Title: Nordic Walking for overweight and obese people: A systematic review and meta-analysis.

Abstract

Background: Nordic Walking (NW) is a potentially beneficial exercise strategy for overweight and obese people. To date, no reviews have synthesized the existing scientific evidence regarding the effects of NW on this population. This systematic review and meta-analysis aimed to identify the characteristics, methodological quality and results of the investigations that have studied the effects of NW in overweight and obese individuals.

Methods: Six electronic databases were searched up to June 2019 for studies that examined the effects of NW on people with a body mass index ≥25 kg/m^2. The methodological quality of the included randomized controlled trials was retrieved from the Physiotherapy Evidence Database or evaluated using the PEDro scale.

Results: Twelve studies were included in the review. The investigations were mostly good-to-fair methodological quality. NW groups had a significant improvement on parameters such as fasting plasma glucose, abdominal adiposity and body fat compared to the baseline, but no significant improvements were found when compared to control groups.

Conclusions: NW can potentially lead to improvements in parameters related to major health outcomes in overweight and obese people. The lack of control for confounding variables in the analyzed studies prevents further elaboration on its potential benefits.

Keywords: Overweight; Obesity; Exercise; Exercise prescription; Guidelines and recommendations

Introduction

Most of the world's population live in countries where obesity kills more people than being underweight. Worldwide, the proportion of overweight people has nearly tripled since 1975, affecting up to 39% (1,900 million) adults in 2016, from which 13% (650 million) were obese.[1] Obesity raises the risk of morbidity from a variety of diseases originating from different etiologies, including hypertension, dyslipidemia, type 2 diabetes mellitus, coronary heart disease, stroke, and some cancers.[2] Overweight and obesity have been consistently associated with higher all-cause mortality worldwide.[3] In Europe, the relative economic burden from obesity-derived diseases ranged from 0.09% to 0.61% of each country's Gross Domestic Product and burdens of up to €10.4 billion have been reported.[4] The combined medical costs associated with treatment of these conditions are estimated to increase by $48–66 billion/year in the USA and by £1.9–2 billion/year in the UK by 2030.[5] Both conditions, as well as related diseases, are largely preventable.

Overweight (also known as pre-obesity) and obesity are defined as a body mass index (BMI) $\geq$ 25 and $\geq$30, respectively.[1] The fundamental cause is an imbalance in energy intake between calories consumed and calories expended. To prevent this imbalance, limiting calorie consumption and engaging in regular physical activity are key factors. Physical activity, in addition to the increase in energy expenditure, decreases fat around the waist and total body fat, slowing the development of abdominal obesity [6] This is of particular interest, since evidence indicates that higher risk of mortality is associated with high waist circumference compared to BMI.[7–9]

Supportive environments and communities are fundamental in shaping people's choices, by making the choice of healthier foods and regular physical activity the easiest, most accessible, and affordable choice.[1] Despite the benefits derived from an active lifestyle for the management of weight gain and obesity, increasing the levels of physical activity in the population is still challenging. Indeed, overweight and obese people are more likely to have lower rates of adherence to physical activity compared to the general population.[10–13] Several barriers to physical activity have been identified for overweight and obese individuals, including excess body fat making movement difficult and physically uncomfortable, poor physical fitness leading to perceptions of submaximal exercise being more strenuous, and a higher overall risk of injury.[14] In addition, the perception of being too overweight to exercise is linked to feelings of shyness and embarrassment, as well as a lack of enjoyment and an increased risk of depression, which can reduce the motivation to engage in physical activity.[14,15]

In order to solve this problem, authors have suggested that a greater emphasis should be placed on programs encouraging easily achievable, regular low-to-moderate intensity activity. Substituting vigorous exercise or competitive sports with activities such as walking or simple body weight exercises, as well as emphasizing the social nature of physical activity, may help encourage individuals to continue participating at levels sufficient to reap the health benefits associated with physical activity.[14]

To this purpose, the practice of Nordic walking (NW), a low-cost, easy-to-perform and low impact aerobic activity consisting of a variety of walking techniques using poles, has gained popularity in recent years and is an alternative exercise option for overweight and obese people for several reasons. First, because it is a safe and relatively easy to learn form of exercise, recommended for different groups of people with special needs.[14] Second, it is based on walking, a type of activity that has been reported to be generally enjoyed in the population.[16] Third, it has been reported that NW, while reducing the load of the lumbar spine and lower limb joints,[17] it also increases energy expenditure compared to ordinary walking, despite a similar rate of perceived exertion.[18] Fourth, the beneficial effects of NW have been found on a range of health-related parameters, including resting heart rate, blood pressure, exercise capacity, and maximal oxygen consumption, in people with different diseases.[19] Finally, compliance has been shown to be high in NW interventions targeting chronic conditions.[20–23]

Due to the interest of NW as an exercise therapy for overweight and obese people, it is important that health and rehabilitation professionals can easily access all existing evidence regarding its effects on this population. Furthermore, it is also essential to have the knowledge on how to accurately prescribe NW programs to meet the requirements of this population, as well as the personal needs and abilities of specific individuals. To achieve these objectives, it is essential to make available the best scientific evidence regarding the prescription NW and its effects on overweight and obese people. This goal can be achieved by conducting systematic reviews and meta-analyses that synthesize the scientific knowledge available on the subject, especially those based on the results from randomized controlled trials (RCTs), which are traditionally considered the gold standard for judging the benefits of treatments.[24] To the very best of the author's knowledge, only one systematic review[25] has been performed to analyze the effects of NW interventions on overweight and obese individuals, including RCTs and non-randomized studies, but no meta-analysis has been performed so far. The advantages of meta-analyses include an increase in power, an improvement in precision, the ability to answer questions not posed by individual studies, and the opportunity to settle controversies arising from conflicting claims.[26]

Under these circumstances, the purpose of this study is to conduct a systematic review and meta-analysis aimed to identify the characteristics, methodological quality, and results of the investigations that have studied the effects of NW in overweight and obese individuals.

Methods

Search Strategy

This systematic review was conducted in accordance with the PRISMA guidelines.[27] Articles published before June 2019 were identified using PubMed, Scopus, Sport-Discus, CINAHL, The Cochrane Library, and the Physiotherapy Evidence Database (PEDro). The search was based on the Population, Intervention, Comparison and Outcome (PICO) strategy. Following the recommendations from Cochrane's Handbook for Systematic Reviews of Interventions,[28] only terms regarding the population and the intervention were used, in a combination of standardized MeSH and free-text terms. Therefore, the following combination of keywords and of Boolean operator was used: "overweight" OR "obesity" OR "obese" AND "Nordic walking" OR "pole walking". Additional searches of relevant references within included articles and existing systematic reviews were performed manually. The protocol for this review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) on June 9th 2019 (registration number: blinded).

Eligibility criteria and study selection

Inclusion criteria were: a) sample overweight or obese defined as BMI ≥ 25 kg/m^2; b) a NW intervention was performed in at least one group; c) randomized controlled trial. Investigations were excluded if: a) the sample included participants who were not overweight or obese; b) NW was included as an additional treatment arm or it was performed as part of a combined exercise training program and its effects could not be isolated; c) the intervention was based on the performance of a single exercise training session; d) the research was not published in a peer-reviewed journal written in English, French, Portuguese or Spanish. Titles and abstracts of search results were screened for key criteria, with full-text versions of potentially relevant articles obtained and assessed for inclusion. Eligibility was assessed independently by two authors (M.S. and A.G.), with discrepancies resolved through discussion with a third author (C.A.).

Data extraction

Information on participants' characteristics, exercise programs, outcomes, drop-outs, and results were extracted from the original reports by two researchers (A.G. and K.M.) and confirmed by a third investigator (M.S.). Missing data were obtained from the study authors, whenever possible.

Methodological quality assessment

Quality appraisal of the RCTs was retrieved directly from PEDro database[29] and cases in the database which had not been previously assessed were appraised by two authors (M.S. and A.G.). In case of disagreement, advice was sought from a third author (C.A.). The suggested cut off points to categorize studies by quality were excellent (9–10), good (6–8), fair (4–5), and poor (<3).[30]

Data analysis

Meta-analysis was used to measure post-intervention changes in the NW group, compared to the baseline, as well as between NW and control groups. Baseline and post-intervention data were presented for the intervention and control groups as mean ± standard deviation (SD). Standardized mean differences (SMD) and their 95% confidence intervals (CIs) were calculated to assess the change in each outcome. The SMD was calculated using intervention and control group sample sizes, baseline and post-intervention means, and SDs for each of the selected outcome measures. Statistics were evaluated to identify multiple publications from the same trial and avoid double-counting the same sample of participants.[31]

To obtain the pooled effects, a fixed effect model was used. In the case of heterogeneity (I-squared > 30%), a random effects model was applied.[32] Forest plots displaying SMD and 95% CIs were used to compare the effects between the intervention and control groups. SMDs were significant when their 95% CIs excluded zero, while pooled SMD values were evaluated as small (less than ± 0.2), medium (ranging from ± 0.2 to ± 0.8), or large effects (greater than ± 0.8). Meta-regression was used to test moderation effect because it reduces the probability of type I errors by computing concurrent estimates of independent effects by multiple moderators on the variation in effect size across trials,[33] adjusting for age, BMI, length of the intervention in weeks, and the percentage of women in the intervention and control groups. All statistical analyses were performed using Stata 13.

Results

Figure 1 provides a full depiction of the screening process. A total of 415 records were obtained from the database search. After excluding duplicates, 384 records were identified. Titles and abstracts were screened, with 68 studies retrieved for the full-text assessment. Finally, 12 RCTs[34,35,44,45,36–43] met the full inclusion criteria and were included in the systematic review. These investigations reported comparable baseline and post-intervention data for both the intervention and control groups. The independent reviewers agreed on 381/384 citations (99.2%). The inter-rater agreement (Kappa) was 0.83. Five studies were identified as using the same sample of participants,[35–37,41,45] as well as two more for another study.[42,43] Therefore a total of seven RCTs[34,39–41,43–45] were included in the meta-analyses. Of the remaining seven RCTs, two derived from the same sample[41,45] but did not include any overlapping variables, avoiding double-counting.

[Insert Figure 1 around here]

Intervention characteristics

The characteristics of the interventions are shown in Supplementary file 1. The duration of the programs ranged between four[40] and 16[42–44] weeks in length, with sessions between

30[38] and 90[39] minutes long, and organized from one[44] to five[40] days per week. The intensity of the exercise was often prescribed according to the participants maximum heart rate (MHR), ranging from 40-75% MHR[34–37,40,41,45]. One study prescribed the intensity of exercise based on 40% maximum oxygen consumption (VO_2 max).[44] Two studies did not report how intensity was prescribed or controlled.[38,39]

Eight studies included a progression in the exercise load. This was achieved by increasing both frequency and intensity in MHR while reducing the duration of the session,[34] increasing the intensity by faster walking pace and extending the duration,[40] or increasing only the intensity in MHR[35–37,41,45] or the frequency.[44] Most studies did not combine NW with other types of non-exercise therapies, although one study did include a pharmacological treatment for hypertension in both NW and control groups.[40] Control groups did not take part in other exercise programs except for one study,[38] consisting of unsupervised walking at a normal pace three times per week for at least 30 minutes per session. Only four studies[35,36,44,45] reported the adherence to the programs, which ranged between 63-65%.

Methodological quality

The methodological quality of the included RCTs were mostly good[34,42–44] or fair,[35–40,45] with poor quality reported in one study.[41] See Table 1 for full quality appraisal criteria.

[Insert Table 1 around here]

Main findings

The RCTs reported significant improvements between baseline and post-intervention scores in the NW groups across several variables, as the BMI[39,40,43] and body weight.[39,40] Improvements were also observed in concentrations of high-density lipoprotein (HDL) cholesterol,[39] total cholesterol,[40] triglycerides[40] and aspartate aminotransferase,[37] as well as improvements in free fatty acids, fasting plasma glucose, and insulin.[34] Moreover, benefits were reported for the percentage of glycosylated hemoglobin A1c (HbA1c),[39] the homeostasis model assessment of insulin resistance (HOMA-IR),[34] the metabolic syndrome score, and the atherogenic index of plasma.[37] Improvements were also observed in physical parameters, including hand-grip strength [39] and exercise tolerance,[40] as well as claudication distance and total walking distance in walking tests.[38]

Results of the meta-analyses

A total of 465 participants were included in the meta-analysis for concentrations of total, HDL, and low-density lipoprotein (LDL) cholesterol, while 421 participants were included for triglycerides (Figure 2). In the analyses for concentrations of fasting plasma glucose, HOMA-IR and HbA1c, a total of 395, 375 and 356 participants were pooled, respectively (Figure 3). Systolic (SBP) and diastolic blood pressure (DBP) were analyzed in 362 participants (Figure 4). Finally, 439 participants were included in the meta-analysis for body weight, 419 for abdominal adiposity, including both waist circumference and visceral fat area measurements, as well as 386 participants in general adiposity by means of the BMI, and 226 in the body fat and fat free mass analyses (Figure 5).

In the meta-analysis comparing baseline scores to post-intervention scores in the NW intervention groups, significant reductions were found in fasting plasma glucose (random effects model, SMD = -0.39; 95% CI = -0.58, -0.03), abdominal adiposity (in both models, SMD = -0.31; 95% CI = -0.51, -0.11), and body fat (random effects model, SMD = -0.50; 95% CI = -0.95, -0.05). In the case of fixed effect models, significant reductions were found in total cholesterol (SMD = -0.19; 95% CI = -0.39, -0.01), triglycerides (SMD = -0.35; 95% CI = -0.56, -0.15), and HOMA-IR (SMD = -0.44; 95% CI = -0.66, -0.22). In these analyses, however, the I-squared heterogeneity was above

30% and the random effects model found no significant results (Supplementary file 2). Moderation analyses did not show significant interactions.

In the meta-analysis comparing the NW intervention groups versus control groups, significant reductions were found in favour of the interventions only in the fixed effect model for LDL (SMD = 0.30; 95% CI = 0.11, 0.49) and total cholesterol (SMD = 0.28; 95% CI = 0.09, 0.47), triglycerides (SMD = 0.29; 95% CI = 0.09, 0.48; Figure 2), HOMA-IR (SMD = 0.25; 95% CI = 0.04, 0.45), HbA1c (SMD = 0.40; 95% CI = 0.18, 0.62; Figure 3), and fat mass (SMD = 0.55; 95% CI = 0.28, 0.82; Figure 5). In these analyses, the I-squared heterogeneity was above 30% and the random effects model found no significant results. In the case of triglycerides, this model approached significance (SMD = 0.30; 95% CI = -0.00, 0.60) in favour of a larger post-intervention reduction in the NW intervention group. No significant differences were found in any models for blood pressure (Figure 4), body weight, abdominal adiposity, BMI, or fat free mass (Figure 5). The meta-regression analyses did not find any significant influences of the established moderators on these results.

[Insert Figures 2,3,4 and 5 around here]

Discussion

The present study aimed to systematically review the efficacy of NW interventions as a therapy to improve the health of overweight and obese individuals, as well as to analyze the methodological quality of the studies published so far in this regard. The findings from this review are of considerable interest to the healthcare professionals responsible for prescribing physical exercise in overweight and obese individuals, which is imperative for the prevention and/or treatment of weight-related diseases.

It is important to highlight that RCTs are traditionally considered the gold standard for judging the benefits of treatments, particularly when systematically examined using a quantitative synthesis such as meta-analysis.[24] The methodological quality of the included RCTs was rated as good-to-fair, except for one study with poor quality. This finding provides a solid base for the conclusions that can be drawn from this review.

The primary aim of this review was to ascertain the efficacy of NW as an exercise strategy in overweight and obese people. Following the intervention phase, most of the included studies reported significant improvements in the NW groups across a range of biochemical and physical function parameters of interest in obese people. Furthermore, no detrimental effects were found in any outcomes following the interventions.

In this review, two types of meta-analysis were performed on the different parameters in the RCTs, including data from up to 465 participants, increasing the power from individual studies and allowing a more precise analysis of the actual evidence in this regard. On the one hand, when the meta-analysis was performed comparing only the baseline and post-intervention scores in NW groups, significant reductions were found in the fasting plasma glucose, abdominal adiposity, and body fat. These are substantial findings, as these parameters have been reported to be independent predictors of major health-outcomes such as all-cause mortality,[46–50] as well as cardiovascular disease[50,51] and cancer mortality[50]. On the other hand, however, in the meta-analysis comparing the NW interventions to control conditions, no significant benefits were found in any of the parameters for NW (accounting for heterogeneity). It should be noted that in parameters such as LDL and total cholesterol, triglycerides, HOMA-IR, and HbA1c, a tendency towards improvement was observed. In this regard, it is plausible that the lack of significant results in the random-effects model could be expected to be significant (as it is in many cases of the fixed-effect model) if the power was increased by including additional RCTs with greater samples. Furthermore, in some of these cases (i.e.

triglycerides or HOMA-IR), while the level of heterogeneity was moderate (I^2=30-60%), the CIs were generally narrow. Thus, the level of heterogeneity in these cases in particular might not be that influential and the results of the fixed-effect model (significant improvements following NW) could be considered as determinant as those from the random-effects model.

The lack of significant results in the remaining parameters, particularly in the meta-analysis comparing NW groups to the control groups, could be influenced by several factors. First, strong evidence supports the relationship between greater amounts of physical activity and attenuated weight gain in adults, and this is more pronounced when physical activity exposure is above 150 minutes per week.[52] While most of the NW programs carried in the studies seem to be above this cut-off point, the lack of adherence reporting did not allow a clear investigation into whether this duration was reached. Second, similarly, it is impotant to note that it was not possible to analyze the influence in the results derived from the exercise intesity, due to the inconsistent reporting of this parameter. This would be important, since studies have shown that the intensity may be important when measuring effect of exercise not only when focusing on weight loss, but on some of the other outcome measures of interest, such as cholesterols and triglycerides.[53] Third, while evidence strongly demonstrates attenuated weigh gain when a greater time is spent in moderate-to-vigorous physical activity, the intensity of exercise could have further complicated this interaction. For instance, while brisk walking is usually considered moderate intensity, it is not necessarily the case with normal pace walking.[54] Considering the altered perceived exertion of exercise in this population,[14] as well as the fact that some of the studies did not use objective tools to control the exercise intensity, the subjective perception of the walking pace could have influenced the actual exercise intensity. Fourth, there was in general a lack of details regarding the level of exercise of the non-active control groups during the interventions. This is important to be noted, since contamination is common in the control groups of exercise RCTs.[55] Finally, nutrition is strongly related to the management obesity,[56] and in the present investigation, none of the studies reported nutrition as a potential confounding factor. This, in conjunction with a lack of control for exercise performed by control group participants during the intervention period, may partially explain the lack of significant results comparing NW to the control participants, even though significant results were found between NW baseline and post-intervention parameters.

In general, the NW programs were safe, since most of the included studies did not report any adverse events derived from the NW interventions. Nevertheless, one study[44] reported a hypoglycemic event in an insulin-treated participant. This should be taken into account when prescribing or designing NW studies with diabetic participants. Also, this study reported that, in one participant with previous musculoskeletal symptoms of overload these were aggravated by the program.

It should be noted that there are other parameters of interest that were not examined in the current review, warranting further investigation. For example, strong evidence demonstrates a reduction in depression and anxiety following physical exercise,[52] and this mood-enhancing effect may motivate people to adhere to a healthier lifestyle. The effects of NW in overweight or obese people in these aspects remain unstudied.

The present investigation has several key strengths. To the authors' knowledge, this is the first review that has systematically investigated the benefits of NW as exercise therapy in overweight and obese cohorts. Moreover, two types of meta-analysis of RCTs were performed on a variety of major health-related outcomes, comparing both the baseline and post-intervention measurements in the NW groups, along with comparisons to the control conditions. The number of participants and the methodological quality of the RCTs should also be highlighted.

It is also important to note that the current review had several limitations worthy of mention. First, important participant and intervention data, such as adherence to the interventions, were not reported consistently thorough the investigations, and therefore, the analysis of moderating effects was limited. Second, samples usually consisted of people with type I obesity, so there is a lack of evidence regarding the effects of this therapy in people with a higher BMI. Third, the authors of the RCTs did not report whether the requisite 80% power for the selected sample size was met, which may have increased the risk of type II errors. Fourth, some of the studies included people with other health conditions in addition to being overweight or obese. Finally, the methodological limitations inherent to the review design (e.g., language restrictions, grey literature not reviewed, and publication bias) should be considered, due to their potential influence on the results obtained.

Conclusion

Nordic Walking is a feasible exercise modality that can be prescribed to overweight and obese people, since its practice can potentially lead to improvements in parameters related to major health outcomes in this population. However, the lack of control for confounding variables noticed in the analyzed studies prevents further elaboration on its potential benefits. Researchers should take this into consideration when designing future RCTs on this topic.

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Table 1. PEDro results of the methodological quality evaluation of the included studies.

PEDro criteria (RCTs)	First Author, Year											
	Gram, 2010[41]	Fritz, 2011[38]	Fritz, 2013[39]	Wiklund, 2014[42]	Kucio, 2017[40]	Sentinelli, 2015[44]	Spafford, 2014[43]	Venojarvi, 2013[35]	Venojarvi, 2013[37]	Wasenius, 2014[33]	Wasenius, 2014[34]	Korkmaz, 2019[36]
1. Random allocation	+	+	+	+	+	+	+	+	+	+	+	+
2. Concealed allocation	-	-	-	+	-	-	-	-	-	+	-	-
3. Baseline comparability	+	+	+	+	+	+	+	+	+	-	+	-
4. Blind subjects	-	-	-	-	-	-	-	-	-	-	-	-
5. Blind therapists	-	-	-	-	-	-	-	-	-	-	-	-
6. Blind assessors	-	-	-	-	-	-	-	-	-	-	-	-
7. Adequate follow-up	+	+	+	-	+	+	-	-	-	-	-	-
8. Intention-to-treat analysis	+	+	+	+	-	-	-	-	-	-	-	-
9. Between-group comparisons	+	+	+	+	+	+	+	+	+	+	+	+
10. Point estimates and variability	+	+	+	+	+	+	+	+	+	+	+	+
Total score	6/10	6/10	6/10	6/10	5/10	5/10	4/10	4/10	4/10	4/10	4/10	3/10

Figure 1. Flow chart of the systematic review process.

Figure 2. Forest plot of the meta-analysis for concentrations of cholesterol and triglycerides.

Figure 3. Forest plot of the meta-analysis for concentrations of glucose, insulin resistance, and glycosylated haemoglobin A1c.

Figure 4. Forest plot of the meta-analysis for blood pressure.

Figure 5. Forest plot of the meta-analysis for weight, abdominal adiposity, body mass index, fat mass, and fat free mass.

Supplementary File 1. Characteristics and individual results of the included studies.

Supplementary file 2. Results of the meta-analysis comparing baseline versus post-intervention scores in the NW intervention groups.

Figure 1

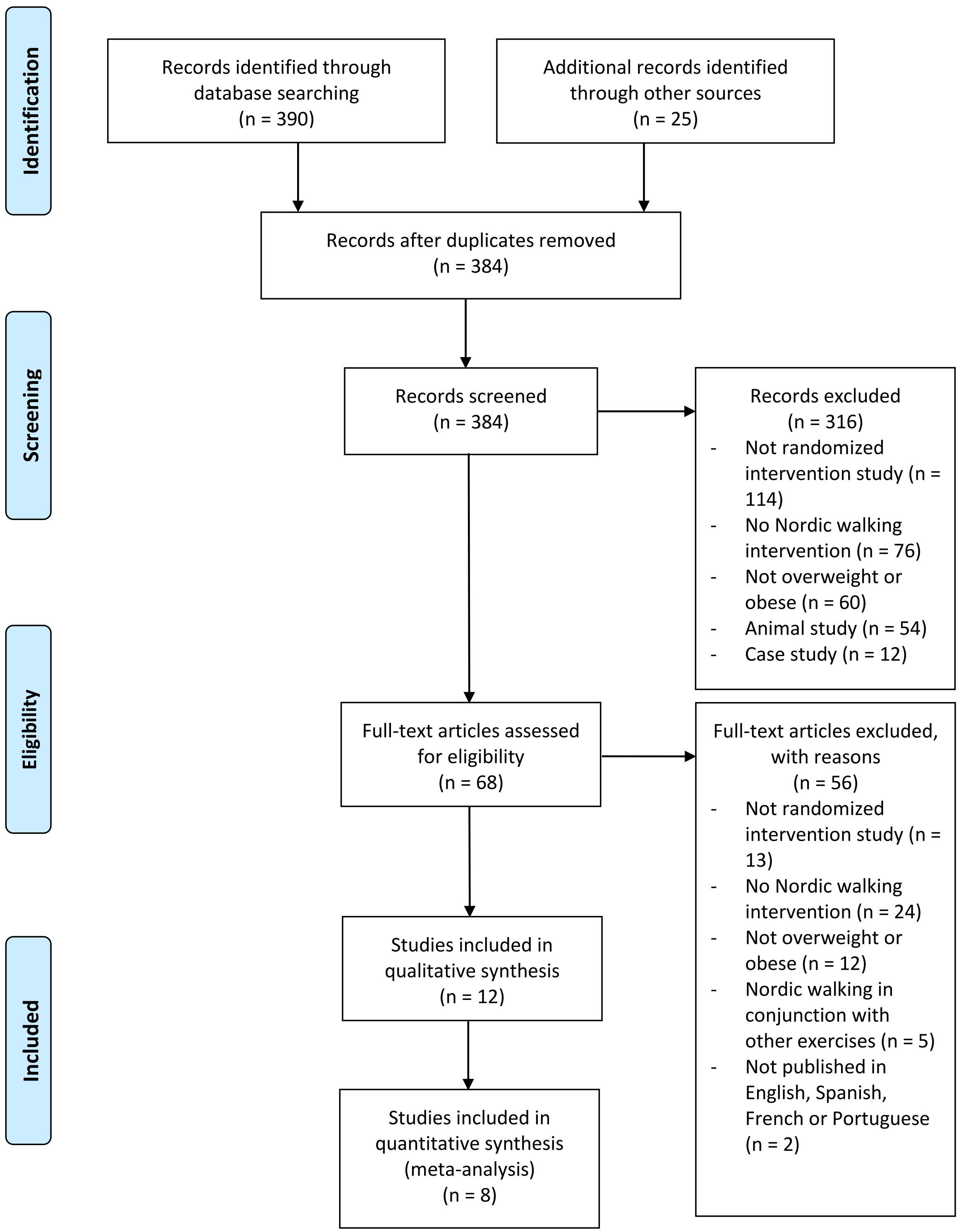

Identification
Screening
Eligibility
Included
Records identified through database searching (n = 390)
Additional records identified through other sources (n = 25)
Records after duplicates removed (n = 384)
Records screened (n = 384)
Records excluded (n = 316)
- Not randomized intervention study (n = 114)
- No Nordic walking intervention (n = 76)
- Not overweight or obese (n = 60)
- Animal study (n = 54)
- Case study (n = 12)
Full-text articles assessed for eligibility (n = 68)
Full-text articles excluded, with reasons (n = 56)
- Not randomized intervention study (n = 13)
- No Nordic walking intervention (n = 24)
- Not overweight or obese (n = 12)
- Nordic walking in conjunction with other exercises (n = 5)
- Not published in English, Spanish, French or Portuguese (n = 2)
Studies included in qualitative synthesis (n = 12)
Studies included in quantitative synthesis (meta-analysis) (n = 8)

Figure 2

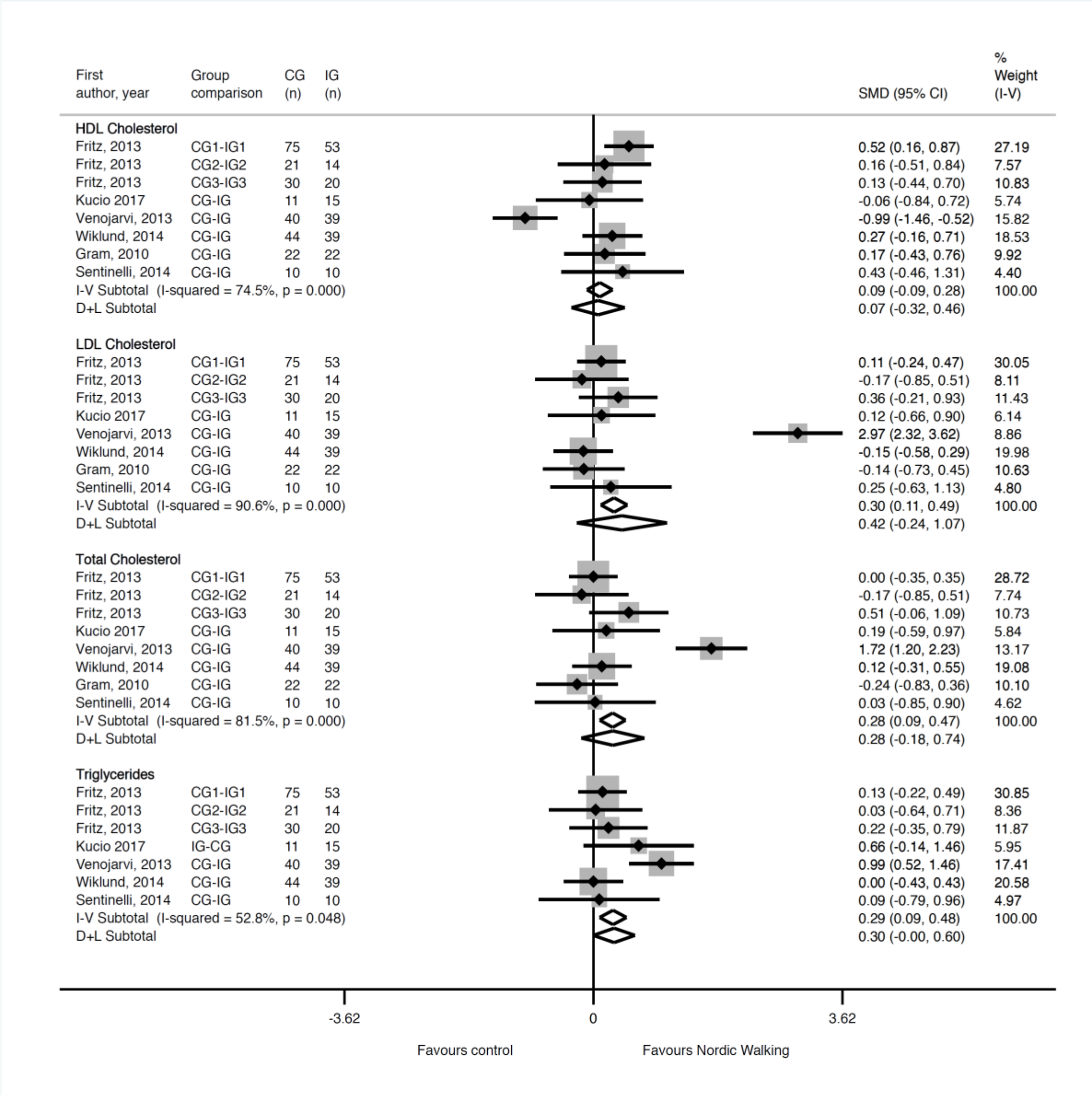

First author, year
Group comparison
CG (n)
IG (n)
SMD (95% CI)
% Weight (I-V)
HDL Cholesterol
Fritz, 2013 CG1-IG1 75 53 0.52 (0.16, 0.87) 27.19
Fritz, 2013 CG2-IG2 21 14 0.16 (-0.51, 0.84) 7.57
Fritz, 2013 CG3-IG3 30 20 0.13 (-0.44, 0.70) 10.83
Kucio 2017 CG-IG 11 15 -0.06 (-0.84, 0.72) 5.74
Venojarvi, 2013 CG-IG 40 39 -0.99 (-1.46, -0.52) 15.82
Wiklund, 2014 CG-IG 44 39 0.27 (-0.16, 0.71) 18.53
Gram, 2010 CG-IG 22 22 0.17 (-0.43, 0.76) 9.92
Sentinelli, 2014 CG-IG 10 10 0.43 (-0.46, 1.31) 4.40
I-V Subtotal (I-squared = 74.5%, p = 0.000) 0.09 (-0.09, 0.28) 100.00
D+L Subtotal 0.07 (-0.32, 0.46)
LDL Cholesterol
Fritz, 2013 CG1-IG1 75 53 0.11 (-0.24, 0.47) 30.05
Fritz, 2013 CG2-IG2 21 14 -0.17 (-0.85, 0.51) 8.11
Fritz, 2013 CG3-IG3 30 20 0.36 (-0.21, 0.93) 11.43
Kucio 2017 CG-IG 11 15 0.12 (-0.66, 0.90) 6.14
Venojarvi, 2013 CG-IG 40 39 2.97 (2.32, 3.62) 8.86
Wiklund, 2014 CG-IG 44 39 -0.15 (-0.58, 0.29) 19.98
Gram, 2010 CG-IG 22 22 -0.14 (-0.73, 0.45) 10.63
Sentinelli, 2014 CG-IG 10 10 0.25 (-0.63, 1.13) 4.80
I-V Subtotal (I-squared = 90.6%, p = 0.000) 0.30 (0.11, 0.49) 100.00
D+L Subtotal 0.42 (-0.24, 1.07)
Total Cholesterol
Fritz, 2013 CG1-IG1 75 53 0.00 (-0.35, 0.35) 28.72
Fritz, 2013 CG2-IG2 21 14 -0.17 (-0.85, 0.51) 7.74
Fritz, 2013 CG3-IG3 30 20 0.51 (-0.06, 1.09) 10.73
Kucio 2017 CG-IG 11 15 0.19 (-0.59, 0.97) 5.84
Venojarvi, 2013 CG-IG 40 39 1.72 (1.20, 2.23) 13.17
Wiklund, 2014 CG-IG 44 39 0.12 (-0.31, 0.55) 19.08
Gram, 2010 CG-IG 22 22 -0.24 (-0.83, 0.36) 10.10
Sentinelli, 2014 CG-IG 10 10 0.03 (-0.85, 0.90) 4.62
I-V Subtotal (I-squared = 81.5%, p = 0.000) 0.28 (0.09, 0.47) 100.00
D+L Subtotal 0.28 (-0.18, 0.74)
Triglycerides
Fritz, 2013 CG1-IG1 75 53 0.13 (-0.22, 0.49) 30.85
Fritz, 2013 CG2-IG2 21 14 0.03 (-0.64, 0.71) 8.36
Fritz, 2013 CG3-IG3 30 20 0.22 (-0.35, 0.79) 11.87
Kucio 2017 IG-CG 11 15 0.66 (-0.14, 1.46) 5.95
Venojarvi, 2013 CG-IG 40 39 0.99 (0.52, 1.46) 17.41
Wiklund, 2014 CG-IG 44 39 0.00 (-0.43, 0.43) 20.58
Sentinelli, 2014 CG-IG 10 10 0.09 (-0.79, 0.96) 4.97
I-V Subtotal (I-squared = 52.8%, p = 0.048) 0.29 (0.09, 0.48) 100.00
D+L Subtotal 0.30 (-0.00, 0.60)
-3.62
0
3.62
Favours control
Favours Nordic Walking

Figure 3

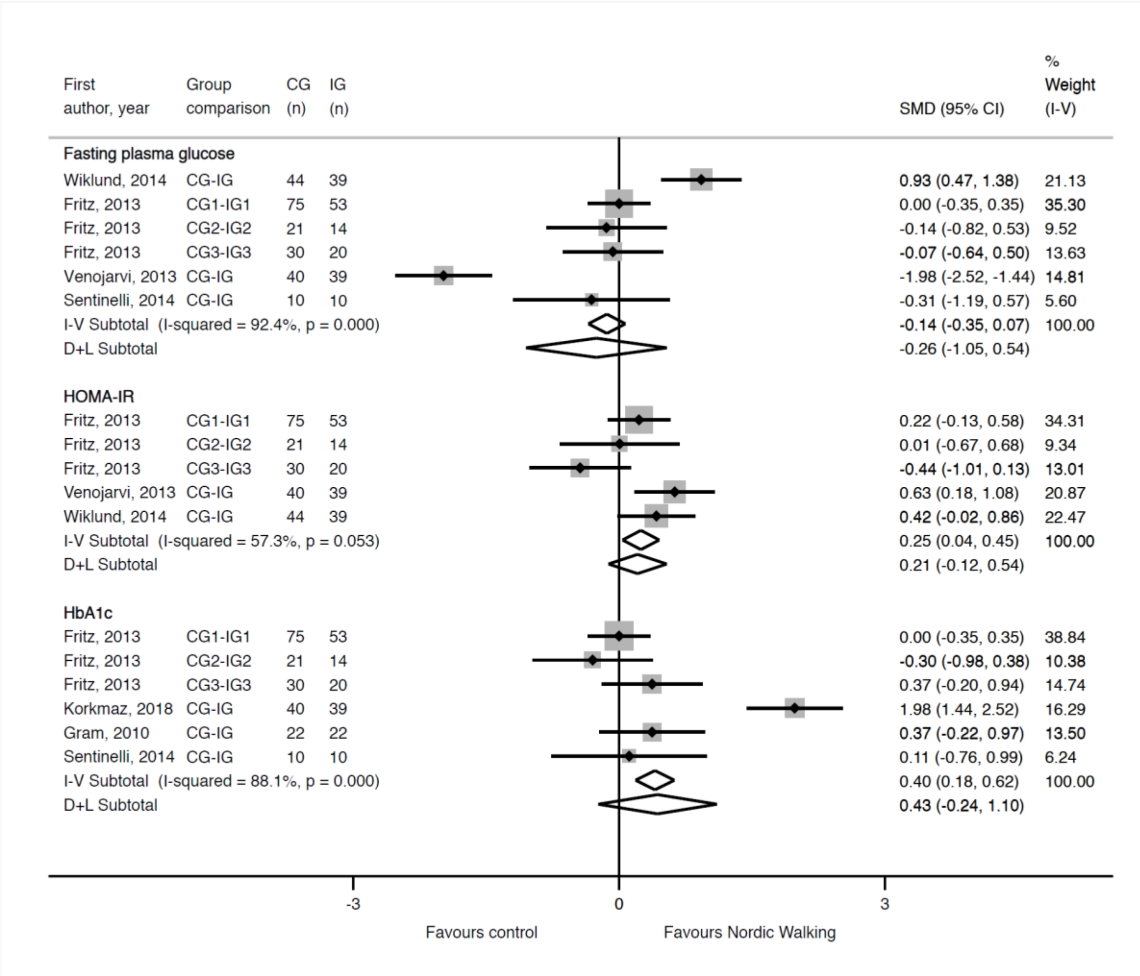
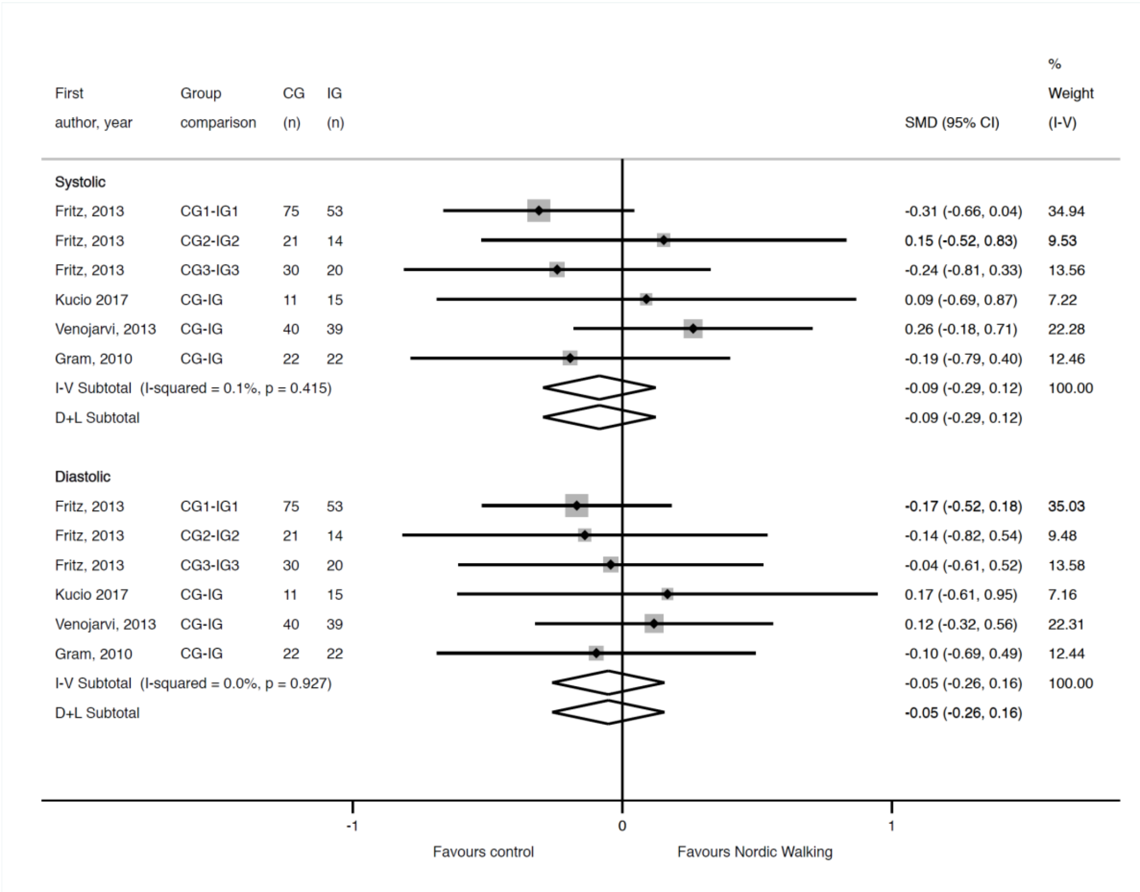
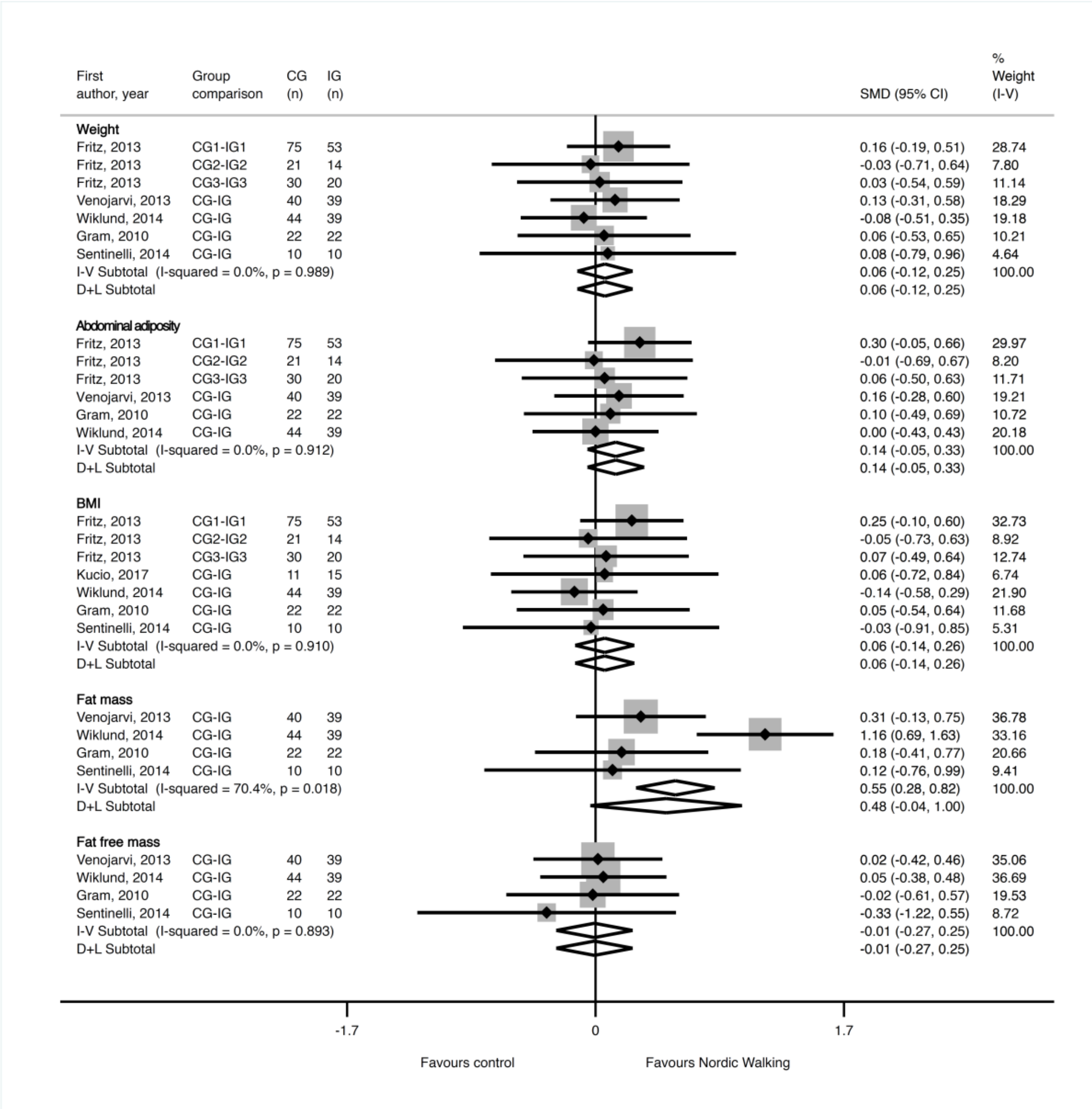

First author, year
Group comparison
CG (n)
IG (n)
SMD (95% CI)
% Weight (I-V)
Fasting plasma glucose
Wiklund, 2014 CG-IG 44 39 0.93 (0.47, 1.38) 21.13
Fritz, 2013 CG1-IG1 75 53 0.00 (-0.35, 0.35) 35.30
Fritz, 2013 CG2-IG2 21 14 -0.14 (-0.82, 0.53) 9.52
Fritz, 2013 CG3-IG3 30 20 -0.07 (-0.64, 0.50) 13.63
Venojarvi, 2013 CG-IG 40 39 -1.98 (-2.52, -1.44) 14.81
Sentinelli, 2014 CG-IG 10 10 -0.31 (-1.19, 0.57) 5.60
I-V Subtotal (I-squared = 92.4%, p = 0.000) -0.14 (-0.35, 0.07) 100.00
D+L Subtotal -0.26 (-1.05, 0.54)
HOMA-IR
Fritz, 2013 CG1-IG1 75 53 0.22 (-0.13, 0.58) 34.31
Fritz, 2013 CG2-IG2 21 14 0.01 (-0.67, 0.68) 9.34
Fritz, 2013 CG3-IG3 30 20 -0.44 (-1.01, 0.13) 13.01
Venojarvi, 2013 CG-IG 40 39 0.63 (0.18, 1.08) 20.87
Wiklund, 2014 CG-IG 44 39 0.42 (-0.02, 0.86) 22.47
I-V Subtotal (I-squared = 57.3%, p = 0.053) 0.25 (0.04, 0.45) 100.00
D+L Subtotal 0.21 (-0.12, 0.54)
HbA1c
Fritz, 2013 CG1-IG1 75 53 0.00 (-0.35, 0.35) 38.84
Fritz, 2013 CG2-IG2 21 14 -0.30 (-0.98, 0.38) 10.38
Fritz, 2013 CG3-IG3 30 20 0.37 (-0.20, 0.94) 14.74
Korkmaz, 2018 CG-IG 40 39 1.98 (1.44, 2.52) 16.29
Gram, 2010 CG-IG 22 22 0.37 (-0.22, 0.97) 13.50
Sentinelli, 2014 CG-IG 10 10 0.11 (-0.76, 0.99) 6.24
I-V Subtotal (I-squared = 88.1%, p = 0.000) 0.40 (0.18, 0.62) 100.00
D+L Subtotal 0.43 (-0.24, 1.10)
-3
0
3
Favours control
Favours Nordic Walking

Figure 4



First author, year
Group comparison
CG (n)
IG (n)
SMD (95% CI)
% Weight (I-V)
Systolic
Fritz, 2013 CG1-IG1 75 53 -0.31 (-0.66, 0.04) 34.94
Fritz, 2013 CG2-IG2 21 14 0.15 (-0.52, 0.83) 9.53
Fritz, 2013 CG3-IG3 30 20 -0.24 (-0.81, 0.33) 13.56
Kucio 2017 CG-IG 11 15 0.09 (-0.69, 0.87) 7.22
Venojarvi, 2013 CG-IG 40 39 0.26 (-0.18, 0.71) 22.28
Gram, 2010 CG-IG 22 22 -0.19 (-0.79, 0.40) 12.46
I-V Subtotal (I-squared = 0.1%, p = 0.415) -0.09 (-0.29, 0.12) 100.00
D+L Subtotal -0.09 (-0.29, 0.12)
Diastolic
Fritz, 2013 CG1-IG1 75 53 -0.17 (-0.52, 0.18) 35.03
Fritz, 2013 CG2-IG2 21 14 -0.14 (-0.82, 0.54) 9.48
Fritz, 2013 CG3-IG3 30 20 -0.04 (-0.61, 0.52) 13.58
Kucio 2017 CG-IG 11 15 0.17 (-0.61, 0.95) 7.16
Venojarvi, 2013 CG-IG 40 39 0.12 (-0.32, 0.56) 22.31
Gram, 2010 CG-IG 22 22 -0.10 (-0.69, 0.49) 12.44
I-V Subtotal (I-squared = 0.0%, p = 0.927) -0.05 (-0.26, 0.16) 100.00
D+L Subtotal -0.05 (-0.26, 0.16)
-1
0
1
Favours control
Favours Nordic Walking

Figure 5



First author, year
Group comparison
CG (n)
IG (n)
SMD (95% CI)
% Weight (I-V)
Weight
Fritz, 2013 CG1-IG1 75 53 0.16 (-0.19, 0.51) 28.74
Fritz, 2013 CG2-IG2 21 14 -0.03 (-0.71, 0.64) 7.80
Fritz, 2013 CG3-IG3 30 20 0.03 (-0.54, 0.59) 11.14
Venojarvi, 2013 CG-IG 40 39 0.13 (-0.31, 0.58) 18.29
Wiklund, 2014 CG-IG 44 39 -0.08 (-0.51, 0.35) 19.18
Gram, 2010 CG-IG 22 22 0.06 (-0.53, 0.65) 10.21
Sentinelli, 2014 CG-IG 10 10 0.08 (-0.79, 0.96) 4.64
I-V Subtotal (I-squared = 0.0%, p = 0.989) 0.06 (-0.12, 0.25) 100.00
D+L Subtotal 0.06 (-0.12, 0.25)
Abdominal adiposity
Fritz, 2013 CG1-IG1 75 53 0.30 (-0.05, 0.66) 29.97
Fritz, 2013 CG2-IG2 21 14 -0.01 (-0.69, 0.67) 8.20
Fritz, 2013 CG3-IG3 30 20 0.06 (-0.50, 0.63) 11.71
Venojarvi, 2013 CG-IG 40 39 0.16 (-0.28, 0.60) 19.21
Gram, 2010 CG-IG 22 22 0.10 (-0.49, 0.69) 10.72
Wiklund, 2014 CG-IG 44 39 0.00 (-0.43, 0.43) 20.18
I-V Subtotal (I-squared = 0.0%, p = 0.912) 0.14 (-0.05, 0.33) 100.00
D+L Subtotal 0.14 (-0.05, 0.33)
BMI
Fritz, 2013 CG1-IG1 75 53 0.25 (-0.10, 0.60) 32.73
Fritz, 2013 CG2-IG2 21 14 -0.05 (-0.73, 0.63) 8.92
Fritz, 2013 CG3-IG3 30 20 0.07 (-0.49, 0.64) 12.74
Kucio, 2017 CG-IG 11 15 0.06 (-0.72, 0.84) 6.74
Wiklund, 2014 CG-IG 44 39 -0.14 (-0.58, 0.29) 21.90
Gram, 2010 CG-IG 22 22 0.05 (-0.54, 0.64) 11.68
Sentinelli, 2014 CG-IG 10 10 -0.03 (-0.91, 0.85) 5.31
I-V Subtotal (I-squared = 0.0%, p = 0.910) 0.06 (-0.14, 0.26) 100.00
D+L Subtotal 0.06 (-0.14, 0.26)
Fat mass
Venojarvi, 2013 CG-IG 40 39 0.31 (-0.13, 0.75) 36.78
Wiklund, 2014 CG-IG 44 39 1.16 (0.69, 1.63) 33.16
Gram, 2010 CG-IG 22 22 0.18 (-0.41, 0.77) 20.66
Sentinelli, 2014 CG-IG 10 10 0.12 (-0.76, 0.99) 9.41
I-V Subtotal (I-squared = 70.4%, p = 0.018) 0.55 (0.28, 0.82) 100.00
D+L Subtotal 0.48 (-0.04, 1.00)
Fat free mass
Venojarvi, 2013 CG-IG 40 39 0.02 (-0.42, 0.46) 35.06
Wiklund, 2014 CG-IG 44 39 0.05 (-0.38, 0.48) 36.69
Gram, 2010 CG-IG 22 22 -0.02 (-0.61, 0.57) 19.53
Sentinelli, 2014 CG-IG 10 10 -0.33 (-1.22, 0.55) 8.72
I-V Subtotal (I-squared = 0.0%, p = 0.893) -0.01 (-0.27, 0.25) 100.00
D+L Subtotal -0.01 (-0.27, 0.25)
-1.7
0
1.7
Favours control
Favours Nordic Walking

Supplementary File 1

First Author, Year	Sample	Intervention	Outcomes (measurement tool)	Results
Gram, 2010	**Sample size (n pre/post; sex):** 68/67; 31 women **Distribution; age (mean ± SD):** IG1: n = 22; 62 ± 10 IG2: n = 24; 59 ± 10 CG: n = 22; 61 ± 10 **BMI (kg/m^2; mean ± SD):** IG1: 31.4 ± 4.3 IG2: 32.4 ± 4.1 CG: 32.8 ± 4.0	**Design:** RCT **Duration:** 16 weeks **IG1:** 45-minute sessions per week of supervised NW performed at a speed of at least moderate intensity (40% of VO_2 max). Sessions were twice per week for months 1-2, then once per week for months 3-4. **IG2:** 45-minute sessions per week of strength training and aerobic exercise at a workload of at least moderate intensity (40% of VO_2 max). Sessions were twice per week during months 1-2, then once per week during months 3-4. **CG:** No exercise program. Standard written diabetes outpatient clinic information on exercise as a part of the treatment for type 2 diabetes and advised to be physically active.	Anthropometric: - Weight (DM) - BMI (DM of height and weight) - Waist circumference (DM) - Hip circumference (DM) - Lean tissue mass - Fat tissue mass Biochemical: - Total, LDL, and HDL cholesterol - HbA1c Physical fitness: - Systolic and diastolic blood pressure - VO_2 max (exercise test and ergometer)	**IG1 (NW) adherence:** 63.5% **Drop-outs:** 1 **Significant differences (p < .05):** Intragroup (pre vs post) ↓ Fat tissue mass: IG1 Intergroup (pre vs post) ↓ LDL cholesterol: IG2 > CG
Fritz, 2011 Fritz, 2013	**Sample size (n pre/post; sex):** 213/203; 118 women **Distribution; age (mean ± SD):** IG1: n = 53; 59.4 ± 5.4 IG2: n = 14; 59.1 ± 6.2 IG3: n = 20; 61.4 ± 4.6 CG1: n = 75; 59.3 ± 5.9 CG2: n = 21; 61.8 ± 3.4 CG3: n = 30; 61.0 ± 4.7 **BMI (kg/m^2; mean ± SD):** IG1: 29.6 ± 3.8 IG2: 32.0 ± 5.2 IG3: 31.7 ± 5.2 CG1: 29.3 ± 2.7 CG2: 30.8 ± 3.5 CG3: 31.1 ± 3.9 **Other health conditions:** IG1, CG1: Normal glucose tolerance IG2, CG2: Impaired glucose tolerance IG3, CG3: Type 2 diabetes	**Design:** RCT **Duration:** 16 weeks **IG1, IG2, IG3:** To increase their weekly level of physical activity by five hours of NW, walking intensity was prescribed as a pace that caused slight shortness of breath and perspiration. After 2 months, the participants in the intervention group received a supportive telephone call from an assisting nurse. **CG1, CG2, CG3:** No exercise program. Waiting list with physical activity during the intervention.	***Fritz et al. 2011*** Self-reported: - Sleep quality (waist accelerometer) - Quality of life (questionnaire) ***Fritz et al. 2013*** Anthropometric: - Weight (DM) - BMI (DM of height and weight) Biochemical: - Total, LDL, and HDL cholesterol - Fasting glucose Physical fitness: - Exercise tolerance (laboratory ergometer test) - VO_2 peak (exercise test and spirometer) Self-reported: - PA (questionnaire) - Sleep quality (waist accelerometer) - Quality of life (questionnaire)	**IG1, IG2, IG3 (NW) adherence:** NR **Drop-outs:** 10 **Significant differences (p < .05):** Intragroup (pre vs post) ↓ BMI: IG1 Intergroup (pre vs post) ↓ BMI: IG1 > CG1 ↓ Glucose: IG3 > CG3 ↑ Exercise tolerance: IG2 > CG2; IG3 > CG3 ↑ Sleep quality: IG1 > CG1

Wiklund, 2014	**Sample size (n pre/post; sex):** 90/83; 90 women **Distribution; age (mean ± SD):** IG: n = 45; 41.9 ± 7.3 CG: n = 45; 42.2 ± 7.5 **BMI (kg/m^2; mean ± SD):** IG: 28.4 ± 2.1 CG: 31.3 ± 3.1	**Design:** RCT **Duration:** 6 weeks **IG:** NW based on recommendations for sedentary adults: three 60-minute sessions per week (60% MHR) during week 1; four 45-minute sessions per week (65% MHR) during weeks 2-3; four 35-minute sessions per week (70% MHR) during weeks 4-5; three 30-minute sessions per week (75% MHR) during week 6. **CG:** No exercise program. Dietary counselling and instructed to maintain their habitual physical activity.	Anthropometric: - Weight (DM) - BMI (DM of height and weight) - Fat mass - Fat free mass - Visceral fat area Biochemical: - Total, LDL, and HDL cholesterol - Triglycerides - Fasting glucose - Insulin - Insulin resistance (HOMA-IR) - Free fatty acids - Leptin - Adiponectin - Interleukin-6 - Interleukin-8 Diet: - Caloric expenditure - Proteins - Fats - Carbohydrates Physical fitness: - Systolic and diastolic blood pressure - VO_2 max (exercise test and ergometer)	**IG (NW) adherence:** NR **Drop-outs:** 7 **Significant differences (p < .05):** Intragroup (pre vs post) ↓ Fasting glucose: IG ↓ Insulin: IG ↓ Insulin resistance: IG ↓ Free fatty acids: IG ↓ Weight: CG ↓ BMI: CG ↓ Visceral fat area: CG ↓ Fat free mass: CG ↓ Leptin: CG ↑ Adiponectin: CG Intergroup (pre vs post) ↓ Fasting glucose: IG > CG ↓ Insulin resistance: IG > CG ↓ Free fatty acids: IG > CG
Kucio, 2017	**Sample size (n pre/post; sex):** 30/26; 30 men **Distribution; age (mean ± SD):** IG: n = 15; 56.7 ± 5.8 CG: n = 15; 57.0 ± 4.6 **BMI (kg/m^2; mean ± SD):** IG: 31.8 ± 5.0 CG: 31.2 ± 4.2	**Design:** RCT **Duration:** 4 weeks **IG:** Standard pharmacological treatment plus five NW sessions per week (40-70% MHR). Sessions consisted of marching at a speed of 3km/h for 30 minutes during week 1, then 5km/h for 40 minutes during weeks 2-4. **CG:** No exercise program. Standard pharmacological treatment only.	Anthropometric: - Weight (DM) - BMI (DM of height and weight) - Body mass Biochemical: - Total, LDL, and HDL cholesterol - Triglycerides Physical fitness: - Systolic, diastolic, and mean blood pressure - Exercise tolerance (laboratory ergometer test)	**IG (NW) adherence:** NR **Drop-outs:** 4 **Significant differences (p < .05):** Intragroup (pre vs post) ↓ BMI: IG ↓ Body mass: IG ↓ Total cholesterol: IG ↓ Triglycerides: IG ↑ Exercise tolerance: IG Intergroup (pre vs post) ↑ Exercise tolerance: IG > CG
Sentinelli, 2014	**Sample size (n pre/post; sex):** 20/20; 20 women **Distribution; age (mean ± SD):** IG: n = 10; 54 ± 9 CG: n = 10; 60 ± 5	**Design:** RCT **Duration:** 12 weeks **IG:** Three 60-90 minutes per week of supervised NW. Sessions consisted of low/moderate intensity NW	Anthropometric: - Weight (DM) - BMI (DM of height and weight) - Fat mass - Fat free mass - Total body water	**IG (NW) adherence:** NR **Drop-outs:** None **Significant differences (p < .05):**

	BMI (kg/m²; mean ± SD): IG: 32.3 ± 6 CG: 32 ± 7	focused on proper technique during weeks 1-6, then moderate/high intensity NW with progressive exercise loads. **CG:** No exercise program. PA counselling.	Biochemical: - Total, LDL, and HDL cholesterol - Triglycerides - Fasting glucose - HbA1c - Gamma-glutamyl transferase - Aspartate aminotransferase - Alanine aminotransferase Physical fitness: - Systolic and diastolic blood pressure - Handgrip strength (hydro-mechanical dynamometer)	Intragroup (pre vs post) ↓ Weight: IG ↓ BMI: IG ↓ Total body water: IG ↑ HDL cholesterol: IG ↓ Triglycerides: IG ↓ HbA1c: IG ↓ Aspartate aminotransferase: IG ↑ Handgrip strength: IG Intergroup (pre vs post) ↓ LDL cholesterol: IG > CG ↓ Total cholesterol: IG > CG ↓ HbA1c: IG > CG ↓ Aspartate aminotransferase: IG > CG ↑ Handgrip strength: IG > CG
Spafford, 2014	**Sample size (n pre/post; sex):** 52/38; 17 women **Distribution; age (mean ± SD):** IG: n = 28; 65 ± 2 CG: n = 24; 65 ± 2 **BMI (kg/m²; mean ± SD):** IG: 28 ± 1 CG: 29 ± 1	**Design:** RCT **Duration:** 12 weeks **IG:** Three unsupervised NW sessions per week for at least 30 minutes per session. **CG:** Unsupervised home exercise program with written instruction to walk at normal pace three times per week for at least 30 minutes per session.	Anthropometric: - BMI (DM of height and weight) Diet: - Caloric expenditure Physical fitness: - Claudication distance (meters, time, and heart rate) - Maximum walking distance (meters, time, and heart rate) - Ankle: brachial pressure index (hand-held Doppler) Self-reported: Perceived exertion and pain (questionnaire)	**IG (NW) adherence:** NR **Drop-outs:** 14 **Significant differences (p < .05):** Intragroup (pre vs post) ↑ Claudication distance: IG ↑ Maximum walking distance: IG Intergroup (pre vs post) ↑ Caloric expenditure: IG > CG ↑ Maximum walking distance: IG > CG ↑ Ankle: brachial pressure index: IG > CG
Venojärvi, 2013 Korkmaz, 2018 Wasenius, 2014	**Sample size (n pre/post; sex):** 144/115; 144 men **Distribution; age (mean ± SD):** IG1: n = 48; 55.4 ± 6.2 IG2: n = 49; 54.4 ± 6.1 CG: n = 47; 53.6 ± 7.3 **BMI (kg/m²; mean ± SD):** IG1: 30.0 ± 3.4 IG2: 30.3 ± 3.2 CG: 28.7 ± 3.0	**Design:** RCT **Duration:** 12 weeks **IG1:** Three 60-minute sessions per week of supervised NW (55% MHR during weeks 1-4, 65% MHR during weeks 6-8, and 75% MHR during weeks 9-12). **IG2:** Three 60-minute sessions per week of supervised resistance training (50-85% maximal strength according to five-repetition maximum test).	***Venojärvi et al. 2013a*** Anthropometric: - Weight (DM) - BMI (DM of height and weight) - Fat mass - Waist circumference (DM) Biochemical: - Total, LDL, and HDL cholesterol - Triglycerides - Fasting glucose - Insulin - Insulin resistance (HOMA-IR) - HbA1c - Gamma-glutamyl transferase	**IG1 (NW) adherence:** 64% **Drop-outs:** 29 **Significant differences (p < .05):** Intragroup (pre vs post) ↓ Oxygen radical absorbance capacity: CG ↓ Metabolic syndrome score: IG1; IG2 ↓ Atherogenic index of plasma: IG1 Intergroup (pre vs post) ↓ Weight: IG1 > IG2 and CG ↓ BMI: IG1 > IG2 and CG

	CG: No exercise program. Advised about the health benefits of exercise during first assessment.	- Fatty liver index - Chemerin - Leptin - Adiponectin - Interleukin-6 - High-sensitivity CRP - Tumor necrosis factor alpha - Retinol-binding protein 4 - Uric acid <u>Diet:</u> - Caloric expenditure - Proteins - Fats - Saturated fats - Carbohydrates - Fiber - Alcohol <u>Physical fitness:</u> - Systolic and diastolic blood pressure - UKK fitness index ***Venojärvi et al. 2013b*** <u>Anthropometric:</u> - BMI (DM of height and weight) <u>Biochemical:</u> - HDL cholesterol - Triglycerides - Oxygen radical absorbance capacity - Atherogenic index of plasma - Adiponectin - Lipid hydropseroxides - Malondialdehyde - Osteoprotegerin - Osteopontin <u>Self-reported:</u> - SPEA (questionnaire) - LTPA (questionnaire) <u>Global health status:</u> - Metabolic syndrome score ***Korkmaz et al. 2018*** <u>Anthropometric:</u> - Fat free mass <u>Biochemical:</u> - HbA1c - Insulin - Adiponectin		↓ Fat mass: IG1 > IG2 and CG ↓ LDL cholesterol: IG1 > IG2 ↓ Total cholesterol: IG1 > IG2 ↓ Fatty liver index: IG1 > IG2 ↓ Chemerin: IG1 and IG2 > CG ↓ Leptin: IG1 > CG ↑ Interleukin-6: IG1 > CG ↑ UKK fitness index: IG1 > CG ↑ Plasma irisin: IG1 > CG ↑ SPEA volume: IG1 > IG2 ↑ SPEA intensity: IG1 > IG2 ↑ LTPA volume: IG1 > IG2; CG > IG1 ↑ LTPA intensity: IG1 > IG2 > CG ↑ LTPA frequency: IG2 > CG; CG > IG1

			- Malondialdehyde - Oxygen radical absorbance capacity - Atherogenic index of plasma - McAuley index - Chemerin - Plasma irisin Physical fitness: - METpeak Global health status: - Metabolic syndrome score ***Wasenius et al. 2014a*** Anthropometric: - BMI (DM of height and weight) - Fat mass - Waist circumference (DM) Physical fitness: - VO_2 peak (exercise test and ergometer) Self-reported: - SPEA volume, intensity, and frequency (questionnaire) - LTPA volume, intensity, and frequency (questionnaire)	
Wasenius, 2014	**Sample size (n pre/post; sex):** 23/23; 23 men **Distribution; age (mean ± SD):** IG1: n = 8; 56.6 ± 8.3 IG2: n = 7; 55.0 ± 6.9 CG: n = 8; 58.1 ± 5.1 **BMI (kg/m^2; mean ± SD):** IG1: 29.9 ± 3.5 IG2: 33.3 ± 1.2 CG: 27.6 ± 2.4	**Design:** RCT **Duration:** 12 weeks **IG1:** Three 60-minute sessions per week of supervised NW (55% MHR during weeks 1-4, 65% MHR during weeks 6-8, and 75% MHR during weeks 9-12). **IG2:** Three 60-minute sessions per week of supervised resistance training (50-85% maximal strength according to five-repetition maximum test). **CG:** No exercise program. Advised about the health benefits of exercise during first assessment.	***Wasenius et al. 2014b*** Anthropometric: - Weight (DM) - BMI (DM of height and weight) - Fat mass Physical fitness: - VO_2 peak (exercise test and ergometer) Self-reported: - Total PA volume and intensity (questionnaire) - LTPA volume and intensity (questionnaire)	**IG1 (NW) adherence:** 65% **Drop-outs:** None **Significant differences (p < .05):** Intragroup (pre vs post) ↑ LTPA volume: IG1 ↓ LTPA volume: IG2; CG Intergroup (pre vs post) ↑ LTPA volume: IG1 > CG

BMI: Body mass index. **CG:** Control group. **DM:** Direct measurement. **HbA1c:** Glycosylated hemoglobin A1c. **HDL:** High-density lipoprotein. **HOMA-IR**: Homeostasis model assessment of insulin resistance. **IG**: Intervention group. **LDL:** Low-density lipoprotein. **LTPA:** Leisure-time physical activity. **MHR:** Maximum heart rate. **NR:** Not reported. **NW:** Nordic walking. **PA:** Physical activity. **RCT:** Randomized controlled trial. **SPEA:** Structured physical exercise activity. **VO_2 max:** Maximal oxygen uptake. **VO_2 peak:** Peak oxygen uptake.

Supplementary file 2

Studies and variables	Group	SMD	95% CI Lower Limit	95% CI Upper Limit	Weight (%)	I^2 Heterogeneity
HDL cholesterol						
Fritz, 2013	IG1	-0.06	-0.44	0.32	25.13	0.0% p = 0.499
Fritz, 2013	IG2	0.13	-0.61	0.88	6.62	
Fritz, 2013	IG3	-0.02	-0.64	0.60	9.49	
Kucio, 2017	IG	-0.32	-1.04	0.40	7.01	
Venojarvi, 2013	IG	0.00	-0.44	0.44	18.50	
Wiklund, 2014	IG	0.28	-0.17	0.726	18.31	
Gram, 2010	IG	0.23	-0.37	0.819	10.36	
Sentinelli, 2014	IG	0.48	-0.41	1.375	4.58	
	I-V pooled SMD	0.07	-0.12	0.26	100.00	
	D+L pooled SMD	0.07	-0.12	0.26	100.00	
LDL cholesterol						
Fritz, 2013	IG1	-0.06	-0.44	0.32	27.01	87.8% p < 0.001
Fritz, 2013	IG2	0.04	-0.70	0.79	7.14	
Fritz, 2013	IG3	-0.06	-0.68	0.56	10.19	
Kucio, 2017	IG	-0.18	-0.90	0.53	7.61	
Venojarvi, 2013	IG	-1.98	-2.53	-1.43	13.11	
Wiklund, 2014	IG	0.71	0.25	1.17	18.66	
Gram, 2010	IG	0.06	-0.53	0.65	11.21	
Sentinelli, 2014	IG	-0.17	-1.04	0.71	5.08	
	I-V pooled SMD	-0.16	-0.36	0.03	100.00	
	D+L pooled SMD	-0.205	-0.79	0.38	100.00	
Total cholesterol						
Fritz, 2013	IG1	-0.05	-0.43	0.33	25.89	

Fritz, 2013	IG2		0.05	-0.69	0.79	6.84	
Fritz, 2013	IG3		-0.14	-0.76	0.49	9.75	
Kucio, 2017	IG		-0.38	-1.10	0.35	7.18	
Venojarvi, 2013	IG		-1.25	-1.74	-0.77	15.79	
Wiklund, 2014	IG		0.13	-0.31	0.58	19.01	70.6% p = 0.001
Gram, 2010	IG		0.56	-0.33	0.852	10.65	
Sentinelli, 2014	IG		0.00	-0.88	0.877	4.89	
		I-V pooled SMD	-0.19	-0.39	-0.01	100.00	
		D+L pooled SMD	-0.18	-0.56	0.19	100.00	
Triglycerides							
Fritz, 2013	IG1		-0.10	-0.48	0.29	29.34	75.9% p < 0.001
Fritz, 2013	IG2		-0.07	-0.82	0.67	7.75	
Fritz, 2013	IG3		-0.17	-0.79	0.45	11.04	
Kucio, 2017	IG		-0.54	-1.27	0.19	7.98	
Venojarvi, 2013	IG		-1.49	-1.99	-0.98	16.75	
Wiklund, 2014	IG		0.00	-0.44	0.44	21.62	
Sentinelli, 2014	IG		-0.16	-1.03	0.72	5.52	
		I-V pooled SMD	-0.35	-0.56	-0.15	100.00	
		D+L pooled SMD	-0.37	-0.81	0.08	100.00	
Systolic BP							
Fritz, 2013	IG1		0.16	-0.22	0.54	32.86	21.1% p = 0.275
Fritz, 2013	IG2		-0.04	-0.78	0.70	8.71	
Fritz, 2013	IG3		-0.02	-0.64	0.60	12.44	
Kucio, 2017	IG		-0.35	-1.07	0.38	9.17	
Venojarvi, 2013	IG		-0.53	-0.98	-0.08	23.40	
Gram, 2010	IG		-0.38	-0.98	0.21	13.42	
		I-V pooled SMD	-0.16	-0.38	0.06	100.00	

		D+L pooled SMD	-0.17	-0.43	0.08	100.00	
Diastolic BP						
Fritz, 2013	IG1	0.14	-0.24	0.52	32.86	15.8% p = 0.313
Fritz, 2013	IG2	0.18	-0.56	0.92	8.66	
Fritz, 2013	IG3	-0.13	-0.75	0.49	12.40	
Kucio, 2017	IG	-0.38	-1.11	0.34	9.13	
Venojarvi, 2013	IG	-0.48	-0.93	-0.03	23.52	
Gram, 2010	IG	-0.37	-0.96	0.23	13.42	
	I-V pooled SMD	-0.15	-0.37	0.07	100.00	
	D+L pooled SMD	-0.16	-0.40	0.08	100.00	
Fasting plasma glucose*						
Wiklund, 2014	IG	-0.81	-1.28	-0.35	21.00	35.5% p = 0.170
Fritz, 2013	IG1	-0.22	-0.60	0.16	30.83	
Fritz, 2013	IG2	0.00	-0.74	0.74	8.19	
Fritz, 2013	IG3	-0.24	-0.86	0.38	11.61	
Venojarvi, 2013	IG	0.00	-0.44	0.44	22.83	
Sentinelli, 2014	IG	-0.60	-1.50	0.30	5.54	
	I-V pooled SMD	-0.30	-0.51	-0.09	100.00	
	D+L pooled SMD	-0.30	-0.58	-0.03	100.00	
HOMA-IR						
Fritz, 2013	IG1	-0.19	-0.57	0.19	34.14	83.9% p < 0.001
Fritz, 2013	IG2	-0.03	-0.77	0.71	9.06	
Fritz, 2013	IG3	0.42	-0.21	1.05	12.63	
Venojarvi, 2013	IG	-1.40	-1.90	-0.90	20.06	
Wiklund, 2014	IG	-0.60	-1.06	-0.15	24.10	
	I-V pooled SMD	-0.44	-0.66	-0.22	100.00	

		D+L pooled SMD	-0.38	-0.96	0.19	100.00	
HbA1c						
Fritz, 2013	IG1	0.00	-0.38	0.38	33.78	0% p = 0.782
Fritz, 2013	IG2	-0.31	-1.05	0.44	8.80	
Fritz, 2013	IG3	-0.38	-1.01	0.24	12.49	
Korkmaz, 2018	IG	0.00	-0.44	0.44	24.86	
Gram, 2010	IG	-0.41	-1.01	0.19	13.71	
Sentinelli, 2014	IG	-0.09	-0.97	0.78	6.36	
	I-V pooled SMD	-0.09	-0.36	0.084	100.00	
	D+L pooled SMD	-0.09	-0.36	0.084	100.00	
Weight						
Fritz, 2013	IG1	-0.20	-0.58	0.18	26.86	0.0% p = 0.992
Fritz, 2013	IG2	-0.05	-0.79	0.70	7.13	
Fritz, 2013	IG3	-0.10	-0.73	0.52	10.17	
Venojarvi, 2013	IG	-0.27	-0.72	0.18	19.68	
Wiklund, 2014	IG	-0.02	-0.47	0.42	19.87	
Gram, 2010	IG	-0.06	-0.65	0.53	11.20	
Sentinelli, 2014	IG	-0.14	-1.02	0.74	5.08	
	I-V pooled SMD	-0.14	-0.34	0.06	100.00	
	D+L pooled SMD	-0.14	-0.34	0.06	100.00	
Abdominal adiposity*						
Fritz, 2013	IG1	-0.57	-0.96	-0.18	27.65	0.0% p = 0.767
Fritz, 2013	IG2	-0.30	-1.05	0.44	7.51	
Fritz, 2013	IG3	-0.17	-0.79	0.45	10.83	
Venojarvi, 2013	IG	-0.26	-0.71	0.18	21.01	
Gram, 2010	IG	-0.25	-0.84	0.34	11.86	

Wiklund, 2014	IG		-0.14	-0.58	0.31	21.15	
		I-V pooled SMD	-0.31	-0.51	-0.11	100.00	
		D+L pooled SMD	-0.31	-0.51	-0.11	100.00	
BMI							
Fritz, 2013	IG1		-0.28	-0.66	0.11	30.45	0.0% p = 0.992
Fritz, 2013	IG2		-0.03	-0.77	0.72	8.12	
Fritz, 2013	IG3		-0.11	-0.73	0.52	11.59	
Kucio, 2017	IG		-0.08	-0.8	0.63	8.70	
Wiklund, 2014	IG		-0.05	-0.49	0.40	22.62	
Gram, 2010	IG		-0.13	-0.72	0.47	12.74	
Sentinelli, 2014	IG		-0.13	-1.005	0.75	5.79	
		I-V pooled SMD	-0.14	-0.35	0.07	100.00	
		D+L pooled SMD	-0.14	-0.35	0.07	100.00	
Body fat*							
Venojarvi, 2013	IG		-0.41	-0.86	0.03	36.74	59.7% p = 0.059
Wiklund, 2014	IG		-1.08	-1.55	-0.60	32.57	
Gram, 2010	IG		-0.19	-0.79	0.40	21.08	
Sentinelli, 2014	IG		-0.11	-0.99	0.77	9.61	
		I-V pooled SMD	-0.55	-0.83	-0.28	100.00	
		D+L pooled SMD	-0.50	-0.95	-0.05	100.00	
Fat free mass							
Venojarvi, 2013	IG		0.01	-0.43	0.45	35.57	0.0% p = 0.828
Wiklund, 2014	IG		-0.06	-0.50	0.39	35.55	
Gram, 2010	IG		-0.06	-0.65	0.53	20.05	
Sentinelli, 2014	IG		-0.46	-1.36	0.43	8.82	
		I-V pooled SMD	-0.07	-0.33	0.20	100.00	
		D+L pooled SMD	-0.07	-0.33	0.20	100.00	

*****Significant results taking into account the I-squared heterogeneity and the model. **BMI:** Body mass index. **BP:** Blood pressure. **CI:** Confidence interval. **D+L:** Random effects model. **HbA1c:** Glycosylated hemoglobin A1c. **HDL:** High-density lipoprotein. **HOMA-IR:** Homeostasis model assessment of insulin resistance. **I-V:** Fixed effects model. **LDL:** Low-density lipoprotein. **SMD:** Standardized mean difference.