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The effect of a weighted vest on perceived health status and bone density in older persons

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To assess the effect of an exercise intervention using a weighted vest on perceived health status and bone density in older persons, we enrolled 36 seniors in a randomized controlled trial. The vest-use group met weekly for 1 h for a low level exercise class. They wore a weighted vest during the class and as tolerated at home. The discussion controls met for 1 h weekly. At baseline and follow-up (20 weeks), subjects completed a questionnaire that incuded the 20 item MOS Short-Form Health Survey, Multidimensional Health Locus of Control Scale, and Philadelphia Geriatric Center Morale Scale, and bone density was measured by dual energy X-ray absorptiometry. Subjects also completed daily activity diaries. Subjects in the vest group reported a statistically significant decrease in bodily pain, improved physical functioning, and increased internal health locus of control. Bone density increased by 1% in the vest group and decreased by 0.6% in the controls ($p = 0.12$). We conclude that our exercise intervention had a positive effect on some measures of perceived health in older persons.

Key words: Bone density, controlled trial, health perception, pain, quality of life.

Introduction

Chronic diseases cause 80% of deaths in the United States.[1] Because cure is rarely possible, medical interventions are usually targeted at disease control and symptom amelioration. In this context, the individual's perceived quality of life and subjective well-being assume particularly important roles in evaluating the effectiveness of therapies. Strategies that can delay the premorbid period of disability due to chronic disease are assuming a greater role in their treatment.[2] This 'compression of morbidity' is a worthwhile goal of medical interventions, independent of gains of longevity. Maintaining quality of life, by maximizing physical, mental, and social functioning, is a valid end in itself; increasing the older individual's period of optimal performance has intrinsic value independent of mortality endpoints.[1]

One such chronic disease that has become the focus of intense research interest is osteoporosis. This common, debilitating, costly, and lethal disease affects 30 in 100 females and 15 in 100 males in the form of hip fracture by the age of 90.[3] Exercise is a promising new strategy for osteoporotic fracture prevention, as it has the potential to benefit both bone and quality of life outcomes. Many lines of evidence suggest that exercise can maintain or improve bone mass.[4] Moreover, exercise is appealing from the standpoint of its potential positive effect on quality of life. Improvements in both general health and mental health have been reported as a result of physical activity in older persons.[5,6] However, much remains unknown with respect to the effectiveness of different forms of exercise on both bone health and subjective well-being. Endurance training and muscle strengthening regimens have been shown to benefit bone density, but current knowledge cannot determine whether either modality is superior.[4] In fact, both forms may be effective in maintaining bone, although through different mechanisms.[7–10] Similarly, whether an improved sense of well-being accrues from all forms of physical activity has not been carefully evaluated.

The feasibility of exercise interventions in an older population is also an important consideration when designing exercise interventions. Although it is clear that subjects in their ninth decade can perform muscle strengthening programmes,[11] such training programmes may not be practical or

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acceptable for a substantial proportion of older persons. Cardiovascular problems or musculoskeletal constraints may render many older persons unable to perform strenuous activities.[12,13]

In an effort to circumvent these obstacles to exercise in older persons, we have designed an exercise intervention using a weighted vest, the ease of use of which may facilitate its use by older subjects. A randomized, controlled pilot study was performed to assess the safety, acceptability, and effectiveness of this weighted vest in older persons. The effects of vest use on perceived health status and bone density, as measured by standardized self-report instruments and dual energy X-ray absorptiometry, are reported here.

Methods

Study population

Subjects were recruited by offering participation in the study as a 'class' at a senior citizen center in West Los Angeles. This center offers recreational activities to independent elderly people, and has no medical or meal-site services. Potential subjects signed a consent to be screened for eligibility in accordance with the Human Subjects Protection Committees of the UCLA Center for Health Sciences and the West Los Angeles Department of Veterans Affairs Hospital. All persons requesting admission to the class were screened on a first-come basis to acquire 36 eligible subjects, the maximum this pilot study could accomodate.

Exclusion criteria were (number of persons excluded is given in parentheses following each exclusion criterion); inability to read and write in English or to complete questionnaire without assistance, active angina or congestive heart failure, uncontrolled hypertension, uncontrolled seizure disorder, severe chronic back pain (1), severe disorder of gait or balance (1), history of non-traumatic hip fracture (1), or use of bisphosphonates or calcitonin (1) at any time within the past year. Female volunteers were excluded if they were presently taking oestrogens (1) or progestins, or had taken these within the past 3 months.

Measurements

All measurements were collected at baseline and at the termination of the study (20 weeks). After signing written informed consent, subjects completed a confidential questionnaire that included demographic questions and several previously published self-report instruments: the 20-item MOS Short-Form General Health Survey (SF-20), the Philadelphia Geriatric Center Morale Scale (PGC-MS), and the Multidimensional Health Locus of Control Scale (MHLC).[14-18] The SF-20 measures six health concepts: the extent to which health interferes with physical functioning; the extent to which health interferes with role functioning; health interference with social function; general mood and affect; rating of health in general; and amount of bodily pain. The range of all scores is 0–100, with a higher score demonstrating better health. This includes the pain score, where higher scores indicate less pain. The PGC-MS is 22 items and assesses three dimensions of morale: agitation, attitude toward own ageing, and lonely dissatisfaction. High morale responses to each item are given 1 point, for a maximum score of 22. The MHLC scales are three measures which gauge an individual's belief that health is under his or her own (internal) control (IHLC), a consequence of chance (CHLC), or due to the forces of powerful others (PHLC). Each health locus of control scale is six items long with a maximum score of 42. A high score on the IHLC reflects a high degree in internal control, while high scores on CHLC and PHLC indicate strong beliefs that chance and powerful others control one's health.

For the duration of the trial, participants kept structured diaries in which they recorded the type and duration of exercise performed daily. These were collected monthly. The pre-printed diaries included 10 forms of exercise or active chores (e.g., walking, cycling, gardening, and heavy housework) and spaces for other activities to be written in. The amount of exercise performed per week was quantified by summing the number of minutes spent in each activity. Subjects in the vest group also indicated whether they wore the vest and the number of minutes it was worn each day; the average number of minutes of vest per week was calculated apart from the remaining listed exercise activities for each vest subject.

Subjects were asked about any difficulties with vest use at each class and were encouraged to call in with any problems between classes. Subjects with any physical complaint were interviewed by a physician. Complaints were classified as unrelated, possibly related, and definitely related to vest use.

Bone mineral density (BMD) of the L_2–L_4 vertebral bodies was measured with a Lunar DPX dual energy X-ray densitometer. In four subjects, the inferior margin of L_4 was not discernible, so L_2–L_3 were analysed. The BMD technician was unaware of treatment assignment. A quality-control phantom was scanned daily.

Endurance was measured by the timed ten-stands test (TTS), which measures the length of time required to stand up from a chair 10 times.[19] At follow-up, the TTS examiner was aware of treatment assignment.

Interventions

Subjects were randomly assigned using a table of random numbers to either the discussion group or the vest group. Both groups met for 1 h per week for 20 weeks. The discussion group employed an interactive format. One experienced health educator moderated all sessions. Expert guest lectures presented a 30–45 min talk and entertained questions and discussion. The topics were designed to enhance the knowledge and improve the decision making capabilities of the subjects in several areas relevant to ageing, including How to choose a doctor, How to choose health insurance, and Proper use of medicines.

At their weekly meeting, the vest group initially performed 10 min of stretching followed by 20 min of exercise. The duration of the session was increased by 5 min week to a maximum of 45 min at Week 5, where it was maintained for the next 15 weeks. Classes were led by a single trained kinesiologist, with three student assistants. A specific exercise routine was performed to music. The list of class exercises is given in Appendix 1. One set was comprised of 10 repetitions of each exercise. The number of repetitions was increased to 12 and the number of sets of three as the length of the class increased.

Vest subjects wore the weighted vest during class (Figure 1). The beginning weight load in the vest was 0.45 kg; this was increased according to individual tolerance to a total of 3.6 kg maximum. (Details of how weight increments were permitted are given below under home use.) Weight was always equally distributed anteriorly and posteriorly.

Between months 2 and 20, vest subjects were also allowed to wear the weighted vest at home while performing routine and leisure activities such as walking, cycling shopping, and house cleaning. Because of the novel nature of this intervention, the beginning vest weight load and duration of vest use were empirically chosen. Starting weight was 0.45 kg, distributed evenly among two front and rear pockets. The starting

Figure 1. Weighted vest worn by subjects during exercise class and some routine daily activities. Each of eight pockets may be loaded with 0.23–1.8 kg of weight in 0.23 kg increments. Maximum allowable weight in this trial was 3.6 kg.

prescription for home vest use was a *maximum* of 60 min/day and a maximum frequency of three times weekly.

After 2 weeks, subjects were permitted to add to the weight load by a maximum of 0.9 kg/week to a maximum of 3.6 kg total. Subjects were instructed to increase the length of time and/or number of days the vest was worn as subjectively tolerated. They were encouraged to increase weight or time of use, but to observe for any pain or undue fatigue and to report these to the study physician immediately.

An empirically derived list of activities during which vest use was *not* advised was also distributed. These activities were those in which back injury or impairment of balance might be threatened (list available from first author on request).

Data analysis

Data were analysed by intention to treat. The unpaired t-test, Fisher's exact test and χ^2-test were used for differences in the baseline characteristics of the treatment groups.

Internal consistency of multi-term scales used to measure perceived health, health locus of control, and morale were assessed using Cronbach's alpha.[20] Correlations between scores at baseline and follow-up were assessed by Pearson's correlation coefficient. Correlations between SF-20, PGC-MS, MHLC, bone density, average minutes of weekly physical activity, and minutes of vest use were assessed using the same techniques. For the correlation analyses only, change scores for each scale (differences between pre- and post-intervention) were correlated with percent change in BMD.

The relationship between each multi-item scale and treatment assignment was examined with ordinary least squares regression.[21] Non-covariate ANCOVA models were analysed using the post-intervention score on each health measurement scale as the dependent measure with the baseline score and treatment assignment as predictor variables. ANCOVA models that controlled for differences in age, income, marital status, and ethnicity were also examined. The selection of covariates as potential confounders of the relationship between perceived health, health locus of control, morale, and vest use was based on univariate screening for between group differences that were significant at $p \leq 0.25$.[22] Univariate screening of the data set with a less stringent alpha is useful in small data sets, to decrease the likelihood of Type II error.[22]

Significance of treatment effect on BMD was also tested using a non-covariate ANCOVA model, with final BMD regressed on baseline BMD and treatment status. To facilitate comparison to the BMD literature, the change in BMD (calculated as percent change and absolute difference in g/cm^2) were also calculated, and tested for significance by unmatched t-test.

No adjustment was made for multiple comparisons.

Results

Thirty-six subjects were randomized, 19 to the discussion group and 17 to the vest group. Five subjects, three in the discussion group and two in the vest group, discontinued participation in the trial and were lost to follow-up, giving a retention rate of 83%. In the three discussion section dropouts, stated reasons were respiratory allergy, medical evaluation of undisclosed illness, and unspecified unwillingness to continue. The two exercise group dropouts left due to vertigo (from an unrelated vestibular disorder) and relocation. One discussion group baseline questionnaire was lost, and one subject in each group completed the study but did not submit a follow-up questionnaire. Therefore, the follow-up data represent 28 subjects, or 78% of the original sample.

Baseline characteristics of the study subjects are summarized in Table 1. The majority were female. A diverse range of educational level and socioeconomic status was represented. The treatment groups differed at baseline with respect to age, ethnicity, and marital status. Discussion group subjects were, on average, 2 years older than the exercisers and a higher proportion of vest-use subjects were married or living with partners. All subjects were fully ambulatory and none used assistive devices. All participants travelled independently using public transportation or private cars. None required home help for daily activities. In answer to the question, "Compared to other persons your age, how would you describe your physical activity?", the mean response was 3.8 in both groups at baseline and follow-up. The response set ranged from one to five; 3 represented average, 4 represented somewhat more active. The baseline demographics of the eight persons for whom follow-up questionnaires are not available are compatible with those who are reported here.

Table 1. Demographic and anthropomorphic characteristics of participants by treatment group

Characteristic	Discussion group ($n = 19$)	Vest use group ($n = 17$)	p
Mean age (range)	72.6 (58–80)	69.1 (63–76)	0.03[a]
Mean body mass index (range)	26.3 (19–43)	27.2 (20–37)	0.60[a]
Female	89%	82%	0.54[b]
Highest degree			
<high school	5%	13%	
High school	28%	20%	
Some college/technical	28%	40%	
College	11%	20%	
Graduate	28%	7%	0.47[b]
Annual income ($)			
<10,000	33%	9%	
10,000–29,999	45%	67%	
30,000–39,999	22%	8%	
40,000–49,999	0%	8%	
50,000+	0%	8%	0.20[c]
Marital status			
Single/widowed/divorced	83%	47%	
Married/significant other	17%	53%	0.03[b]
Ethnic background			
Hispanic	5%	0%	
Black	0%	24%	
Asian	5%	0%	
White	90%	76%	0.05[c]

[a]Between groups t-test
[b]χ^2
[c]Fisher exact test

Seven of eight were female, two were White, and the mean age was 70.3 years.

Weekly class attendance averaged 84% (range 75–100%) and 88% (range 73–100%) in the discussion and exercise sessions, respectively. The overall adherence rate with completion of the weekly activity diary was 88% (range 13–100%), 84% among the vest group and 94% among the discussion group. As recorded in the diaries, the average weekly physical activity was similar to the discussion and vest groups. Discussion group subjects were physically active for an average of 294 (± 215) min/week, while vest use subjects reported 298 (± 200) min/week of activity ($p = 0.953$). An increase in physical activity over the course of the trial was not evident in either group. In fact, both groups declined somewhat in activity, with the initial to final weekly totals ranging from 343 (± 262) to 256 (± 227) in the discussion group and 331 (± 332) to 243 (± 223) in the vest group. The test for a time effect was significant at the $p = 0.10$ level. No between groups difference was apparent in the analysis of exercise over time ($p = 0.84$).

Among the vest subjects, the average number of days per week that the vest was worn, in addition to the weekly class, was 3.8 (± 2.2). On average, the participants wore the vest for 62 (± 50) min/day of vest use. The overall average weight load carried was 1.1 kg (± 0.52), range 0.45–2.72 kg. The average load during weeks 1–4 was 0.45 kg. Between weeks 5 and 15, subjects carried an average of 1.0 (± .32) to 1.25 ± (0.45) kg. From weeks 16 to 20, the load increased from 1.36 (± 0.57) to 1.64 (± .55) kg. On average, the weight load increased by 0.06 kg/week ($p < 0.0001$).

Reliability estimates for the multi-item scales are presented in Table 2. Each of the internal consistency estimates (alpha coefficients) of the multi-item subscales that comprise the SF-20 and two of the three MHLC scales are above the recommended level of 0.70 for group comparisons, and are comparable at baseline and follow-up.[23] The alpha coefficients of the MHLC Chance subscale and the PGC-MS are somewhat low, at 0.54–0.60. Correlations between the initial and final scores for these scales are also shown in Table

Table 2. Reliability estimates for MOS-Short Form, Multiple Health Locus of Control, and Geriatric Morale Scales

Scale	Alpha Reliability Estimates[a]		Correlation between baseline and follow-up scores[b]
	Baseline	Follow-up	
MOS Short-Form			
Physical Function	0.85	0.84	0.17
Role Function	0.70	0.95	0.17
Social Function	—	—	0.18
Mental Health	0.78	0.84	0.72
Health Perceptions	0.82	0.89	0.66
Bodily Pain	—	—	0.66
Multiple Health Locus of Control			
Internal	0.73	0.81	0.37
Powerful others	0.70	0.74	0.62
Chance	0.54	0.58	0.53
Geriatric Morale Scale	0.60	0.54	0.69

[a]Cronbach's alpha
[b]Pearson product moment correlation coefficient

2. Because real change in status could occur during this time interval, these correlations cannot strictly be interpreted as test–retest reliabilities: 20 weeks had elapsed and all subjects had undergone an intervention.

Table 3 summarizes baseline and post-intervention scores on each of the SF-20 subscales by treatment assignment. Baseline levels of the SF-20 scales did not differ by treatment group, although there was a seven point difference in pain ($p = 0.3$). The vest group reported improvement in level of physical function while the discussion group declined in this domain. This difference was significant in both the non-covariate ($p = 0.01$) and covariate ANCOVA models ($p = 0.05$). The amount of reported bodily pain also diminished in the vest users, by approximately 10 points. This difference in pain score was significant in the adjusted analysis ($p = 0.05$).

As shown in Table 4, baseline values of the Multiple Health Locus of Control scales were also similar in the treatment groups. After the intervention, vest subjects experienced a shift in their health locus of control in an internal direction on

Table 3. Baseline and post-intervention SF-20[a] by treatment group

	Physical function	Role function	Social function	Mental function	Health perceptions	Bodily pain
Baseline						
Discussion	71.1	89.6	96.6	80.0	79.7	74.4
Vest use	70.7	94.1	96.5	80.0	79.7	67.1
p^b	0.92	0.75	0.95	1.0	1.0	0.30
Follow-up						
Discussion	64.9	78.3	93.3	83.1	85.5	73.3
Vest use	84.4	89.5	92.9	81.0	81.0	77.1
p^c	0.01	0.22	1.0	0.56	0.65	0.10
Adjusted follow-up						
Discussion	58.9	75.3	92.2	83.6	79.7	69.2
Vest use	80.5	82.9	89.2	81.9	80.8	76.9
p^d	0.05	0.25	0.61	0.98	0.64	0.05

[a]Higher scores indicate better health, including the pain scale where higher scores indicate less pain.
[b]Between groups *t*-test
[c]Non-covariate ANCOVA model of follow-up score regressed against baseline score and treatment
[d]ANCOVA model with covariates of age, marital status, ethnic group, and income

Table 4. Baseline and follow-up values of Multiple Health Locus[a] of control and Geriatric Morale Scales[b] by treatment group

	Internal MHLC	Powerful MHLC	Chance MHLC	Geriatric morale
Baseline				
Discussion	11.7	25.5	29.7	12.8
Vest-use	13.9	27.5	31.4	12.9
p^c	0.37	0.44	0.41	0.89
Follow-up				
Discussion	11.7	29.8	31.96	12.7
Vest-use	15.9	26.2	28.3	12.8
p^d	0.08	0.01	0.005	0.89
Adjusted follow-up				
Discussion	11.2	29.8	32.5	12.4
Vest use	14.16	24.8	28.8	12.8
p^e	0.18	0.05	0.04	0.84

[a]Higher score on the Internal scale of the MHLC reflects a high degree of internal control. Higher score on the Powerful Others and Chance scales indicate stronger beliefs that health is controlled by others or chance
[b]Higher score indicates better morale
[c]Between groups *t*-test
[d]Non-covariate ANCOVA model of follow-up score regressed against baseline score and treatment
[e]ANCOVA model with covariates of age, marital status, ethnic group, and income

all subscales. (A higher score on the Internal scale and lower scores on the Powerful and Chance scales represent more internal loci in each of these domains.) The final scores were significantly different on the Powerful Others and Chance subscales. In general, the move toward internal locus of control by the vest subjects was uniform and consistent. Conversely, movement in the external direction was evident on all health locus scales in discussion group subjects. There were no treatment effects seen on the Geriatric Morale Scale.

Bone density was similar in the vest and discussion groups at baseline (1.037 g/cm^2 and 1.016 g/cm^2 respectively, $p = 0.75$). At 20 weeks, the average change in bone density in the discussion group was -0.0068 g/cm^2, while the average change in bone mineral density in the vest subjects was 0.0101 g/cm^2. The discussion group showed a -0.59% decrease and the exercise subjects averaged a 1.02% increase in BMD. The difference between groups (0.017 g/cm^2; 95% CI -0.004, 0.038), did not reach statistical significance. The between-groups percentage change was 1.61%.

The effect of treatment on BMD was tested using an ANCOVA model, with final BMD as the outcome variable, and treatment assignment and baseline BMD as predictor variables. The regression coefficient for treatment assignment accounting for BMD at baseline was not significant ($\beta = 0.017$, $p = 0.12$).

Percent change in bone density had a strong positive correlation with the number of minutes of vest use per week ($r = 0.75$, $p = 0.002$) and a modest but not-significant correlation with the average amount of weekly activity (min/week) in the vest group ($r = 0.33$, $p = 0.22$). In the discussion group, change in BMD was unrelated to average minutes of exercise ($r = 0.003$, $p = 0.99$). A significant correlation was also found between percent change in BMD and change in perceived pain among vest users ($r = 0.56$, $p = 0.04$), but not among discussion group subjects ($r = -0.10$, $p = 0.75$). Change in BMD was not correlated with changes in the remainder of the SF-20 scales, the MHLC scales, or the Geriatric Morale Scale.

Initial mean TTS scores were 20.3 and 20.4 s in the vest and control subjects, respectively. At follow-up decreases of 3.0 and 1.2 s occurred in the same respective groups, but no between-group difference emerged ($p = 0.466$).

There were two possible minor adverse effects attributed to the exercise programme. Both occurred in subjects who dropped out of the trial. One subject cited both relocation and the recrudescence of a former knee injury. One subject who completed the trial, but did not fill out a follow-up questionnaire, had transient upper back pain during the study which resolved with the use of less weight in the vest.

Discussion

This randomized, controlled study of the effect of a weighted vest on bone density and self-report measures of health status demonstrated improvements in some measures of perceived health and health locus of control in the group randomized to vest use. The most profound change was seen in the area of health locus of control, with change toward an internal locus reported on all three subscales by vest users while the converse was seen among discussion subjects. Vest subjects also reported greater relative improvement than discussion subjects on SF-20 measured pain and physical functioning. BMD, the major physical outcome measure, did show a 1.6% increase in the vest compared to the discussion group, but this difference achieved significance only at the $p = 0.12$ level. However, intriguing relationships were noted in post-hoc correlational analyses between increase in BMD and decrease in pain, increase in BMD and number of minutes of vest use per week, and decrease in pain and number of minutes of vest use.

At baseline, these ambulatory, independent-living volunteers were remarkably external in their health locus of control. The average Internal Health Locus score was 12.5, Powerful-Others score was 26.5, and Chance Locus score was 30.6 (with a maximum score of 42 on each). Normative data for the MHLC series in older populations are not published. However, some frame of reference can be gained by examining other reported MHLC values in young and middle-aged populations.[24] Average Internal Locus scores in the general population range from 25 to 27; those from persons with chronic conditions average between 21 and 27; and Internal Locus ratings are between 26 and 28 in persons engaged in health prevention behaviours. Powerful-Others ratings from the same categories of previously reported subjects average 14–24, 18–26, and 18–20, respectively. Chance Locus scores average 16–18, 15–19, and 14–19 in the same groups. Although cross-sectional comparisons must be interpreted with great caution, it would appear that older persons in our study were substantially less internal than a broad range of young to middle-aged subjects reported by other investigators. This finding leads to the implication that health locus of control may become less external as people age. No studies have examined this specific question. However, age-related changes in general (not health specific) internal locus of control measures have been reported. While opinion on this matter is far from uniform, large cross-sectional surveys find increasing externality with ageing.[25,26] In addition to cohort effects which may produce apparent, rather than real, age-related changes in cross-sectional analyses, physical, mental, and social declines associated with ageing may explain an increase in externality.[25,27]

In our study, health locus of control was malleable. We witnessed movement toward internality in the three spheres of health locus of control measured. Is such movement feasible? Numerous authors have discussed whether locus of control is a state or a trait.[28] The importance of this debate is that while a state may be mutable, a trait tends to be a stable and consistent characteristic of an individual, which remains generally constant over time. The global locus of control may be a relatively stable trait of each individual, while the specific health-related locus of control, as conceived by Wallston and others, may be a trait that may be influenced by personal health and functional status, and that can be changed by circumstance, or persuaded by an appropriate intervention.[28] The data from our study support this hypothesis.

An important issue is whether an internal health locus is beneficial to the health of older persons. This question has not been addressed in the literature. One possible benefit of a more internal health locus of control lies in its potential relationship to symptom under-reporting. Under-reporting of symptoms is a well-known phenomenon in geriatric medicine[29] that can represent a major obstacle to the delivery of health care for remediable diseases and dysfunctions in elderly persons. Several explanations of under-reporting have been postulated. Some older persons minimize their symptoms by comparing themselves to worse-off peers, by attributing major illnesses to minor causes, and by assuming that ageing *per se* accounts for declines in health and function.[30] One component of this exaggerated concept of normal ageing may be a belief on the part of older persons that health-related changes are outside their control, and therefore not worth bringing to the attention of a health care provider. A more internal health locus of control might then decrease symptom under-reporting. It may also lead to increased participation in health promoting behaviours, such as exercise and better nutrition. If patients believe that they can influence their health outcome, then they may take steps to do so.

The SF-20 scores of our study group were comparable to that of a previously reported large general-population sample and a large sample of patients without chronic illness in the domains of mental health, health perceptions, pain, social, and role functioning.[16] Our patients scored more like arthritis patients in the domain of physical function (i.e., lower physical function than the general or non-chronically ill patient population.[16]

Improvement was demonstrated on the bodily pain scale and physical function scales of the MOS-short form, with a decrease in the amount of self-reported pain (a higher score means more freedom from pain) and improvement in self-reported physical function among vest subjects. The concomitant changes in function, pain perception and health locus of control offer insight into a possible mechanism. Bodily pain is strongly related to physical and social functioning in the elderly.[31] It is plausible that as subjects engaged in the weighted vest intervention and perceived improvements in pain and function, they internalized an implicit message that they can achieve some mastery over physical functioning. It should also be noted that while the vest group's baseline pain score was not significantly different from that of discussion group's at baseline, it was seven points worse, raising the possibility of regression to the mean as a spurious cause of the observed treatment effect. However, the significant correlation between minutes of vest use and improved pain score argues for a real, rather than artefactual, change.

Although substantial gains in well-being and mood are commonly attributed to physical exercise, few randomized studies have carefully examined this issue. A few reports of quality of life effects of exercise in older persons have been published and their findings are in agreement with the present study. One study of the effect of aerobic exercise, yoga, or waiting-list control in 101 men and women with a mean age of 67 found a significant improvement on the Center for Epidemiologic Studies Depression Scale (CESD) in males only in the exercise group.[6] In another report from the same study, improved sleep, self-confidence, social life, and sex life in the combined exercise and yoga groups was noted.[5] However, it is difficult to discern the discrete effect of exercise versus group interaction in that design, because control subjects did not have social interaction comparable to that of the exercise and yoga groups. Recently, using the same instrument as in the current study (SF-20), Stewart *et al.* have reported the effect of a graded exercise programme on quality of life.[32] The intervention was comprised of a class-based high intensity programme, a home-based high intensity programme, or home-based lower intensity programme. Interestingly, no significant between-group differences on any of the SF-20 scales were found. However, within the exercise groups, physical function, role function, pain and health perceptions showed significant improvements with increasing level of participation in the exercise programme. This effect was not associated with the level of fitness, nor did it appear that the healthier people simply exercised more. The authors interpret these findings as showing improved quality of life as a result of participation in an exercise programme.

Our study finds a 1% increase in BMD and 0.6% decrease in BMD in the vest and control subjects, respectively; this difference is significant at the 10% level. The percent change and difference in g/cm^2 analyses facilitate comparison to the BMD literature. Although a 1.6% difference may appear modest, the effect size seen over a longer period (9–12 months) in clinical trials of oestrogen, as well as high-level aerobic interventions, are of the same order of magnitude.[33,34] The correlation between minutes of vest use and gain in BMD corroborates the effectiveness of the weighted vest in increasing BMD. Our small sample size may not have provided enough power to detect a clinically meaningful effect. Further studies will be needed to confirm these findings.

We also examined the relationship of percentage change in BMD, minutes of vest use, and minutes of daily activity to change in SF-20 and MHLC scales. A significant correlation was found between percentage change in BMD and bodily pain improvement. To our knowledge, the relationship between change in BMD and pain has not been previously reported. However, the analysis was post-hoc and our sample is small; further study of this intriguing observation is warranted.

The finding that an exercise intervention using a weighted vest can produce gains in quality of life and perceived control over health is encouraging from the standpoint of feasibility in older populations. While programmes directed at gains in endurance have other positive preventive health outcomes,[35] they may not be feasible in a substantial portion of the ageing population. Barriers to achieving endurance exercise in older subjects include the requirement of exercise stress testing in unconditioned subjects over the age of 45 before initiation.[12] In addition, the increased risk of musculoskeletal injuries can impede the use of even high intensity walking regimens in older subjects.[36]

A strength of the present trial is its use of a discussion control group. The improvements in quality of life and change in the direction of internal health locus of control in the vest group are evidenced when compared to a group which also met weekly and, in fact, discussed potentially empowering topics related to medicine and health. The use of such a control group addresses the potential confounding effect of group process, which itself may produce beneficial changes in perceived well-being.

The major limitation of our trial is its small sample size. Small samples may be non-representative, and are subject to Type II error. Nonetheless, the demographics of population and the community-based study site argue that the sample is fairly representative of what could be achieved in other communities. While our differences in BMD and some perceived health scales may not have achieved statistical significance, we were able to detect improvements in physical function, pain, and health locus of control. Our correlations support a mechanistic hypothesis, relating minutes of vest use to increasing BMD and decreasing pain.

A second limitation of the study is that the intervention group wore the weighted vest and also attended a weekly exercise class. The intensity and frequency of exercise in this class were far below interventions previously reported to improve bone density or achieve a training effect.[34,35] It is our belief, based on the infrequency and low level of muscle loading of the class, that the increase in BMD is attributable to the vest. Support for this also comes from the absence of a treatment effect on endurance (TTS) and the correlation between vest use and gain in BMD. The diary records show that neither group increased its exercise level outside the study, nor did minutes of non-vest exercise correlate with BMD outcome. The relationship of gains in quality of life and internal health locus of control are not as easily attributed to the use of the vest versus the combination of vest use plus the exercise class.

The use of a weighted vest as a potential bone-trophic intervention with concomitant positive effects on perceived pain, physical function and health locus of control deserves further research. Larger studies are needed to confirm the encouraging results of this small study, to clarify the role of the vest alone, and to explore its mechanism. The safety and feasibility date provided by the current study will allow a more uniform prescription and higher dosage of weight use, and prior hypotheses regarding the relationship of change in BMD to pain and minutes to vest use may be tested.

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Appendix[1,2] Senior Stretching Programme ("Warm-Up"): each set is composed of four repetitions of each position

Flexed-Leg Back Stretch: to maintain flexibility in torso, low back and legs. Stand erect, feet shoulder-width apart, arms relaxed. Slowly bend forward as far as possible, preferably until you touch ground with hands. Keep knees flexed. Bend to 5 count, hold for 5 count, 5 count rest.

Stimulated Crawl Stroke/Back Stroke/Breast Stroke: to stretch shoulder girdle. Stand with feet shoulder-width apart, arms at sides relaxed. Bend knees and alternatively move right and left arms backward, upward, and forward as if swimming.

Chair Reach: to stretch girdle and rib cage. From a seated position, take deep breath, extend arms overhead. Hold for 5 count, relax for 5 count. Exhale slowly, dropping arms.

Chair Backstretch: to improve the flexibility of the lower back. Sit up straight. Inhale. Bend far forward. Exhale while bending forward. Straighten up. Repeat, clasping hands on left knee. Repeat clasping hands on right knee. Hold each position for 5 count, relax for 5 count.

Chain Breaker: to stretch chest muscles. Stand erect, feet about six inches apart. Let arms dangle between legs. Tighten leg muscles, tighten stomach by drawing it in, hips forward, extend chest, bring arms up with clenched fists check high, take deep breath, let it out slowly. Slowly put arms back as far as possible keeping elbows chest high.

[1] The authors have adapted these stretches and exercises from several published sources.
[2] All exercises were performed against gravity (without added weight resistance on the hands and feet), except as noted.

Appendix

Exercise programme

Four Pike: to stretch lower back and hamstring. Sit on floor, legs extended forward, knees together. Exhale and stretch forward, slowly sliding hands down to ankles. Hold for 5 counts. *Don't bounce.* Return to starting position inhaling deeply over 5 count.

Dynamic strength training for older adults:
each set is composed of 10–12 repetitions of each exercise

Wall Push-ups: Push-ups against a wall (using the calf stretch position, wide arms, weight on back leg, front foot resting lightly on the ground).

Biceps Curls: Flexion and extension of biceps. Performed standing with back against wall and knees slightly bent. (Handweights; 0.45 kg, are used.)

Pelvic Tilts: The back is placed against the wall, with feet placed about 1 foot from the wall (knees flexed. Held for 10 counts).

Chair Abdominal Twisters: While seated, opposing elbow and knee are brought together.

Chair Squats: Standing up from chair without use of hands.

Back Leg Swing: Stand erect behind chair, feet together, hands on chair back for support. Lift one leg back and up as far as possible, keeping knee straight and body erect. Return to starting position.

Two Leg Toe Raises: With two legs on the floor, stand on tip-toes then release.

Demi-Lunges: Step forward, slowly lowering yourself partway to the ground (alternate legs).

Buttock Lift: Lying on back, lift buttocks so that the trunk and thighs are in line.

Back Strengthening: On stomach, lift one foot at a time off the ground.

Floor Arm Weights: Lie on back on floor with knees flexed. Grasp 0.45 kg weights in each hand over chest. Inhale and lower weights to sides with elbow slightly bent. Raise weights in an arc to the starting position, exhaling in the process.