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https://doi.org/10.15017/2230692

出版情報：健康科学. 41, pp.23-39, 2019-03-20. 九州大学健康科学編集委員会
バージョン：
権利関係：

Journal of Health Science
Vol.41, March 2019

－Review－

Effect of brisk walking on the body weight, body fat, waist circumference and blood lipids in adults: A systematic review

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Abstract

Purpose: The purpose of this review was to assess the effect of brisk walking on the body weight, body fat, waist circumference and blood lipid values in adults.
Methods: In August 2018, we conducted electronic searches of PubMed and Web of Science to identify pertinent studies; those with an experiment period exceeding two weeks, human randomized controlled trials (RCTs), and those that only assessed brisk walking was included. **Results**: A total of 523 citations were identified from our search of the electronic literature, and 29 RCTs that included 1697 individuals were identified. Overall, 15 studies found a significant change in the decrease in body weight, body fat, and waist circumference. In addition, eight of these studies demonstrated statistically significant improvements in the low density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), triglyceride (TG) and total cholesterol (TC) values. **Conclusion**: Brisk walking was able to reduce the body weight, body fat and waist circumference, and improved the levels of blood lipids. However, these effects are associated with the amount and intensity of exercise and the state of health of the participants.
Key words: brisk walking, adults, blood lipids, body weight, body fat
(Journal of Health Science, Kyushu University, 41: 23-39, 2019)

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Introduction

It is widely assumed that regular physical activity can help prevent primary and secondary chronic diseases[1]. Most countries' government and health organization recommend that subjects engage in regular moderate or vigorous intensity physical activity. However, modern society has changed our approach to work, and the modern lifestyle has also changed our behaviors. Whether working or enjoying leisure time, we spend a great proportion of our life engaged in sedentary behavior. Sedentary behavior is defined as any waking behavior characterized by an energy expenditure (as well as postural「sitting or reclining」 and contextual「waking」) ≤1.5 metabolic equivalents (METs)[2]. According to this definition, a person may be described as sedentary if they engage in a large amount of sedentary behavior. However, there was different energy expenditure in sedentary. For example, sitting in a classroom is assigned 1.8METs, while driving a car is assigned 2.5METs. There is no consistent definition of sedentary behavior; nevertheless, a common phenomenon exist namely a lack of ambulatory movement in any posture. This is an important characteristic that distinguishes sedentary behavior from physical activity. Physical activity is defined as any body movement generated by the contraction of skeletal muscles, such activity should increase energy expenditure above the resting metabolic rate. Physical activity is characterized by its modality, frequency, intensity, duration, and context of practice[3]. A number of studies have found moderate-to-strong evidence that diabetes and mortality are associated with sedentary behavior[4,5]. Warren et al.[6] found that sedentary behavior and riding in a car were significant predictors of mortality due to cardiovascular disease (CVD). A review study showed that increased physical activity helps prevent chronic disease and promote public health[7].

Sedentary behavior is a major factor that increases the risk of chronic diseases, and it also significantly affects on one's body weight. Over the last three to four decades, the prevalence of overweight and obesity has increased dramatically. For instance, in 2015, about 107.7 million children and 603.7 million adults were obese around the world. Obesity is a major risk factor for CVD, type 2 diabetes mellitus (T2DM), hypertension, coronary artery diseases, metabolic syndrome, and some cancers[8]. It is also an important risk factor for death due to non-communicable disease.

Over nutrition is an obvious candidate contributor to the rise in obesity, but increased rates of physical inactivity and sedentary behavior are also implicated. Several studies have found that regular moderate physical activity was able to improve blood lipids, reduce the risk of CVD diseases, and prevent and control T2DM. It is also a good method of managing obesity. The World Health Organization[9] recommends that adults spend at least 150 minutes per week engaged in aerobic physical activity (moderate intensity) per week, or at least 75 minutes of high-intensity physical activity. The American College of Sports Medicine has similar recommendations in its physical activity guidelines.

Walking has been described as a near perfect ''exercise'' and has been recommended by health organizations worldwide[10]. Walking programs have a higher level of adherence than other forms of exercise[11]. Brisk walking as a simple, economic and safe form of exercise is the most popular moderate-intensity aerobic physical activity for both men and women, especially for most middle-aged and/or overweight and obesity individuals. It is the most likely exercise or

physical activity to be chosen to improve chronic diseases, and T2DM and to manage body weight[12]. According to the definition of moderate-intensity activity, walking is ‘‘brisk’’ at a speed of 2.5 to 4.2 mph on firm ground. Studies have shown that 30 minutes of moderate-to-vigorous walking corresponds to a total of 3100-4000 steps[13]. Previous studies have demonstrated that brisk walking can result in improved low density lipoprotein cholesterol (LDL-C), total cholesterol (TC)[14], and high-density lipoprotein cholesterol (HDL-C)[15]. However, conflicting results have also been reported, with some studies showing that brisk walking has no substantial effect on the blood lipid values[16,17], although a systematic review and meta-analysis showed that brisk walking was able to significantly reduce the body weight, body mass index (BMI), waist circumference, and fat mass in obese subjects[18]. Brisk walking proved to be an economic and feasible form of exercise that can be performed by nearly all individuals (especially for those with overweight and obesity), in all kinds of places and at almost any time.

The aim of this system review was to systematically summarize, analyze, and interpret the health benefits of brisk walking in human with regard to its effects on body weight, the BMI, waist circumference, HDL, LDL, TC, triglyceride (TG), and other health-related measures.

Method

Literature search strategy

This systematic review followed the Cochrane systematic review guidelines. The online database Web of Science and PubMed were evaluated through August 3, 2018, for relevant periodicals. The PICO patient, intervention, comparison, and outcome (PICO) approach was used in this review search strategy. Our search eliminated two sets of keywords using the Boolean operator ‘‘NOT’’, and combined two sets of keywords using ‘‘AND’’, with ‘‘OR’’ used to combine the keywords. Our keywords search strategy included both full and abbreviated terms as follows: brisk walking, adults, body weight, waist circumference, BMI, LDL-C, TC, HDL-C, fat ratio, and TG. The search initially yielded 523 potentially relevant articles. The duplicate articles were removed based on titles and abstracts. Due to the number of results, a second researcher independently screened a random sample of 20% of the retrieved record, and completed the inclusion of articles (Figure 1).

Inclusion and exclusion criteria

A study was included if the following requirements were met: (a) subjects $\geqslant$ 18 years old; (b) randomized trial; and (c) brisk walking or moderate exercise evaluated. The exclusion criteria were as follows: (a) study period of less than 2 weeks; (b) subjects $\leqslant$ 18 years; (c) no relevant results; (d) a Nordic walking study or walking program study (not brisk walking).

Assessing the quality

The quality of the studies was assessed using the Cochrane Risk of Bias Tool. The criteria included random allocation, blinding of supplement, outcome assessors and individuals, allocation concealment, use of an intention-to-treat analysis, and other biases. Two researchers assessed the studies, separately. If any differences in their findings were noted, the conflict was resolved by a discussion.

Data extraction

Two researchers extracted all relevant data independently. One author extracted the following data from the eligible articles: the first author and publication year, study design, intervention duration, participants, intervention characteristics, control group characteristics, exercise (volume and intensity),

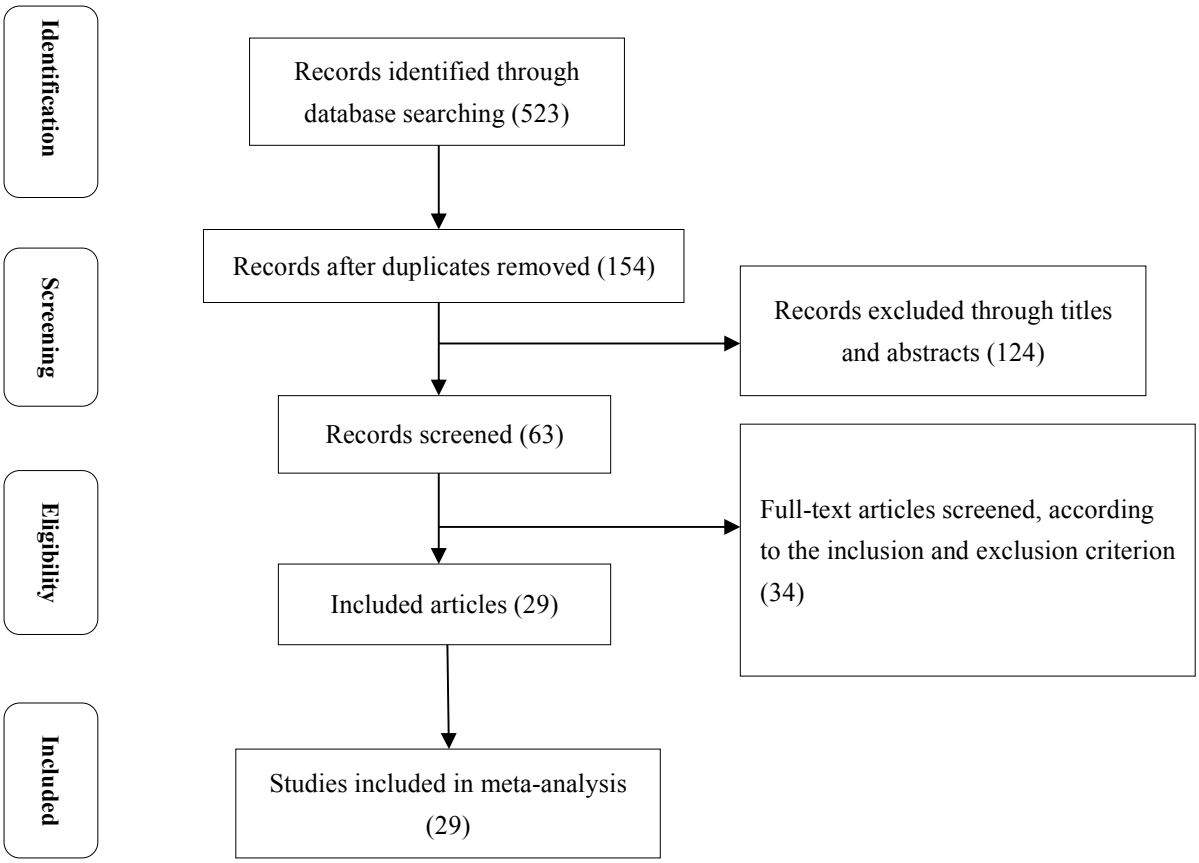

Figure 1 Flow diagram showing the literature search and selection process

and outcomes of body weight, waist circumference, BMI, LDL-C, TC, HDL-C, TG.

Results

A total of 523 RCTs studies were identified through initial searches. Following the removal of duplicates, titles, and abstracts were screened, resulting in 72 articles undergoing full-text screening for inclusion. Overall, 29 RCT articles were identified (Fig. 1). We excluded 34 articles for the following reasons: 6 were testing studies; 17 were combined with other exercises; 8 did not include indices, and 3 had no sedentary control group. This review identified a total of 1697 individuals (brisk walking group, n=931; control group, n=766), investigating the long-term health effects of brisk walking. Mean research duration was 3-48 weeks. The health of participants varied among studies, including overweight and/or obese, T2DM, nonalcoholic fatty liver, physically deconditioned, hypercholesterolemic, and eumenorrheic patients. Two studies did not report the values of body weight, body fat or waist circumference. And nine did not report the values of LDL, HDL, TG or TC (Table 1).

Brisk walking intensity

The definition of brisk walking differed among the studies included in this review. Regarding the definition of brisk walking, the maximum heart rate ranged from 40% to 80%. Several studies were based on breathing difficulty, faster than normal, 62±2% VO_2max, 3~5 km/h. In addition, one study did not clearly define the meaning of brisk walking used in their trial. Eight studies reported that

the definition of brisk walking was based on the participants' self reported description.

Body weight and waist circumference

Four studies did not report the body weight. And 13 did not report waist circumference. Twelve studies included only women participants, 3 included only men, and 14 included both men and women participants. Thirteen studies[26,27,28,30,33,38,39,40,42,46,47,48,50] found a significant decrease in the body weight at the end of the study period. Twelve studies failed to show a significant decrease in the body weight, but seven of these trails included both men and women as participants; the physiology differs between sexes, which may have been a major confounding factor in our review. John's study, the first evaluated in this review, found that brisk walking significantly reduced the body weight in the intervention group compared with the control group. This was a long-term study, and the participants were sedentary obese women, however, the participants' BMI was not reported. Another study[19] showed that sedentary obesity and a long intervention period were important factors influencing the reduction in body weight.

Body fat

Seventeen trials measured the effect of brisk walking on body fat. Eight of these studies[26,27,38,39,40,46,50,52] showed statistically significant decreases in body fat after intervention.

LDL and TC

Seventeen trials measured the effect of brisk walking on the LDL and TC levels. Three of these trials[28,32,42] found statistically significant reductions in the LDL levels; however, one of these three studies included hypertensive participants, another had only a three-week intervention period and the third did not describe the BMI of the participants. Two[40,42] of seventeen studies shown a significant reduction in the TC levels; however, one of these two studies included hypercholesterolemic patients, and the other only had a three-week intervention period.

HDL and TG

Nineteen trials measured the effects of brisk walking on the HDL-C levels. Four[24,32,43,45] of these studies found statistically significant reductions in the HDL-C levels. However, the BMI of the participants was not mentioned in two of these studies, another included hypertensive participants, and the remaining one included type 2 diabetes patients. Seventeen trials measured the effect of brisk walking on the TG levels. Only two[37,40] of these studies showed statistically significant reductions in TG. However, only two of these studies showed statistically significant reductions in the TG levels, with one including hypertensive subjects and the other one including high-triglyceride value subjects.

Discussion

The aim of this review was to assess the effect of brisk walking on the body weight, body fat, waist circumference, and blood lipid values in adults. A total of 29 intervention studies met the inclusion criteria and were included in this review. While all of the included trials assessed brisk walking as the modality, the intensity of the exercise varied widely. Brisk walking has been confirmed as a suitable activity for maintaining a healthy lifestyle by the world health organization, public health agencies, and health research institutions around the globe. However, the precise definition of brisk walking remains unclear. Porcari et al.[20] showed that brisk walking is defined as a maximal heart rate of $\geqslant$ 70%. Spelman et al.[21] similarly suggested that the maximal heart rate should be above 70%. Previous studies[22,23] have shown that brisk walking is defined as a speed of walking ranging from three to four miles per hour.

Table 1 Basic characteristic of included 29 studies

Study	State of health	Participants	N	Age(years)	BMI	Intervention	Weeks	Intensity	Results	
									physical fitness	blood lipids
Hardman A et al. (1989)[24]	sedentary	women	44	44.9 ± 7.9; 44.4 ± 9.2	unknown	IG=28, 155±48min/week, BW, 16.1-17.4km/week; CG=16, habitual lifestyle	48	1.72±0.26m/s～1.87±0.37m/s	unknown	HDL ↑ TC： none
Sylvia RC et al. (1991)[25]	sedentary overweight and obesity	women	35	36.0 ± 1.6; 32.4 ± 1.5	28.3± 0.7 27.8± 0.9	IG=18, 45min/week, 5 time/week, 62±2% VO_{2max}; CG=17, habitual lifestyle	15	62±2% VO2max	BW none BF: none	unknown
John PF et al. (1993)[26]	obesity	men and women	165	25~45	unknown	IG=43, 45min/time, 3~5 sessions/week, CG=38, habitual lifestyle	48	self-monitoring; breathing difficulty.	BW ↓ BF ↓ WC ↓	unknown
Stensel DJ et al. (1993)[27]	sedentary healthy	men	72	42~59	25.3± 0.4 24.9± 0.6	IG=48, 20~25min to 40~45min/day, 2~3 sessions/week, CG=24, habitual lifestyle	48	self-monitoring	BW ↓ BF ↓ WC :none	HDL: none TC: none LDL：none TG: none
Aldred HE et al. (1995)[28]	sedentary (overweight/ obesity)	women	26	41~55	unknown	IG=13, 60~180min/week, 3time/week, 20~50min/session , CG=13, habitual lifestyle	12	self-monitoring	BW ↓ WC :none	HDL: none TC: none LDL： ↓ TG: none
Santiago MC et al. (1995)[29]	sedentary eumenorrheic women	women	32	22~40	24.6± 3.8 23.6± 3.5	IG=21, 4.8km/week, 4time/week, mean intensity 72% maximal heart rate ; CG=11, habitual lifestyle	40	72% maximal heart rate	BW none BF none	HDL: none

Brooke-Wavell K et al. (1997)[30]	sedentary post-menopausal women (health and overweight)	women	84	60~70	25.8± 3.8 25.6± 3.5	IG=43, 20~50min/day, 7time/week ; CG=41, habitual lifestyle	48	self-monitoring	BW ↓	unknown
Coleman KJ et al. (1999)[31]	sedentary men (health and overweight)	men	36	18~45	25.0± 3.4 26.0± 4.5 26.4 ±4.1	IG1=12, 30min/day, 6time/week; IG2=12, 3×10min/day, 6 time/week; CG=12, self walk;	16	accelerometer	BW none	unknown
Higashi Y et al. (1999)[32]	Hypertensive Subjects	men and women	27	53±10; 51±8	24.0± 1.7 24.2± 1.8	IG1=20, 30min/day, 5~7 time/week; CG=7, habitual lifestyle;	12	self-monitoring; 52 ± 6%	BW none	HDL: ↑ TC: none LDL：↓ TG: none
Brooke-Wavell K et al. (2001)[33]	Postmenopausal Women (overweight/ obesity)	women	68	60~70	unknown	IG=16, 120~280min/ two weeks, 3time/week, 20~45min/session ; CG=20, habitual lifestyle	48		BW ↓	unknown
Murtagh EM et al. (2005)[34]	health	men and women	30	45.7± 9.4	unknown	IG=8, 20min/day, 3 time/week; CG=7, habitual lifestyle;	12	heart rate; treadmill	BW : none BF :none WC : none	HDL: none TC: none LDL：none TG: none

Tully MA et al. (2005)[35]	sedentary, overweight and obesity	men and women	31	50~65	28.09± 3.98 27.29 ±3.25	IG=17, 30min/day, 5 time/week; CG=9, habitual lifestyle;	12	self-monitoring	BW : none BF : none WC : none	HDL: none TC: none LDL：none TG: none
Audette JF et al. (2006)[36]	sedentary; (health and overweight)	elderly women	27	71.4 ± 4.5	unkown	IG=10, 60min/day, 3 time/week; CG=8, habitual lifestyle;	12	maximal heart rate: 50%~70%	unknown	unknown
Lee MR et al. (2006)[37]	overweight and obesity; high triglyceride	women	19	35 ~ 50	26.25± 1.83 26.53 ±1.38	IG=9, 20~50min/day, 3 ~6 time/week; CG=10, BW plus diet;	12	maximal heart rate: 40-50% ~ 60-70%	unknown	TG ↓
Kirkwood L et al. (2007)[38]	overweight and obesity	women	69	30 ~ 50	31.6 ±3.8 31.6± 4.2	IG=19, 60min/day, 6 time/week; CG=18, habitual lifestyle;	12	accelerator monitors	BW ↓ BF ↓ WC ↓	HDL: none TC: none LDL：none TG: none
Tully MA et al. (2007)[39]	sedentary (overweight and obesity)	men and women	106	40 ~ 61	27.79± 4.85 25.77± 4.09 26.32 ±5.94	IG1 =44, 30min/day, 3 time/week; IG2 =42, 30min/day, 5 time/week; CG=20, habitual lifestyle;	12	faster than normal, pedometer	BW ↓ BF ↓ WC ↓	HDL: none TC: none LDL：none TG: none

Coghill N et al. (2008)[40]	hypercholesterolaemic (overweight and obesity)	men	67	55.1 ± 4.9	28.13 ± 3.86 27.27 ± 2.98	IG =38, 30min/day, 5 - 7 time/week; CG=29, habitual lifestyle;	12	accelerator monitors; RPE: 12 -14	BW ↓ BF ↓ WC ↓	HDL: none TC ↓ LDL：none TG ↓
Pierce GL et al. (2011)[41]	sedentary	men and women	22	55 - 79	25.3 ± 0.7 25.1 ± 0.8	IG = 26; 40 - 50 min/day, 6 - 7 time/week; CG=10, habitual lifestyle;	12	maximal heart rate: 70%~75%	BW : none BF : none WC : none	HDL: none TC: none LDL：none TG: none
Pagels P et al. (2012)[42]	health	men and women	33	25 -45	26.2 ± 4.4 23.7 ± 2.3	IG = 16; 30 min/day, 7 time/week; CG=17, habitual lifestyle;	3	pedometer and accelerometer	BW ↓	HDL: none TC ↓ LDL ↓ TG：none
Foulds,HJ et al. (2014)[43]	health and overweight	men and women	72	44 ± 13.0	unknown	IG 1 = 10; 10min/week; IG 2 = 10; 10min/day, 3 time/week; IG 3 = 18; 30min/day, 3 time/week; IG 4 = 10; 60min/day, 3 time/week; CG=10, habitual lifestyle;	13	self-report	unknown	HDL ↑ IG2; IG4 TC: none LDL：none TG: none
Kearney TM et al. (2014)[44]	sedentary; overweight and obesity	men and women	77	30 - 55	29.3 ± 4.3 29.2 ± 4.3	IG = 16; 3 × 10 min/day, 5 time/week; CG=17, habitual lifestyle;	24	self-report	BW : none BF : none WC : none	HDL: none TC: none LDL：none TG: none

Johnson ST et al. (2015)[45]	Type 2 Diabetes	postmenopausal women	198	59.5 ± 8.3	34.6 ± 6.4 32.5 ± 6.4	IG = 102; 30 min/day, 3 time/week; CG=96, habitual lifestyle;	24	self-monitoring; pedometer	BW : none WC : none	HDL ↑ LDL：none
Hui SS et al. (2016)[46]	no exercise habits	men and women	374	36 -60	23.2± 3.0 22.7 ± 3.3	IG = 121; 45 min/day, 5 time/week; CG=124, habitual lifestyle;	12	self-monitoring	BW : ↓ BF ↓	unknown
Zhang HJ et al. (2016)[47]	Nonalcoholic fatty liver	men and women	220	53.9 ± 7.1	28.1 ± 3.3 28.0± 2.7	IG=73, 150min/week; CG=74, habitual lifestyle;	48	maximal heart rate: 45%~55%; pedometer	BW ↓ BF : none WC ↓	HDL: none TC: none LDL：none TG: none
Blain H et al. (2017)[48]	sedentary and physically deconditioned	women	121	65.7 ± 4.3	24.25± 3.46 26.64 ± 4.22	IG=51, 150min/week, 3 time/week; CG=47, habitual lifestyle;	24	maximal heart rate: 40%~80%; HR monitor	BW ↓ BF : none	unknown
Buyukyazi G et al. (2017)[49]	health	premenopausal women	30	33 - 50	23.6 ~ 29.6 20.9 ~ 30.1	IG=11, 30 - 51 min/week, 3 time/week; CG=8, habitual lifestyle;	8	maximal heart rate: 70%~75%; HR monitor	BW : none WC : none	unknown
Herzig KH et al. (2014)[50]	health	men and women	78	58.8±10.4	32.6± 5.7 30.9 ± 4.8	IG=33, 60 min/week, 3 time/week; CG=35, habitual lifestyle;	12	3 ~ 5 km/h	BW ↓ BF ↓ WC ↓	HDL: none TC: none LDL：none TG: none

Ho SS et al. (2012)[51]	overweight and obesity	men and women	81	40 - 66	32.7± 1.3 32.4 ±1.4	IG=15, 30 min/week, 5 time/week; CG=16, habitual lifestyle;	12	maximal heart rate: 60%±10%; treadmill	BW : none BF : none WC ↓	HDL: none TC: none LDL：none TG: none
McNeilly AM et al. (2011)[52]	sedentary; obesity	men and women	24	54 ± 8	33 ± 6 32± 7	IG=12, 30 min/week, 5 time/week; CG=12, habitual lifestyle;	12	maximal heart rate: 65%; HR monitor	BW : none BF ↓ WC ↓	HDL: none TC: none LDL：none TG: none

N = number; BMI = body mass index; IG = intervention group; CG = control group; BW = body weight; BF = body fat; WC = waist circumference; HDL = high-density lipoprotein cholesterol; LDL = low density lipoprotein cholesterol; TC = total cholesterol; TG = triglyceride.

However, only 7 trials in our review reported that a maximal heart rate ⩾70% was achieved. Other studies used self-monitoring to assess the presence of brisk walking (accelerator, pedometer and rate of perceived exertion scale). One of these studies reported that the maximal oxygen consumption should be 62% ±2% for brisk walking. However, another study that assessed the speed and intensity of walkers showed that the threshold of maximal oxygen consumption was 68.6% ±14.9%.

A systematic review and meta-analysis[53] demonstrated that brisk walking was able to reduce the body weight, body fat and waist circumference in obese adults. Twelve studies in our review reported statistically significant changes in the body weight, and eight reported statistically significant changes in the body fat and waist circumference. The intensity of brisk walking differed markedly among our included studies. Nemoto et al.[54] found that brisk walking, defined as a maximal oxygen consumption of 50%-70%, was able to reduce the body mass. Blain et al.[48] also showed that brisk walking, defined as a maximal oxygen consumption of 60% - 80%, was able to reduce the body mass and body fat of sedentary women. Maintaining or increasing the amount of moderate or vigorous intensity physical activity is recommended by a number of health organizations to reduce the risk of chronic diseases in sedentary adults. As the one of the most popular physical activities, brisk walking could reduction the body mass, body fat or waist circumference. However, the recommended levels of such physical activities have generally not led to clinically significant body mass loss[55]. Previous studies[56,57] also have shown that statistically significant weight loss generally does not occur with moderate-intensity physical activity. However, it was able to change the other favorable cardiometabolic. Thus, while brisk walking can reduce body weight, no significant reduction in body weight may occur.

Several studies have shown that physical activity has favorable effects on the blood lipid and lipoprotein profiles. A previous review[58] found that exercise increased the HDL-C levels and reduced those of TG and LDL. However, other studies on the effects of aerobic exercise on the lipids and lipoproteins in adults with cardiovascular disease have yielded conflicting results, with the changes in the blood lipid values not always being statistically significant. Indeed, only six trials among the studies included in our review reported statistically significant reductions in the blood lipid and lipoprotein values, and four of these studies included chronic disease patients as participants. Another meta-analysis showed that aerobic exercise increased the HDL and decreased the TG levels in adults, especially men, with cardiovascular disease[59]. This finding, along with others, confirmed that physical activity could improve the blood lipid and lipoprotein levels. Physical activity can not only improve the health of chronic disease patients, but also reduce the risk of chronic disease altogether in healthy humans. A meta-analysis found that the effect of physical activity on blood lipids was associated with increased levels of such activity, and Duncan et al.[60] found that a difference in the amount of-exercise appears to result in a different outcome in the blood lipid values. Another study[61] showed that different intensity levels also significantly affected the lipoprotein levels.

In conclusion, present review found that a brisk walking program was able to reduce the body weight, body fat, and waist circumference, as well as reduce the levels of LDL, TC and TG, and increase the levels of HDL. Furthermore, two factors were found to influence the effects of brisk walking on the

body weight, body fat, waist circumference and blood lipids: (1) the amount and intensity of the brisk walking, and (2) the state of health of the participants.

Limitation

Several limitations associated with the present review warrant mention. First, our review was confined to published research, and we simply searched PubMed and Web of Science to find appropriate articles. Second, there may have been some bias in a few of the selected studies, which may have influenced the results. Finally, the health of the subjects among the different studies may have influenced the findings, including type 2diabetes mellitus, physically deconditioned, hypercholesterolemic, and eumenorrheic patients. Such limitations may thus have been major confounding factors in this review.

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