Original Article

Therapeutic Treatment for Abdominal Obesity in Adults

A Meta-Analysis and Systematic Review of Randomized Controlled Trials

Dorothea Kesztyüs, Julia Erhardt, Dorothee Schönsteiner, Tibor Kesztyüs

Summary

Background: Abdominal obesity, an accumulation of fat in the abdominal region, is a risk factor for several non-communicable diseases. This review aims to identify non-surgical treatment options for abdominal obesity in adults. Interventions with behavioral, dietary, physical activity, or pharmaceutical components were compared to control conditions.

Methods: A systematic literature research for randomized controlled trials was conducted in Medline, Embase, and the Cochrane Central Register of Controlled Trials according to a prespecified and registered protocol (PROSPERO CRD42017057898).

Results: Out of 2954 articles, 15 studies with 2918 participants remained after applying inclusion and exclusion criteria. Altogether the programs achieved a -2.65cm (95% confidence interval (CI) $[-3.77, -1.53]$) reduction in waist circumference (WC), as a measure of abdominal obesity. Eight behavioral interventions reduced WC by -1.88cm (95% CI $[-2.55, -1.22]$), and six combined interventions with behavioral plus dietary and/or physical activity components by -4.11cm (95% CI $[-6.17, -2.05]$). The only pharmaceutical trial did not find any effect on WC.

Conclusion: Overall, the identified interventions showed a moderate effect on WC. One reason may be that in most studies WC was a secondary outcome parameter, while only a small number of interventions primarily targeted abdominal obesity. Further research regarding the treatment of abdominal obesity is urgently needed.

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The World Health Organization (WHO) defines obesity as abnormal or excessive fat accumulation that may impair health (1). Furthermore, obesity is the visible sign of a metabolic disturbance caused by excessive intake of highly processed foods loaded with sugar of any kind and fat in an unhealthy ratio of omega 6 to omega 3 fatty acids (2). Thus, especially abdominal obesity (AO) is strongly linked to most of the non-communicable diseases (NCD) identified by the WHO to be the main types (3), in particular the following four:

- Cardiovascular diseases (4),
- diabetes (5),
- cancer (6) and
- chronic respiratory diseases (7).

The highest relative mortality risk was detected for the combination of low BMI with high waist circumference (WC) or waist-to-hip ratio (WHR) (8). Although not recognized by many physicians and even less patients (9), AO represents the high risk form of obesity (10). Hence, the identification of effective therapies for AO is of importance to counter the rise in prevalence of both AO and correlated NCDs.

Prevalence and measurement

There exist several measuring methods for assessing AO. The most conventional one is measuring WC and evaluating it in combination with sex-specific cutoffs, most widespread are 80cm for women and 94cm for men (11). A more recent measure is waist-to-height ratio which takes variations in height into account and offers one threshold (0.5) for all (12), yet some researchers propose to apply a threshold of 0.6 for the elderly.

A nationally representative sample of German adults (18–79 years, $n=7013$) from 1998 revealed abdominal obesity ($\text{WC} \geq 94/80\text{ cm}$) in 58.1% of the male and 59.7% of the female participants (13). More recent data assessed throughout the German federal state of Baden-Württemberg in 2010 show a high prevalence of AO in primary schoolchildren and their parents (24–68 years, $n=1659$) with 75% of fathers and 47% of mothers being abdominally obese (waist-to-height ratio (WHtR) ≥ 0.5) (14).

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TABLE 1

PICO formula

Population	Adults with abdominal obesity, overweight or obesity (BMI ≥ 25)
Intervention	Therapeutic interventions for abdominal obesity (excluding surgery) including behavioral, dietary, physical activity, pharmacological and combined approaches
Comparison	Usual care, no intervention, intervention with alternative components without influence on the outcome parameter (e.g. general health information), placebo plus the same regimen as the intervention group for pharmaceutical interventions
Outcome	Changes in measures of abdominal obesity (WC, WHtR, WHR, visceral adipose tissue [VAT]), treatment harms: any kind of adverse events
Study design	Randomized controlled trials (RCTs)

PICO, „Participants, Interventions, Comparisons and Outcomes“; BMI, Body-mass-Index; WC, „waist circumference“; WHtR, „waist-to-height ratio“; WHR, „waist-to-hip ratio“

The treatment of AO may help to improve public health and save resources. The influence of exercise on abdominal fat has already been systematically reviewed (15, 16), but no systematic review for lifestyle and pharmaceutical interventions could be found in relevant databases. Therefore, the aim of this systematic review is firstly to identify therapeutic options for AO and secondly to establish a basis for further research into specific therapies. The formula depicted in *Table 1* was defined according to the “Participants, Interventions, Comparisons and Outcomes (PICO)” framework (17)

Methods

The protocol of this review was registered in advance at the International prospective register of systematic reviews PROSPERO (<https://www.crd.york.ac.uk/PROSPERO/>, registration number CRD42017057898).

Databases

Medline, Embase and the Cochrane Central Register of Controlled Trials (CENTRAL) were systematically searched for RCTs published between January 1990 and January 2017. The search strategy for Medline is illustrated in the *eBox*. This strategy was adapted for Embase and the CENTRAL. References were stored in the web-based reference management software package RefWorks (ProQuest LCC, Ann Arbor, MI, USA), and duplicates were eliminated program-controlled.

TABLE 2

Inclusion and exclusion criteria for RCTs on therapeutic options for abdominal obesity in adults

	Inclusion	Exclusion
Population	Adults (18+ years) Abdominal obese, overweight or obese (BMI ≥ 25)	Children
		Morbid obesity (BMI ≥ 40)
		Pregnancy
		Overweight/obese due to disease (e.g. Hypothyreosis) or medication (e.g. Cortisone)
		Cancer, eating disorder, psychiatric condition or medication, HIV, diseases of the musculoskeletal system (e.g. Parkinson, MS)
Intervention	Behavioral, dietary, physical activity, pharmacological (e.g. Orlistat, Metformin) and combined interventions	Institutionalized (hospital, retirement home)
		Surgical interventions (bariatric surgery)
Control	No intervention, usual care, placebo, interventions without influence on outcome variables (e.g. general health information)	Dietary supplements
Outcome	Changes in measures of abdominal obesity: WC, WHtR, WHR, VAT	Control condition with any suspected influence on abdominal fat accumulation
Study design	Randomized controlled trials (RCT)	
	Duration of intervention at least 3 months (12 weeks)	
	Total time of observation at least 12 months	
Publication	English or German language	Conference abstracts

BMI, Body mass index; MS, multiple sclerosis; VAT, visceral adipose tissue; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio

Study selection, data extraction and risk of bias

Two researchers (JE, DS) independently screened titles and abstracts of retrieved articles according to the pre-specified inclusion and exclusion criteria as depicted in *Table 2*, and removed further duplicates. Discrepancies were solved by a third researcher (DK). The same procedure was applied when screening the full texts.

The data was extracted and sorted into predefined tables that had been developed as a team effort by all participating researchers. All entries were then checked by a second researcher. Extracted data included basic information on

- the study details,
- the characteristics of the participants,
- the description of the intervention and control condition, and
- the numbers of participants in each group as well as
- information on drop outs and, finally,
- data with regard to outcome measures, results and adverse events.

Missing information was taken from study protocols or other publications that were referenced in the text, whenever possible. The principal outcome measure was the mean difference in longitudinal changes in WC between intervention and control group. Where possible, data from a 12 months observation period, independent of the length of the intervention, was used in the meta-analysis.

Risk of bias of the included RCTs was determined using the Cochrane Collaboration's tool for assessing risk of bias (18). Again, two researchers independently evaluated the risk of bias and conflicts were solved in discussion with a third researcher. To evaluate a publication bias, a funnel plot was generated, and a rank correlation test for asymmetry conducted.

Analysis

The meta-analysis was conducted applying the statistical software package R Release 3.2.3 for Windows (<http://cran.r-project.org>). Differences between intervention and control groups regarding changes in WC from baseline to a 12 month follow-up were analyzed. For multi-arm trials the number of controls was equally divided. For those studies reporting data for men and women, sex-specific analyses were conducted. Additionally, the magnitude of the correlation of weight loss in kilogram and reduction in WC was tested utilizing the Pearson correlation coefficient.

Random effect models were applied to account for differences between studies. Group size, length and type of intervention were tested in mixed effects meta-regression as moderator variables. Pooled mean differences were calculated based on raw mean differences in WC in centimeters and are reported as inverse-variance weighted averages with 95% confidence intervals (CI). To quantify heterogeneity the I^2 statistic was calculated and Cochran's Q-test was applied. Sensitivity analysis was performed by leaving out studies with extreme results.

FIGURE 1

PRISMA flow diagram of study selection
CENTRAL, Cochrane Central Register of Controlled Trials

Results

The systematic search returned 2954 records from three medical databases. Within RefWorks 1477 citations were identified as non-duplicates and were subsequently screened applying the predefined inclusion/exclusion criteria. 262 articles were retrieved for the full text screening after which 19 articles remained, reporting 15 trials. *Figure 1* shows the PRISMA flow diagram of study selection.

Study characteristics

The RCTs were conducted between 2001 and 2011, if specified. There were two trials from the USA and Canada, one from Australia and 12 from Europe. Eight out of 15 trials conducted a behavioral therapy intervention, six an intervention combining behavioral change strategies with a specific diet and/or physical activity program and one a pharmacological intervention. Three studies included more than one intervention group testing different types of intervention. All interventions, except for three, were described as “lifestyle intervention” and incorporated recommendations on diet and physical activity. One of these studies examined the effects of diet and physical activity each separately and combined (e1). The comparator in nine studies was usual care or no intervention, two control groups received a delayed intervention, three investigators provided self-help

FIGURE 2

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Burke et al. 2005 (e5)	+	?	?	?	-	?	-
Clark et al. 2004 (e2)	+	?	-	?	+	+	?
Dekkers et al. 2011 (e11)	+	+	-	?	-	+	-
Ferré et al. 2012 (e12)	?	-	-	-	-	-	-
Foster-Schubert et al. 2012 (e1)	+	?	+	+	+	+	?
Franco et al. 2005 (e8)	+	?	+	+	?	?	?
Gomez-Huelgas et al. 2015 (e9)	?	?	?	?	-	+	-
Haapala et al. 2009 (e13)	+	?	?	?	+	+	-
Nanchahal et al. 2012 (e4)	+	?	?	+	?	?	?
Puhkala et al. 2015 (e14)	+	+	?	?	?	?	+
Ross et al. 2012 (e6)	+	?	?	?	+	+	+
ter Bogt et al. 2011 (e7)	+	-	-	-	+	?	-
Tuomilehto et al. 2009 (e10)	+	?	?	+	?	+	-
van Dyck et al. 2013 (e3)	?	?	?	?	+	?	-
Yates et al. 2009 (e15)	+	?	?	+	-	?	?

Overview of the risk of bias

“+”, low risk; “-”, high risk; “?”, unclear risk

materials or general recommendations, and the pharmacological intervention was placebo-controlled.

The number of study participants varied between 34 and 439 per study, in sum, 2918 datasets were included in the meta-analysis. The duration of intervention varied between three months and three years with a median duration of 12 months. Measurement data at 12 months were available from 13 studies. For one study, data were available from a 6 months measurement only, and for another study, we had to use data from a 3 year measurement. Seven studies reported baseline and follow-up values, eight studies reported follow-up change scores for intervention and control group. Most studies were conducted in a university hospital or a general practitioner setting. WC in centimeters was measured in all studies and was primary or secondary outcome in eight studies. More details are found in the *eTable*.

Risk of bias and completion rates

Published study protocols, where available, were taken into account to assess the risk of bias. All studies were randomized but blinding of participants and personnel was only partly possible. Some studies reported significant baseline differences. Only one study reached an overall low risk of bias (e1), all others were at high risk or unclear risk. An overview of the risk of bias in individual studies is depicted in *Figure 2*. A funnel plot is illustrated in the *eFigure*. The rank correlation test showed no significant asymmetry (Kendall’s tau=0.123, p=0.489).

Completion rates varied considerably between 48% and 100%. Most studies performed complete case analyses, four studies followed an intention-to-treat principle (e1–e4).

Meta-analysis

Altogether the programs achieved a -2.65cm (95% CI $[-3.77; -1.53]$) reduction in waist circumference (WC). Results of the random-effects meta-analysis for all interventions are depicted in *Figure 3*. Leaving out the sole pharmaceutical intervention leads to a slightly higher overall effect (-2.78 $[-3.92; -1.63]$). Participants in behavioral change programs reduced their WC on average by -1.88 cm $[-2.55; -1.22]$, those in a combined program lost in mean -4.11cm $[-6.17; -2.05]$. Meta-regression revealed a significant difference of -2.39cm between both types of programs (p=0.024), favoring a combined approach. When leaving out the study with the greatest effect the difference became smaller (-1.74 $[-3.59; 0.12]$) and lost its significance. Three studies (e5–e7) reported sub-group analysis by gender (n=1035). Male participants lost a mean of -2.61 cm WC $[-4.38; -0.83]$, female participants reduced their WC on average by -1.63cm $[-2.76; -0.49]$. Finally, weight loss in kilogram and reduction in WC were strongly correlated ($r[16]=0.95$, p<0.001).

Adverse events

Only six studies provided information on adverse events. Clark et al. reported three deaths during the study period, one in the intervention and two in the control group (e2). The growth hormone intervention caused side effects related to fluid retention in mild to moderate severity (e8). Gomez-Huelgas et al. indicate that during three years of study duration 15 participants died and 7 were disabled, but there is no information given regarding their respective group (e9). Ross et al. reported numbers of musculoskeletal events during or after exercise and potential cardiovascular events without differences between intervention and usual care (e6). Ter Bogt et al. lost four participants in the intervention and six in the usual care group because of disease/death (e7). Tuomilehto et al. lost two intervention participants because of intolerance of the meal replacement products used in the weight reduction program (e10).

FIGURE 3

Forest plot of raw means of differences in change scores between intervention and control groups of included studies.
95%-CI, 95% confidence interval; Q, Cochran's Q-test; I², I² statistic; df, degrees of freedom

Discussion

Initially, the conduction of a meta-analysis was not planned in the protocol because of considerable doubt that a consistent summary measure would be found, due to various possibilities of measuring and defining abdominal obesity (19). However, all included studies provided data on WC and therefore a meta-analysis was added. Results showed superiority for approaches combining behavioral counseling with either a diet or exercise program or both. Though, heterogeneity was considerable between combined interventions. The most successful intervention with regard to WC was a lifestyle intervention with a very low calorie diet (e10). The sole pharmaceutical intervention applying a growth hormone treatment did not show any changes in WC, but reported a reduction in visceral adipose tissue, measured with computed tomography scans (e8). This result also indicates a limitation of the use of WC as a proxy for visceral fat. Nonetheless, its use is strongly recommended and of vital importance for the estimation of cardiovascular risk (20).

The overall effect was only moderate with -2.65cm [-3.77; -1.53], representing a 2.5% reduction from a 102.7 cm average baseline value. However, the meta-regression confirmed the superiority of combined interventions over behavioral counseling alone. From six combined interventions four choose a physical activity (PA) component, one a very low calorie diet and one tested diet and PA separately as well as combined, with the combination showing the best result. Basically, continuing exercise training may help to maintain the results and prevent the regain of abdominal fat (21).

The overall effect was also small compared to a loss in WC of 4.4 cm which were associated with a 58% reduction in the incidence of type 2 diabetes mellitus (T2DM) in a prevention study (22). In obese Japanese men at least 3 cm reduction of WC was needed for improving metabolic syndrome (MetS) (23). One possible reason for the restricted effectiveness is that in most studies WC was a secondary outcome parameter, while only a small number of

Key messages

- Abdominal obesity is an underestimated health risk
- Therapies for abdominal obesity need not necessarily aim at or lead to weight loss but a reduction in waist circumference
- Interventions combining behavioral counseling with diet and/or physical activity are superior to behavioral counseling alone
- Post-interventional reductions in waist circumference were more pronounced in males than in females
- More research of effective therapies for abdominal obesity is urgently needed

interventions primarily targeted abdominal obesity. The result of this review is also sobering in the light of the urgent need to prevent non-communicable diseases (NCD), the main cause of morbidity and mortality in the world (24).

WC is an obligatory part of the definition of the metabolic syndrome by the International Diabetes Federation (13) and the main determinant of elevated C-reactive protein in patients with metabolic syndrome (25). MetS itself is a cluster of risk factors of cardiovascular disease (CVD) with an estimated prevalence of 20–25% of the world's adult population, bringing about a new CVD epidemic (13). The close relationship between MetS and T2DM is self-evident as well as the worldwide rise in the incidence and prevalence of both (13). Hence, the reduction of WC or even better, visceral adipose tissue, is a promising preventive measure for CVD, and T2DM, and possibly further NCDs. The American Heart Association criticizes that “WC measurements have not been well adopted in clinical practice” despite WC being “a simple and inexpensive tool for assessing body fat distribution” (26).

Strengths and Limitations

This review was, except for the meta-analysis, conducted according to a registered protocol and is, as far as applicable, reported following the PRISMA statement.

Results have to be treated with caution due to considerable heterogeneity and risk of bias in the included RCTs. Differences in components and contents, duration, intensity, completion rates and adherence to the intervention are among others causes of heterogeneity. The preference of complete-case-analysis over the intention-to-treat approach may also have influenced the results.

Conclusion

Presumably there is no sustainable intervention for AO but a permanent change of lifestyle habits with preventive ability for major NCDs, as proposed by several authors (2, 27, 28). Since losing weight is not obliga-

tory to reduce abdominal fat (16, 29), new strategies that might even be better acceptable for patients need to be developed, easing the pressure of inevitable weight loss. Especially those with greater visceral fat mass might benefit from any intervention because visceral fat seems to be broken down preferentially compared to general body fat (30). More specific research in the treatment of abdominal obesity is urgently needed.

Conflict of interest statement

The authors declare that no conflict of interest exists.

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► Supplementary material

For eReferences please refer to:
www.aerzteblatt-international.de/ref2918

eFigures, eBox, eTable:
www.aerzteblatt-international.de/18m0487

Supplementary material to:

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eFIGURE

Funnel plot of the observed outcome in the random effects model

eBOX

Search strategy in Medline (Ovid)

- 1 exp Obesity, Abdominal
- 2 Sagittal Abdominal Diameter/ or Waist Circumference/ or Waist-Height Ratio/ or Abdominal Fat/ or Waist-Hip Ratio/ or Subcutaneous Fat, Abdominal/
- 3 (waist\$ or ((abdominal\$ or central\$ or visceral\$) adj obes\$)).mp.
- 4 or/1-3
- 5 Diet Therapy/ or Exercise Therapy/ or Behavior Therapy/ or Counselling/ or Anti-Obesity Agents/ or Life Style/
- 6 Obesity, Abdominal/dt, dh, th
- 7 Obesity/dt, dh, th
- 8 Metabolic Syndrome X/dt, dh, th
- 9 or/5-8
- 10 ((lifestyle or nutrition or diet\$ or weight\$ or exercise\$ or physical activity) adj3 (program\$ or counsel\$ or education\$ or intervention\$ or therapy or trial or study)).ti,ab.
- 11 9 or 10
- 12 4 and 11
- 13 bariatric surgery/ or Obesity, Morbid/ or Pregnancy/ or Child/ or Dietary Supplements/
- 14 12 not 13
- 15 limit 14 to randomized controlled trial
- 16 (random\$ adj ((control\$ or clinic\$) adj trial\$)).ti,ab.
- 17 14 and 16
- 18 15 or 17
- 19 limit 18 to (evidence based medicine reviews or „article reviews (acp journal club)“ or „review articles“ or „article reviews (dare)“ or „topic reviews (cochrane)“)
- 20 18 not 19
- 21 limit 20 to (human and „all adult (19 plus years)“)

eTABLE

Main characteristics of the included studies

Author, name of program	Country, ethnicity, year of recruitment/trial	Setting	Participants	Duration, intervention, follow-up	Intervention	Control	Primary outcome	WC [cm] baseline, m (sd), raw mean difference of change score, m (se)	Completion rate* [%]
Burke et al., 2005 The Activity, Diet and Blood Pressure Trial (ADAPT) (e5)	Australia, no year stated	Research studies unit	Overweight hypertensive patients aged 40–70	4 months, 16 months follow-up	Lifestyle, nutrition, PA, weight loss (n=123)	Usual care, information material (n=118)	Anti-hypertensive drug requirements, ABP, WC	IG: 96.6 (9.98) CG: 93.7 (9.78) –3.1 (1.35)	IG: 82.9 CG: 76.3
Clark et al., 2004 (e2)	United Kingdom, no year stated	UK national Health Service diabetes center	T2DM patients aged 40–70	3 months, 12 months follow-up	Tailored lifestyle self-management (n=50)	Usual care (n=50)	Dietary behavior, PA, BMI, WC	IG: 104.2 (10.46) CG: 101.3 (11.44) –3.87 (2.14)	IG: 96 CG: 92
Dekkers et al., 2011 (e1) ALIFE@Work	Netherlands, 2004–2006	Different companies	Healthy overweight employees	6 months, 24 months follow-up	Lifestyle, behavior counseling by phone (n=91) or e-mail (n=93)	Self-help materials (n=92)	Body weight, BMI, diet, PA, secondary outcome WC	Phone: 99.9 (10.2) E-mail: 102.9 (11.1) CG: 101.7 (8.5) Phone: –1.1 (2.04) E-mail: –1.0 (1.94)	Phone: 48.4 E-mail: 51.6 CG: 53.3
Ferré et al., 2012 (e12)	Spain, no year stated	University hospital	Patients with AO and moderate CV risk, aged 30–75	1 year intervention	Therapeutic lifestyle changes, PA program (n=60)	Conventional medical care (n=82)	Not explicitly stated, PAT ratio, WC	IG: 104.8 (8.9) CG: 106.0 (8.7) –1.10 (1.690)	IG: 88.2 CG: 100
Foster-Schubert et al., 2012 Nutrition and Exercise in Women (NEW) (e1)	United States of America, non-hispanic whites (85%) 2005–2009	Cancer research center	Overweight-to-obese sedentary post-menopausal women	1 year intervention	Lifestyle change intervention, diet (D, n=118), aerobic exercise (E, n=117), combination (DE, n=108)	Delayed intervention, advised to not change diet or exercise habits (n=87)	Change in body weight, secondary outcome WC	D: 94.6 (10.2) E: 95.1 (10.1) DE: 93.7 (9.9) CG: 94.8 (10.2) D: –5.3 (1.48) E: –2.9 (1.41) DE: –7.9 (1.47)	D: 99.0 E: 90.6 DE: 92.3 CG: 92.0
Franco et al., 2005 (e8)	Sweden, no year stated	University hospital	Abdominal obese post-menopausal women aged 50–65	12 months intervention	Growth hormone treatment (n=20)	Placebo (n=20)	Insulin sensitivity	IG: 104.0 (5.42) CG: 102.0 (6.97) 0.00 (2.44)	IG: 75 CG: 95
Van Dyck et al., 2013 (e3)	Belgium, 2007	University hospital	T2DM patients aged 35–75	24 weeks, 1 year follow-up	Behavioral and PA intervention (n=60)	Usual care (n=32)	PA and sedentary behavior	IG: 1.05 (9.0) CG: 1.04 (11.0) –1.0 (2.09)	IG: 98 CG: 97
Gomez-Huelgas et al., 2015 (e9)	Spain, no year stated	Health center in Malaga	Persons with MetS	3 years intervention	Lifestyle intervention, recommendations on diet and daily exercise (n=298)	General health recommendations (n=303)	Changes in the mean values of components of MetS	IG: 102.1 (11.4) CG: 103.0 (11.2) –2.40 (0.63)	IG: 77.2 CG: 56.1
Haapala et al., 2009 (e13)	Finland, 2001–2002	Not stated	Healthy overweight volunteers aged 25–44	12 months intervention	Mobile phone operated weight-loss program (n=62)	No intervention (n=63)	Changes in body weight and WC	IG: 98.5 (10.3) CG: 96.6 (10.4) –2.90 (0.88)	IG: 73 CG: 63

Nanahal et al., 2017 Camden Weight Loss (CAMWEL) (e4)	United Kingdom, 2009–2011	General practices	Overweight adults	36 weeks, 12 months follow-up	Sessions with ad- visors for behavior change, healthy eating, increased PA (n=191)	Usual weight man- agement care (n=190)	Not explicitly stated, weight loss	IG: 107.6 (12.78) CG: 105.8 (13.01) –1.88 (0.95)	IG: 53.9 CG: 60.0
Puhkala et al., 2015 (e14)	Finland, no year stated	Workplace	Male truck or bus drivers aged 30–62, WC ≥ 100 cm	12 months, 24 months follow-up	Lifestyle counseling on diet, PA and sleep (n=55)	Delayed shortened intervention (n=58)	Not explicitly stated, percentage of weight loss	IG: 113.8 (9.50) CG: 114.9 (10.30) –4.6 (0.99)	IG: 85 CG: 83
Ross et al., 2012 Pre- vention and Reduction of Obesity Through Active Living (PROAC- TIVE) (e6)	Canada, 2004–2008	Family medicine clinics, primary care	Sedentary, over- weight, abdominally obese adults	2 years intervention	Lifestyle-based behavioral interven- tion, PA and diet (n=249)	Usual care (n=241)	WC, MetS	IG: 109.1 (11.05) CG: 108.0 (10.87) –1.60 (0.57)	IG: 83.1 CG: 86.3
ter Bogt et al., 2011 Groningen Overweight and Lifestyle (GOAL) (e7)	The Netherlands, 2005–2006	General practices	Overweight patients aged 40–70 with hypertension and/or dyslipidemia	3 years intervention	Lifestyle counsel- ing, PA and diet, pedometer (n=225)	Usual care (n=232)	Not explicitly stated, weight loss	IG: 104 (7.8) CG: 105 (9.5) –1.50 (0.68)	IG: 80.2 CG: 75.1
Tuomilehto et al., 2009 (e10)	Finland, 2004–2006	University hospital	Overweight adults with mild obstruc- tive sleep apnea	12 weeks, 1 year follow-up	Lifestyle interven- tion, very low calorie diet (n=40)	General dietary and exercise counseling (n=41)	Change of apnea- hypopnea index	IG: 112.5 (8.7) CG: 105.3 (8.3) –8.6 (1.49)	IG: 88 CG: 90
Yates et al., 2009 Pre- diabetes Risk Education and PA Recommendation and Encouragement (PREPARE) (e15)	United Kingdom, 2006–2008	Diabetes Research Unit	Overweight individ- uals with IG T	6 months, 12 months follow-up	Education program promoting walking IG: no pedometer (n=31) IGP: pedometer (n=33)	Usual care (n=32)	OGTT 2-hour glucose value	IG: 103 (11) IGP: 99 (12) CG: 103 (9) IG: 0.2 (2.10) IGP: 1.20 (2.11)	IG: 94 IGP: 88 CG: 85

IG, intervention group; CG, control group; m (sd), mean (standard deviation); ABP, ambulatory blood pressure; T2DM, type 2 diabetes mellitus; AO, abdominal obesity; CV, cardiovascular; PA, physical activity; PAT, peripheral artery tonometry, IG T, impaired glucose tolerance; MetS, metabolic syndrome; OGTT, oral glucose tolerance test

* If possible, for reasons of consistency, the values at 12 months were taken