Medicine & Science in Sports & Exercise

Health promotion in older Chinese: 12-mo cluster RCT of pedometry and 'peer support'

--Manuscript Draft--

Manuscript Number:	MSSE-D-11-00437R2
Full Title:	Health promotion in older Chinese: 12-mo cluster RCT of pedometry and 'peer support'
Article Type:	Original Investigation
Corresponding Author:	Duncan James Macfarlane, PhD The University of Hong Kong Pokfulam, HONG KONG
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	The University of Hong Kong
Corresponding Author's Secondary Institution:	
First Author:	G Neil Thomas
First Author Secondary Information:	
All Authors:	G Neil Thomas
	Duncan James Macfarlane, PhD
	Boliang Guo
	Bernard MY Cheung
	Sarah M McGhee
	Kee-Lee Chou
	Jonathan J Deeks
	Tai-Hing Lam
	Brian Tomlinson
All Authors Secondary Information:	

Health promotion in older Chinese: 12-mo cluster RCT of pedometry and 'peer support'.

G Neil Thomas*[1], Duncan J Macfarlane*[2], Boliang Guo[1], Bernard MY Cheung[3], Sarah M McGhee[4], Kee-Lee Chou[5], Jonathan J Deeks[1], Tai Hing Lam[4], Brian Tomlinson[6].

Public Health, Epidemiology and Biostatistics[1], University of Birmingham, Edgbaston, Birmingham, UK; Institute of Human Performance[2], Departments of Medicine[3], Community Medicine[4] and the Sau Po Centre on Ageing[5], University of Hong Kong, Pokfulam, Hong Kong; Department of Medicine and Therapeutics[6], Chinese University of Hong Kong, Shatin, Hong Kong.

Short title: Exercise health promotion in older adults

Corresponding authors:

G Neil Thomas, Public Health, Epidemiology and Biostatistics, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK. Tel: +44 121 4148696, Fax: +44 121 4147878; Email: gneilthomas@yahoo.co.uk

Duncan J Macfarlane, Institute of Human Performance, University of Hong Kong, Pokfulam, Hong Kong. Tel: +852 28179451, Fax: +852 28188042; Email: djmac@hku.hk

Funding: The study was funded by the Hong Kong Government Health and Health Services Research Fund (HHSRF# 01030681).

Purpose: Ageing in conjunction with decreasing physical activity is associated with a range of health problems. Simple, low-maintenance, population-based means of promoting activity to counteract the age-associated decline are required. We therefore assessed the impact of pedometry and buddy support to increase physical activity.

Methods: We undertook a clustered randomised trial (HKCTR-346) of 24 community centres involving 399 older Chinese participants (≥60 years). Centres were randomly allocated to 1) pedometry and buddy; 2) pedometry and no-buddy; 3) no-pedometry and buddy; 4) no-pedometry and no-buddy with a 2x2 factorial design. The trial simultaneously tested the individual and combined effects of the interventions. The intervention groups also received monthly organised group activities to provide encouragement and support. Outcome measures were assessed at 6 and 12 months, including physical fitness and activity and cardiovascular disease (CVD) risk factors (anthropometry and blood pressure).

Results: From the 24 centres, 356 volunteers (89.2%) completed the study. Those receiving the interventions had higher mean physical activity levels at 12-months of 1820 (95%CI 1360, 2290) Metabolic Equivalent (MET) minutes per week and 1260 (780, 1740) MET·min·wk^{-1}, respectively relative to the decrease in the control groups. The buddy peer support intervention significantly improved mean aerobic fitness (95%CI 12 (4, 21)%), and reduced both body fat (-0.6 (-1.1, 0.0)%) and time to complete the 2.5m get-up-and-go test (-0.27 (-0.53, -0.01)s). No other improvements in the CVD risk factors were observed. The combination of motivational tools was no better than the individual interventions.

Conclusions: Both motivational interventions increased physical activity levels, and the buddy-style improved fitness. These tools could be useful adjuncts in the prevention of obesity and age-related complications.

Key words: buddy; elderly; exercise; pedometer; physical activity

Introduction

Paragraph 1. The increasing proportion of older people over 65 years in developed countries is strikingly reflected in Hong Kong where the current proportion (13% in 2008) is expected to more than double to 28% by 2039 (17). Concomitant with ageing is the high burden of associated physical and mental problems, which have major social and economic consequences (43). Epidemiological and clinical intervention studies have shown the benefits of exercise on health, including a reduction in cardiovascular disease mortality (2, 4, 18). However, only 25% of the US population meet current public health recommendations based on self-reported non-occupational physical activity, a level that has not changed over the past decade (10). Similarly, we have found that levels of inactivity remain high in Hong Kong at over 30-40% in the older population, which contributes to their disease burden (18, 33, 35, 36). In 1995, 25% of elderly (65-74 years) Hong Kong subjects in a population-based study had Type 2 diabetes, 53% hypertension and 64% dyslipidaemia (35, 36). Physical activity programmes that improve weight loss and related metabolic parameters have shown benefits in clinically relevant surrogate markers of improving health (2, 22, 23, 40, 42).

Paragraph 2. Well-designed and -implemented interventions can increase regular physical activity (10, 22). The Task Force on Community Preventive Services reviewed the effectiveness of a range of physical activity interventions involving informational, behavioural and social approaches (22). They concluded that social support health behaviour interventions in community settings and individually-adapted health behaviour change programmes were feasible and effective in improving aerobic fitness (22), and thus may reduce obesity and its associated metabolic abnormalities. Social support interventions focus on changing physical activity behaviour through building, strengthening, and maintaining social networks that provide support relationships for behaviour change. Specifically, the interventions involve setting up a "buddy" peer support system, making a "contract" with one or more others to achieve specified levels of physical activity and additionally to provide companionship and social support (22, 25, 26).

Findings suggest that this approach may be effective in increasing frequency and time spent in exercise as well as aerobic capacity (22, 26). Individually-adapted health behaviour change programmes are promoted as they are tailored to the individual's specific interests and preferences (21, 24). These types of intervention have been shown to be effective in changes in time and frequency in engaging in exercise, energy expenditure, and maximum oxygen uptake (21, 24, 38). It has been suggested that all programmes should incorporate components of the following behavioural approaches: 1) setting goals for physical activity and self-monitoring of progress toward goals; 2) building social support for new behavioural patterns; 3) behavioural reinforcement through self-reward; 4) structured problem-solving geared to maintenance of the behavioural change; and 5) prevention of relapse into sedentary behaviour (22). Pedometers provide a useful means of self-monitoring changes in physical activity as they objectively quantify the number of steps an individual takes. They are also simple, cheap and have been shown to correlate with physical fitness and activity (38). However, to date few intervention studies and no well-powered randomised controlled trial with elderly participants lasting 12 months has incorporated pedometers as motivational tools (8). We chose to use a cluster randomised design to minimise the potential for contamination of the interventions groups.

Paragraph 3. Population-based exercise intervention studies that are applicable to the general community need to be simple, cheap, and have low maintenance. The formation of small support groups utilising the peer social support “buddy” system or providing pedometers as motivational tools are two examples of such potentially useful approaches. The present study was designed to assess the usefulness of these interventions in improving physical activity and fitness, and cardiovascular risk factors, specifically, the anthropometric variables body mass index, waist circumference and percentage body fat, and blood pressure in an older general Chinese population.

Methods

Subject recruitment

Paragraph 4. We undertook a randomised trial to evaluate the effects of provision of a pedometer and participation in a 'buddy-style' peer support programme on physical fitness and activity and cardiovascular risk factors (anthropometry and blood pressure). Twenty-four community centres for older persons, which provide social and recreational day services for members, were selected from a pool of centres with whom the Sau Po Centre on Ageing of the University of Hong Kong actively collaborates. No criteria other than agreement to particpate were placed on the centres, however, the participants were recruited from these centres using the following criteria: 1) aged 60 yr or over; 2) planned to stay in their current residence over the next year; 3) had no recent history of myocardial infarction or stroke; 4) no physical disabilities that made activity or the use of pedometer difficult. All participants received information of the study, and that they would be randomly allocated into either an exercise intervention group or one in which they were to maintain their existing levels of activity. The subjects did not know whether they would receive the intervention or be in the control group prior to randomisation. All participants were given opportunities to ask questions regarding the study and gave written informed consent.

Allocation

Paragraph 5. A cluster design was used to counter potential cross-over contamination, with all participants within each community centre being allocated to the same combination of the two interventions. Centres were randomly allocated to 1) pedometry and buddy; 2) pedometry and no-buddy; 3) no-pedometry and buddy; 4) no-pedometry and no-buddy according to a 2x2 factorial design. The trial was designed to simultaneously test the effects of the two interventions: the effect of pedometer by comparing all those randomly allocated pedometry (groups 1 and 2) with those allocated to a non-pedometry control (groups 3 and 4), and the effect of buddy by comparing those allocated to buddy style support (groups 1 and 3) compared to a no-buddy support control (groups 2 and 4). Blocked (n=4) randomisation was used to ensure allocate similar numbers of centres to each study arm using two sequences (one for allocating buddy/no-buddy and one for allocating pedometry/no-pedometry) created using computer-generated random numbers.. The allocations were made an independent researcher blinded to the names and characteristics of the centres. The study conformed with the Declaration of Helsinki and was granted approval by the University of Hong Kong's Ethics Committee. The study is registered with the University of Hong Kong Clinical Trials Register (registration code HKCTR-346, www.hkclinicaltrials.com).

Measures

Paragraph 6. The main outcome measures were changes in physical activity measured using the International Physical Activity Questionnaire (IPAQ) (19), and fitness levels. Additionally we investigated the impact on cardiovascular risk factors which were likely to convey the health benefits of improved activity levels including anthropometric measures, body mass index (BMI), waist circumference and percentage body fat and blood pressure. At each of the three visits, baseline, 6, and 12 mo follow-up, the following were measured: The International Physical Activity Questionnaire-short form was used to estimate total physical activity levels, rather than just leisure time activity (19), and has been validated in Hong Kong Chinese generally (29), and in older Southern Chinese specifically (13). The IPAQ data were converted to metabolic equivalent scores ($\mathrm{MET \cdot min \cdot wk^{-1}}$) for each type of activity. The MET score weights each type of activity by its energy expenditure, using 1 MET for sitting, 3.3 METs for walking, 4 METs for moderate activity, and 8 METs for vigorous activity (see www.ipaq.ki.se) (19). The activity of the volunteers was then coded into low, medium or high activity according to the algorithms provided on the IPAQ website (19). We have previously shown that the intraclass correlation coefficient (ICC) for each of the physical activity domains of the IPAQ over time are high, ranging from 0.81 to 0.89 ($p \leq 0.001$) (13). Body weight was measured in light clothing to the nearest 0.1kg, and height using a stadiometer, without shoes, and the BMI calculated. Waist circumference, after loosening of any restrictive clothing or belts and unobstructed by upper body clothing, was measured at the narrowest point between the lowest rib and iliac crest (20). A foot-to-foot bioimpedance device (Tanita BF350, Tanita, Japan) was used to derive percentage body fat, which has been validated on Chinese adults (27). Measurements were made with bare feet. Participants were requested to refrain from exercise and drinking an hour prior to the evaluation and were encouraged to void their bladder on arrival. Measures were also taken at the same time of day for each visit to further minimise variations in body hydration. Seated blood pressure and heart rate (HEM-705CP, Omron, IL), were measured in triplicate after a 5-10 min rest and the mean of 3 readings was recorded. At the follow-up visits any changes in medical regimens were noted. Socioeconomic details, personal and family medical histories were recorded, as were smoking history and alcohol consumption. A submaximal Astrand cycle exercise test was used to assess aerobic fitness, although some participants were unable (n=56) or unwilling (n=117) to perform the test, therefore only results from 226 (56.6%) subjects were available for this analysis. A number of standard tests were performed to assess physical ability. A get-up-and-go test (time taken for the subject to get up from a chair walk 2.5m, round a marker and return), a 30s chair stand test (the number of times a person can stand and sit in 30s) was used as a measure of lower body strength. A 30s arm curl test (maximum number of arm curls in 30s) as a measure of arm strength (28) was performed, with resistance provided in the males with an 8lb dumb-bell and in the females with a 5lb dumb-bell. Two maximal effort isometric tests of lower body strength were also performed, including one of hip flexion, and one of knee extension, using the Nicholas Manual Muscle Test (NMMT, Model 01160, Lafayette Instrument Co.) according to the manufacturer's instructions.

Physical activity interventions

Pre-baseline visit

Paragraph 7. Approximately one week prior to the baseline visit, all subjects randomised by centre to receive the pedometer-based intervention were provided with the pedometers (Yamax Digi-Walker SW200 Pedometer, Yamax Corp, Japan), and shown how to use them. Subjects randomised to receive the buddy peer support or pedometry-based intervention were asked to maintain their current level of physical activity and were given a daily physical activity diary summarising any physical activity, either in minutes of spent performing exercise, including walking, for the "buddy" groups and the number of steps taken for the pedometry groups. This provided an approximation of their baseline physical activity levels, although these might be elevated for example, as a result of simply being given the pedometer or the increased awareness from participating in the study.

Baseline visit

Paragraph 8. At the baseline visit, all participants in the intervention arms received group-based face-to-face counselling and advice on how to increase energy expenditure via integration of physical activities into their daily routines, and basic strategies for starting (i.e. start slowly and to work the exercise into the daily routine). They received a contact telephone number for our staff in case they experienced any problems or required additional information regarding the implementation of the intervention. Subjects at those centres randomised to the buddy peer support system were given instructions on how to enlist support and walking partners, such as joining a walking group or with other participants from the same centre. Each buddy peer support participants was asked to reach the daily recommendations from the American College of Sports Medicine/Centers for Disease Control (ACSM/CDC) for 30 mins of moderate physical activity, 3-5 times a week with a partner (2). The participants receiving the pedometers were asked to increase the number of steps they take over a normal day by an extra 3500 steps a day (3-5 times a week), which has been previously reported to correlate with the energy expenditure taken during 30 min of moderate physical activity (38), thus meeting the ACSM/CDC guidelines at the time the study began (2). A gradual exercise plan was used to recommend that these sedentary elderly progressively increase their activity to reach these recommended activity levels over the first 2 months of the 12-mo intervention.

Intervention period

Paragraph 9. The subjects in the intervention groups received monthly telephone calls for the first 6 months of the 12-mo intervention. The subjects provided the interviewer of the frequency, time, and distance they had been walked based on the weekly walking data recorded in their physical activity diaries. If the participants had walked, the feedback was supportive of the amount of walking the individual has accomplished. If the participant had not walked, the feedback was supportive of future attempts. Additionally, the research staff set walking goals with the participants on a weekly basis using a structured protocol. The average time for these telephone prompts was about 15 minutes. The calls were also used to inform the subject of the details of the monthly organised face-to-face meeting. The organised events promoting physical activity that were rotated through each of the participating centres, ensuring all subjects should be able to attend at least one of the events. The events, such as organised walks, were tailored to the specfic intervention during the intensive phase, and were available to all of those subjects, including those from other centres with the same intervention. The events were preceded by further motivational meetings, when staff reinforced the earlier counselling and provided assistance in overcoming any potential hurdles that might have arisen whilst implementing the behaviour modification. The subjects in the control groups received no intervention and were not approached until the completion of the study period.

Statistical analyses

Paragraph 10. Data are presented as mean (standard deviation), whereas skewed data were log-transformed and expressed as median (interquartile range). Analysis of baseline differences between groups and the effects of the interventions were all undertaken using multilevel modelling allowing for clustering of participants within centres. Effects of interventions were estimated adjusting for age, sex and baseline levels of the variables of interest and clustering. For each outcome, measurements were available at baseline, 6 mo and 12 mo. Baseline measures were included in models as a covariate. Estimates of intervention effects are presented for the 12 mo outcome with outcomes at 6 mo included in the model using a repeated measures structure with a time term. Estimates are given as differences in means between intervention and control groups, together with 95% confidence intervals. For outcomes (physical fitness) with positively-skewed distributions, values were log-transformed before analysis and results are presented as median with the interquartile range. The multilevel analyses for such variable estimates the relative effect which can be interpreted as a percentage difference; for example, a estimate of 1.0 implies parity, 1.05 implies a 5% increase. Last recorded values were carried forward for participants who did not complete all outcome assessments. Those who dropped out of their allocated interventions were retained in the group to which they were allocated in an intention-to-treat style analysis. The standard analytical approach for factorial trials was followed with estimates of the effects of each intervention (pedometer or 'buddy support') first being estimated by comparing all individuals in the study who received the intervention with all those who did not, regardless of whether they received the alternative intervention. Subsequently we also assessed for a potential interaction between the two interventions, and estimated the effect of the combined intervention in comparison with the group who received neither intervention. If an interaction was detected, the effects of the individual interventions were estimated comparing the control group who received no intervention with those who received only one intervention. The multilevel analysis was conducted with STATA 10 (34). A post-hoc analysis to assess whether responses to changes in overall activity and anthropometry may differ in those stratified by baseline activity level described by IPAQ using the organisation's predefined cutpoints (19) into low/moderate activity (n=208) and high activity (n=191) was also performed.

Paragraph 11. Sample size estimations were used to provide the number of study participants needed for the cluster adjusted analyses. For the main outcome of IPAQ, intraclass correlations of between 0.05 and 0.10 were considered, with a median centre size of 17. A study of 400 evaluable participants would have more than 80% power to detect differences with effect sizes of 0.4 (if ICC=0.05) and 0.5 (if ICC=0.1) at the 5% significance level, and takes into account an expected drop out of 15%. These effect sizes corresponded to differences in IPAQ score of 600 and 750 $\mathrm{MET{\cdot}min{\cdot}wk^{-1}}$ presuming an underlying standard deviation of 1500.

Results

Paragraph 12. From the 24 community centres, we identified 412 eligible subjects initially interested in participating, of whom there were 399 (96.8%) who agreed to participate. The flow diagrams shown in figures 1 and 2 describe the subject enrolment, intervention allocation, follow-up, completion of intervention and data analysis at 12 months (1, 9). The consenting subjects were allocated to the study arms in a factorial manner as follows: 1) pedometry group (11 centres with 12-19 participants per centre, n=204, 63.2% female) and control group (13 centres with 10-23 participants per centre; n=195, 69.2% female, Figure 1); and for the buddy peer support comparison study arms 2), buddy peer support (12 centres with 10-23 participants per centre, n=193, 65.3% female) and control group (12 centres with 15-18 participants per centre, n=206, 67.0% female, Figure 2);

Baseline observations

Paragraph 13. The baseline data describing demographic, anthropometric and blood pressure were generally similar between the pedometry and buddy peer support groups compared to their respective control groups (Table 1), but buddy control subjects had a slightly larger BMI (2.9%), but similar waist circumference or percentage body fat. There was a higher estimated level of physical activity energy expenditure in the buddy group, but the 5 measures of strength were similar between the groups.

Paragraph 14. When the subjects were categorised by baseline levels of physical activity using the IPAQ definition (19), only 11 were found to be in the lowest category of activity. We therefore grouped together low and medium levels of activity. Overall, there were 208 subjects (52.1%) with low/medium levels of activity, while the remaining 191 had high levels of activity at baseline. In those who had recorded the duration of activity (n=91) or number of walking steps taken (n=201) during the 7 days prior to completing the IPAQ questionnaire, there was a significantly lower time or average number of steps$\cdot$d^{-1} taken in those classified by the questionnaire into low/medium compared to those with high activity levels (1.79 (1.53-2.10) vs 2.47 (2.23-2.73) hr, $p=0.001$, and 7405 (6736-8140) vs 9806 (8915-10787) steps, $p<0.001$), respectively.

Paragraph 15. The estimates of the levels of physical activity from the IPAQ questionnaire correlated with both the estimates of the duration spent performing exercise in the 7 d prior to the questionnaire in those receiving the “buddy” peer support ($r=0.46$, $p<0.001$, and $r=0.57$, $p<0.001$) or the pedometry interventions ($r=0.26$, $p<0.001$, $r=0.31$, $p<0.001$) for baseline and 12 mo respectively.

12-month longitudinal pedometry intervention

Paragraph 16. Of the 399 participants randomised by centre, 356 (89.2%) completed the study, with 16 (8.5%) in the pedometry intervention group and 27 (16.1%) in the control group not completing the study. The 43 subjects who did not complete the study withdrew for a variety of reasons, including injury or sickness (n=10, 23.3%), travelling or moving away from the vicinity of the study site (n=5, 11.6%), loss of contact (n=4, 9.3%), or in the majority of cases, refusal to continue with no additional reason given (n=24, 55.8%).

Paragraph 16. Using last-observation carried-forward, intention-to-treat multilevel data analysis, those participants in the centres randomised to the pedometry group significantly increased their levels of physical activity energy expenditure as recorded by the IPAQ questionnaire by 1820 (95% CI 1360, 2290) $MET \cdot min \cdot wk^{-1}$ relative to the control group (Table 2). We recorded the number of steps taken as measured by the pedometer in those carrying it, i.e. not the control subjects. We aimed to raise the daily number of steps walked by at least 3500 on 3-5 days a week, but, despite the significant increase in physical activity, only a limited number reached this target (n=16, 7.9%), with only 31.5% (n=64) increasing the number of steps by 1000, and indeed only 50.7% (n=103) actually had any increase in steps taken. A significantly greater proportion of the men achieved a positive increase in the number of steps taken compared to the women (60.8% vs. 45.7%, p=0.042). There was a significant increase in those being in the most active IPAQ category in the pedometry group relative to the controls ($p<0.001$). Despite the improvements in activity levels, there was only a tendency for aerobic fitness, as measured by predicted oxygen uptake, to improve, by 7% (-1, 15)%, after adjustment for body weight (p=0.10). In conjunction with these changes, no other improvements in the cardiovascular risk factors or physical function was observed, with only a borderline significant reduction in the number of chair stands (p=0.05).

In the post-hoc analysis to assess whether responses to changes in overall activity and anthropometry may differ in those stratified by baseline activity level, only in the low/moderate activity group was there a statistical increase in physical activity ($p<0.001$), but neither strata showed any improvement in the anthropometric measures when stratified by activity.

12-month longitudinal buddy peer support intervention

Paragraph 17. For the buddy group comparison, 15 (8.4%) in the buddy peer support intervention group and 28 (15.7%) participants in the control group did not complete the study. The reasons for not completing the study are described above. Using last-observation carried-forward, intention-to-treat multilevel data analysis the buddy group significantly increased their levels of physical activity energy expenditure relative to the controls by 1260 (780, 17460) $MET \cdot min \cdot wk^{-1}$ (Table 2). Only a small proportion (6.6%) of the buddy group reached the targeted goal of increasing their participation in physical activity by at least 30 min on 3-5 days a week, with 48% having a positive change in levels of activity of any size during 12 months. However, there was a significant increase in those being in the most active category relative to the controls ($p<0.001$). The improvements in activity were paralleled with positive changes in aerobic fitness both before (12% (3, 20)%) and after adjustment for body weight (12% (4, 21)%). However, those significant changes in the intervention group relative to the controls only resulted in a small reduction in percentage body fat (-0.6% (-1.1, -0.0)%), with a significant, although borderline, small reduction in the duration required to complete the 2.5m get-up-and-go (-0.3 (-.05, -0.0)s).

Post-hoc combined pedometry and buddy peer support intervention

Paragraph 18. In addition to the interventions described above, we also assessed whether the combination of the interventions provided additional benefits (Table 2). There was a significant interaction for the two intervention groups on the impact on physical activity, both when assessed as a continuous or dichotomous parameter, with observed improvements being similar to those only receiving the single interventions. The interactions were therefore antagonistic, that is, the effect of the combined intervention package was significantly less than the sum of the effects of the two individual interventions. There was no significant benefit on aerobic fitness observed in the combined group relative to those with the no-intervention control group.

Stratification into low/moderate IPAQ activity levels, as expected, had significantly lower activity levels relative to the high activity group in the pedometry intervention group (1921 (708) vs 4483 (1157) MET·min·wk^{-1}, $p<0.001$), and in the buddy intervention group (2056 (626) vs 4681 (1365) MET·min·wk^{-1}, $p<0.001$). In the post-hoc analysis to assess whether responses to changes in overall activity and anthropometry may differ in those stratified by IPAQ baseline activity level, in contrast to the pedometry results, there was a statistical increase in physical activity ($p<0.001$) in both the low/moderate and high physical activity groups. In those with low/moderate activity there was also significant improvements in BMI ($p=0.026$), waist circumference ($p=0.027$) with a tendency to a reduction in percentage body fat ($p=0.097$), but no improvements were observed in the high activity group.

Discussion

Paragraph 19. In this Hong Kong Chinese population, which has high levels of CVD risk factors, we found that both physical activity interventions significantly increased levels of physical activity over the 12 mo period relative to their control groups, with pedometry changing activity on average by 1820 (1360, 2290) MET·min·wk^{-1} and the buddy peer support group by 1260 (780, 1740) MET·min·wk^{-1}. We asked the subjects to try to increase their physical activity to meet the earlier ACSM/CDC guidelines of 30 min of moderate physical activity (2), or the equivalent of at least 3500 steps (38) on 3-5 days a week. There are few well-powered studies reporting the use of pedometry to increase activity, for instance a meta-analysis of randomised, controlled studies to increase step count identified 8 studies (8), which clearly increased step count, but were generally of a short duration and had a combined total of only 265 subjects, which is not too disimilar to the number from one arm in the current study. We could not identify any similar buddy peer support programmes in older, generally healthy populations.

Paragraph 20. However, despite significant improvements with both interventions overall, only a small proportion of 7-8% reached the target by either method with about half showing a positive increase in activity levels. This suggests that reporting of the proportions achieving activity goals in addition to the overall improvements are important in interpreting the benefits of an intervention. It also shows that even in a successful intervention, there is potentially a proportion of the population that is not benefiting and may require additional actions to increase activity levels.

Paragraph 21. The small proportion reaching their target goals of increasing daily step counts by 3500, 3-5 times a week for the pedometry group, and walking for 30 mins, 3-5 times a week for the buddy group, may result from a "ceiling effect" for physical activities such as daily walking which may have been approached in our volunteers. The results from the post-hoc analysis also appear to support this contention, with a more prominent effect being observed in those with low/moderate activity relative to those who had high baseline activity levels. Even the low/medium activity group were achieving an average of 7405 (6736-8140) steps·d^{-1} and the high activity group 9806 (8915-10787) steps·d^{-1}. For people aged over 60 years, these levels of daily step counts appear high by international standards, where 6500 is considered common (37), with 53% (low/moderate fit) of our Hong Kong subjects averaging nearly 1000 more than this, and 48% in the high activity group achieving over 3000 more. However, these results are consistent with other studies from Hong Kong (3, 29). The high step counts might in part due to the “very high walkability” of the Hong Kong environment with easy access to multiple nearby destintations, safe streets, and a low need to take motorised transport (11). Indeed a study showed Hong Kong citizens accruing a greater percentage of their total daily activity from walking than any of the 20 other countries examined (3). Especially for the high activity group that averaged nearly 10000 steps·d^{-1}, exceeding this ceiling would be difficult, and hence the relatively low ability to achieve another 3500 steps·d^{-1}. Overall baseline activity levels were similar to those from other studies from Hong Kong and Europe (3, 15, 29), and supports that a large part of their activity levels results from walking. The motivational aid of directly visualising the number of footsteps taken with the pedometer and the support and cohesion provided by the social network developed by the buddy peer support intervention were likely to contribute to the efficacy of the interventions (22, 25, 26). However, the ceiling threshold issue might explain the absence of an additional effect in those receiving both interventions with a single motivational tool appearing as effective as the combination. Data supporting this contention can be found in a meta-analysis of pedometry interventions which suggested that pedometry interventions in subjects with higher baseline activity levels appear to be slightly less effective (8). Although caution should be taken with the interpretation of post-hoc analyses, our data in the buddy intervention support this concept, suggesting those with lower activity levels may have benefitted the most.

Paragraph 22. Perhaps surprising, given the improvements in physical activity and, in the buddy group, aerobic fitness, was the limited improvement in the cardiovascular risk factors, namely the anthropometric and blood pressure parameters, with the exception of the small, and probably clinically insignificant reduction, in percentage body fat in the buddy group. Bioimpedance determination of body fat can be influenced by other aspects such as body hydration that might introduce noise. We measured body fat at the same time of day, and subjects were asked not to exercise or drink in the hour prior to the measurement, and were encouraged to void their bladder on arrival to minimise this issue, but this may still have attenuated body fat changes. However, given the limitations described above in the ability to increase activity greatly it is possible that the small observed improvements would take longer to impact on the anthropometric measures and subsequently on the other risk factors, as in the situation of the small body fat difference which might reflect such changes commencing. Increasing the intensity of the intervention with increased numbers of contacts has shown to improve the response in lifestyle interventions targetting incident diabetes (31, 39), and would likely improve the outcome in the current study. However, in contrast to the current study which hoped to assess an intervention that could be readily used within the current health care system, such an approach would unlikely be feasible in this setting given the additional resources that would be required. An alternative could be reporting bias, with a proportion of subjects over-reporting levels of activity in the IPAQ to "save face" or to espouse the research team, although similar increases were reported for the step counts and time performing activities, such a consistency in reporting suggests this may not be a major issue, but is one that cannot be excluded.

Paragraph 23. There are few studies that have reported the impact of changes in physical activity as measured by the IPAQ on the anthropometric measures and other cardiovascular disease risk factors (8). Such changes in exercise level measured by other instruments have been reported to attenuate the age-related decline in many physical and psychological functions (4, 7, 23, 30). Exercise also improves maintenance of muscle mass and attenuates muscle loss, which is a major determinant of frailty that results in loss of balance, and subsequent falls leading to institutionalisation of older individuals (23). It is possible the reduction in percentage body fat and improvement in the get-up-and-go test times may reflect such improvements in physical function. The improvements we observed in aerobic fitness resulting from the increasing levels of physical activity reflects previously reported observations linking fitness and activity in a dose-dependent manner (16). Self-reported physical activity and functional capacity have been reported to be more important than weight status in determining cardiovascular disease risk factors, particularly in females (41), who have generally been shown to be less fit than their male counterparts (6). Physically fit individuals are at lower mortality risk than unfit individuls with similar vascular risk profile, including those who smoke or with concomitant disease (5), which suggests that the increase in physical activity in both our pedometry and buddy groups and aerobic fitness in the buddy group should, if maintained, have a significant long-term benefit on both all-cause and vascular disease mortality, including in older Chinese (33). However, given the lack of significant improvement to the CVD risk factors examined in this trial, larger studies, perhaps with additional CVD risk factors or other endpoints would be required to confirm this assumption.

Paragraph 24. There is a clear lack of larger, long-term studies addressing the use of these motivational aids, which this study helps address. The study population had a similar CVD risk factor profile to general Hong Kong population with 66% having hypertension, 14% had Type 2 diabetes based on fasting glucose levels, with a further 18% having prediabetes, 72% have some form of dyslipidaemia 40% central obesity using the Asian criteria of >80cm or >90cm in women and men (36), respectively which supports the external validity of the study. Although significant increases in physical activity were observed, the relatively high baseline activity of our subjects might have attenuated any measurable benefit from the increased activity and is thus a limitation of the current study. In order to elicit greater physiological benefits, more strenuous activity is recommended for asymptomatic elderly by the American College of Sports Medicine (e.g moderate-to-vigorous activity such as quite brisk walking), rather than just recreational walking, but the intensity should be based as their ability and conditions allow (12).

We did not have substantial numbers of truly sedentary elderly, and this population should be an important target for future studies. As resistance training has been shown to benefit the elderly (14), addition of some resistance exercises would be recommended to our already active subjects because of their relatively low upper and lower body strength measures when compared to international norms (32).

Conclusions

Paragraph 25. This study is one of the few longer-term, large, randomised, controlled studies investigating means of increasing physical activity in older general populations. Both pedometry and buddy peer support interventions significantly increased the mean physical activity and the latter intervention also improved aerobic fitness levels compared to controls. The buddy group also showed reduced body fat and time required to complete the 2.5m get-up-and-go test, although these were of marginal significance. Our results suggest that the use of pedometers and the buddy peer support system should be a simple method to increase physical activity in older subjects and target obesity and age-related complications. Further research is needed to find alternative or additional means to modify the behaviour of the approximately 50% of subjects who did not increase in their physical activity levels. The reproducibility and long-term maintenance of the improvements of the surrogate risk factors and subsequent impact on vascular disease morbidity and mortality should be assessed.

Acknowledgments

We wish to thank Tonia Chan and Dora Tsung for their invaluable assistance in conducting the study. The study was funded by the Hong Kong Government Health and Health Services Research Fund (HHSRF# 01030681). The results of the present study do not constitute endorsement by ACSM.

References

1. Altman DG, Schulz KF, Moher D, Egger M, Davidoff F, Elbourne D, Gotzsche PC, Lang T, for the CONSORT Group (Consolidated Standards of Reporting Trials). The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Ann Intern Med*. 2001;134:663-94.
2. American College of Sports Medicine. Position stand on exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise*. 1998;30:992-1008.
3. Bauman A, Bull F, Chey T, Craig CL, Ainsworth BE, Sallis JF, Bowles HR, Hagstromer M, Sjostrom M, Pratt M, The IPS Group. The International Prevalence Study on Physical Activity: results from 20 countries. *International Journal of Behavior, Nutrition & Physical Activity*. 2009;6:21.
4. Blair SN, Cheng Y, Holder JS. Is physical activity or physical fitness more important in defining health benefits? *Med Sci Sports Exerc*. 2001;33 (6 Suppl):S379-99.
5. Blair SN, Kampert JB, Kohl HW, Barlow CE, Macera CA, Paffenbarger RS, Gibbons LW. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *JAMA*. 1996;276:205-10.
6. Booth M, Owen N, Bauman A, Clavisi O, Leslie E. Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Preventive Medicine*. 2000;31:15-22.
7. Bortz WM. Disuse and aging. *JAMA*. 1982;248:1203-8.
8. Bravata DM, Smith-Spangler C, Sundaram V, Gienger AL, Lin N, Lewis R, Stave CD, Olkin I, Sirard JR. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA*. 2007;298:2296-304.
9. Campbell MK, Elbourne DR, Altman DG, CONSORT group. CONSORT statement: extension to cluster randomised trials. *BMJ*. 2004;328:702-8.

10. Centers for Disease Control. http://www.cdc.gov/nccdphp/bb_nutrition/index.htm. 2003;Last accessed 11.11.2010.
11. Cerin E, Macfarlane DJ, Ko H-H, Chan AK-C. Measuring perceived neighbourhood walkability in densely-populated urban areas in Asia. *Cities*. 2007;24:209-17.
12. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, Skinner JS. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc*. 2009;41:1510-30.
13. Deng HB, Macfarlane DJ, Thomas GN, Lao XQ, Jiang CQ, Cheng KK, Lam TH. Reliability and validity of the IPAQ-Chinese: the Guangzhou Biobank Cohort study. *Med Sci Sports Exerc*. 2008;40:303-7.
14. Fiatarone MA, O'Neill EF, Ryan ND, Clements KM, Solares GR, Nelson ME, Roberts SB, Kehayias JJ, Lipsitz LA, Evans WJ. Exercise training and nutritional supplementation for physical frailty in very elderly people. *New Engl J Med*. 1994;330:1769-75.
15. Hagstromer M, Oja P, Sjostrom M. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Pub Health Nutr*. 2006;9:755-62.
16. Haskell WL. What to look for in assessing responsiveness to exercise in a health context. *Medicine & Science in Sports & Exercise*. 2001;33(6 Suppl):S454-8.
17. Hong Kong Government Census and Statistics Department. *Hong Kong Annual Digest of Statistics, 2002 Edition*. Hong Kong: Hong Kong: Hong Kong Government Printer; 2002,
18. Hui SC, Tomlinson B, Thomas GN. Relationship between physical activity, fitness and CHD risk in middle-aged Chinese. *Journal of Physical Activity and Health*. 2005;3:307-23.
19. International Physical Activity Questionnaire. https://sites.google.com/site/theipaq/ [last accessed 13 May 2011]. 2008.
20. ISAK - International Society for the Advancement of Kinanthropometry. *International standards for anthropometric assessment*. Potchefstroom, South Africa: International Society for the Advancement of Kinanthropometry; 2001, p. 83

21. Jette AM, Lachman M, Giorgetti MM, Assmann SF, Harris BA, Levenson C, Wernick M, Krebs D. Exercise - It's never too late: The Strong-for-Life Program. *Am J Pub Health*. 1999;89:66-72.
22. Kahn EB, Ramsey LT, Brownson RC, Heath GW, Howze EH, Powell KE, Stone EJ, Rajab MW, Corso P, and the Task Force on Community Preventive Services. The effectiveness of interventions to increase physical activity: A systematic review. *American Journal of Preventive Medicine*. 2002;22:73-107.
23. King AC. Physical activity and health enhancement in older adults: Current aspects and future prospects. *Ann Behav Med*. 1991;13:87-90.
24. King AC, Haskell WL, Taylor B, Kraemer HC, DeBusk RF. Group- vs home-based exercise training in healthy older men and women. *JAMA*. 1991;266:1535-42.
25. King AC, Taylor CB, Haskell WL, Debusk RF. Strategies for increasing early adherence to and long-term maintenance of home-based exercise training in healthy middle-aged men and women. *American Journal of Cardiology*. 1988;61:628-32.
26. Lombard DN, Lombard TN, Winett RA. Walking to meet health guidelines: the effect of prompting frequency and prompt structure. *Health Psychology*. 1995;14:164-70.
27. Macfarlane DJ. Can bioelectric impedance monitors be used to accurately estimate body fat in Chinese adults? *Asia Pac J Clin Nutr*. 2007;16:66-73.
28. Macfarlane DJ, Chou KL, Cheng YH, Chi I. Validity and normative data for thirty-second chair stand test in elderly community-dwelling Hong Kong Chinese. *American Journal of Human Biology*. 2006;18:418-21.
29. Macfarlane DJ, Lee CC, Ho EY, Chan KL, Chan DT. Reliability and validity of the Chinese version of IPAQ (short, last 7 days). *Journal of Science & Medicine in Sport*. 2006;10:45-51.

30. Paffenbarger RS, Jr., Hyde RT, Wing AL, Lee IM, Jung DL, Kampert JB. The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *New Engl J Med*. 1993;328:538-45.

31. Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar AD, Vijay V. The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia*. 2006;49:289-97.

32. Rikli RE, Jones CJ. *Senior fitness test manual*. Champaign, Ill: Human Kinetics; 2001, p. 124-131

33. Schooling CM, Lam TH, Li ZB, Ho SY, Chan WM, Ho KS, Tham MK, Cowling BJ, Leung GM. Obesity, physical activity, and mortality in a prospective Chinese elderly cohort. *Archives of Internal Medicine*. 2006;166:1498-504.

34. STATA. Stata Longitudinal/Panel Data reference Manual-Release 10. College Station, Texas: StataCorp LP 2007, p. 1-474

35. Thomas GN, Ho S-Y, Lam KSL, Janus ED, Hedley AJ, Lam TH, for the Hong Kong Cardiovascular Risk Factor Prevalence Study Steering Committee. Impact of obesity and body fat distribution on cardiovascular risk factors in Hong Kong Chinese. *Obesity Research*. 2004;12:1805-13.

36. Thomas GN, Ho SY, Janus ED, Lam KSL, Hedley AJ, Lam TH, for the Hong Kong Cardiovascular Risk Factor Prevalence Study Steering Committee. The US National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III) prevalence of the metabolic syndrome in a Chinese population: the Hong Kong Cardiovascular Risk Factor Study. *Diabetes Research and Clinical Practice*. 2005;67:251-7.

37. Tudor-Locke C, D R Bassett Jr. How many steps/days are enough: preliminary pedometer indices for public health. *Sports Medicine*. 2004;34:1-8.

38. Tudor-Locke CE, Myers AM. Methodological considerations for researchers and practitioners using pedometers to measure physical (ambulatory) activity. *Research Quarterly for Exercise & Sport*. 2001;72:1-12.

39. Tuomilehto J, Lindstrom J, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Parikka P, Keinanen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Uusitupa M, Finnish Diabetes Prevention Study Group. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med*. 2001;344:1343-50.

40. Wenger HA, Bell GJ. The interactions of intensity, frequency and duration of exercise training in altering cardiorespiratory fitness. *Sports Medicine*. 1986;3:346-56.

41. Wessel TR, Arant CB, Olson MB, Johnson BD, Reis SE, Sharaf BL, Shaw LJ, Handberg E, Sopko G, Kelsey SF, Pepine CJ, Merz NB. Relationship of physical fitness vs body mass index with coronary artery disease and cardiovascular events in women. *JAMA*. 2004;292:1179-87.

42. Williams PT. Physical fitness and activity as separate heart disease risk factors: a meta-analysis. *Medicine & Science in Sports & Exercise*. 2001;33:754-61.

43. Woo J, Ho SC, Chan SG, Yu AL, Yuen YK, Lau J. An estimate of chronic disease burden and some economic consequences among the elderly Hong Kong population. *J Epidemiol Community Health*. 1997;51:486-9.

Figure 1: Flow diagram describing subject enrolment, pedometry intervention allocation, follow-up and data analysis at 12 months as outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement (1, 9)

Figure 2: Flow diagram describing subject enrolment, buddy intervention allocation, follow-up and data analysis at 12 months as outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement (1, 9)

Table 1: Baseline demographic, anthropometric, blood pressure, physical activity measures, and strength test parameters in the pedometry, buddy interventions and their respective control groups. Figures are mean (SD) unless otherwise indicated.

Parameter	Pedometry analyses		Buddy analyses	
	Control group (13 centres; n=195)	Intervention group (11 centres; n=204)	Control group (12 centres; n=206)	Intervention group (12 centres; n=193)
Centres				
Number, participant number range	13, 10-23	11, 12-19	12, 15-18	12, 10-23
Participants				
Number	195	204	206	193
Age (yr)	73.0 (6.3)	71.3 (5.6)	72.4 (6.3)	71.7 (5.7)
Sex (females, %)	69.2	63.2	67.0	65.3
Education (< primary school, %)	28.2	22.1	29.1	20.7
(primary school, %)	50.3	48.0	43.7	54.9
(≥ secondary school, %)	21.5	29.9	27.2	24.4
Smoking status (ever, %)	21.5	30.4	28.6	23.3
Drinking status (current, %)	24.2	15.2	20.3	19.0
Physical activity/fitness				
IPAQ expenditure ($MET \cdot min \cdot wk^{-1}$)	3172 (1757)	3157 (1596)	2811 (1565)	3539 (1709)
VO2max absolute ($L \cdot min^{-1}$)*	1.35 (0.99, 1.72)	1.35 (1.11, 1.76)	1.35 (1.06, 1.74)	1.37 (1.07, 1.76)
VO2max weight adjusted ($ml \cdot kg^{-1} \cdot min^{-1}$)*	23.5 (18.3, 29.2)	23.9 (19.3, 29.7)	23.0 (18.7, 28.9)	24.6 (19.4, 29.4)
Anthropometry				
Body mass index ($kg \cdot m^{-2}$)	24.2 (3.5)	24.4 (3.5)	24.6 (3.6)	23.9 (3.3)
Waist circumference (cm)	80.9 (8.8)	81.4 (9.7)	82.0 (9.3)	80.3 (9.2)
Bioimpedance body fat (%)	30.2 (8.9)	29.9 (8.5)	30.8 (9.1)	29.3 (8.2)

Blood pressure				
Systolic blood pressure (mmHg)	144 (20)	140 (22)	143 (23)	141 (20)
Diastolic blood pressure (mmHg)	76 (10)	75 (10)	75 (10)	75 (10)
Physical function measures				
30s chair stand (n)	14.4 (2.8)	14.6 (2.9)	14.3 (2.5)	14.7 (3.2)
30s arm curls (n)	14.4 (3.3)	14.8 (3.0)	14.8 (3.2)	14.4 (3.0)
2.5m get-up-and-go (s)	7.4 (1.8)	7.3 (1.6)	7.42 (1.75)	7.20 (1.63)
NMMT hip flexion (kg)	12.0 (3.3)	12.0 (3.2)	12.2 (3.4)	11.8 (3.1)
NMMT knee extension (kg)	12.5 (4.2)	13.0 (4.0)	13.1 (4.0)	12.4 (4.2)

Nicholas Manual Muscle Test (NMMT). *Median (interquartile range) for the VO2max predicted from the submaximal Astrand cycle exercise test.

Table 2: Differences in mean values on anthropometric, blood pressure, physical activity measures, and strength test parameters between the pedometry and buddy intervention groups relative to the control groups (95% confidence intervals)

Change in mean value	Pedometry group	p value	Buddy group	p value	Buddy and pedometry group[1]	p value[1]	Interaction p value[2]
Physical activity/fitness							
IPAQ expenditure (1000 MET·min·wk^{-1})*	1.82 (1.36, 2.29)	<0.001	1.26 (0.78, 1.74)	<0.001	1.74 (1.27, 2.21)	<0.001	<0.001
VO2max absolute (%)†	6 (-1, 15)	0.11	12 (3, 20)	0.005	5 (-2, 13)	0.11	0.03
VO2max weight adjusted (%)†	7 (-1, 15)	0.10	12 (4, 21)	0.004	6 (-2, 14)	0.14	0.03
Anthropometry							
Body mass index (kg·m^{-2})	-0.03 (-0.19, 0.12)	0.7	-0.08 (-0.23, 0.08)	0.3			0.7
Waist circumference (cm)	-0.30 (-0.90, 0.31)	0.3	-0.14 (-0.76, 0.47)	0.7			0.13
Bioimpedance body fat (%)	-0.30 (-0.89, 0.30)	0.3	-0.59 (-1.14, -0.04)	0.04			0.7
Blood pressure							
Systolic BP (mm Hg)	-0.9 (-4.2 2.4)	0.6	-1.6 (-4.9, 1.8)	0.4			0.5
Diastolic BP (mm Hg)	-0.6 (-2.2, 1.0)	0.5	-1.3 (-2.8,0.2)	0.08			0.9
Physical function measures							
30s chair stand (n)	-0.66 (-1.32, -0.00)	0.05	0.10 (-0.59, 0.79)	0.3			0.6
30s arm curls (n)	-0.42 (-1.12, 0.29)	0.3	0.19 (-0.53, 0.90)	0.6			0.5
2.5m get-up-and-go (s)	0.11 (-0.18, 0.39)	0.5	-0.27 (-0.53, -0.01)	0.05			0.2
NMMT hip flexion (kg)	0.21 (-0.97 1.38	0.7	-0.55 (-1.75, 0.64)	0.4			0.5
NMMT knee extension (kg)	0.34 (-0.44 1.12)	0.4	0.20 (-0.60, 1.00)	0.6			0.12

Nicholas Manual Muscle Test (NMMT); *IPAQ was divided by 1000, †log transformed data used in analyses, results are therefore relative changes (shown as percentage change, %).

All analyses were adjusted for baseline values, age, sex and clustering. Estimates of intervention effects are presented for the 12 mo outcome with outcomes at 6 mo included in the model using a repeated measures structure with a time term.

1 estimate and P-value comparing the combined intervention group with the group not receiving any intervention.

2 p value for interaction effects

Figure1
Click here to download high resolution image

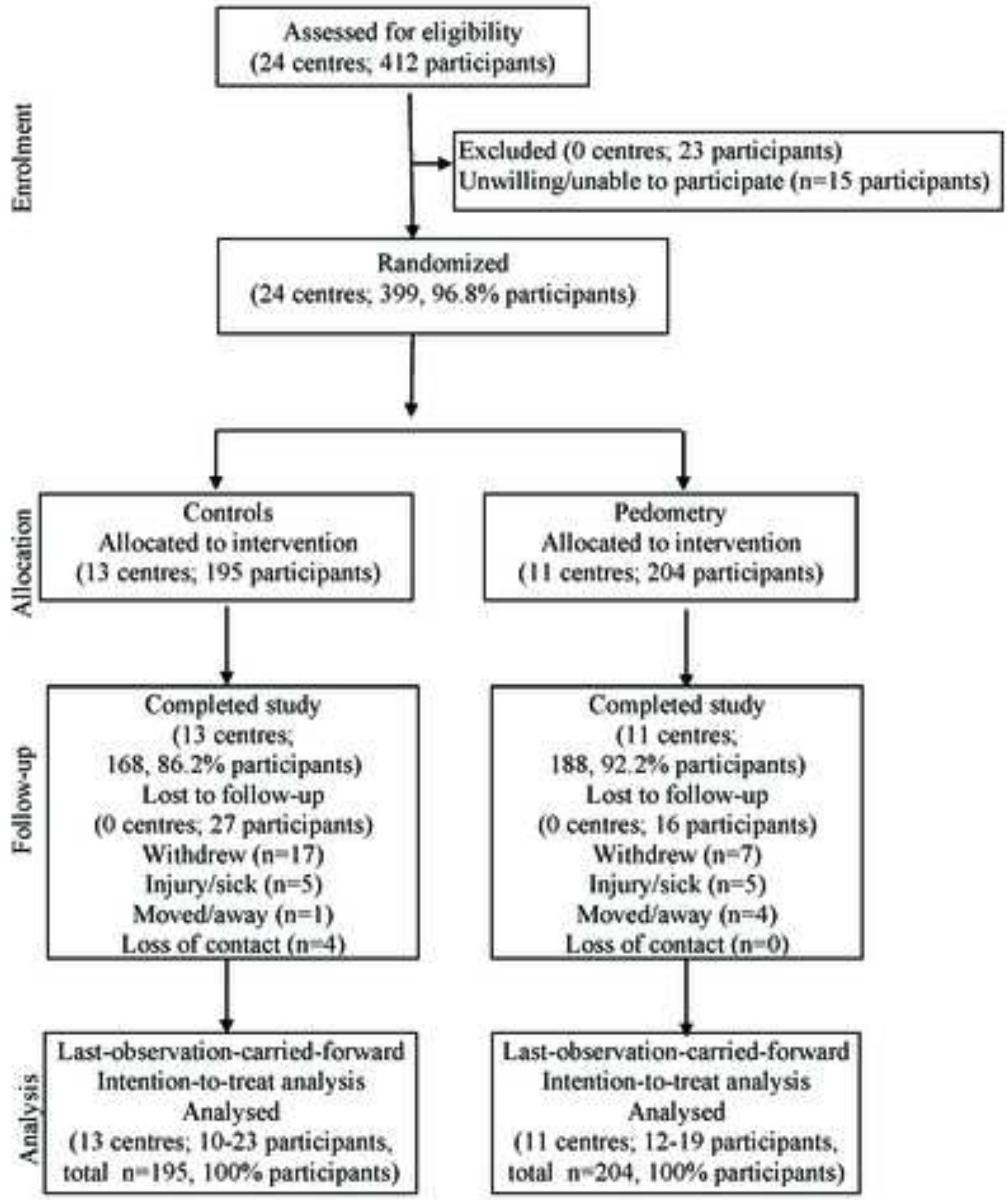

Figure2
Click here to download high resolution image