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Review

Preventing weight gain through exercise and physical activity in the elderly: A systematic review

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ABSTRACT

This review examines the role of exercise and physical activity for preventing weight gain in older people. A structured search using MeSH-vocabulary and Title/Abstract-searches was conducted in PubMed for January 2000 to June 2011, identifying weight gain and exercise or physical activity as study topics, and aged adults as target group. In study selection, all types of exercise and physical activity and any measure of weight change in aged adults (≥65 years) or postmenopausal women were considered. $N = 9$ primary studies were identified. All were conducted in the US, with one study additionally including samples from Canada and the UK. Three studies focused on aged adults, while six concentrated specifically on postmenopausal women. Forms of exercise or physical activity comprised self-reported exercise history in four studies and low, moderate or high intensity exercise interventions in five studies. Four studies combined exercise with a hypocaloric diet and included comparison groups receiving either diet only, health education, stretching or a delayed intervention (one study each). Exercise was associated with weight loss (1.1–6 kg) in all intervention studies, all of which studied an overweight sample, and with weight maintenance in most observational studies, all of which studied a general population or otherwise overweight-unspecific sample. In sum, exercise and physical activity can effectively prevent weight gain in older adults and postmenopausal women either in terms of weight loss or maintenance. They can preserve lean body mass and thus are important for the balance between potentially positive and negative effects of weight reduction in later life. In addition, since all intervention studies were conducted with an overweight sample, it seems that primordial prevention (in terms of preventing the development of risk factors such as excess weight in the first place) might be a neglected issue in geriatric and postmenopausal prevention.

Contents

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1. Introduction

Traditionally, underweight and frailty represented the most important issues in geriatric nutrition. However, in recent years the prevalence of overweight has increased in all age groups including aged adults in many countries [1–4]. The proportion of older people is growing in developed countries, and more obese middle-aged persons reach older age. Thus, preventing and treating overweight in the elderly is an increasingly important and challenging task.

The prevalence of obesity increases steadily up to the age of 59 years, with a peak between 50 and 59 years. A decrease in mean body weight and body mass index (BMI) after the age of 60–70 years is only observed in cross-sectional data and might be due to survival bias, whereas longitudinal data suggest that body weight and BMI do not change or decrease only slightly in old age [5]. With ageing the proportion of fat free mass progressively decreases while relative fat mass increases (sarcopenia) and is concurrently redistributed in the abdominal area. Since sarcopenia is not necessarily depicted by BMI, waist circumference might be a more appropriate index for obesity in the elderly [6].

Although there are continuing debates on how harmful obesity is for older people, the most recent review of obesity and weight management in the elderly confirms that overweight and – particularly abdominal – obesity are associated with metabolic disorders, cardiovascular disease, arthritis, respiratory dysfunction, urinary incontinence, cancer, and impaired physical and cognitive function [7]. Endocrine changes contribute to the changes in metabolism and body composition that accompany ageing. In this context, postmenopausal women also warrant special attention. Decreased energy expenditure and decreased physical activity with ageing predispose to fat accumulation and redistribution as well as to muscle loss. For this reason, treatment and prevention of overweight in the elderly should focus on preservation of muscle mass and strength through physical activity or exercise. Against this background, this paper reviews recently published studies which have investigated the role of physical activity or exercise for preventing weight gain in older people.

Table 1
Search strategy.

	"weight gain"[mesh] OR "obesity/prevention and control"[mesh] OR "overweight/prevention and control"[mesh]
AND	"exercise"[mesh] OR "exercise"[tiab] OR "physical activity"[tiab]
AND	"aged"[mesh] OR "older adults"[tiab] OR "older people"[tiab] OR "older women"[tiab] OR "older men"[tiab] OR "elderly"[tiab] OR "elder adults"[tiab] OR "elder people"[tiab] OR "elder men"[tiab] OR "elder women"[tiab] OR "seniors"[tiab]

2. Materials and methods

2.1. Literature search and study selection

The literature search was conducted on July 22nd, 2011, in PubMed (http://www.pubmed.gov) for the print publication period of January 01st, 2000, to June 30th, 2011. The search terms used are shown in Table 1. The terms to identify both weight gain and exercise as study topics, and aged adults as the target group, combined MeSH-vocabulary and/or Title/Abstract-searches of these and related expressions. This search resulted in the identification of 324 publications (Fig. 1). Via manual search one additional paper was added, resulting in an initial list of 325 publications.

Titles and abstracts of these publications were assessed by the two authors independently by screening titles, abstracts and, if necessary, full texts. Only those studies (or parts of studies) were included to which the following criteria applied:

- study exposures include exercise or related physical activity either as observed or as (part of) an intervention, and study outcomes include change of body weight or related indicator(s) with reference to the prevention of weight gain (criterion of "relevance" in Fig. 1),
- study includes aged adults (≥65 years) and reports aged-specific analysis, or postmenopausal women in any relevant age group,
- primary study,
- longitudinal study, i.e. weight or related indicator(s) were assessed twice at least.

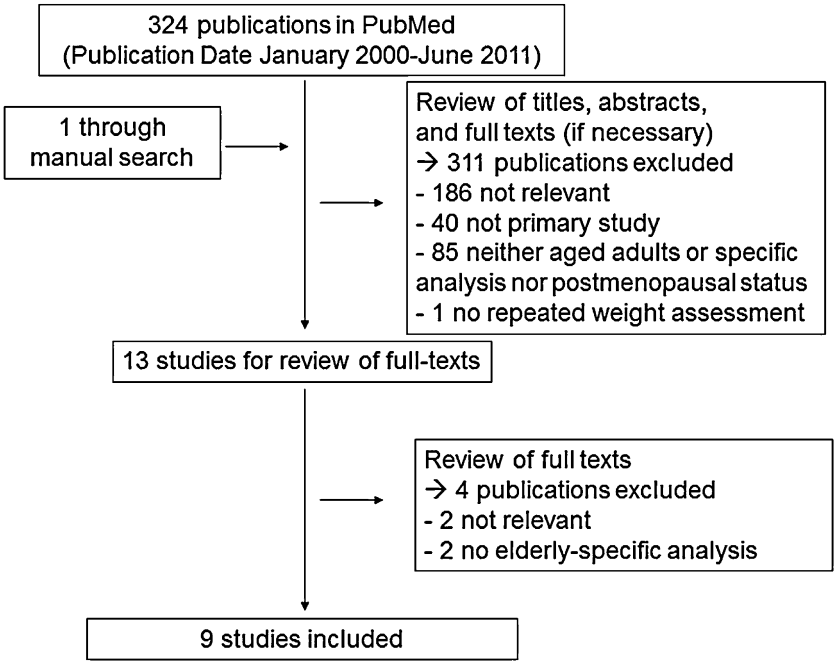

Fig. 1. Flow chart of study selection.

By these criteria, 13 studies were selected for obligatory full text review. These reviews revealed that two studies actually did not report any analysis relevant to the prevention of weight gain through exercise, and two other studies did not include any aged adults-specific analysis. Finally, this resulted in a final $N = 9$ publications included in the review.

2.2. Assessment of studies

For all 9 studies, key features and results were synthesised by the two authors independently, and differences were discussed until agreement was reached. No meta-analytic quantification of results across studies was attempted due to their methodological heterogeneity. In order to give an overview of key findings, studies with a sample of aged adults (either women or men or both) as well as postmenopausal women were categorized as indicating that exercise or physical activity tended to be associated with weight loss, weight maintenance, or weight gain. These results are presented separately for studies with overweight samples vs. general population samples or other not overweight-specific sample, in recognition of the different roles of weight loss vs. weight maintenance vs. weight gain for these subgroups. If applicable, within every publication distinguishable subanalyses (e.g. results stratified by gender) were categorized and reported. Finally, in line with WHO-classifications [8], the following body weight categories are used where appropriate: normal weight (BMI of 18.5–24.99), overweight (≥25), preobesity (25–29.99), obesity (≥25), moderate obesity (30–34.99, i.e. obesity class I), and severe obesity (≥35, i.e. obesity classes II–III).

3. Results

As shown in Table 2, three studies focused on samples of aged adults (≥65 years: AGED ADULTS) [9–11], while in six publications, specifically postmenopausal women were studied (POSTMENOPAUSAL WOMEN) [12–17]. All studies were conducted in the United States of America, with one study additionally including samples from Canada and the United Kingdom [10]. Publication dates range from January 2003 to January 2012.

The objectives of the studies varied in that four studies described and tested the associations of some form of exercise or physical activity with body composition change in an observational design [9,11,12,17], whereas all other studies tested the effects of some form of intervention designed to promote exercise or physical activity on body weight and/or related indicators. Four of these intervention studies conducted a randomized controlled trial [10,13,14,16], one of which used a delayed intervention control group [10], while one other study did not include any control group [15].

Forms of exercise or physical activity examined in the studies differed and may be described as follows. In studies in which the respective indicators were not part of an intervention, assessments used self-report questionnaire items either on participation in vigorous physical activity or exercise (e.g. sports, heavy housework, or a job that involves physical labour) [9], running history in terms of average mileage [11], sports in terms of walking, jogging/running, lap swimming, tennis/racquetball, bicycling/stationary bike, aerobics/calisthenics and dancing [12], or frequency, duration and speed of walking outside the home and recreational physical activity in terms of exercise at strenuous levels (e.g. aerobics, aerobic dancing, jogging, tennis, and swimming laps), moderate levels (e.g. biking outdoors, using an exercise machine, calisthenics, easy swimming, fairly fast walking, and popular or folk dancing), and mild levels (e.g. slow dancing, bowling, and golf) [17], respectively.

In the largest intervention study [10], 15 min of strength training exercise every other day and 30 min of endurance exercise each day were recommended in a personalized workbook, and adherence was assessed by the Community Health Activities Model Program for Seniors questionnaire [18]. In another study [13], the exercise intervention consisted of at least 45 min of moderate intensity exercise 5 days a week for 12 months, with decreasing number of sessions at study facilities (treadmill walking and stationary bicycling with optional strength training) and increasing home exercises (e.g. walking, aerobics, and bicycling), and was compared to a stretching control group. Here, adherence was assessed by daily activity logs, while in [14], the Modifiable Activity Questionnaire [19] and (for a subgroup of participants) pedometers were employed to assess whether the predetermined goal of 150 min per week of moderate intensity activity (similar to brisk walking) had been reached (here, the control group received a health education intervention). Finally, the other two intervention studies encouraged either low-intensity walking on 3 days per week for 30–45 min, the effect of which was evaluated by a motor-driven treadmill measurement of maximal oxygen consumption [15], or centre-based treadmill walking on 3 days per week at individualised target heart rates [16]. In this latter study, the exercise intervention was compared to a hypocaloric diet only control group, physical activity was assessed by the Physical Activity Scale for the Elderly [20], and energy expenditure measured by accelerometric devices.

Among observational studies, sample sizes varied from $N = 3354$ [9], $N = 8340$ [11], and $N = 18{,}583$ [12] to $N = 58{,}610$ [17], while intervention studies examined smaller samples ranging from $N = 34$ [16] to $N = 641$ [10]. All studies in the AGED-category category included men and women, with following age ranges: 70 years or older [9], 65–91 years [10], and 65–74 years (men) and 50 years or older (women) [11] (an analysis included in the present AGED-category because postmenopausal status was not assessed in the study). Studies with postmenopausal women also used different age ranges: 40–69 years [12], 50–75 years [13], mean age of 56–57 years [14], 50–73 years [15], 50–70 years [16], and 50–79 years [17]. Thus, in this context no specific information on postmenopausal women of 80 years or older is available.

Regarding body weight, five studies sampled overweight adults [10,13–16], while the other four analysed samples from the general population or some other, overweight-unspecific samples. Thus, this feature is completely confounded with the studies' designs in that all intervention studies sampled overweight adults, while all observational studies analysed overweight-unspecific samples. Outcome change was defined by body weight in all nine studies, and supplemented by change in BMI [10,11,15], change in waist circumference [11,14,15], and changes in other relevant anthropometric indicators such as total body fat [13,15,16] in three studies each (in addition, one study reported change in hip circumference for women [11]).

Studies presented their results in different formats. Most studies highlighted changes in body composition scores in terms of differences between follow-up and baseline levels [9–11,13–16], with one study reporting such data in graphic format only [17]. This was also one of two studies reporting a regression analytical approach as their final statistical model. Specifically, either the odds of different levels of weight gain [12] or absolute body weight changes [17] were examined in these models. No study reported measures of effect sizes such as proportions of explained variances or the like, while all provided p-values or confidence intervals. In the intervention studies with over-weight samples using a control group, eventual excess weight loss in the intervention group compared with controls varied from 0.3 kg (diet plus low intensity exercise group vs. diet only group) [16], −1.1 kg [10], −1.3 kg vs. −1.6 kg vs. −1.1 kg in the age groups of 50–59, 60–69 and 70–75 years,

Table 2
Main characteristics and results of included studies.

Ref.	Publication	Country, year of data collection	General and weight gain-related objectives	Study design, data sources	Exposure or intervention/physical activity indicators	Participants/type of sample regarding overweight status	Obesity or weight gain indicators	Main results
***FOCUS OF STUDY:* AGED ADULTS**								
[9]	He and Meng (2008)	USA, 1993–2002	Describe the patterns and predictors of weight change among U.S. adults aged 70 and older	Longitudinal data from national survey Study on Assets and Health Dynamics among the Oldest Old (AHEAD)	Vigorous physical activity or exercise on average 3 times per week and more during the last 12 months	*N* = 3354 participants aged ≥70 years at baseline General population or other not overweight-specific sample	Self-reported weight (BMI also assessed but not reported re change of body weight)	Physical activity was associated with lower mean weight loss among men (−1.21 kg, $p < .01$) but not among women ($p = .05$)
[10]	Morey et al. (2009)	Canada, United Kingdom, and 21 US states, recruitment: July 1, 2005, through May 17, 2007	Determine whether a telephone counselling and mailed print material-based diet and exercise intervention is effective in reorienting functional decline in older, overweight cancer survivors	Secondary data analysis of the Reach out to Enhance Wellness (RENEW) randomized controlled trial	12 months of endurance exercise 30 min/d, 15 min. strength training exercise every other day, and healthy calorie-restricted diet (delayed intervention as control group)	*N* = 641 long-term (≥5 years) cancer survivors aged 65–91 years Overweight sample (25 < BMI < 40)	Self-reported body weight and height, BMI	Mean change in weight (kg) and BMI at 12 months: Intervention: Weight −2.06, BMI −0.69 Control: Weight −0.92, BMI −0.31 Both group differences significant with $p < .001$
[11]	Williams (2007)	USA, 1991–1995 with 7-year follow-up	To test the association of maintained running distance and change in adiposity among runners	Prospective study of the National Runners' Health Survey	Running	6119 male and 2221 female runners with maintained running distance at follow-up General population or other not overweight-specific sample	Self-reported body weight, BMI, and waist circumference	Annual average increases in body weight, BMI, waist circumference (WC) and hip circumference (HC) by average running distance (km/week) in men (65–74 years) and women (≥50 years): *Men:* 0–23: Weight 0.10, BMI 0.03, WC 0.24*** 24–47: Weight 0.06, BMI 0.02, WC 0.18** ≥48: Weight 0.08, BMI 0.03, WC −0.18†† *Women:* 0–23: Weight 0.31***, BMI 0.12***, WC 0.42***, HC 0.38*** 24–47: Weight 0.11*,††, BMI 0.04**,††, WC 0.21**, HC 0.14† ≥48: Weight 0.15*, BMI 0.06*, WC 0.31*, HC 0.13 Significant weight increase: *$p < .05$, **$p < .01$, ***$p < .001$ Weight increase significantly different from the increase at 0–23 km/week: †$p < .05$, ††$p < .01$, †††$p < .001$

Table 2 (*Continued*)

Ref.	Publication	Country, year of data collection	General and weight gain-related objectives	Study design, data sources	Exposure or intervention/physical activity indicators	Participants/type of sample regarding overweight status	Obesity or weight gain indicators	Main results
***FOCUS OF STUDY:* POSTMENOPAUSAL WOMEN**								
[12]	Blanck et al. (2007)	USA, 1992 and 1999	Assess the relationship among recreational physical activity, non-occupational sedentary behaviour, and 7-year weight gain among postmenopausal women	Secondary analysis of the Cancer Prevention Study II Nutrition Cohort	Summary metabolic equivalent score (MET) hours per week of recreational sports activities and hours per day of sedentary leisure time	*N* = 18,583 healthy postmenopausal women aged 40–69 years General population or other not overweight-specific sample	Self-reported weight (BMI also assessed but not reported re change of body weight)	No significant association between PA and 5–9 pound weight gain (neither in overweight nor in non-overweight group) No significant association between PA and ≥10 pound weight gain in overweight group No significant association between PA up to MET of 18 h/week and ≥10 pound weight gain in non-overweight group Adjusted odds ratio (95% CI) for association of ≥10 pound weight gain and MET ≥18 h/week compared to >0 to <4 h/week in non-overweight group: 0.88 (0.77, 0.99)
[13]	Irwin et al. (2003)	USA, Seattle, Washington, 1997–2001	Examine the effects of exercise on total and intra-abdominal body fat overall and by level of exercise	Randomized controlled trial	Intervention: at least 45 min of moderate intensity exercise 5 days/week for 12 months Control: stretching 45 min/week for 12 months Minnesota Physical Activity Questionnaire	*N* = 173 sedentary post-menopausal women aged 50–75 years Overweight sample	Weight, total body fat, body fat percentage, intra-abdominal and subcutaneous fat based on measurements (BMI also assessed but not reported re change of body weight)	Mean change in weight, total body fat (TBF), intra-abdominal fat (VAT) and subcutaneous fat (SAT) after one year for age groups: *50–59 years:* Interv. / Contr. / *p* Weight −0.5 / 0.7 / .05 TBF (%) −0.7 / 0.4 / .003 VAT (g/cm^2) −2.5 / −2.1 / .95 SAT (g/cm^2) −12.3 / 10.0 / .03 *60–69 years:* Interv. / Contr. / *p* Weight −2.2 / −0.6 / .09 TBF (%) −1.8 / −0.7 / .009 VAT (g/cm^2) −19 / 4.5 / .007 SAT (g/cm^2) −33.3 / 6.1 / .05 *70–75 years:* Interv. / Contr. / *p* Weight −1.7 / −0.5 / .45 TBF (%) −1.4 / −1.0 / .77 VAT (g/cm^2) −8.8 / −3.5 / .75 SAT (g/cm^2) −28 / 3.3 / .26

Table 2 (*Continued*)

Ref.	Publication	Country, year of data collection	General and weight gain-related objectives	Study design, data sources	Exposure or intervention/physical activity indicators	Participants/type of sample regarding overweight status	Obesity or weight gain indicators	Main results
[14]	Kuller et al. (2006)	USA, Allegheny County, Pennsylvania, 2002–2003	Examine the changes in risk factors of coronary heart disease by use of hormone therapy (HT)	Secondary data analysis of The Women On the Move through Activity and Nutrition (WOMAN) randomized controlled trial	Lifestyle change (LC): 150 min/week of moderate physical activity, calorie reduced low-fat diet Control: health education (HE)	*N* = 508 postmenopausal women with mean age 56 years (LC) and 57 years (HE), respectively Overweight sample (BMI = 25–29.9 and WC ≥ 80 cm)	Weight and waist circumference (WC) and based on measurements (BMI also assessed but not reported re change of body weight)	Mean differences in WC (cm) and weight (kg) at 6 and 18 months (all LC/HE-comparisons $p < .05$): *6 months:* LC HE Weight −7.71 −1.36 WC −3.99 −1.13 *18 months:* LC HE Weight −7.71 −1.81 WC −4.53 −1.81
[15]	Nicklas et al. (2003)	USA, Baltimore metropolitan area, year not given	Determine the efficacy of a lifestyle weight loss intervention in reducing total and abdominal obesity and improving CHD risk factors in obese Caucasian and African-American postmenopausal women	Intervention study (no control group)	Hypocaloric diet and 30–45 min of low intensity walking on 3 days/week for 6 months	*N* = 76 healthy, sedentary, and weight stable Caucasian (72%) and African-American (28%) postmenopausal women aged 50–73 years Overweight sample (BMI > 25)	BMI, waist (WC) and hip (HC) circumference based on measurements, fat mass and body fat percentage based on DXA, abdominal visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) based on CT	Mean changes in weight (kg), BMI (kg/m^2), body fat (%), fat mass (kg), WC (cm), HC (cm), VAT (cm^2) and SAT (cm^2): Caucasian African-American Weight −6*** −4** BMI −2*** −2** Body fat −4*** −2* Fat mass −6*** −4** WC −5*** −2 HC −5*** −2 VAT −23*** −13 SAT −57*** −62** *$p < .05$, **$p < .01$, ***$p < .001$
[16]	Wang et al. (2008)	USA, not given	To examine whether adaptations in physical activity energy expenditure (PAEE) and resting metabolic rate (RMR) during weight loss were associated with future weight regain in overweight postmenopausal women	Randomized controlled trial	20-Week weight loss intervention of either hypocaloric diet (HD), HD and low-intensity exercise (L-EX), and HD and high-intensity exercise (H-EX)	*N* = 34 postmenopausal women aged 50–70 (nonsmoking, no HT, sedentary and weight-stable for 6 months) Overweight sample (BMI between 25–40)	Height and weight, lean body mass, fat mass and body fat percentage based on measurements (BMI also assessed but not reported re change of body weight)	Body weight change (kg), change in fat mass (kg) (FM), and body fat (%) (BF) and lean body mass (LBM) at end of intervention: HD L-EX H-EX Weight −12.8** −13.1** −10.8** FM −8.2** −8.3** −7.2** BF −3.7** −4.1** −3.3** LBM −4.2** −3.9** − 3.2** Body weight regain after intervention: HD L-EX H-EX 6 months 2.7* 3.9** 2.1* 12 months 4.7* 6.3** 4.4* *$p < .05$; **$p < .001$

Table 2 (*Continued*)

Ref.	Publication	Country, year of data collection	General and weight gain-related objectives	Study design, data sources	Exposure or intervention/physical activity indicators	Participants/type of sample regarding overweight status	Obesity or weight gain indicators	Main results			
[17]	Sims et al. (2011)	USA, 1993–1998, 40 US clinical centers, annual weighing over 8 years	To test the association of habitual physical activity on body weight, BMI and measures of fat distribution (waist-to-hip-ratio, WHR) in post-menopausal women by age	Prospective cohort study within the Women's Health Initiative Clinical Trials of Diet Modification and/or Hormone Therapy	High vs. low habitual physical activity in terms of walking and recreational exercise	*N* = 58,610 post-menopausal women aged 50–79 years General population or other not overweight-specific sample	Weight, BMI and fat distribution based on measurements (BMI also assessed but not reported re change of body weight in final model reported)	Physical activity and weight change by age at baseline:			
								Age	PA level (ref.: <500 MET-min/week)	est.	95%CI
								50–59	>100–500	−.069	−.271, .133
									>500–1200	−.301	−.529, −.074
									≥1200	−.469	−.725, −.213
								60–69	>100–500	.148	−.016, .312
									>500–1200	−.027	−.196, .142
									≥1200	−.035	−.238, .168
								70–79	>100–500	.051	−.207, .310
									>500–1200	.272	.020, .524
									≥1200	.335	.038, .632

respectively [13], to −5.9 kg after a combined diet and physical activity intervention group (vs. health education) [14]. Comparable to this latter study, the one intervention study without a control group [15] – which also examined a combined hypocaloric diet and low intensity walking intervention – found a −6 kg loss in its Caucasian and −4 kg in its African-American subsample. A diet plus high intensity exercise intervention (vs. diet only) was found to mitigate weight regain by −0.3 kg in one study [16]. Finally, in studies in which body composition indicators such as total body fat were examined, their changes mostly paralleled those in body weight [13,15,16], though some results did not reach statistical significance (e.g. intra-abdominal fat in the 50–59 years age group in [13], and both waist and hip circumference in the African-American subsample in [15]).

Among the observational studies with general population or other overweight-nonspecific samples, results were more heterogenous both regarding format of presentation (and thus formals comparability) and magnitude of weight changes. In one study, physical activity was associated with lower mean weight loss among men, but the difference in weight loss between active and less active women was not reported [9]. In the one study on runners, body composition changes were reported in terms of annual averages [11], indicating that among men, only long distance running (≥48 km/week) was associated with a loss of −0.18 cm/year in waist circumference compared to 0–23 km/week, while among women, running 24–47 km/week was associated with relatively lower but still significant weight and BMI gain (0.11 kg per year and 0.04 kg/m^2 per year, respectively). In the two studies in which ultimately a regression analytical model was reported, results differed across over- vs. non-overweight subgroups [12] and age subgroups [17], and confidence intervals for significant odds ratios or estimates tended to barely not include unity [12] or zero [17].

Table 3 presents a summary of the results by classifying all twelve distinguishable (sub−)analyses from the nine included studies as indicating that exercise or physical activity tended to be associated either with weight loss, maintenance, or gain. All analyses from intervention studies (and thus all those with overweight samples) found that exercise or physical activity tended to be associated with weight loss, regardless of the focus of the study in terms of aged adults vs. postmenopausal women. In contrast, results were mixed for observational general population studies. One analysis of postmenopausal women aged 50–59 years of age found evidence for weight loss, while four analyses (two each on aged adults and postmenopausal women) found evidence for weight maintenance, and two (one each within the two study types) for weight gain.

4. Discussion

4.1. Key findings

In sum, the findings suggest that exercise is effective to prevent weight gain in the elderly, either in terms of weight loss or weight maintenance. For both groups considered, i.e. aged adults and postmenopausal women, exercise or physical activity was associated with weight loss in all intervention studies with an overweight sample. This was found for low, moderate and high intensity exercise and for different indicators of obesity (such as BMI, waist circumference, visceral adipose tissue, and total body fat). The greatest weight loss was found for interventions that combined exercise with a hypocaloric diet. Regarding the observational studies with a general population or otherwise overweight-unspecific sample, exercise tended to be associated with weight maintenance in most analyses. At the same time, weight loss was also observed for younger postmenopausal women, as well as weight gain for elderly women and a subgroup of older postmenopausal women.

4.2. Limitations

Some limitations have to be noted. First, given the heterogeneity of both methodology and types of exercise across the 9 included

Table 3
Associations of exercise/physical activity with weight change by focus of study and type of sample regarding overweight status.

Focus of study	Study design and type of sample regarding overweight status		Exercise/physical activity tends to be associated with weight loss	Exercise/physical activity tends to be associated with weight maintenance	Exercise/physical activity tends to be associated with weight gain
Aged adults	Intervention study with overweight sample	*Number of analyses*	1		
		Reference(s) and specifications (if applicable)	[10]		
	Observational study with general population or other overweight-unspecific sample	*Number of analyses*		2	1
		Reference(s) and specifications (if applicable)		[9(men)], [11(waist circumference among men)]	[11(BMI and waist circumference among women)]
Postmenopausal women	Intervention study with overweight sample	*Number of analyses*	4		
		Reference(s) and specifications (if applicable)	[13–16]		
	Observational study with general population or other overweight-unspecific sample	*Number of analyses*	1	2	1
		Reference(s) and specifications (if applicable)	[17(age group 50–59)]	[12(non-overweight subsample)], [17(age group 60–69)]	[17(age group 70–79)]

studies, this review makes no meta-analytic claims. Furthermore, classification of (sub-)analyses as indicating an association with weight loss, maintenance or gain was not always straightforward. For example, in one case – namely the subanalysis for women in [9] – classification was not possible at all due to an underreporting of results. Second, our inclusion criterion that study exposures should include exercise or related physical activity either as observed or as (part of) an intervention did contribute to this heterogeneity. It resulted in a wide range of scrutinized levels of exercise as well as combinations of exercise with a specific diet (vs. not), and different comparison groups across studies (such as neither diet nor exercise, diet only, or none at all). Finally, this review cannot provide an update on how effective (different types of) exercise vs. (different types of) physical activity are in preventing weight gain in the elderly. This is a weakness as, e.g., different types of physical activity have been shown to be differentially associated with health (favouring leisure time physical activity [21]). Yet, to be broad in this respect did increase the chance to identify studies on the role of both for weight management in this target group.

4.3. Implications

One interesting finding of the present review is that while all observational studies were conducted with a general population or otherwise overweight-unspecific sample, all of the intervention studies were conducted with an overweight sample. This suggests at least for older adults that interventions comprising exercise or physical activity to prevent weight gain are by and large implemented only in case of overweight as a given risk factor, and thus in terms of primary prevention or, re morbid obesity, secondary or tertiary prevention. Conversely, it seems that primordial prevention, i.e. preventing the development of risk factors such as overweight in the first place, might be a neglected issue in this context.

In regard to exercise as a specific measure to prevent weight gain, it seems to contribute to weight loss in particular if people are instructed how to exercise, i.e. when exercise is part of a professionally supervised intervention (paralleling findings in the area of dieting). In contrast, older people exercising without supervision rather maintain than lose weight, or even gain weight in some cases. Still, it has to be re-iterated that across the studies included in this review, design (intervention vs. observational) and sample (overweight vs. overweight-unspecific) were completely confounded. That is, many participants in the overweight-unspecific studies probably had no need to lose weight, and maintenance may have been the indicated goal in this group. Moreover, only one intervention study did not combine exercise with a hypocaloric diet, while another study compared an exercise plus diet intervention with diet only. Furthermore, that for obese elderly people the combination of exercise and diet interventions is more effective for weight loss than each individual component by itself has been confirmed in a recent meta-analysis [22].

Another important question is how much weight loss, or if weight loss at all, is desirable for older persons to begin with. Intentional weight loss is accompanied with a decrease in lean muscle mass and bone mineral density [23]. Muscle loss on the other hand has been shown to correlate negatively with functional capacity for independent living in older persons [24]. However, previous systematic reviews have in fact suggested that intentional moderate weight loss has beneficial effects on joints and is associated with improvements in metabolic control and cardiovascular risk factors [23–25]. Moderate weight loss means a reduction in body weight for 5–10%. Across the studies included in our review, weight loss ranged from 1.1 to 6 kg, and thus represented rather low or moderate reductions.

Previously, it has been stated that the key determinant for the balance between potential beneficial and detrimental effects of weight loss in the elderly was the preservation of muscle mass [24]. A decrease in lean body mass during weight loss can be offset by exercise. Consistent with this, weight loss was found to be associated with increased mortality in a prospective cohort study among adults who initially were or became physically inactive while losing weight compared with those who remained or became physically active [26]. Two studies included in this review had also collected data on lean body mass. One of them found no differences in lean body mass before and after the intervention comprising a combination of diet and exercise [15], in the other one the decrease in lean body mass could be reduced by exercise [16]. This underlines the importance of exercise in weight management in the elderly.

At the same time, some studies have suggested that weight maintenance seems to be even more favourable for older people than weight loss, or, for that matter, any weight change. In later life, weight loss seems to be a short term risk factor (<1 year) for mortality, whereas weight gain seems to be a long-term risk factor (>3 years) [27]. Considering life course perspectives of obesity, weight maintenance is favourable for older persons who became obese after the age of 65, while weight loss interventions show benefits with regard to osteoarthritis, physical function, diabetes mellitus type 2 and coronary heart disease [23]. All told, this implies that the prevention of weight gain should be considered to be a continuing undertaking lasting from younger to older age.

For women, menopause is accompanied by several hormonal and metabolic alterations that result in an increased risk of weight gain. The present review indicates that exercise is an effective method to prevent weight gain in postmenopausal women. Moreover, physical activity has positive effects on muscular and bone tissue, and can enhance quality of life in this population [28].

4.4. Conclusions

This review suggests that exercise and physical activity can prevent weight gain in aged adults and postmenopausal women both in terms of weight loss or weight maintenance. It seems that professionally instructed and supervised exercise is more effective than solely self-initiated activity. Although exercise tended to be associated with weight maintenance in observational studies as well, it was also associated with weight gain in some of these analyses. This might indicate a lack of knowledge or skills on the side of the participants as to how exercise healthily and effectively. For further research it would be interesting to investigate effects of exercise interventions in non-overweight elderly.

The greatest weight loss was achieved through interventions that combined physical activity with a hypocaloric diet. Although there are continuing debates on how desirable weight loss actually is for older persons, exercise seems to be a key determinant for the balance between potentially positive and negative effects of weight reduction in later life. Studies included in this review also confirmed that lean body mass can be preserved through exercise or physical activity, which underlines the potentials of exercise in the prevention of weight gain in the elderly.

Contributors

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Competing interests

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