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Research article

Low-Volume Walking Program Improves Cardiovascular-Related Health in Older Adults

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Abstract

Although numerous sources of evidence show that regular physical activity is beneficial to health, most individuals do not engage in a sufficient amount of physical activity to meet the guidelines set out by expert panels. In addition, the minimum amount of physical activity associated with reduced cardiovascular disease risk markers is not clear in older adults. The purpose of this study was to determine the effects of a 12-week walking program involving an exercise volume below the current minimum physical activity recommendation on cardiovascular disease risk markers in older adults. The participants were recruited from the following two groups separately: a walking group (n = 14) and a control group (n = 14). In the walking group, participants walked 30 to 60 minutes per session on 2 days per week for 12 weeks (average walking time, 49.4 ± 8.8 min/session). Plasma oxidised low-density lipoprotein concentrations tended to be lower than baseline values in the walking group after 12 weeks (paired t-test, p = 0.127). The ratio of oxidised low-density lipoprotein to high-density lipoprotein cholesterol was significantly lower than the baseline ratio in the walking group after 12 weeks (paired t-test, p = 0.035). Resting systolic blood pressure and diastolic blood pressure were significantly lower than baseline values in the walking group after 12 weeks (paired t-tests, p = 0.002, p < 0.0005, respectively). Our findings demonstrate that a 12-week walking program comprising a low volume of physical activity confers a benefit to cardiovascular-related health in older adults.

Key words: blood pressure, exercise, lipid metabolism, older adults, oxidised low-density lipoprotein.

Introduction

The current physical activity guidelines recommended that adults should accumulate 30 minutes of moderate-to-vigorous intensity activity on most, preferably all, days of the week (i.e. at least 150 minutes of moderate-to-vigorous intensity activity per week) (Haskell et al., 2007; O'Donovan et al., 2010). Meeting the current physical activity recommendation as above is associated with a reduced risk of metabolic syndrome, hypertension, and cardiovascular diseases (Haskell et al., 2007; WHO, 2010). Despite these health benefits, less than one-half of the adult population in East Asian countries, including Japan, failed to meet the public health guidelines for physical activity (Wai et al., 2008). Therefore, the development of effective strategies to promote physical activity among adults should be a public health concern.

Although a recent prospective cohort study demonstrated that approximately 90 minutes a week (15 min/day) of physical activity is sufficient to reduce mortality and extend life expectancy among Taiwanese men and women (Wen et al., 2011), a few studies have directly examined the effects of an exercise program below the current minimum recommendation on cardiovascular risk markers in adults (Murtagh et al., 2005; Tully et al., 2007).

Previous studies have indicated that oxidised low-density lipoprotein (LDL) induces reactive oxygen species production in monocytes. Thus, oxidised LDL has been identified as a potent chemoattractant, oxidative stressor of atherogenesis, and generator of monocyte emigration into the subendothelial space (Holvoet et al., 2001, Libby et al., 2002). Furthermore, circulating concentrations of oxidised LDL are associated with cardiovascular disease risk markers such as blood pressure and lipid levels (Holvoet et al., 2007; Hulthe and Fagerberg, 2002). Above all, recent evidence suggests that the ratio of oxidised LDL to high-density lipoprotein (HDL) cholesterol is a powerful marker for cardiovascular disease risk factors and is a better biomarker than standard lipid measurements for discriminating between patients with coronary artery disease and healthy subjects (Johnston et al., 2006). However, no studies to date have examined the effects of a low-volume walking exercise program on plasma oxidised LDL in older adults.

Therefore, the purpose of the present study was to determine the effect of a 12-week walking program below the current minimum recommendation (<150 min/week, 2 times/week) on plasma oxidised LDL concentrations and other cardiovascular disease risk markers in older adults.

Methods

Participants

Participants were recruited from the general populations (i.e., none were trained athletes competing in any sporting events, but some participants were recreationally active) of local communities. Two groups of 14 older (≥ 60 years of age) participants were recruited separately. One group of 14 participants was assigned to a walking group, and

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the other group of 14 participants was assigned to a control group. Participants using lipid- and/or glucose-lowering medications were excluded from the present study. This study was approved by the institutional ethics advisory committee. Informed consent was obtained from all participants after the experiment was described to them in detail.

Walking program

The exercise program comprised 30 to 50 minutes of walking on 2 days per week (i.e., Tuesday and Friday) for 12 weeks. Each 30- to 50-minute walking session included 5 minutes of warm-up activities and 5 minutes of cool-down activities in the morning (10:00–11:00). During weeks 1 to 5, participants completed a 30- to 40-minute walking session (walking distance was 2.5–3.5 km). During weeks 6 to 12, participants completed a 40- to 50-minute walking session (walking distance was 3.5–4.5 km). All walking sessions were performed outdoors and supervised by experienced assistants. The participants were asked to indicate their exercise intensity during each walking session using the Borg scale (Borg, 1973), and heart rate was measured using short-range telemetry (Polar RS400, Polar Electro Oy, Finland). Participants in the control group were advised to maintain their usual activities of daily living during the study.

Physical activity measurement

To determine physical activity levels, participants were asked to wear a uniaxial accelerometer (Lifecoder-EX; Suzuken Co. Ltd., Nagoya, Japan) for 12 consecutive weeks. Participants in both groups were contacted by phone at the beginning of each week to assess adherence and any device problems. All participants reported that there were no problems with their use of the accelerometer. We collected accelerometer data from each group simultaneously, indicating that seasonality was not an issue in the present study. By measuring the magnitude and frequency of accelerations, the device determines the activity intensity level (11 levels: 0, 0.5, and 1–9; 0 is the lowest activity and 9 is the highest activity) every 4 seconds. Data from participants who had worn the accelerometer for at least 10 hours (600 min) a day for at least 4 weekdays and 1 weekend day in total after calculation of wear time were considered valid (Chen et al. 2009; Matthews et al. 2008). We noted that all participants wore the accelerometer every day during the data collection period. The main physical activity outcome used in this study was the time spent in moderate to vigorous physical activity (MVPA). MVPA was calculated on a daily basis and then used to estimate weekly activity by taking a weighted average of daily weekday and weekend activity [i.e., weekly MVPA = (average daily weekday MVPA × 5) + (average daily weekend MVPA × 2)] (Chen et al. 2009; Matthews et al. 2008). All recordings with a total of ≥4 activity levels were classified as MVPA. A threshold activity level of 4 was derived from a calibration study (Kumahara et al., 2004) and corresponded to approximately three metabolic equivalents.

Anthropometry and blood pressure measurements

Anthropometric parameters were measured at baseline and after 12 weeks in each group. Body mass was measured to the nearest 0.05 kg using a digital scale (InnerScan 50; Tanita Co, Tokyo, Japan). Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer (YS-OA; As One Co, Osaka, Japan). Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Waist circumference was measured to the nearest 0.1 cm at the level of the umbilicus using a flexible plastic tape while the participants were in the standing position. Arterial blood pressure was measured with a mercury sphygmomanometer (605P; Yagami Co. Ltd., Nagoya, Japan) after participants had been seated at rest for 5 minutes. Two measurements were taken at each time point, and the mean of these values was used.

Dietary assessments

In the present study, participants were not provided with any foods or beverages throughout the study period in each group. To examine whether dietary intake influences outcome factors, diet recall questions were conducted at baseline and during the study period (i.e., at week 10) in each group. Diet records were analysed using a computerised nutritional analysis system (Excel Eiyokun, Kenpakusha, Tokyo, Japan). Dietary assessments were conducted by a registered dietician.

Blood collection and laboratory assays

After a 48-hour period of physical activity avoidance, fasting (i.e., after an overnight fast of at least 10 h) venous blood samples were taken from an antecubital vein at baseline and at 12 weeks in both groups. Blood samples were analysed for the measurements of oxidised LDL, glucose, insulin, HbA1c, soluble E-selectin (sE-selectin), soluble vascular cell adhesion molecule (sVCAM-1), C-peptide, triacylglycerol, total cholesterol (TC), HDL cholesterol, and LDL cholesterol. For triacylglycerol, TC, HDL cholesterol, and LDL cholesterol, the samples were collected into tubes containing clotting activators for isolation of serum. Thereafter, samples were allowed to clot for 45 minutes at room temperature and then centrifuged at 3000 rpm for 10 minutes at 4°C. After separation, serum was dispensed into plain microtubes and stored at –80°C for later analysis. For HbA1c, oxidised LDL, insulin, sE-selectin, sVCAM-1, and C-peptide, venous blood samples were collected into tubes containing disodium salt-EDTA. Thereafter, samples were immediately centrifuged and treated as above. For glucose measurements, venous blood samples were collected into tubes containing sodium fluoride-EDTA. Thereafter, samples were immediately centrifuged and treated as above.

Concentrations of plasma oxidised LDL (Mercodia AB, Uppsala, Sweden), insulin (Mercodia AB, Uppsala, Sweden), sE-selectin (eBioscience, Inc., San Diego, USA), sVCAM-1 (eBioscience, Inc., San Diego, USA), and C-peptide (Mercodia AB, Uppsala, Sweden) were measured by enzyme-linked immunosorbent assay using commercially available kits. Concentrations of serum triacylglycerol, TC, HDL cholesterol, LDL cholesterol,

plasma glucose and HbA1c were determined by standard laboratory methods.

Statistical analysis

Data were analysed using Predictive Analytics Software (PASW) version 18.0 for Windows (IBM SPSS Japan Inc., Tokyo, Japan). Assumptions of distributional normality were tested using the Shapiro-Wilk test. The distribution of all parameters did not differ significantly from normal. Paired Student's t-tests were used to assess within-group differences between pre- and post-intervention data. A two-factor repeated-measures analysis of variance (ANOVA) was used to determine the interaction (group × time) effects for all outcome variables. The 95% confidence intervals (95% CI) for each group were calculated and absolute standardised effect sizes (ES) were provided to supplement the findings. Statistical significance was accepted at the 5% level. Results were presented as the mean ±standard error of the mean (SEM).

Results

Adherence to the walking program was 92.3 ± 1.8% in the walking group. The pulse rate and ratings of perceived exertion during the walking program were 97.1 ± 4.5 beats/min and 10.8 ± 0.2 (i.e., light), respectively. This corresponded to an exercise intensity of 64 ± 3 % of the age-predicted maximum heart rate.

MVPA during the study duration (i.e., 12 weeks) was 136.6 ± 16.9 min/week in the control group and 235.5 ± 14.3 min/week in the walking group. There was a significant difference in MVPA between the two groups (95% CI = -98.91 to 27.86 min/week, ES = 1.34, $p < 0.05$). Daily MVPA in the walking group on days when supervised walking was performed (Walking days), on days when no supervised walking was performed (Normal days), and on all days during the program are shown in Table 1. Participants in the walking group engaged in significantly more physical activity on the "walking" days compared with on the "normal" days ($p < 0.001$). Participants in the walking group undertook more voluntary physical activity (MVPA per day, not including any accrued activity from supervised walking) on the "normal" days (23.0 ± 3.0 min/day) than on the "walking" days (9.3 ± 3.9 min/day) ($p < 0.001$).

Table 1. Moderate to vigorous physical activity (MVPA) levels for the walking group (n = 14).

	Mean (SEM)	Range
Walking days (min/day)	59.2 (3.9)**	42.0 – 95.2
Normal days (min/day)	23.0 (3.0) **	7.9 – 49.5
All days (min/day)	30.0 (3.2)	14.0 – 58.9

Walking days, participate in walking program; Normal days, free-living conditions. ** Significantly different from walking days vs. normal days (Paired Student`s t-test $p < 0.001$).

At baseline, the physical characteristics were not significantly different between the two groups (Table 2). Within-group analyses showed that body mass was significantly lower than baseline values in the walking group after 12 weeks (95% CI = 0.27 to 1.10 kg, $p = 0.003$), and BMI was also lower in only the walking group (95% CI = 0.11 to 0.45 $kg \cdot m^{-2}$, $p = 0.003$). Within-group analyses showed that waist circumference was significantly lower than baseline values in both the walking and control groups after 12 weeks (95% CI = 1.72 to 8.90 cm, $p = 0.007$ and 95% CI = 0.54 to 6.95 cm, $p = 0.025$, respectively). Within-group analyses showed that systolic and diastolic blood pressures were significantly lower than baseline values in the walking group after 12 weeks (95% CI = 3.91 to 13.38 mmHg, $p = 0.002$ and 95% CI = 5.42 to 12.15 mmHg, $p < 0.001$, respectively).

Analysis of dietary data revealed that daily energy intake did not differ between or within groups at baseline or during the study. Analysis of dietary data revealed that antioxidant intake (i.e., vitamin C, vitamin E and β-carotene) also did not differ between or within groups at baseline or during the study. In the walking group, antioxidant intake at baseline and during the study period (i.e., at week 10) was 121.9 ± 7.2 mg vitamin C, 6.7 ± 0.3 mg vitamin E, and 5.4 ± 0.3 mg β-carotene and 125.1 ± 7.3 mg vitamin C, 6.8 ± 0.3 mg vitamin E, and 5.4 ± 0.3 mg β-carotene, respectively. In the control group, antioxidant intake at baseline and during the study period (i.e., at week 10) was 140.6 ± 4.6 mg vitamin C, 7.6 ± 0.3 mg vitamin E, and 5.8 ± 0.3 mg β-carotene and 139.3 ± 5.1 mg vitamin C, 7.5 ± 0.3 mg vitamin E, and 5.7 ± 0.4 mg β-carotene, respectively.

Table 2. Changes in body composition at baseline and after 12 weeks. Values are mean (± SEM).

		Walking Group ($n = 14$)	Control Group ($n = 14$)	*P* -value (time, interaction)
Sex, male/female	Baseline	6/8	3/11	-
Age (years)	Baseline	67.8 (1.3)	71.4 (1.6)	-
Height (m)	Baseline	1.57 (.01)	1.57 (.02)	-
Body mass (kg)	Baseline	55.0 (2.7)	55.2 (2.0)	.018, .132
	12 weeks	54.3 (2.7) *	55.0 (2.1)	
BMI ($kg \cdot m^{-2}$)	Baseline	22.3 (.9)	22.4 (.5)	.010, .156
	12 weeks	22.1 (.9) *	22.3 (.5)	
Waist circumference (cm)	Baseline	82.3 (2.1)	80.5 (2.3)	.001, .487
	12 weeks	77.0 (2.6) *	76.7 (1.7) *	
SBP (mm Hg)	Baseline	131 (3)	131 (3)	.011, .103
	12 weeks	123 (2) *	128 (3)	
DBP (mm Hg)	Baseline	79 (2)	80 (2)	.001, .236
	12 weeks	70 (2) **	76 (3)	

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.
* Significantly different from the baseline value in the same group (Paired Student`s t-test $p < 0.05$)
** Significantly different from the baseline value in the same group (Paired Student`s t-test $p < 0.001$)

Table 3. Changes in blood parameters at baseline and after 12 weeks. Values are mean (± SEM).

		Walking Group (n = 14)	Control Group (n = 14)	*P* -value (time, interaction)
Triacylglycerol (mmol/L)	Baseline	1.05 (.10)	1.11 (.12)	.558, 1.000
	12 weeks	1.10 (.149	1.16 (.19)	
TC (mmol/L)	Baseline	5.84 (.21)	5.67 (.19)	.979, .189
	12 weeks	5.93 (.24)	5.58 (.17)	
HDL-C (mmol/L)	Baseline	1.79 (.10)	1.64 (.10)	.001, .049
	12 weeks	1.93 (.10) *	1.69 (.10)	
LDL-C (mmol/L)	Baseline	3.40 (.18)	3.36 (.17)	.215, .603
	12 weeks	3.34 (.17)	3.23 (.17)	
Glucose (mmol/L)	Baseline	5.20 (.24)	5.10 (.69)	.460, .849
	12 weeks	5.15 (.15)	5.01 (.63)	
Insulin (pmol/L)	Baseline	23.2 (3.1)	23.7 (3.2)	.155, .687
	12 weeks	26.8 (3.3)	30.2 (8.3)	
HbA1c (%)	Baseline	5.12 (.85)	5.00 (.03)	.294, .065
	12 weeks	5.22 (.12)	4.97 (.37)	
sE-selectin (ng/ml)	Baseline	37.0 (3.1)	41.2 (3.2)	.002, .231
	12 weeks	34.8 (3.6)	36.6 (2.8) *	
sVCAM-1 (ng/ml)	Baseline	529 (32)	608 (40)	.001, .878
	12 weeks	435 (33) **	518 (37) **	
C-peptide (pmol/L)	Baseline	368 (32)	410 (34)	.629, .357
	12 weeks	387 (27)	404 (36)	
Oxidised LDL (U/L)	Baseline	53.8 (5.5)	51.2 (5.7)	.075, .743
	12 weeks	46.0 (3.7)	45.8 (4.4)	

TC, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; sE-selectin, soluble E-selectin; sVCAM-1, soluble vascular adhesion molecule-1; Oxidised LDL, Oxidised low-density lipoprotein.
* Significantly different from the baseline value in the same group (Paired Student`s t-test $p < 0.05$)
** Significantly different from the baseline value in the same group (Paired Student`s t-test $p < 0.001$)

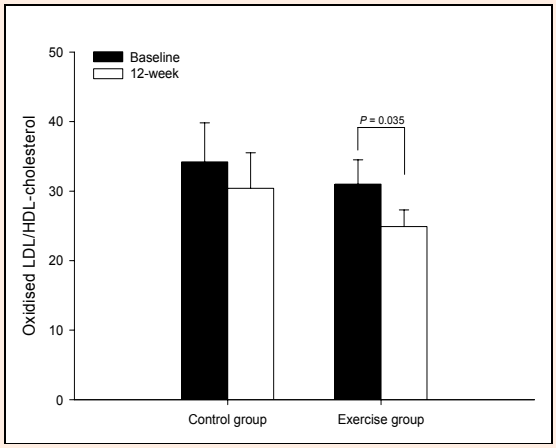

Figure 1. The ratio of oxidised low-density lipoprotein (LDL) to high-density lipoprotein (HDL) cholesterol concentrations measured at baseline and 12 weeks in the control and walking groups. Data are means ± SEM. Main effect of time (p = 0.028) and time × group interaction (p = 0.592, 2-factor ANOVA). Significantly different from the baseline value in the same group (Paired Student's t-tests, p = 0.035).

At baseline, there was no difference in plasma oxidised LDL concentrations between the two groups. For plasma oxidised LDL concentrations, two-factor ANOVA revealed that there were no main effect of time, and time by group interaction. Within-group analysis showed that plasma oxidised LDL concentrations did not change significantly in either group after 12 weeks, but values tended to be lower than baseline values in the walking group after 12 weeks (95% CI = -2.53 to 18.06 U/L, p = 0.127). At baseline, there was no difference in the ratio of oxidised LDL to HDL cholesterol between the two groups (Figure 1). For the ratio of oxidised LDL to HDL cholesterol, two-factor ANOVA revealed that there was a main effect of time (ES = 0.20, p = 0.028), but no time by group interaction was found. Within-group analysis showed that the ratio of oxidised LDL to HDL cholesterol was significantly lower than baseline values in the walking group after 12 weeks (95% CI = 0.50 to 11.76, *P* = 0.035).

Biochemical and hormonal parameters measured at baseline and after 12 weeks in the walking and control groups are presented in Table 3. At baseline, there were no differences in any biochemical or hormonal parameters between the two groups. For serum HDL cholesterol concentrations, two-factor ANOVA revealed that there were main effects of time (ES = 0.39, p = 0.001) and time by group interactions (p = 0.049). Within-group analysis showed that serum HDL cholesterol concentrations were significantly higher than baseline values in the walking group after 12 weeks (95% CI = -0.22 to -0.06 mmol, p = 0.003). Within-group analysis showed that plasma sE-selectin concentrations were significantly lower than baseline values in the control group after 12 weeks (95% CI = 1.54 to 7.74 $ng \cdot ml^{-1}$, p = 0.007).Within-group analysis showed that plasma sVCAM-1 concentrations were significantly lower than baseline values in both the walking and control groups after 12 weeks (95% CI = 68.36 to 119.26 $ng \cdot ml^{-1}$, p = 0.001, 95% CI = 42.30 to 137.56 $ng \cdot ml^{-1}$, p = 0.001, respectively). No significant changes were observed for both between-group and within-group analysis in triacylglycerol, TC, LDL cholesterol, glucose, insulin, HbA1c, or C-peptide concentrations.

Discussion

To our knowledge, the present study is the first to examine the short-term effects of walking equivalent to an amount below the current minimum physical activity recommendation (< 150 min of moderate-intensity walking per week) on cardiovascular risk markers in older adults. The main findings of this study are that (1) oxidised LDL concentrations do not appear to be reduced after a low volume of walking, but the ratio of oxidised LDL to HDL cholesterol appear to be reduced, and (2) performing a low volume of walking equivalent to an amount of exercise below the current minimum physical activity recommendation improves cardiovascular disease risk markers, including blood pressure and HDL cholesterol. These findings indicate that because an amount of exercise below the minimum recommended confers a benefit to health in older adults, our findings might encourage more people to engage in physical activity.

In 2007, the American College of Sport Medicine and American Heart Association published physical activity and public health recommendations for older adults (performing at least 150 min of moderate-intensity aerobic activity and muscle-strengthening activities) to prevent general chronic disease. These recommendations are widely accepted as the current public health global standard for physical activity in older adults (Nelson et al., 2007). Most exercise intervention studies have been conducted to meet these guidelines (Butcher et al., 2008; Cornelissen et al., 2009; Ziegler et al., 2006) but compliance with these recommendations requires considerable commitment in terms of time spent exercising per week (≥150 min) (Haskell et al., 2007; WHO, 2010). Indeed, some adults fail to achieve such an exercise volume because of lack of time (National Institute for Clinical Excellence, 2006). Therefore, it is important to consider even a small amount of physical activity for particularly older adults. In the present study, serum HDL cholesterol concentrations were significantly increased and resting systolic blood pressure and diastolic blood pressure were significantly reduced in the walking group after 12 weeks. These observations are consistent with those of previous studies showing that a low-volume walking program (30 min/session, 2 times/week for 6 months) improved cardiorespiratory fitness and daily living patterns in elderly women (Hamdorf and Penhall, 1999; Hamdorf et al., 1992). Another study also provided evidence that middle-aged sedentary civil servants showed decreases in systolic blood pressure and body fat percentage after short-term walking (45 min/session, 2 times/week for 8 weeks) (Murphy et al., 2006). Thus, our findings that a small volume of walking increased serum HDL cholesterol concentrations and lowered blood pressure could have public health implications because such activity modifications may be easier for people to integrate into daily life.

In the present study, a low volume of walking was not effective for reducing plasma oxidised LDL concentrations, but values tended to decrease in the walking group (from 53.8 ± 5.5 to 43.1 ± 1.1 U/L). One previous study showed that a high volume of running training (66% of heart rate reserve, 60 min/session, 3 times/week for 10 weeks), but not a low volume of running training, significantly reduced plasma oxidised LDL concentrations (baseline, 73.1 ± 3.9 U/L; change during the training period, –5.92) in older adults (Cornelissen et al., 2009). These inconsistencies may be explained in part by the initial baseline oxidised LDL level and the variety of training stimuli. Previous studies have involved treadmills (Butcher et al. 2008, Cornelissen et al. 2009), but our study involved outdoor walking with a minimal investment in time. Nonetheless, it is important to note that outdoor walking is a free form of exercise that can be engaged in everyday life and is achievable by virtually all older adults (Morris and Hardman, 1997; Simonsick et al., 2005).

The ratio of oxidised LDL to HDL cholesterol is a useful marker for cardiovascular disease risk factors and is a better biomarker than standard lipid measurements for discriminating between patients with coronary artery disease and healthy subjects (Johnston et al., 2006). In the present study, a low volume of walking significantly decreased the ratio of oxidised LDL to HDL cholesterol. We speculate that increased concentrations of HDL cholesterol may prevent and play an important role in oxidation of LDL (Ahotupa et al., 2010; Meisinger et al., 2005). A recent cross-sectional study reported that healthy young men with the lowest cardiorespiratory fitness and muscle fitness index had a higher ratio of oxidised LDL to HDL cholesterol (Kosola et al., 2011). In addition, the ratio of oxidised LDL to HDL cholesterol was higher in the overweight/unfit subgroup compared with the overweight/fit subgroup (Kosola et al., 2012). These results suggest that good cardiovascular and muscular fitness changes this association by improving the ratio of oxidised LDL to HDL cholesterol. It is worth noting that the extent to which these observations are clinically relevant is unknown because there is no defined clinical cut-off point for the ratio of oxidised LDL to HDL cholesterol. Nonetheless, a high ratio of oxidised LDL to HDL cholesterol is a powerful risk factor for cardiovascular disease in men and women (Johnston et al., 2006). A previous study found that the ratio of oxidised LDL to HDL cholesterol of >53 versus <53 was associated with a 14-fold increase in the risk of coronary heart disease in men and women (Johnston et al., 2006). Thus, a small change in the ratio of oxidised LDL to HDL cholesterol brought about by physical activity could have important public health implications in terms of reducing cardiovascular disease risk. Indeed, a recent prospective cohort study demonstrated that as little as 90 minutes a week (15 min a day) of physical activity is sufficient to reduce mortality and extend life expectancy among Taiwanese men and women (Wen et al., 2011). Thus, it seems feasible that the small volume of physical activity needed to change the ratio of oxidised LDL to HDL cholesterol is likely to be clinically important despite a lack of long-term observations relating to physical activity, the ratio of oxidised LDL to HDL cholesterol, and clinical endpoints.

During the intervention in the present study, physical activity levels were significantly increased in the walking group on “walking” days compared with “normal” days. However, consistent with previous findings

(Goran and Poehlman, 1992; Hagiwara et al. 2000; Murphy et al. 2006), there was a significant difference between the amounts of voluntary MVPA on "walking" days compared with that on "normal" days. This result indicates that participants decreased their non-program activity on the "walking" days, which could be explained by a decrease in spontaneous physical activity because of an increase in voluntary physical activity (Goran and Poehlman, 1992). Therefore, in addition to time spent in voluntary physical activity, future studies should consider the time spent in spontaneous physical activity. It is worth noting that approximately half of our participants completed sufficient amounts to meet the minimum physical activity guidelines (Haskell et al., 2007; O'Donovan et al., 2010) – 7 of our participants in the walking group had achieved > 150 min of moderate-vigorous intensity activity per week (i.e. excluding the walking program for 100 min per week) and 5 of our participants in the control group had achieved > 150 min of moderate-vigorous intensity activity per week. Thus, it is possible to speculate that these additional activities may have affected the findings. In addition, it would also be of interest to examine individuals with low activity levels (i.e., for those who do not meet the minimum recommended volume of physical activity) to see whether this influences cardiovascular risk markers.

Conclusion

In conclusion, plasma oxidised LDL concentrations were not reduced after 12 weeks, but a low-volume walking program reduced the ratio of oxidised LDL to HDL cholesterol and resting arterial blood pressure and increased the HDL cholesterol concentration in older adults. The effect of longer-term modifications of daily activities on cardiovascular disease risk markers in a large population warrants attention.

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Key points

- It is important to consider baseline physical activity levels when evaluating physical activity program.
- Being physically active is important to reduce the potential risk marker of cardiovascular disease in older adults.
- These data imply that a small volume of 12-week walking program confers a benefit to cardiovascular-related health in older adults.

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