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Lifestyle-focused interventions at the workplace to reduce the risk of cardiovascular disease – a systematic review

by Iris F Groeneveld, MSc,[1, 2] Karin I Proper, PhD,[1, 2] Allard J van der Beek, PhD,[1, 2] Vincent H Hildebrandt, PhD,[2, 3] Willem van Mechelen, PhD [1, 2]

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Objective The goal of this review was to summarize the evidence for an effect of lifestyle-targeted interventions at the workplace on the main biological risk factors for cardiovascular disease (CVD).

Methods We performed an extensive systematic literature search for randomized controlled trials (RCT) that met the following inclusion criteria: (i) targeted at workers; (ii) aimed at increasing physical activity and/or improving diet; and (iii) measured body weight, body fat, blood pressure, blood lipids and/or blood glucose. We used a nine-item methodological quality list to determine the quality of each study. A best-evidence system was applied, taking into account study quality and consistency of effects.

Results Our review included 31 RCT, describing a diversity of interventions (eg counseling, group education, or exercise). Of these studies, 18 were of high quality. Strong evidence was found for a positive effect on body fat, one of the strongest predictors of CVD risk. Among populations "at risk", there was strong evidence for a positive effect on body weight. Due to inconsistencies in results between studies, there was no evidence for the effectiveness of interventions on the remaining outcomes.

Conclusions We found strong evidence for the effectiveness of workplace lifestyle-based interventions on body fat and, in populations at risk for CVD, body weight. Populations with an elevated risk of CVD seemed to benefit most from lifestyle interventions; supervised exercise interventions appeared the least effective intervention strategy. To gain better insight into the mechanisms that led to the intervention effects, the participants' compliance with the intervention and the lifestyle changes achieved should be reported in future studies.

Key terms body fat; body weight; effectiveness; evidence; randomized control trial; RCT; review; worker.

In Western countries, the prevalence of cardiovascular diseases (CVD) and related disabilities remains high (1). CVD can be divided into three major categories: cerebrovascular disease, coronary heart disease, and peripheral vascular disease. All three disease categories are associated with excess body weight and fat, an elevated blood pressure, disturbed blood glucose, and an abnormal serum lipid profile (ie, low high-density lipoprotein (HDL) cholesterol, high low-density lipoprotein (LDL) cholesterol, and high triglyceride levels) (2). These abnormalities are mainly caused by unhealthy lifestyle behaviors, including smoking. Smoking leads to hypertension and low levels of HDL cholesterol (3, 4). Diet is also strongly associated with several CVD risk factors. A diet rich in saturated fat negatively influences serum lipid profile (5, 6), and excessive salt and alcohol intake contributes to hypertension (7, 8). A diet rich in calories, combined with insufficient physical activity, leads to weight gain and obesity (9) and, more importantly, excess body fat (10). Not only the content of meals but also eating patterns are associated with being overweight and CVD risk (11). For example, skipping breakfast increases the likelihood of eating more energy-dense snacks throughout the day. Physical inactivity is another lifestyle behavior associated

1 Department of Public and Occupational Health, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, the Netherlands.
2 Body@Work, Research Center on Physical Activity, Work and Health, TNO-VU University Medical Center, Amsterdam, the Netherlands.
3 TNO Quality of Life, Department of Physical Activity and Health, Leiden, the Netherlands.

Correspondence to: Dr KI Proper, Department of Public and Occupational Health, EMGO Institute for Health and Care Research, VU University Medical Center, Van der Boechorststraat 7, 1081 BT Amsterdam, the Netherlands. [E-mail: ki.proper@vumc.nl]

with an elevated CVD risk (12–14), not least due to its contribution to weight gain. Since lifestyle is a strong but modifiable risk factor for CVD, it has been the subject of research for many years.

For workers, an unhealthy lifestyle and being overweight not only affect CVD risk, but may also have major disadvantages related to work. Insufficient physical activity is negatively related to physical work capacity (15) and positively related to sick leave (16). Furthermore, in two recently published systematic reviews, it has been shown that obesity is a significant predictor of long-term sick leave (17) and disability pensions (18). Schmier et al also concluded that obesity is related to more injuries (19). Altogether, physical inactivity and obesity are important drivers of indirect costs (19, 20).

Thus, changing smoking, dietary, and physical activity behavior has many benefits. Several studies have investigated the effects of lifestyle-focused interventions on CVD risk. A Cochrane systematic review concluded evidence for the effectiveness of lifestyle interventions (21). In the previous 20 years, some narrative and systematic reviews on health promotion aimed at workers have been performed, focusing on physical activity (22–26), diet (27), smoking (28), or health promotion in general (29–32). However, most reviews have not reported the evidence for effects on biological risk factors, which are objectively measurable, reliable, and strong predictors of CVD risk. Also, not all of the reviews applied a systematic approach to their search or the determination of evidence. Finally, the majority did not make a distinction between interventions aimed at populations at risk for CVD and those aimed at populations including both healthy persons and persons at risk ("mixed populations").

Our goal was to summarize the evidence for the effectiveness of interventions aimed at improving physical activity and dietary behavior on body weight and fat, blood pressure and glucose, and serum lipids among workers. Interventions aimed at smoking cessation were not included since smoking cessation is not associated with body weight loss. First, we describe the evidence based on all the studies together. Second, we describe the evidence derived from studies aimed at populations at risk for CVD and those targeted at mixed populations. Third, we describe evidence for the effectiveness of the three most frequently used intervention methods.

Methods

Literature search

We performed a literature search of several electronic databases (ie, Embase, PubMed, PsycINFO, SPORTDiscus, and the Cochrane Central Register of Controlled Trials). We then screened the reference list of a key systematic review on multiple risk factor interventions for primary prevention of coronary heart disease (21); personal databases of the first two authors of this paper were also searched for additional publications. We sought randomized controlled trials (RCT) and controlled trials, evaluating worksite lifestyle or health-promotion interventions (such as individual counseling, group education, or self-help) aimed at the promotion of physical activity and/or a healthy diet. Due to their inferior design, controlled trials would only be included when the number of RCT would be too low to draw conclusions (33). As for the study population, we included interventions aimed at blue- and white-collar workers of all ages and both genders. Furthermore, interventions had to be implemented in an occupational setting (ie, at the workplace and/or during working hours and/or facilitated by the employer). Outcome measures were defined as biological risk factors for CVD. The search was limited to studies published in English, between 1 January 1987 and 31 December 2008.

Outcome measures

Several biological CVD risk factors were defined as outcome measures: body weight, body mass index (BMI), total, HDL and LDL cholesterol, triglycerides, systolic and diastolic blood pressure, blood glucose, and body fat. Because some measures were highly comparable or only measured sporadically, they were clustered. Body weight and BMI were clustered into "body weight/ BMI". The body fat-related measures were categorized into four categories: (i) overall body fat, as measured by dual energy X-ray absorptiometry (DXA) or bioelectrical impedance; (ii) "central" body fat, as measured by waist circumference, waist–hip ratio, or DXA; (iii) "peripheral" body fat, as measured by DXA or skin folds; and (iv) hip circumference. Peripheral and central body fat both have a positive relation with CVD, but the influence of the latter is largest.

Selection and data extraction

The first and second authors evaluated all titles and abstracts; both based their decision on the previously established inclusion criteria. In case an abstract contained insufficient information, or where both authors disagreed, the full paper was read. If disagreement remained, the third author made the final decision. In the situation where certain quality criteria on study design were not mentioned in the article, we checked if the authors referred to a previous publication that contained more detailed information on these topics. After having collected all relevant publications, the first author extracted the data. Due to the variety of outcome variables, measurement methods, and timing of measurements used in the studies, a meta-analysis was considered inappropriate.

Quality criteria list

The criteria list used for assessing the methodological quality of each study, was based on the Delphi list, developed by authors, epidemiologists, and statisticians (34). The list was adjusted to meet the specific purpose of this systematic review. Two items were added, referring to dropout and the length of follow up, as previously described by Proper et al (35). We pilot tested the adjusted version of the quality criteria list and independently scored two articles. Some items were described in more detail because of interpretation difficulties. Once the first three authors had agreed upon the modified list, as shown in table 1, the first two authors independently assessed the methodological quality of each study. Items were scored negative where they were neither mentioned nor properly explained. In case of disagreement, the third author also scored the article.

Best-evidence synthesis

Conclusions about the effectiveness of the interventions were based on a best-evidence synthesis. For each outcome, four levels of evidence for the effect of the intervention were discerned. The level of evidence depended on the quality of the studies showing this effect, and the consistency of the results. The levels of evidence, adapted from Van Poppel et al (36), were described as: level 1 (strong evidence = multiple high quality RCT with consistent outcomes); level 2 (moderate evidence = 1 high quality RCT *and* ≥1 low quality RCT, all with consistent outcomes); level 3 (limited evidence = only 1 high quality RCT *or* >1 low quality RCT, all with consistent outcomes); level 4 (no evidence = only 1 low quality RCT or contradictory outcomes of the studies).

A study was categorized as being of high quality in case >50% of the methodological quality items scored positively; otherwise a study was categorized as being of low quality. Consistency of results for a certain outcome measure was reached when at least 75% of relevant studies had results in the same direction (ie, significantly positive in the intervention group, no difference between groups, or significantly positive in the control group). Where there were ≥2 high quality RCT, the conclusion was based on these RCT only. If not, the results of the low quality RCT were also taken into account.

In addition to applying the best-evidence synthesis to all the studies together, we applied it to studies aimed at populations at risk for CVD only [ie, studies in which "having ≥1 CVD risk factors at or above a certain cut-off value" was one of the inclusion criteria (as defined by the authors of the studies themselves)]. We also applied the best-evidence synthesis to studies aimed at mixed populations only (ie, studies that had no inclusion criteria related to CVD risk status). Moreover, the evidence for the effectiveness of lifestyle interventions was determined for the three main intervention types separately (ie, individual counseling, group education, and supervised exercise).

Table 1. List of items used for assessing the methodological quality of studies. [Items adapted from Verhagen et al (34).]

Criterion	Definition
Randomization procedure	Positive if there was a clear description of the randomization procedure, and if randomization was adequately performed.
Similarity of study groups	Positive if the study groups were similar at the beginning of the study with regard to age and/or gender and all relevant outcome measures.
Inclusion/exclusion criteria	Positive if clear inclusion and/or exclusion criteria, at the level of the individual, were specified.
Dropouts	Positive if the percentage of dropouts during the study period was ≤20% for short term follow-up (≤3 months) or ≤30% for long-term follow-up (>3 months).
Objectivity [a] and blinding of outcome assessor	Positive if (i) an automatic device was used for the measurement by a blinded or non-blinded outcome assessor or (ii) the outcome was read from a scale by a blinded outcome assessor. Negative if the outcome was (i) read from a scale by a non-blinded outcome assessor (ii) self-reported by the participant.
Compliance	Positive if the compliance was satisfactory according to the opinion of the reviewer.
Follow up	Positive if follow-up was ≥6 months.
Intention-to-treat analysis	Positive if an intention-to-treat analysis was performed.
Control for confounders	Positive if the analysis controlled for potential confounders.

[a] This criterion is met if it holds true for ≥1 outcome measures.

Results

Study selection

Figure 1 shows the flow diagram of the studies identified and subsequently included or rejected. The electronic database search resulted in 1193 studies. The personal database search identified four additional studies, and three were found in the reference lists. Of these 1200 studies, 1130 were excluded as a first step mostly due to a lack of a control group or because the study did not describe the outcome measures sought. After having read the whole text, another 31 studies were excluded, because they did not fulfill the eligibility criteria. This left us with 39 studies, of which 79.5% (N=31) were RCT.

This number was considered sufficient to draw conclusions. Finally, 32 publications describing 31 RCT were included (37–68). Concerning the methodological quality, the first two researchers disagreed on 11.8% of the items. Despite a consensus meeting, disagreement remained for one item. After consulting the third reviewer, the scoring process was completed.

Description of studies

Of 31 studies, 18 were high quality (37, 39, 41–44, 46, 47, 49, 55, 56, 58–64, 66). Study populations varied between 37–2791 workers. Most studies (N=21) were designed as a two-arm RCT that evaluated one or more intervention strategies in the intervention group. In ten studies, more than one intervention group was involved. The three intervention strategies most frequently used were individual counseling (N=18), group education (N=15), and supervised exercise (N=11). Between studies, these strategies showed large differences in frequency, intensity, and duration. Other methods, such as general written advice, a prescribed diet, self-help materials, environmental changes, or monetary incentives, were investigated only sporadically. Of the total, 12 studies aimed at populations at risk for CVD, and 19 targeted mixed populations. In table 2, the characteristics of all studies and the intervention methods are presented in detail. In the last column, all significant effects are indicated.

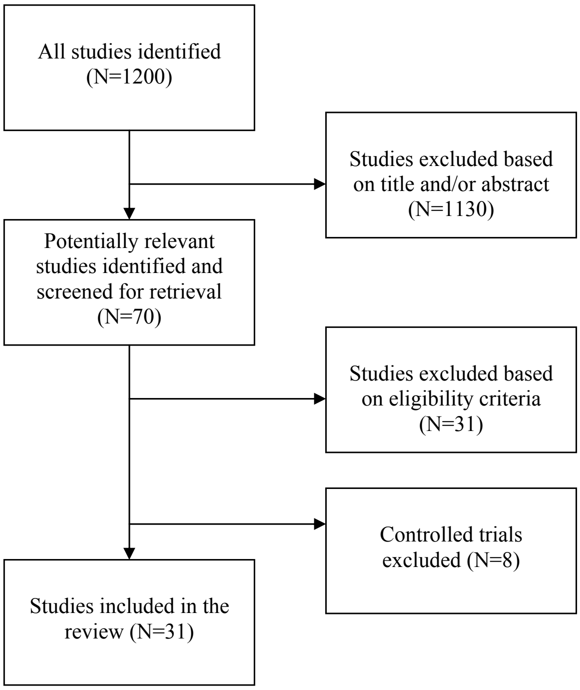

Figure 1: Flow diagram of retrieved and rejected studies.

Body weight/body mass index

Body weight/BMI were reported in 20 studies, 14 of which were high quality. Seven high quality RCT showed a significant difference between groups in favor of the intervention group, whereas six high quality RCT showed no effect, and one showed a significantly positive effect in favor of the control group. Thus, there was no evidence for an effect on body weight/BMI. When considering studies aimed only at populations at risk (N=12), there was strong evidence for an intervention effect on body weight/BMI; one high quality RCT showed no effect on body weight and six high quality RCT showed a significantly positive intervention effect. Among mixed populations (N=19), there was no evidence for an effect on body weight/BMI. There was no evidence for an effect on body weight for any of the three main intervention strategies.

Body fat

Even though three low quality RCT showed no intervention effect, all three high quality RCT in which overall body fat was measured showed a significantly positive effect in favor of the intervention group. Thus, strong evidence was concluded for a beneficial effect on overall body fat. As for central body fat, the results were mixed, and there was no evidence for an effect on this outcome measure. Peripheral body fat was measured in three high quality RCT, two of which showed a significant favorable intervention effect, resulting in no evidence. Hip circumference was measured in two high quality studies, both showing no effect. Therefore, strong evidence for no intervention effect on hip circumference was concluded. Among populations at risk for CVD, the evidence for an effect on overall body fat and peripheral body fat was limited, since it was measured in only one study. When considering studies aimed at mixed populations, there was strong evidence for no effect on central body fat and hip circumference, based on four and two high quality RCT respectively. Among studies using counseling as part of the intervention (N=18), there was strong evidence for a positive effect on peripheral body fat and limited evidence for an effect on overall body fat. The latter was also true for studies using group education (N=15). In studies evaluating exercise interventions (N=11), there was strong evidence for (i) a positive intervention effect on overall body fat and (ii) no effect on hip circumference, the latter conclusion based on two high quality RCT.

Blood pressure

Systolic blood pressure was measured in 18 studies, 12 of which were of high quality. Of those 12 studies, 25% (N=3) showed a positive effect and 75% (N=9) showed

Table 2. Characteristics of included studies. [T1=follow up 1; T2=follow up 2; T3=follow up 3; I=intervention group; C=control group; BMI=body mass index; chol=cholesterol; HDL= high-density lipid; LDL=low-density lipid; SBP=systolic blood pressure; DBP=diastolic blood pressure; WC=waist circumference; HC=hip circumference; CVD=cardiovascular disease; BP= blood pressure; ?=unknown].

Author (quality) [a]	Study population	Intervention and control conditions	Follow up	Outcome measures	Results [b]
Aldana et al, 2005 (37) (high: 6/9)	145 workers, medical personnel and staff (male/ female); used for analyses: 141 at T1, 137 at T2	Topics: Diet and physical activity I: 4 weeks, 4 meetings/week (eg, on health risks and lifestyle change) + workbooks and assignments + access to shopping tours and cooking demonstrations + questions answered + encouragement to present dietary and exercise goals C: Waiting list	T1: 6 weeks T2: 6 months	1) Body weight (kg) 2) BMI (kg/m²) 3) Total chol (mmol/l) 4) HDL chol (mmol/l) 5) LDL chol (mmol/l) 6) Triglycerides (mmol/l) 7) SBP (mmHg) 8) DBP (mmHg) 9) Overall body fat (%)	Significantly larger improvements in body weight, BMI, total and HDL chol and body fat (T1 and T2), and LDL chol (T1) in favor of intervention group. 1) I: - 2.9 versus C: -0.4 (T1), I: -4.4 vs. C: -1.0 (T2) 2) I: -1.1 versus C: -0.2 (T1), I: -1.6 vs. C: -0.03 (T2) 3) I: -0.41 versus C : +0.27 (T1), I : +0.02 versus C : + 0.35 (T2) 4) I: +0.08 versus C: -0.11 (T1), I: -0.01 versus C: -0.11 (T2) 5) I: -0.32 versus C: +0.19 (T1) 9) I: -1.1 versus C: -0.3 (T1), I: -2.4 versus C: -0.4 (T2).
Anderson et al, 1999 (38) (low: 2/9)	204 blue-collar workers (male/ female); aged 18–64 years; total chol ≥5.18 mmol/l; used for analyses: 167 (?) at T1, 122 (?) at T2	Topic: Diet I1: Four education classes, aimed at skill building I2: Self-help nutrition education program, aimed at skill building C: Health results and printed materials	T1: 6 months T2: 12 months	1) Body weight (kg) 2) BMI (kg/m²) 3) Total chol (mmol/l) 4) SBP (mmHg) 5) DBP (mmHg)	No significant differences between groups in any of the outcome measures.
Atlantis et al, 2006 (39) (high: 7/9)	73 workers (male/ female); sedentary casino employees; 42 used for analyses	Topics: Diet and physical activity I: 24 weeks ≥3 days/ week 20 minutes. Supervised moderate to high intensity aerobic exercise + 24 weeks ≥3 days/ week 30 minutes moderate to high intensity whole body weight-training + health education on nutrition and exercise through group seminars + 6 months 1 day/month 60 min. counselling + manual + prizes C: Waiting list	24 weeks	1) Body weight (kg) 2) BMI (kg/m²) 3) WC (cm)	Significantly larger decrease in waist circumference in favor of the intervention group. 3) I: -4.3 versus C: -1.1
Barratt et al, 1994 (40) (low: 4/9)	683 workers (male/ female); hospital staff; total chol ≥5.2 mmol/l; used for analyses: 417 at T1, 430 at T2	Topic: Diet I1: Workbook + quizzes + shopping guidelines + recipes + 3-minute video + monitoring of suggested dietary changes I2: 5×1 hour group session led by dietician concerning fiber, fat and dietary change + workbook + tasting recipes C: Screening only	T1: 3 months T2: 6 months	1) Body weight (kg) 2) Total chol (mmol/l) 3) HDL-chol (mmol/l)	Significant greater decrease in body weight in favor of intervention 2, at T2. 1) I2 : -0.35 versus C: unknown (T2)
Bloch et al, 2006 (41) (high: 6/9)	171 workers (male/ female); eg, school and casino employees; LDL chol ≥3.37 mmol/l *or* LDL chol ≥2.59 mmol/l and diabetes type-2 or coronary heart disease; 155 used for analyses.	Topics: Diet and physical activity I1: C + $100 check if achieving study goal of lowering LDL chol I2: 4 Classes (eg, on chol, fat, food labels, lifestyle change, and heart disease), cooking, shopping + 6 telephone calls on goals, reinforcement, review of emails. C: Chol health tips by weekly email + chol screening results	6 months	1) Total chol (mmol/l) 2) HDL chol (mmol/l) 3) LDL chol (mmol/l) 4) Triglycerides (mmol/l)	Significant greater decrease in total and LDL chol in favor of both intervention groups. 1) I1: -0.67 versus I2: -0.67 versus C: -0.33 3) I1: -0.46 versus I2: -0.46 versus C: -0.14
Braeckman et al, 1999 (42) (high: 5/9)	770 blue-collar workers (male); aged 35–59 years; 638 used for analyses	Topic: Diet I: Video and Q&A + feedback on screening results in counseling session + food changes and messages in cafeteria + posters/leaflets + diet group sessions + newsletter; all aimed at awareness raising C: No intervention	3 months	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) HDL chol (mmol/l) 4) Waist–hip ratio	Significant difference in BMI in favor of control group. Significant difference in HDL chol in favor of control group. 1) I: +0.1 versus C: -0.2 3) I: -0.01 versus C: +0.08

(continued)

Table 2. Continued.

Author (quality) [a]	Study population	Intervention and control conditions	Follow up	Outcome measures	Results [b]
Byers et al, 1995 (43) (high: 5/9)	864 workers (male/female); total chol ≥5.18 mmol/l; used for analyses 553 at T1, 510 at T2	Topic: Diet I: 1 month, 2 hours in multiple sessions, education concerning chol, aimed at knowledge and skills + 30-minute video + 5 minutes of nutrition counseling after chol testing + brochures C: 5 minutes of nutrition counseling after chol testing + brochures	T1: 6 months T2: 12 months	1) Total chol (mmol/l)	Significant greater decrease in total chol in favor of intervention group at T2. I: -0.18 versus C: -0.08 (T2)
Chesney et al, 1987 (44) (high: 5/9)	158 workers (male/female); mean of 4 diastolic pressures between 90 and 104 mmHg; 118 used for analyses	Topic: physical activity (I5: diet + smoking) I: 13×50-minute instruction sessions: I1: Muscle relaxation training + homework booklets I2: I1 + cognitive restructuring I3: I1 + (bio-) feedback on temperature and muscle activity during sessions I4: I1 + I2 + I3 I5: I2 + self-monitoring of health behaviors; instructor contact for behavior change C: BP monitoring	T1: 9 weeks T2: 18 weeks T3: 27 weeks T4: 36 weeks T5: 45 weeks T6: 54 weeks	1) SBP (mmHg) 2) DBP (mmHg)	Significant difference between groups in clinic DBP at T4, in favor of control group. 2) I: -4.0 versus C: -6.3 (T4)
Connell et al, 1995 (45) (low: 4/9)	1432 workers (male/female); office workers, nurses, and instructional staff; 801 used for analyses	Topic: Diet, physical activity and smoking I1: I2 + I3 I2: Monthly individual health counseling and/or self-help materials. I3: Booklet with computer-tailored personalized health risk appraisal and behavior change recommendations. C: Screening results	12 months	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) SBP (mmHg) 4) DBP (mmHg)	All three interventions significantly negatively related (β) to BMI and SBP. 1) I1: β=-0.05, I2: β=-0.05, I3: β=-0.04. Amount of change unknown. 3) I1: β=-0.13, I2: β=-0.09, I3: β=-0.09. I1 compared to C: -5, I2: ~ -3, I3: ~ -3. SBP reduction in C: unknown
Edye et al, 1989 (46) (high: 7/9)	2489 white-collar workers (male/female); government employees; elevated CVD risk, no pre-existing CVD; 1937 used for analyses	Topics: Diet, physical activity and smoking I: 15–20 minutes of physician counseling, discussing knowledge, attitude and advice, + 3×20-minute counseling sessions with nurse for reinforcement + body weight and BP measurement. C: Explanation of risk factors	3 years	1) Body weight (kg) 2) Total chol (mmol/l) 3) SBP (mmHg) 4) DBP (mmHg)	Significant greater decrease in SBP in intervention group. 3) I: -2.96 versus C: -1.82
Fielding et al, 1995 (47) (high: 7/9)	252 blue- and white-collar manufacturing workers (male/female); non-fasting total chol ≥6.22 mmol/l; 234 used for analyses	Topics: Diet and physical activity I: Screening and referral + monthly 10-minute individual sessions, concerning for example, fat intake, medical treatment + monthly written information + chol measurement + priority enrolment in worksite health promotion classes. C: Screening and referral only	12 months	1) Total chol (mmol/l)	No significant differences in change between groups.
Fisher et al, 1995 (48) (low: 3/9)	65 workers (male/female); college faculty & staff members; 65 used for analyses	Topics: Diet and physical activity I: 3 times/week 45-minute prescribed individualized exercise + 3 times/week 45-minute group exercise activities + nutrition and health management education C: Not described	6 months	1) Body weight (kg) 2) Total chol (mmol/l) 3) LDL chol (mmol/l) 4) HDL chol (mmol/l) 5) Triglycerides (mmol/l) 6) SBP (mmHg) 7) DBP (mmHg) 8) Overall body fat (%)	Significant between-group differences in weight, HDL chol and triglycerides, in favor of intervention group. 1) I: -1.22 versus C: +1.01 4) I: +0.02 versus C: -0.08 5) I: -12.15 versus C: +13.69)
Gemson et al, 1995 (49) (high: 5/9)	161 white-collar workers (male/female); aged ≥30 years; 90 used for analyses	Topics: Diet and physical activity I: Health risk appraisal + printed copy and review of results + counseling C: Health risk appraisal + counseling	6 months	1) Body weight (kg) 2) Total chol (mmol/l) 3) SBP (mmHg)	No significant differences in change between groups.

(continued)

Table 2. Continued

Author (quality) [a]	Study population	Intervention and control conditions	Follow up	Outcome measures	Results [b]
Gilson et al, 2007 (50) (low: 3/9)	70 white-collar workers (male/ female); 64 used for analyses	Topic: Physical activity I1: 15 minutes continuous, brisk walking every working day I2: accumulation of steps through the working day, during normal tasks. C: No intervention	10 weeks	1) SBP (mmHg) 2) DBP (mmHg) 3) Body fat (%) 4) WC (cm)	No significant differences in change between groups.
Glasgow et al, 1995 (51) (low: 4/9)	2791 blue- and white-collar workers (male/female); 1222 used for analyses.	Topics: Diet and smoking I: Contests, feedback and advice + self-help materials and presentations + change of worksite, eg change cafeteria food choices, display posters + participate in community events, publish articles. C: Waiting list	24 months	1) Total chol (mmol/l)	Difference in change between groups unknown.
Gomel et al, 1993 (52) (low: 4/9)	431 workers (male/ female) of ambulance service; used for analyses: 403 at T1, 369 at T2, 364 at T3.	Topics: Diet, physical activity and smoking I1: C + 50 minute-session advice on lifestyle changes I2: C + 6×50-minutes counseling sessions + lifestyle change manual I3: C + I1 + lifestyle change manual + 2 counseling sessions + lottery tickets when having achieved lifestyle change targets C: Assessment of CVD risk + feedback	T1: 3 months T2: 6 months T3: 12 months	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) Overall body fat (%)	Significant increase in BMI in all conditions. Differences between I groups and C group unknown.
Grandjean et al, 1996 (53) (low: 2/9)	37 blue-collar workers (female); previously sedentary; 37 used for analyses	Topic: physical activity I: 24 weeks, at least 3 days / week, 20–60 minutes a day aerobic training by walking, jogging and/or cycling of increasing intensity C: No physical activity outside normal daily routine	24 weeks	1) Body weight (kg) 2) Total chol (mmol/l) 3) LDL chol (mmol/l) 4) HDL chol (mmol/l) 5) Triglycerides (mmol/l) 6) Overall body fat (%)	Significant difference in body weight change, in favor of intervention group. 1) I: -2.0 versus C: +0.7
Harrell et al, 1996 (54) (low: 3/9)	1504 workers (male/ female); law enforcement trainees; higher educated; passed a physical exam; 1504 (?) used for analyses.	Topics: Diet and physical activity I: 4 hours of lecture on health nutrition and fitness + 12 hour of testing + 27 hour of supervised aerobic training and strengthening exercises C: Usual physical training programs	9 weeks	1) Overall body fat (%)	Significant differences in change between intervention and control group. 1) I: -5.6 versus C: -1.2
Lee et al, 1997 (55) (high: 5/9)	37 white- and blue-collar workers (female); university employees; used for analyses: 32 at 12 weeks and 26 at 24 weeks	Topic: physical activity I: Weekly classes with education on exercise and low-impact aerobic exercise + booklet with guidelines for independent exercise 2 or 3 times/week for 12 weeks C: Waiting-list	T1: 12 weeks T2: 24 weeks	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) HDL chol (mmol/l) 4) Triglycerides (mmol/l) 5) SBP (mmHg) 6) DBP (mmHg) 7) Total skinfolds (cm) 8) WC (cm) 9) HC (cm)	No significant differences between groups for any of the variables.
Leslie et al, 2002 (56) (high: 5/9)	122 workers (male); at large industrial worksite; aged 18–55; BMI ≥25; 91 used for analyses	Topic: Diet I: 12 weeks 1×60 minutes + 6×15–20 minutes dietetic consultations, and: I1: Energy deficit diet (-600 kcal of energy requirement) + meat I2: Energy deficit diet - meat I3: Low-calorie diet (1500 kcal) + meat + 5 emails I4: Low-calorie diet – meat + 5 emails C: Waiting list	12 weeks	1) Body weight (kg) 2) BMI (kg/m²) 3) Total chol (mmol/l) 4) LDL chol (mmol/l) 5) HDL chol (mmol/l) 6) Triglycerides (mmol/l) 7) WC (cm)	Significant mean difference in body weight change in favor of intervention groups. 1) I1+I2 versus C: -5.2; I3+I4 versus C: -6.2
Lindquist et al, 1999 (57) (low: 3/9)	104 white-collar workers (male/ female) at government taxation office; 104 used for analyses	Topics: Diet, physical activity and smoking. I: Weekly workshops on stress, coping, lifestyle education + individual 45 minute-counseling + personal action plan + weekly phone calls during 8 weeks C: Waiting list	12 weeks	1) SBP (mmHg) 2) DBP (mmHg)	No significant differences between groups.

(continued)

Table 2. Continued.

Author (quality) [a]	Study population	Intervention and control conditions	Follow up	Outcome measures	Results [b]
Makrides et al, 2008 (58) (high: 6/9)	566 workers (male/female); aged 19–66; ≥2 risk factors (ie, smoking, SBP ≥140, DBP ≥90, total chol ≥6.22 mmol/l, taking BP- or lipid-lowering medication, BMI>27 and/or waist–hip ratio >0.9 [men] and >0.8 [women], physical inactivity); 397 used for analyses.	Topic: Diet and physical activity I: 12-week program including individual exercise prescription, supervised exercise classes, home exercise program, group education (eg, on nutrition, exercise and stress reduction) + nutrition analysis and counseling + smoking cessation program + telephone follow up C: Waiting list	T1: 3 months T2: 6 months	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) HDL chol (mmol/l) 4) SBP (mmHg) 5) DBP (mmHg) 6) Waist–hip ratio	Significant difference in change in BMI at T1 and T2, and in total chol and waist–hip ratio at T2, in favor of intervention group. Mean difference in change between groups: 1) -0.61 (T1), -0.57 (T2) 2) -0.13 (T1), -0.12 (T2) 6) -0.01 (T1), -0.007 (T2)
Murphy et al, 2006 (59) (high: 5/9)	37 workers (male/female); at civil service; aged ≤65; not physically active; non smoking, low BP and total chol, 33 used for analysis	Topic: physical activity I: 8 weeks, 2 days per week outdoor walking programme with progressive duration, 25–45 minutes/day C: No intervention	8 weeks	1) BMI (kg/m²) 2) SBP (mmHg) 3) DBP (mmHg) 4) Total chol (mmol/l) 5) HDL chol (mmol/l) 6) LDL chol (mmol/l) 7) Triglycerides (mmol/l) 8) Overall body fat (%) 9) WC (cm) 10) HC (cm)	Significant difference in change for SBP and overall body fat, in favor of intervention group. 2) I: -5.0 versus C: +2.0 8) I: -0.1 versus C: +1.8
Muto et al, 2001 (60) (high: 5/9)	326 workers (male) of building company; ≥1 abnormality in BMI, BP, total or HDL chol, triglycerides or fasting blood glucose; lifestyle changes advised by physician; used for analyses: ?	Topics: Diet and physical activity. I: 6 months after baseline, in first week 4 days education through lectures, individual counseling, group sessions and self education + goal setting. Within 1 year: 4×self-evaluation + feedback C: Mailed advice to make lifestyle changes following annual health examination	T1: 12 months T2: 24 months	1) Body weight (kg) 2) BMI (kg/m²) 3) Total chol (mmol/l) 4) HDL chol (mmol/l) 5) Triglycerides (mmol/l) 6) SBP (mmHg) 7) DBP (mmHg)	Significant differences in change for body weight, BMI, SBP and total chol (T1, T2), in DBP (T1), and in triglycerides (T2) in favor of intervention group. 1) I: -1.6 versus C: +0.1 (T1), I: -1.0 versus C: +0.5 (T2) 2) I: -0.5 versus C: 0.0 (T1), I: -0.3 versus C: +0.2 (T2) 3) I: -0.19 versus C: +0.08 (T1), I: -0.17 versus C: +0.12 (T2) 5) I: -(?) 32.1 versus C: +0.2 (T2) 6) I: -1.3 versus C: +2.4 (T1) , I: +0.5 versus C: +2.9 (T2) 7) I: -1.0 versus C: +1.5 (T1) 8) I: -2.2 versus C: +2.0 (T1)
Nilsson et al, 2001 (61) (high: 5/9)	128 workers (male/female); eg, nurses, cleaners, and drivers; with elevated CVD risk; used for analyses: 92 at T1, 89 at T2	Topics: Diet, physical activity and smoking I: 16 group sessions a year + individual counseling (based on eg, lectures discussions, video sessions and outdoor activities). C: Standard written and oral advice about CVD risk factors	T1: 12 months T2: 18 months	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) LDL chol (mmol/l) 4) HDL chol (mmol/l) 5) SBP (mmHg) 6) DBP (mmHg) 7) Waist–hip ratio	Significant differences in change in BMI, DBP, and HDL chol in favor of intervention group 1) I: -0.7 versus C: +0.1 (T1), I:-0.5 versus C: -0.0 (T2) 4) I: +0.11 versus C: +0.02 (T1), I: +0.06 versus C: +0.04 (T2) 6) I: -5.4 versus C: -1.1 (T1), I: -5.7 versus C: -0.4 (T2)
Nisbeth et al, 2000 (62) (high: 5/9)	85 white-collar workers (male); aged 25–45 years; 74 used for analyses.	Topics: Diet, physical activity and smoking II: 15-minute counseling, including information about aerobic exercise and healthy diet, construction of exercise and dietary plan+ recommendation to discuss diet with spouse + some recipes + stop smoking advice C: no intervention	12 months	1) Body weight (kg) 2) BMI (kg/m²) 3) Total chol (mmol/l) 4) HDL chol (mmol/l) 5) LDL chol (mmol/l) 6) Triglycerides (mmol/l) 7) SBP (mmHg) 8) DBP (mmHg)	Significant difference in change in body weight and BMI, in favor of intervention group. 1) I: -0.2 versus C: +1.4 2) I: -0.06 versus C: +0.42

(continued)

Table 2. Continued

Author (quality) [a]	Study population	Intervention and control conditions	Follow up	Outcome measures	Results [b]
Pritchard et al, 1997 (63), 2002 (64) (high: 5/9)	66 workers (male) of national business corporation; BMI ≥25; 58 used for analyses	Topics: Diet and physical activity I1: For 12 months, personalised low-fat diet using weight loss guide, + monthly 24-hour recalls + food diaries I2: For 12 months, minimum of 3×week×30-minutes exercise, at 65–75% of maximal heart rate I3: I1 + I2. C: No intervention	12 months	1) Body weight (kg) 2) Overall body fat (kg) 3) Central fat (kg) 4) Peripheral fat (kg) 5) Total chol (mmol/l) 6) HDL chol (mmol/l) 7) LDL chol (mmol/l) 8) Triglycerides (mmol/l) 9) SBP (mmHg) 10) DBP (mmHg)	Significant differences in change in body weight, overall, central, and peripheral body fat, and triglycerides, in favor of the intervention groups. 1) I1:-6.4, I2:-2.6, I3:-4.5, C: +0.3 2) I1: -3.8, I2: -1.9, I3:-3.1, C:-0.1 3) I1:-1.0, I2:-0.5, I3:-1.0, C:+0.07 4) I1:-1.5, I2:-0.8, I3:-1.3, C:-0.01 8) I1:+0.26, I2:-0.72, I3: -0.65, C:-0.12.
Prochaska et al, 2008 (65) (low: 4/9)	1401 medical university employees (male/female); ~981(?) used for analyses.	Topic: Diet and physical activity I1: C + 3 motivational interviewing sessions, face-to-face or by telephone. I2: Online tailored intervention program (as many sessions as desired), based on Transtheoretical Model (TTM) C: HRA + advice on first step necessary to begin progressing in lifestyle change	T1: 6 months	1) BMI (<25 kg/m²)	No significant differences in percent at criteria for BMI (<25 kg/m²) by treatment groups.
Proper et al, 2003 (66) (high: 9/9)	299 white-collar workers (male/female); civil servants; 190 used for analyses	Topics: Diet and physical activity I: During 9 months, 7×20 minutes of individual counseling according to stage of change + brochures C: Brochures	9 months	1) BMI (kg/m²) 2) Total chol (mmol/l) 3) SBP (mmHg) 4) DBP (mmHg) 5) Peripheral body fat (%)	Significant differences in change in peripheral body fat and total chol in favor of intervention group. 2) I:-0.2 versus C: 0.0 (β=-0.18) 5) I: -1.4 versus C: -0.6 (β=-0.79)
Reynolds et al, 1997 (67) (low: 4/9)	635 telephone company workers (male/female); total chol <6.87 mmol/l; used for analysis: 452 at T1 and 412 at T2.	Topic: Diet I1: Results of chol screening + self-help booklet on healthy food items. I2: Self-help booklet on healthy food items. C: No intervention.	T1: 3 months T2: 6 months	1) Total chol (mmol/l)	Significant difference in reduction of total chol at T1 and T2, in favor of control group. Exact figures unknown.
Von Thiele Schwarz, 2008 (68) (low: 4/9)	195 women from a large public dental health organization; 162 used for analyses.	Topic: physical activity I1: On 2 days, 1–2.5 hours of mandatory medium-to-high intensity exercise, during self-chosen activity. I2: 1–2.5 hour reduction in working hours C: No intervention	T1: 6 months T2: 12 months	1) Total chol (mmol/l) 2) HDL chol (mmol/l) 3) LDL chol (mmol/l) 4) Triglycerides (mmol/l) 5) SBP (mmHg) 6) DBP (mmHg) 7) Waist–hip ratio	At T2, a significantly larger increase in waist–hip ratio in the reduced working hours group as compared to both exercise and control group. Results at T1 were not presented. 7) I1: +0.03, I2: +0.05, C: -0.01 (T2)

[a] The quality score is reported, defined as the number of quality items scored positively as opposed to the total amount of quality items (eg 5/9).
[b] Only outcomes measures with statistically significant (P<0.05) intervention effects, as determined by between-group differences at follow up or linear regression analyses.

no effect. Thus, strong evidence for no intervention effect on systolic blood pressure was concluded. Diastolic blood pressure was reported in 17 studies, 11 of which were high quality RCT. Of these, two showed a significantly positive effect in favor of the intervention group, one showed a significantly positive effect in favor of the control group, and 8 showed no effect. These data led to the conclusion of no evidence for an intervention effect on diastolic blood pressure. There was no evidence for an effect on either systolic or diastolic blood pressure in populations at risk. In studies aimed at mixed populations, there was strong evidence for no effect on systolic or diastolic blood pressure, based on six and five high quality RCT respectively. From counseling interventions studies, no evidence for an effect was concluded. In studies using group education, there was strong evidence for no effect on systolic blood pressure, based on five high quality RCT. The same was true for studies using exercise. Moreover, in exercise-based studies, there was no evidence for an effect on diastolic blood pressure.

Serum lipids

Of the 21 studies reporting ≥1 total, HDL, or LDL cholesterol measures, 15 were high quality, and no evidence was concluded for an intervention effect. Triglycerides were significantly positively influenced by the intervention in two high quality studies, but no effect was found in five high quality studies. Thus, no evidence for an intervention effect on triglycerides was concluded. In populations at risk for CVD, there was no evidence for an effect on total or LDL cholesterol and triglycerides. There was strong evidence for no effect on HDL cholesterol, as concluded from five high quality RCT. In mixed populations, there was no evidence for an effect on any of the serum lipids, except for triglycerides, for which we found strong evidence for no effect. Among studies using counseling as (part of the) intervention, there was strong evidence for no effect on LDL cholesterol and no evidence for effects on the other serum lipids. We concluded strong evidence for no effect on triglycerides from studies using group education. Exercise-based studies provided strong evidence for no effect on total, LDL, and HDL cholesterol.

Blood glucose

Of three studies that measured blood glucose, one high quality RCT showed no effect and another showed a significantly positive effect. That said, there was no evidence for an effect on blood glucose. There was no evidence in populations at risk or mixed populations, limited evidence for an effect among studies that used counseling, and no evidence among group education or exercise-based studies.

Discussion

Main findings

Based on the 31 studies examined, we found there was no evidence for a positive effect of workplace lifestyle-focused interventions on body weight, blood pressure, serum lipid profile, blood glucose, and triglycerides. However, there was strong evidence for a favorable intervention effect on overall body fat, which is a better predictor for CVD than body weight; when fat mass is lost and muscle mass is gained, body weight remains unchanged.

The effectiveness of a lifestyle intervention often depends on whether the participants enrolled in the study have an elevated disease risk or not. Studies aimed at high-risk populations may yield different results, have a larger health impact, and be more cost-effective (69) than those targeting non-risk populations. To provide insight into this issue, we separately evaluated the studies aimed at populations (i) with an elevated CVD risk and (ii) for whom no CVD risk-related inclusion criteria were defined (ie, mixed populations). We found that among the latter, there was strong evidence for no effect on most outcome measures. For high risk populations, however, even though there was strong evidence for no effect on HDL cholesterol, there was strong evidence for an effect on body weight. For the other outcome measures, there was limited or no evidence – due to heterogeneous results or small sample sizes. We agree with Fleming et al (70) that lifestyle interventions aiming at low risk populations may be of marginal benefit and resources are better spent on those with an elevated risk of CVD. With respect to intervention strategies, we found that counseling, group education, and exercise were most frequently used. Studies focused on individual counseling and group education were more likely to find positive intervention effects than those examining supervised exercise. In fact, among studies looking at supervised exercise, for half of the outcome measures, there was strong evidence for no effect. These inconsistencies are probably related to differences in study populations.

The lack of evidence for most outcome variables resulted from inconsistencies between the studies' results. These inconsistencies are probably related to study populations, intervention strategies, and measurement methods. Other factors that may have contributed to the inconsistencies in results could be differences in the participants' compliance with the intervention, and the lifestyle changes that they actually achieved. Unfortunately, most articles lacked information in this respect (eg, the frequency and duration of sessions attended and the number of self-help assignments completed). The exact contents of the counseling or group education sessions were also usually not mentioned. Finally, from most studies it was unknown to what extent the interventions led to the intended dietary or physical activity change. Therefore, it was difficult to conclude what exactly happened to the participants during the study, and what was the mechanism that led to the effects.

When considering the results, not only significance, but also clinical relevance should be considered. The clinical relevance of a change in a certain CVD risk factor depends on its initial value and the presence of other risk factors, as illustrated by various (coronary heart disease) risk assessment instruments such as the Framingham risk score (71). Considering body weight, every kilogram of body weight loss was proven to correspond to a 16% reduction in diabetes risk (72). Thus, small changes in body weight and body fat may already be clinically relevant. Consequently, the findings of strong evidence for intervention effectiveness on body fat, and body weight in populations at risk, are certainly interesting.

Comparable studies

Ebrahim et al (21) published an extensive Cochrane systematic review on lifestyle interventions for lowering coronary heart disease risk in different settings, which was updated in 2006. They found insignificant changes in blood pressure but significant falls in blood cholesterol. It is important to note that Ebrahim and colleagues suggested that the changes in cholesterol levels may have been attributable to the use of cholesterol-lowering medication. Prescription of medication was not part of the intervention protocol in any of the studies included in our systematic review. Nevertheless, participants may have used medication before the study had started. Proper et al (23) published a systematic review similar to ours. They summarized the evidence for an effect on physical activity, fitness, and health among workers. Despite that they included only physical activity interventions, their conclusions were comparable to ours (ie, inconclusive evidence for an effect on body composition, and no evidence for an effect on blood pressure and serum lipids). More recently, Conn et al (26) showed that physical activity interventions based on supervised exercise and motivational and educational strategies led to significant improvements in lipids and anthropometrics. In contrast to our study, Conn and colleagues included RCT as well as non-controlled trials and unpublished reports – study designs that we considered less valid. In a systematic review on body weight loss among workers, Anderson et al (29) found a net body weight loss of 1.3 kg based on nine RCT. Since we did not pool our data, our findings cannot be compared to theirs. With respect to the quality of the studies, we differed strongly with the findings of Kjaergard et al (73) who reported that year of publication was not positively related to study quality. In our review, of all included studies published in or after 2000, 78.6% (N=11) were of high quality, whereas of the studies published between 1987–1999, only 41.2% (N=7) were of high quality. This may have been a result of the stricter quality criteria of scientific journals in recent years.

Limitations and strengths

One of the limitations of our study concerned the best-evidence synthesis. When determining the evidence for effectiveness on a certain outcome measure, adding one high quality study may change the conclusion from "no evidence" to "strong evidence". Besides, the cut-off point of 75% for consistency between results often leads to the conclusion that there is no evidence for an effect. However, there is no consensus about which levels of evidence criteria should best be used (74). Another drawback was related to the fact that our quality assessment was based on the data as reported in the articles. In reality, in some articles, relevant data (on, for example, randomization procedure, blinding, and type of analysis) were not presented. This may have led to an underestimation of the study's quality. One way to solve this problem would have been to ask all authors individually to provide missing information. However, in a study of Gibson et al (75), two thirds of the authors simply did not respond to their request for additional information. Lastly, measurements of waist circumference and skin folds are less accurate than DXA and bioelectrical impedance. Still, we decided to cluster all the studies in which body fat was measured. In our opinion, separating them according to the type of measurement would result in an inadequate numbers of studies to draw conclusions. Furthermore, when changes in body fat are determined over time, inaccuracy of measurements is less of a problem than when determining body fat cross-sectionally.

Several strengths of this systematic review can also be mentioned. All relevant publications on workplace lifestyle-focused interventions were systematically collected and evaluated. We described not only the intervention effects, but also the methods and population type used. The quality list was well adapted to the type of intervention studies. By independently scoring all articles, we maintained objectivity. Most importantly, in order to determine the population for whom lifestyle interventions seem most effective, we looked separately at studies aimed at populations at risk and mixed populations. Moreover, in order to define the most promising intervention strategy, we explored the evidence in three frequently used counseling strategies separately.

Concluding remarks

This systematic review fills a gap of knowledge on the effectiveness of lifestyle interventions on the main CVD risk factors among workers. Considering the cardiovascular health- and work-related risks of excessive weight and obesity, the findings of strong evidence for effectiveness on body fat and, among populations at risk, body weight are interesting for employers. For intervention planners and policy-makers it is worth knowing that populations at risk seemed to benefit more from lifestyle interventions than mixed populations, while supervised exercise interventions appeared the least effective intervention strategy. The lack of evidence for effects on most of the remaining CVD risk factors was mainly due to inconsistencies in results. In order to gain better insight into the mechanisms that led to the intervention effects, the participants' compliance with the intervention and their lifestyle change achieved should be reported in future studies.

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