EVIDENCE-BASED PUBLIC HEALTH POLICY AND PRACTICE

Randomised controlled trial of home-based walking programmes at and below current recommended levels of exercise in sedentary adults

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Objectives: To determine, using unsupervised walking programmes, the effects of exercise at a level lower than currently recommended to improve cardiovascular risk factors and functional capacity.
Design: 12 week randomised controlled trial.
Setting: Northern Ireland Civil Service; home-based walking.
Participants: 106 healthy, sedentary 40 to 61 year old adults of both sexes.
Interventions: Participants were randomly allocated to a walking programme (30 minutes brisk walking three days a week (n = 44) or five days a week (n = 42)) or a control group (n = 20). Participants could choose to walk in bouts of at least 10 minutes. They used pedometers to record numbers of steps taken. Intention to treat analysis of changes within groups was done using paired *t* tests; extent of change (baseline to 12 week measurements) was compared between groups using analysis of variance and Gabriel's post hoc test.
Main outcome measures: Blood pressure, serum lipids, body mass index, waist:hip ratio, and functional capacity (using a 10 m shuttle walk test).
Main results: 89% (93/106) completed the study. Systolic blood pressure and waist and hip circumferences fell significantly both in the three day group (5 mm Hg, 2.6 cm, and 2.4 cm, respectively) and in the five day group (6 mm Hg, 2.5 cm, and 2.2 cm) ($p<0.05$). Functional capacity increased in both groups (15%; 11%). Diastolic blood pressure fell in the five day group (3.4 mm Hg, $p<0.05$). No changes occurred in the control group.
Conclusions: This study provides evidence of benefit from exercising at a level below that currently recommended in healthy sedentary adults. Further studies are needed of potential longer term health benefits for a wider community from low levels of exercise.

Physical activity is an important public health issue.[1 2] Recent National Institute for Health and Clinical Excellence (NICE) guidance highlights the contribution of regular physical activity to promoting the health of communities.[1] It is recommended that every adult accumulates at least 30 minutes of moderate intensity exercise on most days of the week[1 2] but few people meet this target currently. There is a need to translate this recommendation into a meaningful behaviour pattern that can fit into daily life[2] and to develop innovative approaches to promote physical activity.[1 2]

Walking is a form of exercise that is very acceptable to many people[3] and may be integrated easily into daily routines. It does not require any formal training or specialist equipment and can be undertaken in an individual's own locality and time.[3] It may involve variable levels of exercise. However, NICE indicates that there is currently insufficient evidence to recommend the promotion of organised walking schemes, and that the effects of low levels of exercise are poorly documented.[1] Within the context of research, reported adherence in supervised programmes tends to be low.[4] There are few reports of adherence within unsupervised walking programmes.[5]

Many people attribute their failure to achieve the currently recommended target for exercise to a lack of time.[1] It has been proposed that future research should focus on identifying the minimum dose of exercise that reduces cardiovascular risk.[6] There are gaps in evidence in relation to the effects of exercising below the currently recommended level,[7] the differential effects of varying doses of exercise, and the use of pedometers as an adjunct to other interventions.[1]

We aimed to determine the effects of unsupervised home-based walking at and below the current recommended level of exercise[1 2] on cardiovascular risk factors and functional capacity in healthy sedentary adults, using pedometers for self monitoring.

METHODS

Participants

All employees aged 40 years and older working in Northern Ireland Civil Service (NICS) departments that agreed to facilitate the study were invited by an email from their employers to participate (March 2003 to July 2003). The researcher (MT) then invited respondents by phone or email to an information session where he explained the study and sought participants' informed consent. The study was approved by the Queen's University of Belfast research ethics committee.

Those who attended an information session completed a lifestyle and health questionnaire and had their blood pressure measured. All who met the inclusion criteria (sedentary (defined by self report as not having undertaken more than one session of moderate intensity exercise each week over the past six months—that is, exercise that results in an increased respiratory and heart rate, but where the individual can still carry out a conversation[2]); blood pressure less than 140/90 mm Hg; no history of musculoskeletal, pulmonary, or cardiac disease that would limit the ability to exercise; and taking no

Abbreviations: NICE, National Institute for Health and Clinical Excellence; SWT, shuttle walk test

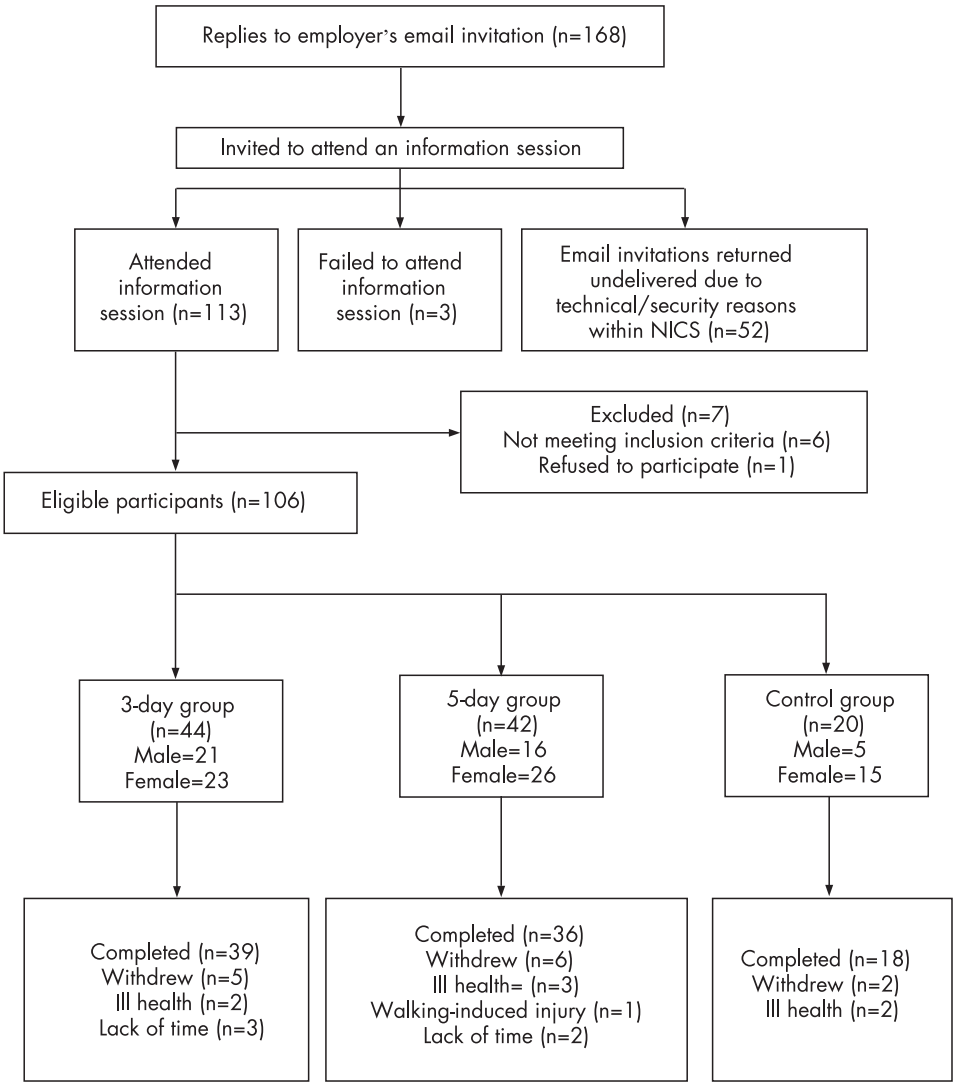

Figure 1 Participant flow through study of home-based walking at and below current recommended levels in sedentary adults. NICS, Northern Ireland Civil Service.

drugs with effects on lipid metabolism) were invited to return one week later for baseline measurements and random allocation to one of three groups. The allocation was determined using computer generated random numbers at a remote location and was revealed only after baseline measurements were completed.

Outcome measurements

Height and weight, measured using a portable stadiometer (Seca Leicester, Germany) and Seca Scales (Seca 761, Germany) respectively, were used to calculate body mass index (BMI). Waist and hip circumferences were measured using standard procedures.[8] Arterial blood pressure and heart rate were measured in the seated position after three minutes of rest, using a validated automatic sphygmomanometer (Omron Devices M5I, USA) according to the manufacturer's instructions. Following these measurements a fasting (10 hour) venous blood sample was taken. Functional capacity was then assessed using a 10 m shuttle walk test (SWT)[9] in which participants walked between two cones in response to a series of beeps of increasing frequency: when they failed to achieve the set pace the distance they had walked was recorded.

All participants completed a brief food frequency questionnaire—a modified version of the DINE questionnaire[10]—at the baseline assessment and were asked not to change their diet during the study. This questionnaire and other measurements were repeated within one week after completion of a 12 week programme.

Blood samples were analysed for total cholesterol, triglycerides, and high density lipoprotein (HDL) cholesterol using enzymatic methods (Sigma Diagnostics, Dorset, UK) and a Cobas FARA bioanalyser (Roche Products Ltd, Herts, UK). Low density lipoprotein (LDL) cholesterol was calculated by the Friedewald equation.[11] Baseline and 12 week samples were analysed at the same time, with blinding to the group allocation.

Walking programme

Participants allocated to the three day group and the five day group were asked to walk briskly (at a pace faster than normal, which led to mild shortness of breath) during three and five days a week, respectively, for 30 minutes a day. They could choose to complete their walking in a single bout, or in shorter multiple bouts of at least 10 minutes. They were given a pedometer (Oregon Scientific PE316CA, England) and a diary and asked to record the number of steps taken, the duration of the walk, the level of breathlessness (Borg scale of dyspnoea (a 10 point linear scale asking subjects to rank their level of breathlessness from 0 = "not breathless at all" to 10 = "maximal")),[12] and any comments or difficulties during each bout of walking. Every two weeks diaries were returned to the researcher, who posted new ones and phoned participants to resolve any difficulties.

Table 1 Data for the three day, five day, and control groups at baseline

Characteristic	Three day group (n = 44)	Five day group (n = 42)	Control group (n = 20)
Age (years)	47.80 (5.97)	46.37 (4.76)	49.05 (6.31)
Height (m)	1.70 (0.11)	1.69 (0.10)	1.65 (0.10)
Weight (kg)	81.51 (17.54)	76.60 (16.33)	70.90 (13.14)
BMI (kg/m^2)	27.79 (4.85)	25.77 (4.09)	26.32 (5.94)
Waist (cm)†	98 (15)	92 (13)	88 (12)
Hip (cm)	109 (11)	106 (9)	105 (10)
WHR	0.89 (0.09)	0.87 (08)	0.84 (0.08)
Systolic BP (mm Hg)	134 (15)	133 (15)	128 (15)
Diastolic BP (mm Hg)	87 (11)	87 (11)	83 (10)
Heart rate (beats/min)	69 (12)	72 (10)	75 (11)
TC (mmol/l)	5.65 (1.06)	5.82 (1.10)	6.15 (1.25)
TG (mmol/l)	1.32 (.80)	1.00 (0.47)	1.04 (.64)
Log_{10} TG*†	0.06 (0.17)	0.13 (0.15)	0.16 (0.18)
HDL-C (mmol/l)	1.31 (0.82)	1.03 (0.51)	1.05 (.63)
LDL-C (mmol/l)	3.83 (0.81)	3.92 (1.21)	4.1 (1.36)
TC:HDL†	5.54 (2.10)	4.38 (1.88)	4.50 (2.64)
Distance walked in 10 m SWT (metres)	631 (146)	610 (128)	560 (134)

Values are mean (SD).
*Pairwise comparison of group means at baseline with Gabriel's post test found a significant difference between the three day and the control group ($p<0.05$).
†Pairwise comparison of group means at baseline with Gabriel's post test found a significant difference between the three day and the five day group ($p<0.05$).
BMI, body mass index; BP, blood pressure; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; SWT, shuttle walk test; TC, total cholesterol; TG, triglycerides; WHR, waist to hip circumference ratio.

Control group participants were asked to maintain their current lifestyle for 12 weeks, given a diary, and asked to record any exercise taken above what they would normally do. After the 12 weeks of the study, they were given pedometers and invited to begin their own walking programme.

Statistical analysis

Based on information available when planning the study,[13] we estimated that a 25% change in HDL could be detected with 80% power and an α level of 0.05 with 40 subjects in a group. Individuals were allocated on a 2:2:1 ratio to the exercise and control groups because of known recruitment problems in exercise studies[14] and an assumption that no change in HDL would be found within the control group. Data were analysed using SPSS v14.0. Baseline differences between groups were compared using analysis of variance (ANOVA) and pairwise post hoc testing with Gabriel's post hoc test. Changes within groups were analysed using paired *t* tests on baseline and 12 week results. The extent of change (between baseline and 12 week measurements) was compared between groups using ANOVA and Gabriel's post hoc test. Data were analysed using an intention to treat procedure, substituting baseline data for those at 12 weeks for the participants who withdrew during the study.

RESULTS

Because of confidentiality requirements we were not given the exact number of individuals invited to participate. The NICS estimated it was approximately 3000; 168 responses were received, giving a response rate of approximately 5.6%. However, as some invitations were not delivered successfully and responses were invited only from those who were inactive and had "decided to exercise a bit more", and the maximum level of exercise in the study was specified, it is likely that the true response rate from potentially eligible participants was higher than this. The flow of participants through the study is shown in fig 1 and their baseline data in table 1. All participants were involved in non-manual occupations.

At baseline, the three day group had a larger waist circumference, lower triglyceride levels, and a higher total cholesterol to HDL cholesterol ratio than the five day group; compared with the control group they had lower triglyceride levels (table 1).

Overall, 89% of participants (93 of 106) completed the study; similar percentages from each group attended for review. Among these, adherence was similar within the three day (89%) and the five day (83%) groups (table 2). Some participants in both the three day and the five day groups (eight and nine, respectively) chose some days to walk in multiple bouts. Relatively small percentages of both programmes were completed in multiple bouts (three day, 2.7%; five day, 6.5%). In both groups similar numbers of steps were recorded for each day's 30 minute programme (approximately 3500) and measures of breathlessness were similar. The mean walking time recorded each day was 2.6 minutes longer in the three day group than in the five day group.

Within the three day group, weight, BMI, waist circumference, hip circumference, total cholesterol to HDL ratio, and systolic blood pressure decreased significantly, and functional capacity and triglycerides (log transformed) increased (table 3). In the five day group, waist circumference, hip circumference, and systolic and diastolic blood pressure decreased significantly, and functional capacity increased. No significant changes were observed within the control group.

To determine whether the significant changes in weight and BMI observed in the three day group but not in the five day group were a result of a sex imbalance between the groups, subsequent subgroup analysis comparing the response of men and women in each of these groups was carried out by independent *t* test. No significant differences were found between the responses of men and women within each group with respect to their change in weight (three day group: men, mean (SD) −0.97 (1.9) kg; women, −1.1 (3.00) kg, $p = 0.78$; five day group: men, −0.79 (2.08) kg; women, 0.05 (2.73) kg, $p = 0.28$), or BMI (three day group: men, −0.29 (0.63) kg/m^2; women, −0.42 (1.10) kg/m^2, $p = 0.79$; five day group: men, −0.27 (0.78) kg/m^2; women, −0.20 (0.93) kg/m^2, $p = 0.26$).

Analysis of the food frequency diaries revealed no changes in diet within any of the groups (Wilcoxon signed rank test).

ANOVA analysis of distance walked in the 10 m SWT ($F = 2.96$, $df = 2$, $p<0.05$) and subsequent post hoc analysis showed no significant differences between the three day and the five day group (Gabriel's post hoc test $p = 0.81$) but the three day group had a significantly greater increase in functional capacity than the control group (Gabriel's post hoc test $p = 0.03$).

DISCUSSION

These findings indicate that a 12 week programme of unsupervised brisk walking equivalent to a level of exercise below the current minimum recommendation confers benefit on measures of health and functional capacity. Systolic blood pressure, anthropometric measurements, and functional capacity improved significantly among participants who walked for 30 minutes three days a week. Those who walked on five days each week also showed improvements in these measures and in diastolic blood pressure.

Changes in blood pressure

The reductions in systolic and diastolic blood pressure observed in the five day group are similar to those reported in a meta-analysis of 16 studies,[15] the majority of which involved supervised or partly supervised walking. Our findings indicate

Table 2 Reported performance of walking programmes by the three day and the five day groups

	Three day gp (n = 39)	Five day gp (n = 36)	p Value
Total number of days prescribed*	1404	2160	–
Total number of days completed	1254	1785	–
Adherence (mean (SD))†	89.3% (17.88)	82.6% (22.17)	p = 0.42‡
Median adherence	97.22%	91.66%	
Number of days completed in multiple bouts (% of total No completed)	38 (2.7%)	137 (6.5%)	p = 0.65‡
No of steps walked each day (mean (SD))	3584 (638)	3493 (557)	p = 0.15§
Borg scale of dyspnoea (mean (SD))	2.1 (1.63)	2.33 (1.35)	p = 0.22
Time (min) spent walking per day (mean (SD))	29.5 (10.5)	26.9 (10.8)	p = 0.04§

*Calculated by multiplying number of days prescribed per week by number in group by 12 (weeks).
†Adherence = number of days completed/number of days prescribed ×100%.
‡Mann–Whitney U test.
§Independent *t* test.

that the extent of reduction in systolic blood pressure which can be achieved with unsupervised walking (6 mm Hg (95% confidence interval, 3.0 to 9.0) in the five day group; 4.5 mm Hg (1.8 to 7.2) in the three day group) is of an order that has clinical significance in reducing the risk of vascular mortality.[16]

Anthropometric measurements

It is difficult to explain the lack of change in weight and BMI in the five day group in comparison with the decrease observed in these variables in the three day group. It was noted that the three day group included relatively more men (48%) than the five day group (38%). However, subsequent subgroup analysis showed no significant difference in the responses of men and women to the walking programmes in respect of their change in weight or BMI. The mean weight appeared greater in the three day group, with possible potential for a greater extent of change, but baseline comparisons between groups showed no statistically significant difference in weight or BMI. In future studies randomisation using stratification by sex might be used to avoid potential confounding effects of sex imbalance between groups.

The three day group walked for slightly longer each day than the five day group (2.6 minutes) but it is unlikely that this would fully explain the findings. Adherence, while not significantly different between the groups, tended to be greater in the three day group; further study may be indicated, with closer monitoring of intensity of exercise. Significant changes in the waist:hip ratio that are associated with a risk of myocardial infarction[17] were not found, possibly because of lack of power with insufficient sample size.

Lipids

A recent meta-analysis[18] of 25 randomised controlled trials of other walking programmes concluded that exercise was associated with a decrease in LDL cholesterol but not in total cholesterol, HDL cholesterol, or triglycerides. We found no significant changes in lipids except for a small increase in log-transformed triglyceride levels in the three day group, which is unlikely to be of clinical significance (0.2 mmol/l). Our failure to find a response in LDL cholesterol may be related to biological variation (genetic differences[19] within groups or day to day fluctuations within individuals), or to inadequate sample

Table 3 Intention to treat analysis of changes in measurements from baseline to completion of study for three day, five day, and control groups

Outcome	Three day group (n = 44)		Five day group (n = 42)		Control group (n = 20)		Between group comparison (ANOVA) (p value)
	Change after 12 weeks (mean (SD))	Change within group (paired *t* test) (p value)	Change after 12 weeks (mean (SD))	Change within group (paired *t* test) (p value)	Change after 12 weeks (mean (SD))	Change within group (paired *t* test) (p value)	
Weight (kg)	−0.97 (2.58)	0.02*	−0.38 (2.45)	0.32	−0.53 (2.34)	0.33	0.54
BMI (kg/m^2)	−0.32 (0.95)	0.03*	−0.15 (0.85)	0.24	−0.23 (0.92)	0.29	0.72
Waist (cm)	−2.63 (4.05)	p<0.001*	−2.48 (4.20)	p<0.001*	−0.87 (3.86)	0.33	0.25
Hip (cm)	−2.40 (5.11)	0.004*	−2.23 (6.12)	0.02*	−0.43 (2.26)	0.41	0.34
WHR	−0.01 (0.05)	0.51	0.00 (0.06)	0.61	0.03 (−0.01)	0.44	0.99
Systolic BP (mm Hg)	−4.51 (8.77)	0.002*	−6.00 (9.72)	p<0.001*	−4.45 (10.26)	0.07	0.73
Diastolic BP (mm Hg)	0.14 (6.69)	0.89	−3.40 (8.88)	0.01*	0.40 (9.18)	0.85	0.09
Heart rate (beats/min)	−0.10 (12.16)	0.96	−2.95 (11.09)	0.10	−1.10 (11.76)	0.68	0.54
TC (mmol/l)	0.11 (0.74)	0.38	−0.19 (0.76)	0.13	−0.15 (0.87)	0.48	0.21
TG (mmol/l)	0.00 (0.53)	–	0.04 (0.61)	–	0.12 (0.50)	–	–
Log_{10} TG	0.07(0.13)	0.002*	0.00 (0.17)	0.94	0.05 (0.11)	0.09	0.09
HDL-C (mmol/l)	−0.04 (0.50)	0.62	0.05 (0.60)	0.62	0.17 (0.57)	0.24	0.42
LDL-C (mmol/l)	−0.08 (0.79)	0.57	−0.20 (0.74)	0.10	−0.33 (1.14)	0.24	0.57
TC:HDL	−0.98 (1.72)	p<0.001*	0.02 (1.78)	0.96	−0.61 (1.69)	0.13	0.04†
Distance walked (m)	84.05 (114.42)	p<0.001*	64.75 (94.49)	p<0.001*	18.00 (74.59)	0.30	0.04‡

*Change within group ($p<0.05$) from baseline to 12 weeks using a paired *t* test.
†Pairwise comparison of change in group means with post hoc Gabriel's test found a significant difference between the three day and the five day group.
‡Pairwise comparison of change in group means with post hoc Gabriel's test found a significant difference between the three day and the control group.
BMI, body mass index; BP, blood pressure; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; SWT, shuttle walk test; TC, total cholesterol; TG, triglycerides; WHR, waist to hip circumference ratio.

size. Behaviour change is an unlikely explanation as no changes in diet, cigarette smoking, alcohol intake, drug treatment, or other physical activities were observed.

Functional capacity

We suggest that the increased 10 m SWT distance found in both walking groups (15%, three day; 11% five day) reflects increased fitness. Functional capacity may be regarded as a substitute measure for fitness, which has been proposed as a factor contributing to cardiovascular risk.[20] Previous studies, using maximum oxygen treadmill testing in walking programmes of more than 12 weeks' duration, found increases in fitness ranging from 8% to 30%.[21 22] The gold standard measure of fitness, maximum oxygen uptake, has been correlated with distance walked in the 10 m SWT among patients with chronic airflow limitations, but remains unstudied in healthy adults.[23] Owing to constraints in the contact time with participants, it was not possible to perform a practice test to avoid the effects of familiarisation confounding the results. Familiarity may explain the small, non-significant increase in distance walked in the control group, but not the greater increase in distance walked in the intervention groups.

Pedometers for self monitoring

Previous studies have used pedometers for objective self monitoring of activity by asking participants to take a predetermined number of steps daily.[24 25] We used the pedometers as a reminder prompt to encourage daily walking rather than to set targets for exercise. Anecdotal comments suggested that participants appreciated having an objective measure of their activity and found "using a gadget" stimulated their interest in compliance. Reported adherence to the walking programme was high. We suggest that adherence was enhanced because no extra time was required in going to a location beyond the participants' daily routine, and there was an option of fulfilling 30 minutes walking in shorter bouts.

Limitations and strengths

The apparently poor response rate is in keeping with previous reports of recruitment to research studies involving exercise[26] and probably reflects low interest in exercise among those who lead sedentary lifestyles. Recruitment levels may be enhanced by using several different methods of inviting potential participants but we were limited in our approach by the research setting and we have reported outcomes which relate to a specific invitation within a workplace setting. We had based our estimated sample size requirement on what we considered was the best available information at the time of inception of our study. However, a meta-analysis was subsequently published which provided evidence to suggest[18] that our sample size calculation, based on HDL cholesterol changes, was inappropriate and that future studies should be powered to detect changes in LDL cholesterol.

We must also recognise that within this study walking was self reported and the walking pace was self selected and not measured; however, a previous research study suggested that people adapt their walking pace in accordance with instructions.[28] The diary returns indicated that the numbers of steps taken within the daily 30 minutes of the programme in different groups were similar, suggesting that the intensity of walking was also similar. It is possible that the three day group did more exercise than was self reported, as the study design did not include an objective measure of all activity undertaken during the study, and this would warrant further exploration. Intervention group participants' motivation to demonstrate improvement may have influenced their performance in the shuttle test at review. However, we have no evidence to suggest that these possible confounding factors exerted a systematic bias within either the three day or the five day group responses. The findings, however, provide new information about the comparative effects of different doses of an exercise intervention[1] which used pedometers as an adjunct. The intervention would be easily implemented in practice, within either a workplace, primary care, or community setting.

What is already known on this subject

- Physical activity is an important factor in preventing ill health.
- Few people meet current recommendations that adults should be moderately active for 30 minutes on five days a week or more.
- Gaps in evidence exist in relation to the effects of low levels of exercise and innovative approaches to promote physical activity are needed.

What this study adds

- An unsupervised home-based programme of brisk walking for 30 minutes on three days a week is associated with significant reduction in blood pressure and increase in functional capacity after 12 weeks.
- Adherence to unsupervised home-based walking programmes using pedometers for self monitoring is higher than levels of adherence previously reported for many research studies of other exercise programmes.
- Few healthy adults opted to complete 30 minutes walking per day in shorter bouts, but some did so; opportunities for integrating bouts of physical activity into daily working routines should not be ignored.

Policy implications

- Few individuals meet the current minimum exercise recommendation to take 30 minutes of exercise on five days a week. Many people cite a lack of time for failing to do so; therefore it is important to identify the minimum dose of exercise that confers a benefit to health.
- The results of this study have current relevance to public policy and government initiatives to increase levels of physical activity in the UK population. They have particular relevance to the recently published NICE guidance on physical activity, which identified gaps in evidence relating to the effects of low levels of exercise and a need for innovative approaches to encourage adults to engage in physical activity.
- Our work addresses these issues and may be of value in the development of strategies aimed at reducing the important public health problem of physical inactivity.

Conclusions

This study shows short term benefits of unsupervised home-based walking programmes both at and below the currently

recommended minimum target level of exercise. The results may encourage people who feel they do not have time to exercise on five days each week to consider finding time to commit to a lower weekly target of exercise. They also indicate the value of taking opportunities for short bouts of physical activity, which for those with time pressures from work or domestic life may be integrated into daily working routines.[28]

Further studies are needed of the longer term effects of low levels of exercise and of unsupervised home-based walking in populations with variable levels of baseline activity and should be of sufficient size to allow detection of meaningful changes in a spectrum of cardiovascular risk factors.

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Competing interests: None.

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