: Dose-response; Occupational health; Office workers; Physical activity; Physical functioning; Rehabilitation; Therapeutic exercise

Introduction

Although physical activity interventions are commonly used in the workplace to promote employees´ physical and psychosocial functioning and work ability, the scientific evidence for the effectiveness of such programmes according to systematic reviews is still limited [1-10]. Study results of these workplace physical activity interventions from the early of 2010 indicated that employees have benefited from these interventions more on the area of physical functioning than on psychological functioning [3,5-7,9,10] or on work-related outcomes [8]. Whereas according to most recent Conn et al. systematic review with meta-analysis the result was that physical activity interventions can improve physical functioning, but also psychosocial functioning and work ability like on work attendance and job stress [2].

Although there is increasing scientific evidence that workplace physical activity interventions affect physical functioning the study results of systematic reviews are not consistent with the most common outcomes, that is, physical activity and/or physical fitness. For example, according to previous systematic reviews participation in workplace fitness programs can enhance physical activity [1,2,4,7,9] fitness [2,3], or health-related fitness and reduce risk-taking behaviour [9]. While some workplace intervention studies has yet to demonstrate a statistically significant increase in physical activity [3] or fitness [3,7], they indicate small favourable changes in anthropometric measures [2,3], muscle strength, flexibility [3], and lipids [2].

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Despite of crowing knowledge of workplace physical activity interventions on physical functioning there is still lack of well-designed originally studies [1,2], with no-intervention controls and measurements of physical fitness[1]. The original studies of reviews were seldom randomised controlled trials (RCT), because common opinion is still that RCTs may be especially difficult to implement at workplace [2,9,11]. Both review and systematic review studies have recommended performing more randomised, controlled trials of high methodological quality. Internal validity scores like randomization, treatment allocation, drop-out rate, blinding, intention-to-treat analysis, relevant outcome measures and definition of the intervention should be taken into account [2,3,7-13]. In addition to that co-interventions should be avoided and compliance with the treatment [14-16] and the adverse effects reported [13]. Most of the evidence in the field of workplace physical exercise interventions currently available seems to concern the effects of physical exercise or activity programmes on functioning rather than the effects of training dose-response on health-related changes.

In order to analyse the relationships between these physical activity factors, the concepts must first be defined. Physical activity (PA) is defined as any bodily movement produced by a contraction of skeletal muscle that substantially increases energy expenditure. The gross cost of an activity, is the total energy expenditure, which comprises the resting metabolic rate and the energy expended on activity itself. The net cost is that associated with the activity alone. PA is an umbrella term covering leisure time activity (LTPA), occupational type of activity (OPA) and commuting. LTPA, OPA and commuting can be categorised into more detailed types of activity like sitting, walking, jogging, resistance training, carrying a load etc. The dose of a any types of physical activity is described by frequency, duration and intensity. Frequency is the number of activity sessions per unit of time (e.g. day or week). Duration refers to the number of minutes spent on the activity in each session. Intensity describes, in absolute or relative terms, the measured or estimated efforts associated with the physical activity in question. [17-21]. The purpose of this study were, among office workers, to investigate: 1) the adherence to the physical exercise intervention 2) the effects of a workplace physical exercise intervention, which consisted of light resistance training and guidance, on body fat percentage, spinal flexibility, muscular strength and subjective physical condition 3) to determine the physical strain of light resistance training as percentage of maximal oxygen consumption 4) to determine training force as a percentage of work time, leisure time and all activities time.

Methods

Research design

Randomization was performed at the department level to prevent contamination between the physical exercise intervention and no-intervention groups, and to be able conduct the study in an undivided and natural working community. The study subjects, cluster randomisation procedure, and the cross-over design are presented in a flow chart in Figure 1.

The criterion for inclusion at the cluster level was physically light work [average intensity about 1.5 metabolic equivalents (MET)] performed by workers in various departments of the central administration of the City of Kuopio in Finland. Four departments with a combined population of 124 office workers (82 women and 41 men) were eligible. All four departments and 90 worker volunteers (73%) took part in the physical exercise intervention. The intervention was performed using a cluster randomized [22] cross-over design. The researcher randomized the four departments (n1=36, n2=19, n3=15, n4=25) into two treatment sequence group by using sealed opaque envelopes. There were two departments in each group and all the workers within the same department received treatment in the same sequence.

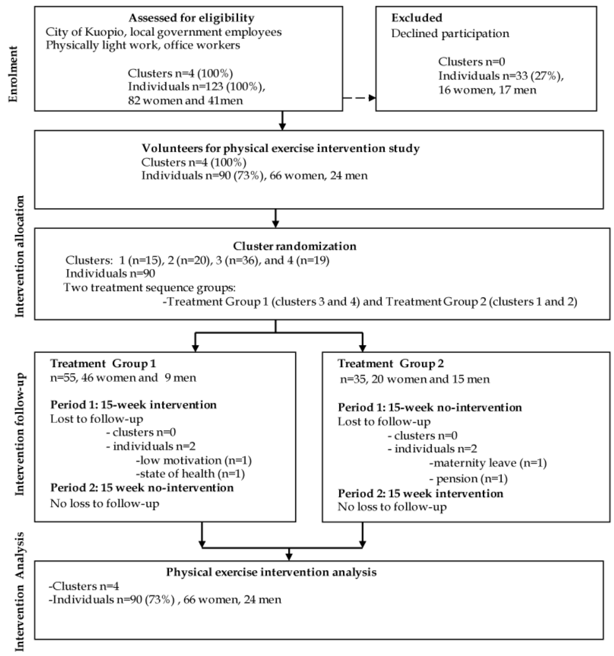

Figure 1: Study design, randomisation, and study subjects.

The baseline measurements were performed and individual feedback discussions held before the first intervention period in September, 1999. After the baseline measurements, the workers were allocated into two treatment sequence groups, Treatment Group 1 and Treatment Group 2. In the first period (autumn), Treatment Group 1 took part in the intervention while Treatment Group 2 did not. In the second period (spring), the roles were reversed so that now Treatment Group 2 took part in the intervention while Treatment Group 1 did not. The cross-over design was conducted without any washout time between the two treatment periods. Therefore, the second period commenced immediately after the first period ended in January. Both periods lasted for 15 weeks. The sequence was concealed from the participants for as long as possible. The study was approved by the ethical committee of the University of Kuopio and the University Hospital of Kuopio (in year 1999) and all subjects gave their written informed consent to participation.

Participants

At the individual level, the health status of the 90 volunteers, 66 women, and 24 men, mean age 45.7 (SD 8.5) years], was assessed in collaboration with an occupational health physician [23]. Among the office workers study population the most common areas of musculoskeletal complaint in the 12-month and 7-day recall at baseline were shoulders, head, neck and low back. In this study there were individuals whose normal life had been restricted during the 12-month recall periods because of neck symptoms, n=37 (41%), shoulder symptoms, n=41(46%), and low back symptoms, n=36 (40%). There was partial overlapping in these pain symptom sub-groups.

None of the subjects met the exclusion criteria for the measurements of the sub-maximal 5RM test and light resistance training, i.e., difficult or neglected musculoskeletal, cardiovascular, respiratory, metabolic, nervous system or sense organ diseases, acute injury or postoperative state. At the baseline, significant gender differences in physical functioning at the individual level were observed. Table 1 presents baseline information, with means and standard deviations, for physical functioning by gender. Among the women in the present study population the physical activity patterns were similar to those found earlier in a large sample of Finnish employees [24] while among the men physical activity was somewhat higher. In addition, significant differences were also found at the cluster level between the treatment groups (Treatment Group 1, Treatment Group 2) in flexion strength of the upper (p=0.022) and lower extremities (p=0.046), extension strength of the lower extremities (p=0.018) and hand grip strength (p=0.39-0.048).

Mean (SD)				
	All	**Women**	**Men**	**p-value**
	(n=90)	(n=66)	(n=24)	
Age, years	45.7 (8.6)	45.4 (8.6)	46.6 (8.6)	0.559
Height, cm	167.7 (7.7)	164.5 (5.7)	176.3 (5.5)	0
Weight, kg	71.3 (13.2)	67.7 (11.4)	81.2 (13.1)	0
Current workplace, years	12.7 (8.5)	13.1 (9.4)	12.7 (8.1)	0.856
Physical Functioning				
Functions of metabolic system				
Body fat percentage (%)	26.9 (7.2)	29.3 (6.2)	20.3 (4.8)	0.000
Neuromusculoskeletal and movement-related functions				
Muscle strength (kg)				
Hand grip strength				
- Right	41.2(11.8)	36.8 (7.1)	53.6 (12.7)	0
- Left	36.6 (10.7)	32.1 (5.4)	49.4 (11.4)	0
Upper extremities muscles				
- Extension	40.1 (14.9)	32.5 (6.2)	59.0 (12.5)	0
- Flexion	52.2 (13.9)	44.8 (5.9)	71.3 (8.7)	0
Lower extremities muscles				
- Extension	49.5 (16.0)	47.9 (13.1)	63.5 (17.3)	0
- Flexion	58.8 (14.4)	52.3 (9.7)	74.9 (10.6)	0
Functions of the cardiovascular and respiratory systems				
Maximum oxygen uptake				
- mL 02 x kg-1 x min-1	29.1 (8.3)	25.8 (6.3)	38.1 (6.1)	0
- MET Capacity	8.3 (2.2)	7.2 (1.4)	10.6 (2.0)	0
Subjective physical condition (0-100)	62.5 (17.1)	58.8 (15.0)	72.3 (18.9)	0.002
Mobility				
Physical activity (MET)				
Leisure time (LTPA)				
- Time-weighted intensity average	5.1 (3.3)	3.6 (1.9)	5.6 (3.1)	0.005
- Maximum intensity	3.7 (2.5)	4.3 (2.4)	6.9 (4.2)	0.019
All activities time (AT)				
- Maximum intensity	2.0 (0.5)	1.9 (0.6)	2.1 (0.6)	0.388
- Time-weighted intensity average	6.0 (2.7)	5.3 (1.8)	7.2 (3.9)	0.063

Table 1: Individual- level baseline information on physical functioning by gender. Physical exercise intervention.

The physical exercise intervention (intervention) consisted of progressive light resistance training and guidance. The participants were entitled take time out during the working day to train by themselves in the departments' own training facilities when they felt the need to counterbalance their sedentary work or to obtain relief from monotonous and fixed working positions. The time at which training could be performed during the working day was not restricted. During the first five-week period, non-supervised light resistance training was to be performed once each working day (5 times a week). During the second and third 5-week periods, resistance training was to be performed 1-2 times each working day (a total of about 7-8 times a week). At the department level, a physiotherapist gave three group sessions on how to train and general guidance on postural and movement control. The average performance time for a single repetition of a training movement was 1.8 seconds and average training time in one light resistance training session was 6.2 minutes. The estimated target training time in minutes for the first 5-week period was 150 minutes and in the second and third periods 210 minutes, the equivalent respectively of 30 / 42 minutes per week or 6/8 minutes per working day.

Light resistance training

The light resistance training consisted of six dynamic symmetrical movements: upper extremity extension, upper extremity flexion, trunk rotation to the right, trunk rotation to the left, knee extension and knee flexion (Figure 2). In the starting position of upper extremity extension ("push up") elbow is in flexed position and shoulder in neutral position, and at the end position shoulder is in flexed position and elbow in extension. In the starting position of upper extremity flexion ("pull down") shoulder is in flexed position and elbow in extension and at the end position elbow is in flexed position and shoulder in neutral position. The training movements were carried out 20 times with a 30-second pause between the training movements. There was no defined sequence between the training movements, except that the physiotherapist recommended that upper extremity flexion should be performed after extension.

The training resistances of 30% of one repetition maximum (1RM) [25] for the upper and lower extremities were estimated at five-week intervals for each individual with a sub-maximal 5RM test performed using air resistance equipment (HUR Ltd, Finland) at the research institute or in the departments' own training facilities. The training load for the right and left trunk rotation movements was determined directly from the result for upper extremity flexion. The upper extremity extension and flexion and knee flexion and extension 1RM values were estimated for the 5 RM value according to the scheme [(-4.18 x RM value of load as per cent) + 103] published by McDonagh and Daves [25]. The corresponding 1RM was read from Table 2.

The training load averages during the physical exercise intervention period were, in upper extremity extension, 17 kg among men and 10 kg among women and, in upper extremity flexion and trunk rotation to the right and left, 21 kg among men and 14 kg among women. Among men knee extension was 19 kg and knee flexion was 21 kg. Among women the corresponding values were 13 kg and 15 kg.

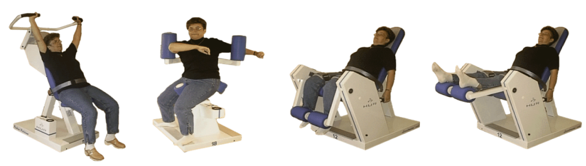

Figure 2: Light resistance training consisted of six dynamic symmetrical movements: upper extremity extension, upper extremity flexion, trunk rotation to the right, trunk rotation to the left, knee extension and knee flexion.

To ensure that our 30% 1RM resistance training was intensive enough we conducted a pilot study at the beginning of the training sessions to measure cardiovascular response (Heart rate=HR, Oxygen consumption= VO2, rating of perceived exertion= RPE) during a light (30% 1RM) exercise session among a similar sedentary occupation population (n=11). Mean HR was 63% HRmax and mean VO2 was 35% VO2max as measured by the direct method (Cosmed, Italy). Mean RPE was 12 (SD 0.3) for all sessions measured by the Borg scale. We also determine the TWA MET of light resistance training. The calculated average TWA was 4.2 (SD 1.0) MET during one light resistance training session and because in our study population (n=90) the average maximal oxygen uptake in MET was 33% lower than in the pilot study population, the estimated average TWA during one light resistance training session was also lower, being 2.8 (SD 0.7) MET. MET values were analyzed using as basic values the 02 consumption of a seated individual at rest (3.5 ml x kg-1x min-1).

Guidance

During the baseline measurement subjects received feedback on their physical functioning from assessors. At the department level, a physiotherapist gave training instructions and general guidance on postural and movement control in three group sessions (3x20 minutes) at 5-week intervals. The subjects learned to use the Borg Rating of Perceived Exertion (RPE 6-20) and pain (CR10) scales [26,27] to control their training. The general instruction given was that the perceived exertion should be light (RPE 10-12) and pain levels on the CR10 scale should not temporarily increase by more than one unit from the starting level during an active training session. Moreover, neck, upper extremities and low back position, dynamic muscle contraction, and maintaining sufficient ranges of motion and respiration were emphasized. Subjects were guided to train under both eyes-open and eyes-closed conditions. Motor control of training movements moves from extrinsic feedback (knowledge of performance, knowledge of results) to subject's intrinsic feedback (muscle force and length, joint position, body position, and vision) [28]. The physiotherapist encouraged the subjects to use the same ergonomic principles: non-loaded positions of neck, upper extremities and low back, and dynamic muscle contraction, in work and leisure.

No-physical exercise intervention and avoiding physical and psychosocial co-interventions

During the 15-week no-physical exercise intervention (no-intervention) period, no light resistance training was performed nor was any guidance provided. The participants simply took part in the measurements. Excluding the light resistance training, the participants were asked to keep the level of intensity and amount of their physical activity unchanged during the intervention and no-intervention periods. The occupational health service personnel were told that they should not initiate any new activities in the field of occupational health and safety during the study.

Measures

Although the measurements used in this study are standard, the validity and consistency values are considered acceptable, and reference values exist, we tested for the consistency of our measurements by conducting a second pilot study among a similar sedentary occupational population (n=14-15). Physical measurements performed three times at intervals of three days and physical functioning questionnaires were administered twice with a one-week interval. Intraclass correlation coefficients (ICC) were used to calculate the consistency of our measurements. According to the scale by Baumgartner (1989), the ICC consistency values were acceptable, varying between fair and high [29]. Detailed information on the data collection, measurement scales, consistency and validity of the measurements, indicators of standardization, and reference values for the measurements are presented in Table 3. In addition, as shown in table 3, the measurements were coded according to the International Classification of Functioning, Disability and Health (ICF) developed by the World Heath Organization [30]. During the physical exercise intervention active spinal range of movement was tested, and five repetition maximum (5RM) tests were performed, six times at five-week intervals. Body fat percentage, hand grip strength, subjective physical condition and maximum oxygen uptake measured two times at 15-week intervals. Pain was not allowed to increase during testing by more than 5 units on the Borg CR10 scale [27]. Other physical activity performed outside the intervention was controlled by a structured interview administered six times at five-week intervals. Figure 3 shows the dose-response interactions and the factors controlled-for. Only the assessors in the five repetition maximum (5RM) tests were blinded.

Physical Functioning Measurement	**Data collection**	**Original reference**	**Scale**	**Consistency (ICC*) - Our study measurements n= 14-16**	**Validity of measurement /Referees**	**Standardization / Reference**	**Classification of ICF**
Functions of the cardiovascular and respiratory systems 1. Maximum oxygen uptake 2. Subjective physical condition	1. Questionnaire/N-Ex- test (mL 02x kg-1 x min-1) 2.Questionnaire/ Descriptive visual rating scales (0-100)	1. Jackson et al. 1990 2. Ojanen 1994 and 2000	1. Ratio scale 2. Ratio scale	1. ICC 0.95 2. ICC 0.89 (last month) 0.88 (last year)	1.Criterion validity (Jackson et al. 1990) 2. Construct validity (Ojanen 1994; Ojanen 2000)	+/+ +/+	1. b4550 2. b4551
Neuromusculosskeel etal and movement-related functions 1. Hand grip strength 2. Strength of upper extremities muscles - flexion and extension 3. Strength of lower extremities muscles - knee flexion and extension 4. Active spine flexibility - lumbar and thoracic range of motion 5. Active cervical flexibility	1. Testing/Anatomically adjusted strength gauge (kg) 2-3. Testing/5 RM 4. Testing/ Myrin goniometer (°) 5. Testing /Cervical measurement system (°)	1. Mälkiä 1983; Mathiowetz 1990 2-3. McDonagh & Daves, 1984 4. Mellin 1986 and 1987	1. Ratio scale 2-3. Ratio scale 4. Ratio scale 5. Ratio scale	1. ICC 0.95- 0.97 (intratester) 0.94-0.95 (intertester) 2. ICC 0.98 (intratester) 0.95-0.97 (intertester) 3. ICC 0.93- 0.97 (intratester) 0.80-0.98 (intertester) 4. ICC 0.75 (intratester) 0.69 (intertester) 5. ICC		+/+ +/ (+) +/+	1. b7300 2. b7300 3. b7300 4. b7101
Functions of metabolic system 1. Body fat percentage	1. Testing/Spectrum II (%)	1. Sipilä et al. 1996	1. Ratio scale			+/+	1. b530
Mobility 1. All activities - time-weighted intensity average in MET - Maximum intensity in MET 2. Leisure physical activity - time-weighted intensity average in MET - Maximum intensity in MET	1-2. Questionnaire/ MetPro□	1-2. Mälkiä et al. 1994 and 1996	1-2. Ratio scale	1. ICC AT 0.91 - 0.94 2. ICC, LTPA 0.62 - 0.76	1-2. Construct validity Mälkiä et al. 1996	+/+	1.-2. d920

Table 2: The validity and consistency of physical function measurements, ICF classification, data collection and measurement scales.

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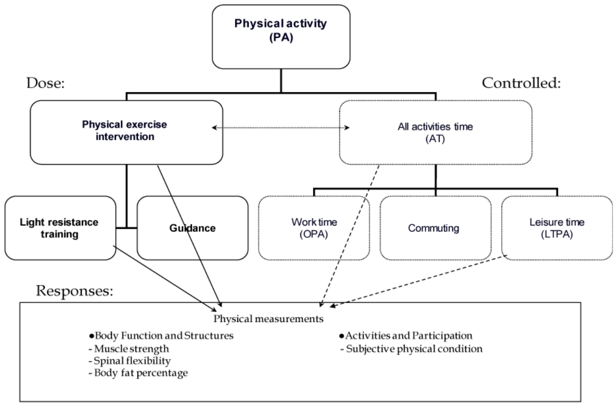


Figure 3: Interactions between physical exercise intervention dose, responses and factors controlled-for.

Body fat percentage and active spinal range of movement

Body fat percentage was measured using bioelectrical impedance with the manufacturer's equations (Spectrum II, RJL Systems, Detroit, MI, USA) on each occasion at the same time of the day. The starting and ending positions as well as test movements of spinal range of movement were precisely defined. The result was measured after two training movements. Lumbar range of movement and thoracic range of movement were separately measured with a Myrin goniometer (Kuntoväline Oy, Finland). Flexion was measured in the sitting position, lateral flexion to the right and to the left was measured in the standing position and extension was measured in the prone position [31,32]. Cervical range of movements (flexion, extension, lateral flexion, rotation) was measured in the sitting position with a cervical measurement system (CMS) (Kuntoväline Oy, Finland).

Muscle strength

Hand grip strength was measured with an anatomically adjusted strength gauge [24,33] in the sitting position without backrest or arm support. The measurements were conducted with the shoulder adducted and neutrally rotated, elbow flexed at 90 degrees, forearm in the neutral position, wrist between 0 and 30 degrees extension and ulnar deviation between 0 and 15 degrees and PIP joint of the index finger at 90 degree flexion. The dominant hand was measured first, followed by the other hand. After the first trial score was recorded, the test was repeated for the second and third trials. The result was the best of the three trials. The measurements separated by a 30-second pause.

The one-repetition maximum (1RM) for the upper and lower extremities was estimated with the sub-maximal 5RM test [25,26] using air resistance equipment (HUR Ltd, Finland, Figure 2). The standardized test movements were upper extremity extension and flexion and knee flexion and extension. A metronome was used to define the speed of muscular contraction. The average performance time for a single repetition of a testing movement was 3.0 seconds. The subjects performed five sets of repetitions with loads of 10 kg, 20 kg, 30 kg etc., until they were unable to perform the defined sets properly. The resting period between the 5RM test sets was 1 minute, with 3 minutes between the different test movement stations.

Maximum oxygen uptake and subjective physical condition

Maximum oxygen uptake was measured by a questionnaire without using an exercise test (N-Ex) according to gender, age, body mass index (BMI), and self–reported activity [34]. We converted the result to maximum oxygen uptake (02 ml x min-1 x kg-1) to METcapacity (METc) with a computer programme (MetPro, SciReha Ltd, Jyväskylä, Finland). In a variable sample of normal adults, the N-Ex models were more accurate than the well-established Åstrand sub maximal models. The major limitation of the N-Ex models is poor discrimination between highly fit individuals. This may be related to the scoring of the activity code scale [34].

Subjective physical condition was measured by descriptive one-month recall visual rating scales (0-100). On the scale, 0 represented the worst possible and 100 the best possible subjective physical condition. 50 represented the neutral position. In the descriptive visual rating scale subjects draw a short line across the vertical line at the point that best corresponds to their self assessment [35].

5 RM*	1RM*	30% 1RM*
10	12	4
20	24	7
30	37	11
40	49	15
50	61	18
60	73	22
70	85	26
80	97	29
(*) kg		

Table 3: Table of 5RM, 1RM and 30% 1RM.

Physical activity during the physical exercise intervention

Physical activity during the physical exercise intervention was measured by a diary. Each subject maintained a weekly diary to record training sessions, including the time in minutes spent performing light resistance training during each session. Physical activity outside the physical exercise intervention was measured by the one-month all-time recall questionnaire, where activity was divided into work, commuting, leisure time and miscellaneous time such as housework. The type, frequency, duration and intensity of each physical activity were converted to MET values with the aid of a special computer programme (MetPro, SciReha Ltd, Jyväskylä, Finland). The intensity of physical activity was assessed on the basis of getting out of breath and sweating [20,21]. 1 MET represents the approximate rate of 02 consumption of a seated individual at rest=3.5 ml x kg-1x min-1 [18,26]. We used gross cost of physical activity values, which included the resting metabolic rate and the cost of the activity in OPA, LTPA and all activities time (AT). AT included OPA, commuting and LTPA. OPA was assessed on a seven-point scale, which was accompanied by illustrations and descriptions of the various types of work corresponding to each scale point. The scale units are in METs from 1.5 (light work) to 10 (extremely strenuous work). In addition, there were two questions about the length of the working day (hours and minutes) and the number of working days during one week. Physical activity during commuting was assessed according to three categories: motor vehicle, bicycle, or on foot. LTPA was assessed by type, frequency, duration and intensity of physical activity [20,21,36]. Physically harder miscellaneous activity like housework or gardening was analyzed in the category LTPA. We used two MET parameters: the time-weighted intensity average (TWA), which was calculated for the activity categories by dividing the sum of MET minutes by the total time in minutes and maximum MET intensity (MMET), which is the highest observed value in the activity categories [20,21,37].

Data analysis

We used cluster-specific methods because it was departments rather than individuals that were randomized. The effects of the intervention on physical functioning were analyzed using linear mixed models [38,39]. This approach has several advantages over traditional analyses using linear models such as ANOVA. Firstly, the clustering effect of department can easily be taken into account in the analysis (people within a certain department tend to be somewhat homogeneous). Secondly, there is no need to exclude any subject for whom complete data were not obtained, as the lost to the follow-up process can be considered random. Thirdly, it is possible to lighten the familiar assumption of equal error variances with mixed models.

The main advantage in cross-over designs is that the period of intervention and no-intervention is compared within subjects; that is, the response of a subject to an intervention will be contrasted with the same subject's response to no-intervention. Removing subject variation in this way makes cross-over trials potentially more efficient than similar sized, parallel group trials in which each subject is exposed to only one treatment. In theory, exercise effects can be estimated with greater precision, given the same number of subjects [40].

The essential features of our cross-over design were modelled as fixed effects: the main effects of treatment (intervention or no-intervention), treatment group (Treatment group 1, Treatment group 2), treatment period (autumn, spring), measurements within the treatment period (1-3), and their possible interactions. The random part of the model consisted of department effects, the effects of individuals within departments, as well as their (random) interactions with the fixed factors. The random part is required to account for the clustering effects of departments (on individuals) and of individuals (on repeated measurements) in order to obtain standard errors and significance tests that correctly reflect the features of our design. Time spent performing light resistance training in the current 5-week period (1-3) in minutes and at the baseline physical functioning measurements were added into the model as covariates. The model was first estimated and then evaluated. We then hierarchically simplified this original model as far as was possible by removing the non-significant effects one by one from the most complex least significant interactions. The model that could not be simplified any further, without dropping a significant effect or violating the hierarchy principle (that is, non-significant lower-order effects cannot be removed if a significant higher-order interaction of the same factors is present), was then evaluated against the original model using the Akaike information criterion (AIC) [41]. If this model appeared to fit the data better than the original model, it was selected as the final one. Otherwise we used the original model.

The estimation and significance testing was carried out by utilizing the MIXED procedure of the SAS software [42], which involved using the restricted maximum likelihood (REML) estimation method [43] with related F tests. The estimates from the final model were used in calculating the confidence intervals (CI) and performing the significance tests for the effects of the physical exercise interventions. The effects of the physical exercise intervention on other physical activity performed outside it were evaluated by applying the same statistical principles as those with the physical functioning measurements.

In cluster randomized designs, there are two levels at which loss to follow-up can occur: the whole cluster or individuals in a cluster. In our data there was no loss to follow-up at the department level. In the study group however, four subjects were lost to follow-up. The reasons were maternity leave (n=1), pension (n=1), state of health (n=1) and low motivation (n=1). The drop-out results were analyzed according to the intention-to-treat principle. The required sample size information was determined according to an unpublished pilot study (n=15). The power calculations were performed using the Power Analysis for ANOVA.

Results

Adherence to the physical exercise intervention

Among the office workers various measures of adherence were conducted. According to the first, which was based on the weekly self-reported questionnaire, the average adherence during a 5-week period was 17 times, which was the equivalent of 53% of the guided sessions. According to the second, which was self-reported training time, the average adherence during a 5-week period was 125 minutes, which was 66% of the estimated target time in minutes, calculated on the basis of the 6 minutes average training time done in one light resistance training session. According to the third, which was based o observation by the authors, 69% of the subjects participated two or three times in the training guidance sessions. The fourth was the average rate of participation in testing and the return of the physical functioning questionnaires, which was 75%. The results of the adherence to the physical exercise intervention are presented in Figure 4.

Average number of light resistance training sessions			
Periods	Self-reported sessions	Guided sessions	Adherence %
First 5 week	14	25	56
Second 5 week	21	35	60
Third 5 week	15	35	43
Total 15 week	50	95	56
Average during 5 week	17	32	53
Average number of light resistance training minutes			
Periods	**Self-reported minutes* (MET minutes) †**	**Estimated target ‡ (MET minutes) †**	**Adherence %**
First 5 week	116 (325)	150 (420)	77
Second 5 week	145 (406)	210 (588)	69
Third 5 week	115 (322)	210 (588)	55

Total 15 week	376 (1053)	570 (1596)	66
Average during 5 week	125 (350)	190 (532)	66

* Light resistance training time in minutes during the intervention (15 weeks) in 5-week periods

† MET minutes were calculated according to TWA 2.8 METs.

‡ Estimated target training time in minutes in 5-week periods: first period, 5 sessions x 6 minutes x 5 weeks = 150 minutes; second and third period, 7 sessions x 6 minutes x 5 weeks = 210 minutes

Table 4: Mean numbers of training sessions, mean training times in minutes and MET minutes as well as adherence percentage ratios during the intervention.

Effect of the physical exercise intervention on physical functioning

The active component of the present intervention, light resistance training, significantly increased (p= 0.015) subjective physical condition. Also the physical exercise intervention, resistance training and guidance together significantly increased (p=0.035) subjective physical condition. The average estimated increasing in subjective physical condition was calculated from the regression coefficient of 0.03175 (95% CI 0.0066228 - 0.056772). The regression coefficient indicates the increase in subjective physical condition if one minute is added to the training time during a 5-week period. The average estimated increasing was 4 units (95% CI 1-7) on the scale 0-100 which an average training time during a 5-week period of 125 minutes (25 minutes per week, 5 minutes per working day). In Treatment Group 1 the average increase was 5% (95% CI 1-12), compared to the baseline measurement (60 units). In Treatment Group 2 the average increase was 6% (95% CI 1-11), compared to the last control measurement (63 units).

The active component of the present intervention, light resistance training, significantly increased (p<0.001) upper extremity extension strength. The average estimated increase in muscle strength was calculated from the regression coefficient of 0.01087 (95% CI 0.0045686 - 0.0171714). The regression coefficient indicates the increase in upper extremity extension strength if one minute is added to the training time during a 5-week period. During the 5-week intervention period, the average increase in upper extremity extension strength was 1.3 kg (95% CI 0.5- 2.1) with an average training time of 125 minutes (25 minutes per week, 5 minutes per working day). In Treatment Group 1 the average increase during the five-week training period was 4% (95% CI 2-6) compared to the baseline measurement (35.8 kg). In Treatment Group 2 the average increase was 3% (95% CI 1-6), compared to the last control measurement (38.7 kg). No significant physical exercise intervention or training effect was found for body fat percentage, spinal range of movement, hand grip strength, flexion strength of the upper extremities or strength of the lower extremities. The results of the statistical tests of the final model are presented in Table 3. Figures 4 and 5 shows the observed mean of subjective physical condition and muscles extension strength of the upper extremities both during the intervention and no-intervention.

Statistical tests *						
Variables	**Light resistance training (minutes)**			**Treatment (intervention, no-intervention)**		
	t	**df**	**p-value**	**t**	**df**	**p-value**
Body Function and Structures						
Muscle Strength						
upper extremities						
extension	11.43	336	0.0008	3.00	171	0.0852
flexion†	0.05	193	0.8164	0.00	125	0.9829
lower extremities						
extension †	0.09	173	0.7585	1.15	125	0.2864
flexion ‡	0.04	340	0.8468	0.77	288	0.381
Hand grip strength						
dominant hand † ‡	0.00	77	0.9789	1.50	78	0.22378
no dominant hand †	0.18	77	0.6768	0.69	77	0.4102
Active range of spinal motion						
lumbar						
flexion	0.28	316	0.5999	0.18	166	0.6755
extension†	0.13	200	0.7191	0.62	141	0.4327

lateral flexion right	0.20	298	0.6559	0.08	173	0.7783
lateral flexion left	0.45	301	0.5021	1.49	172	0.2242
cervical						
flexion-extension	1.96	359	0.1627	0.85	189	0.3589
lateral flexion	0.27	339	0.6051	0.33	177	0.5679
rotation‡ (1,4,7)	0.02	76.8	0.8867	0.02	76.8	0.8867
Body fat percentage †	0.39	75.0	0.5352	3.09	75.0	0.0831
Activities and Participation						
Subjective physical condition	6.13	129	0.0146	4.56	107	0.0351

Table 5: Results of statistical tests of the final model for physical functioning. *Light resistance training (minutes) and treatment (intervention, no-intervention) estimates from the final model utilizing the MIXED procedure of the SAS software program †) Because carry-over effect exists the results analyzed according to the first training period as parallel group trials. ‡ Statistical tests of hierarchically simplified model. Training or treatment effect values were last values before training or treatment effect dropped out of the model.

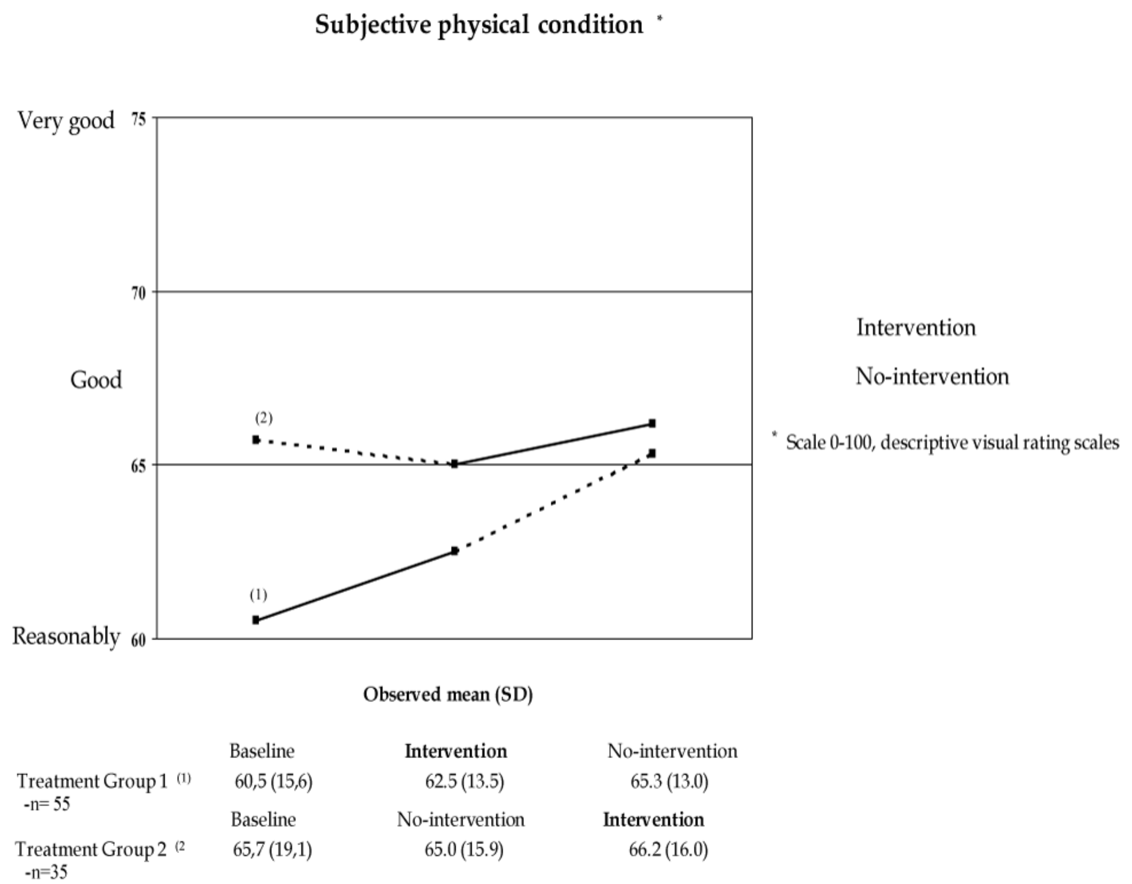
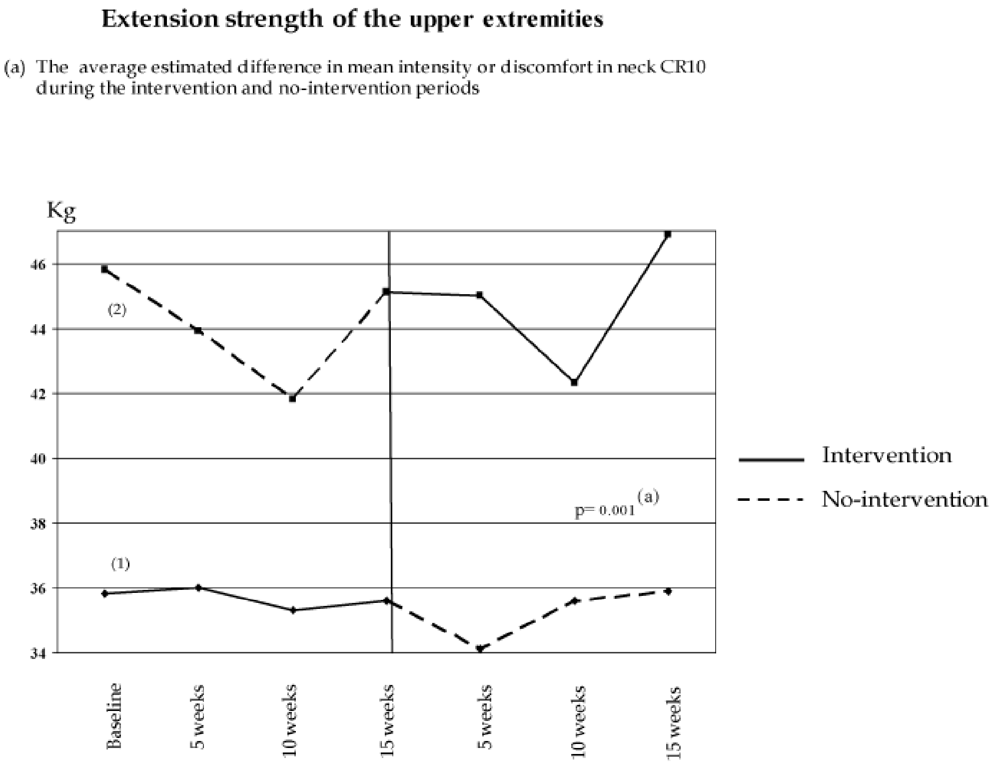


Figure 4: Subjective physical condition during intervention and no-intervention.

Citation: Sjogren T, Nissinen K, Jarvenpaa S, Ojanen M, Vanharanta H, et al. (2014) Effects of Workplace Physical Exercise Intervention on the Physical Perceived and Measured Physical Functioning among Office Workers - A Cluster Randomized Controlled Cross-Over Design. Int J Phys Med Rehabil 2: 238. doi:10.4172/2329-9096.1000238



Observed mean (SD) of neck symptoms

	Baseline	Intervention			No-intervention		
Treatment Group 1 (1) n=55	35.8 (9.6)	36.0 (11.6)	35.3 (10.8)	35.6 (10.4)	34.1 (10.7)	35.6 (10.3)	35.9 (6.9)
	Baseline	No-intervention		**Intervention**			
Treatment Group 2 (2) n=35	45.8 (18.3)	43.9 (16.6)	41.8 (16.0)	45.1 (16.2)	45.0 (16.6)	42.3 (15.4)	46.9 (15.2)

Figure 5: Extension strength of upper extremities during intervention and no-intervention.

Physical strain of light resistance training as percentage of maximal oxygen consumption

The average relative physical strain of the light resistance training (2.8 TWA MET) was 33.7% of maximal oxygen consumption (METc) and 26.4% and 38.9% for men and women, respectively, of METc. The dose of light resistance training according to MET force values was 70.00 METmin and 1.12 METh per week (350 METmin or 5.6 METh during a five-week period). These values were calculated according to estimated average TWA during one light resistance training session and with a mean training time of 25 minutes during a one-week period.

Training force as percentage of work time, leisure time and all activities time

At the baseline measurements average MET force was during one week at work 55.5 METh, during one week of LTPA 19.0 METh, and during one week of AT 96.7 METh. The MET force of light resistance training over one week was 2.0% of OPA, 5.9% of LTPA and 1.2% of AT. MET hours during 15 weeks' light resistance training and training as a percentage proportion of AT and LTPA are presented in Figure 6.

Controlling for confounding factors

Other physical activity: Excluding the light resistance training, the participants were asked tomaintain the intensity and amount of their physical activity unchanged during the intervention and no-intervention periods. Also, occupational health services were not provided and the subjects were not initiated into new activities in occupational health and safety during the study. Other physical activities were controlled for using MET values. During the interventions, no statistically significant changes in physical activity were found in the time-weighted average or maximum intensity of activity in OPA, LTPA, or AT in Treatment Groups 1 and 2. As the level of the other physical activity performed was not statistically significant, this was not added into the statistical model as a covariate.

Clustering effects: We found no clustering effects for workplace in our data, as all therandom department effects, that is, department effects, the effects of individuals within departments, as well as their (random) interactions with the fixed factors were non-significant. As the effect of the physical exercise intervention was similar in all four departments, we were able to simplify the original hierarchical model by leaving department level out of the model.

Carry over: In cross-over designs, the results of the latter intervention period may be contaminated by some transference from the earlier period. Statistical analysis of our data should signs of carry-over effects in body fat percentage, extension strength of upper extremities, extension strength of lower extremities, hand grip strength and active lumbar extension range of motion. In these cases the results were analyzed according to the first period, i.e. in autumn. Seasonal effects: A statistically significant main effect of period was found. Spinal flexibility in cervical flexion-extension (p< 0.0001), lumbar and thoracic flexion (p=0.0024), and lateral flexion (p<0.0001) was lower in spring than autumn. Upper extremity extension strength was higher (p= 0.0049) in spring than in autumn. This seasonal effect gives additional information about seasonal variation of physical functioning.

Learning effects: There were statistically significant positive learning effects. Main effects of the measurements were found in extension strength of the upper extremities (p=0.001) and in extension (p=0.0048) and flexion (p<0.0001) strength of the lower extremities. Statistically significant negative learning effects were in spinal flexibility, i.e., in cervical flexion extension (p<0.0001) and lateral flexion (p=0.0115), and in lumbar and thoracic flexion (p=0.0006). This learning effect gives additional information about repetitive measurements of physical functioning.

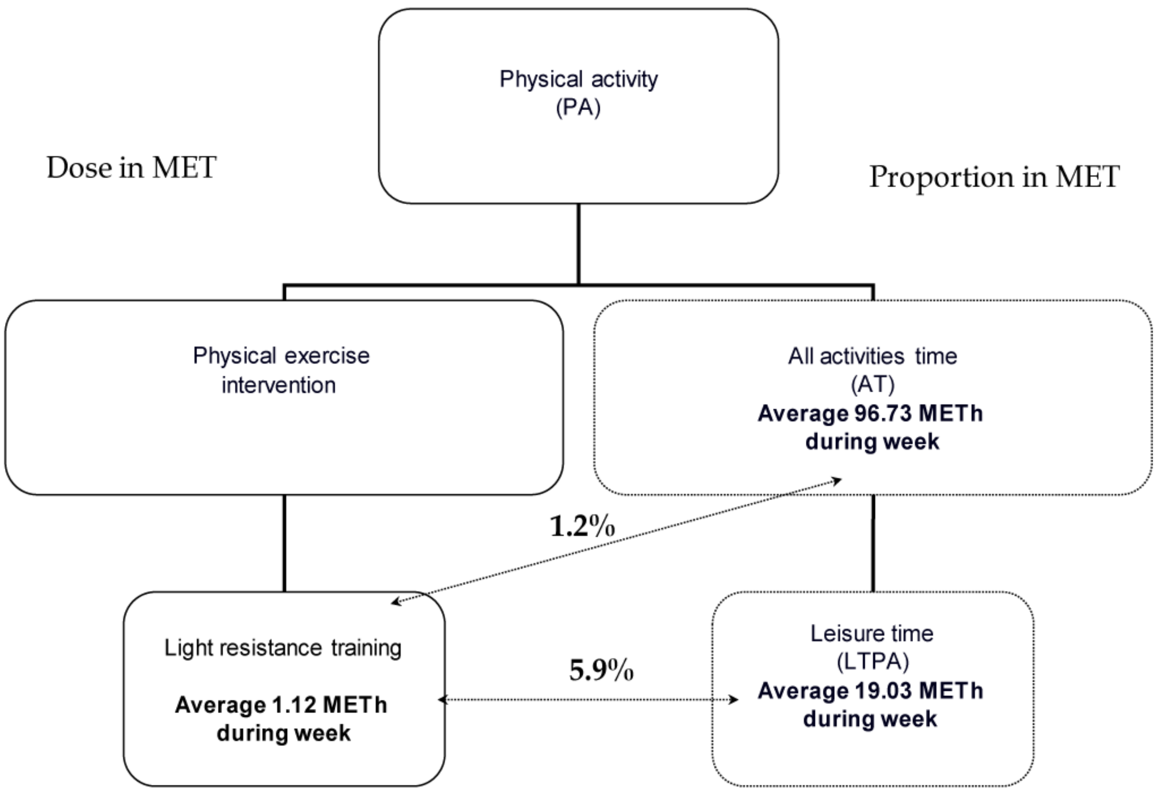


Figure 6: Light resistance training, leisure time and all activities time in MET hours and training as a percentage of leisure time and all activities time.

Discussion

The present study supports partly the findings of previous review study of Shephard (1996) and systematic meta-analysis of Conn et al. (2009) that workplace-based physical exercise interventions have small to moderate effects on the physical functioning [2,9]. According to previous studies there were small changes in anthropometric measures [2,9], small [9] to moderate [2] changes on maximum oxygen uptake and small changes on muscle strength and flexibility [9]. In our study among office workers the light resistance training significantly increased both subjective physical condition and upper extremity extension strength, but had no effect on body fat percentage, spinal flexibility, hang grip strength, upper extremity flexion strength and lower extremity strength.

The small or zero effects obtained in our study are probably due to the ceiling effect, as the subjects were middle-aged healthy volunteers whose level of physical functioning was already high at baseline. We can also assume that the 30% 1RM load seems to be too low to increase strength and hypertrophy of muscles, and physical exercise intervention was not high and/or prolonged enough to affect body composition, or specific enough to improve spinal flexibility in this study population. Also Conn et al. (2009) estimated average that workplace interventions training times were higher than in our study. Median of supervised exercise session was 50 minutes and median of frequency three times per week. These numbers were based on 44-47 reports in Conn et al. meta-analysis of workplace physical activity interventions [2]. Respectively the mean difference between treatment and control subjects´ on VO2max was 3,5 mL/kg/min and on BMI -0.3 units.

Jordan et al (2010) recommended that a standard validated measure of exercise adherence should be used consistently in future studies [44]. Among the office workers (n=90) various measures of adherence were conducted [45]. Adherence to exercise in the light resistance training and also training guidance was satisfactory, although we did not take individual holidays into account, which would have boosted the light resistance training adherence values. The adherence values were similar to those found earlier in the critical review by Proper et al. (2003) among worksite physical activity programs [7].

The minimal training intensity threshold for improvement in maximum oxygen uptake (VO2max) is approximately 40-50% of the maximum oxygen uptake reserve (VO2R) or maximum heart rate reserve (HRR) or 55-65% of the maximum heart rate (HRmax) [17]. VO2max values correspond to the MET values used in this study. MET reserve is METc - METrest (1MET). In our study the average relative physical strain of the light resistance training was 26.4% and 38.9% of METc and 45.2% and 29.2% of MET reserve among men and women, respectively. In our study population the average cardiovascular response during one light resistance training session, especially among men, did not reach a level that is known to improve aerobic fitness, although the participants reported better subjective physical condition during the physical exercise intervention. We can assume that 30% 1RM light training is not sufficient to transfer training to cardiovascular endurance. Although in our previous pilot study (n=11) similar training among a similar sedentary occupation population reached the threshold level that is known to improve aerobic fitness. In this pilot study, during one light resistance training session the average HR was 63% (SD 7) HRmax. The light resistance training investigated here could act as an appropriate and safe introduction to more intensive training among sedentary population. It could also be included in the exercise prescription.

In further studies measurements of maximum oxygen uptake should be determined more objectively, for instance with maximal bicycle ergometry, and the progressiveness of training should be taken care of more carefully in account, although this is more difficult to attain in real life than in a laboratory setting. Future studies should also investigate the efficacy of more progressive training loads (for example 30%, 60%). However, from the psychosocial point of view a 30% load is both supportive and agreeable. According to our previous analyses of our workplace physical exercise intervention might be more important and specific for decreasing musculoskeletal symptoms [46,47] than increasing psychosocial functioning [48] or physical functioning.

Strazdins and Bammer (2004) investigated Public Service employees (73% women and 73% clerical workers) and found gender differences in risk factors. Women's working conditions were more likely to involve physically repetitive work demands. Women were also more likely to work in poorly designed and uncomfortable environments and, in addition, women spent considerably less time than men exercising or relaxing during their leisure-time [49]. Also in our study population men had higher TWA and maximum intensity of LTA than women, but there were no gender differences in AT (work, commuting and LTA combined), but the physical exercise intervention was not more powerful among women office workers than in our originally study population [50].

The methodological quality of study, assessed according to the Physiotherapy Evidence Database (PEDro) quality score and Cochrane Collaboration Criteria [51], were high. In our CRTs the methodological quality was lowered by the fact that neither the subjects nor the therapists were blinded and the assessors were only in some measurements blinded. In physical exercise studies, it is very difficult or even impossible to blind subjects by including a placebo treatment, because it is not easy to develop a good and trustworthy placebo [9,13]. In physical exercise interventions, in particular, the subjects cannot be made unaware that they have received treatment. Therefore, we maintain that physical exercise studies always include some non-specific effects, attraction or placebo effects. In the standard cross-over design the order of the interventions is randomized for each cluster and a time period (called the "washout" period) is often allowed between the two interventions so that the first intervention does not affect the second. In our study we did not have a washout period between the two treatment periods, but we analysed the carry-over effects. Where signs of carry-overs appeared, the results were analysed according to the first treatment period.

The strengths of our physical exercise intervention study were the randomisation by clusters in the natural working environment, controlling for possible confounding factors, such as other physical activity and department, learning, and seasonal effects [13,49], and careful documentation of the training dose. Moreover, a cross-over trial is ethically more acceptable and statistically more efficient than similar-sized parallel group trials. Furthermore, in this study gender differences in physical functioning measurements at baseline and their possible influences on the study results were controlled by using baseline physical functioning measurements in the data analysis as covariates.

The intention-to-treat approach is often inadequately described and inadequately applied. Authors should describe the handling of deviations from randomised allocations and missing responses and discuss the potential effect of any missing response. The absence of an intention-to-treat analysis in intervention studies can lead to bias since subjects may drop out because for reasons that make them non comparable with the group that completes the study with respect to the outcome variable. If the intention-to-treat analysis is not performed, the effectiveness of treatment may be overestimated [8]. In their critical review Proper et al. found that only one out of eight workplace intervention studies had included an intention-to-treat analysis, and this study was a controlled trial [8]. In our CRT cross-over study the intention-to-treat analysis meant that all the subjects, who were randomly assigned to the two treatment sequence groups (Treatment Group 1 and Treatment Group 2), were analysed together, regardless of whether or not they completed or received the physical exercise intervention treatment. An advantage of mixed models [37,38], compared to ANOVA (or MANOVA) for repeated measures, is that there is no technical need to exclude subjects with incomplete data from the analysis. Instead, all the available observations, whether from completers or non-completers, contribute to the statistical inference (parameter estimation, significance testing) by virtue of the likelihood-based estimation method. In the mixed model approach we assume that each single observation obeys the same specified model, even where the observation is lacking no matter if it is observed or not. The model compensates for the missing data. The validity of this model assumption (and inference) requires, however, that the possible drop-out mechanism is random. In our study the number of non-completers was small and we can also assume that the drop-out were random. Thus we do not see any problems of bias due to incompleteness of the data. Although, there was a low level of systematic error during the physical exercise intervention (selection bias, information bias, confounding factors), care must be taken in generalizing the study results beyond the target population (office workers, sedentary workers) as we were not able to control for all non-specific effects, and as the study sample was relatively small. To confirm assumptions of the effectiveness of physical exercise interventions, more randomized and controlled follow-up studies among different sedentary occupations and workplaces are required. There is also a need to study the effects of different training doses and movements, using different training tools and methods of guidance, to clarify the role of PA for physical functioning. Follow-up studies of long duration are also needed to explore the possibility that even slight positive changes could be important in preventing impairments in people's functioning, work ability and general well-being.

In summary, on average 1.12 metabolic equivalent hours per week during the working day had a positive effect on subjective physical condition and upper extremity extension strength among the office workers studied. However the changes in physical functioning were probably not large enough to be of clinical importance. Controlling for training dose, other physical activity and confounding factors provides for a better understanding of the effectiveness of exercise interventions on physical functioning.

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