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The effect of aerobic training on healthy elderly women's walking speed, step length and habitual physical activity

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ABSTRACT

This study's main aim was to investigate whether training could increase walking speed, step length and habitual physical activity (HPA) in elderly women. This randomized controlled trial was carried out with 22 elderly women, who were first monitored for a week (heart rate and movement), had their chosen and faster walking speed determined, as well as their step rate and length, and underwent sub maximal treadmill tests. Data from monitoring were organized into 7 HPA indices. The women were randomly allocated to a control (73.6±1.7 years) or exercise group (75.5±2.9). For 12 weeks the exercisers walked 3 times a week on a treadmill at 60-65% of their predicted HRR. Controls continued with their normal routine. Post-training, all measurements were repeated. Training was associated with significant increases in step length and walking speeds. However, no significant changes in the HPA indices were found. It is concluded that the three-month aerobic training program by treadmill walking resulted in significant increases in step length and self-selected walking speeds in these healthy, independent, elderly women, however, it did not lead to increased habitual physical activity.

INTRODUCTION

Healthy ageing is accompanied by a decline in objectively measured habitual physical activity,[1] decreased maximal aerobic power,[2] muscle strength[3] and power,[4] walking speed and stride length,[5] among other factors.

There is evidence of an association among physical activity, maintenance of health and effective function in old age. Higher levels of habitual physical activity is not only related to better function in later life but also to better quality of life[6] and a lower risk for disability.[7]

Defined as "any bodily movement produced by skeletal muscles that results in energy expenditure", physical activity also includes work and leisure.[8] The complexity of physical activity is reflected on the large number of different methods available for its measurement, which can be grouped as: calorimetry, behavioral observation, dietary measures, survey procedures, movement sensors and physiological markers, such as heart rate (HR).[9] HR and movement monitoring have been suggested as feasible alternatives to assess physical strain/energy expenditure during daily life.[10]

Among the many daily activites developed by humans, walking is the most frequently reported,[11] hence it is important for one's independence that the ability to walk is maintained throughout life. Nonetheless, even healthy aging is accompanied by changes in gait, which are suggestive of a need for greater stability: step length is reduced, step rate is increased, the stride width is broader, and the double support phase time is also increased.[5] These changes result in lower self-selected walking speed. Moreover, shorter step length and higher step rate increase the oxygen cost and thus the physical strain in walking of healthy elderly,[5] as well as in individuals with impairments and disabilities.[10] Furthermore, in older people decreased walking speed and shorter steps are associated with falls, lower cognitive function, disability, dependency and mortality.[12,13,14]

As much as changes occur with aging which can alter an elderly person's physical capacity, almost all of the losses can be counteracted by the many beneficial effects of physical training.[3,4] Exercise has, therefore, been recommended as a means of increasing physical performance capacity in order to decrease the physical strain during some activities of daily living (ADL).[10]

At present, there seems to have been no study that looked at the effect of aerobic training on the performance of daily activities in elderly people, as measured by simultaneous HR and movement monitoring. Further research is, therefore, needed to establish whether exercise will in fact decrease physical strain/energy expenditure during ADL in this age group.

Hence, this study was carried out with a group of healthy, independent, elderly women to determine the effects of a 12-week aerobic training by treadmill program on: (1) step length and walking speeds; (2) level of customary physical activity; (3) physical strain of daily activities estimated by the HR response relative to the HR reserve.

METHODS

Study design, sample and selection criteria

This randomized controlled trial was developed with 22 healthy/medically stable15 elderly women (74± 2.6 years; range= 70 to 78.8), who lived independently. The subjects were recruited through advertisements in the North West London's local papers.

Subjects had to be capable of walking on a motorized treadmill, using a mouth piece and have no history of recent osteomuscular, systemic, respiratory, cardiovascular, cerebrovascular or uncontrolled metabolic disease. The exclusion criteria are described elsewhere.[15]

Approval for procedures was granted by the Ethical Practices Committee of the Royal Free Hospital Medical School. Written informed consent was obtained from each subject.

Data collection

This study was divided into 3 phases (Figure 1): 1) Pre-training assessment (treadmill tests, walking speed, monitoring); 2) Training/ control period and 3) Post-training assessment (treadmill test, walking speed, monitoring).

Subjects undertook two equal sets of assessment, 12 weeks apart, both standardized for time of day and carried out by the same observer without reference to baseline values. Immediately after the first assessment, subjects were randomly allocated to the control (n=12) or exercise group (n=10).

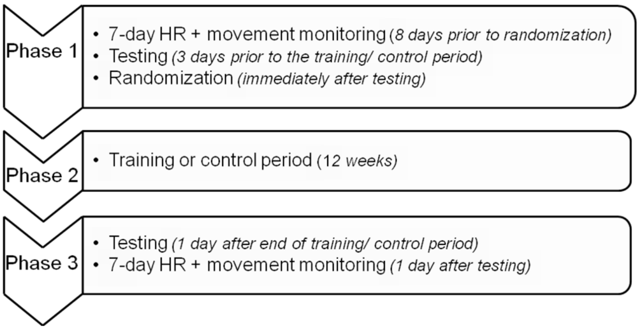

Figure 1. Description of the study's three phases.

Measurements

The measurements consisted of: self-selected and faster walking speed (floor walking), step rate and step length at each of the two walking speeds, sub maximal treadmill tests, HR and movement monitoring. Height (wall mounted stadiometer) and weight (heavy clothing and shoes removed) were also measured.

After standardized verbal instruction, the subjects walked an 87-metre long, rectangular, indoor course three times continuously at their preferred pace (chosen walking speed – CWS) and, after a 10-minutes rest, at a speed faster than their preferred (faster speed – FWS). Laps were individually timed and steps were counted for 30 seconds; the mean values were used for calculation.

Sub maximal treadmill tests (up to 85% of predicted maximal HR – HR_{max}), were carried out to define individualized exercise limits for aerobic training and to determine the relationship between HR and oxygen consumption (VO_2). A modified Naughton protocol[15] and the American College of Sports Medicine's criteria for test termination were used.[16] A HR monitor (Polar Sport Tester by Polar-Electro, Finland) was used. Maximal HRs were predicted from the formula: $HR_{max} = 210 - (0.65 \times age\ in\ years)$.[17] Subjects were asked to rate their perceived exertion (RPE) at the end of the last stage of the tests by pointing at a visual analogue scale.[18]

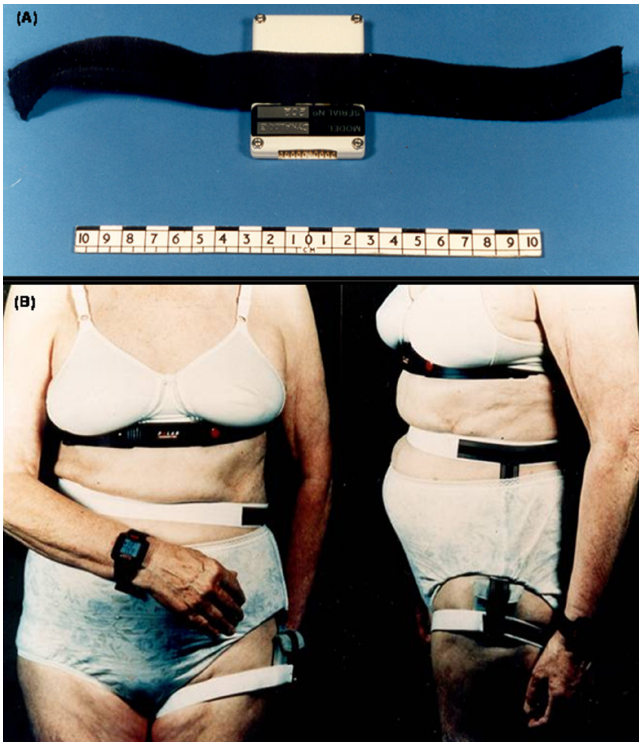

Figure 2. (A) The mercury-tilt switch monitor (Dynalog) used in this study; **(B)** Volunteer wearing the Dynalog (inside its pouch) and the heart rate monitor (transmitter on the chest and receptor on the wrist).

In order to measure habitual physical activity, subjects were asked to wear a movement monitor (Dynalog) and a Polar Sport Tester for 7 consecutive days (Figure 2). The sampling interval was set to 30 seconds for both monitors. This length of time for the monitoring period was based on research work that established the accuracy of shorter periods of time for the measurement of movement monitoring to predict physical activity levels in older adults.[19]

The Dynalog is a mercury-tilt switch movement monitor (Objective Data, Salisbury England), whose rectangular case is small (10 × 50 × 72 mm) and lightweight (50 g), slightly bigger than a pocket watch.

The volunteers were also asked to keep a diary (Daily Logs) of their activities during that week and to behave as usual, carrying out their activities as planned. Logs were used only to check data recorded by movement and HR monitors.

All instruments/equipment used in this study were calibrated regularly, according to their manufacturers' instructions.

Training/Control period

The exercisers underwent a 12-week aerobic training program, while the controls were asked to carry on their usual routine and activites, with no active or placebo intervention prescribed for them. Both groups were also asked not to engage in new activities until the second set of assessments.

Twelve subjects (6 controls) underwent the program from January until June and the other 10 (6 controls) started in July and finished in December.

The exercisers underwent individual sessions of 25 minutes, carried out 3 times a week. The sessions consisted of:

1. warm-up (3 minutes walking on a motorized treadmill at 3 $km.h^{-1}$);
2. endurance [20 minutes of treadmill walking at 60% to 65% of HR reserve (HRR)];
3. cool-down (2 minutes of treadmill walking at 3 $km.h^{-1}$).

The treadmill speed was controlled so that the HR was maintained between 60 and 65% of HRR during the endurance part of training sessions. If the HR did not reach the target but the subject was walking as fast as she could, the inclination of the treadmill was increased.

Blood pressure was measured immediately before and after training sessions. HR was monitored throughout the sessions with a 5-second sampling interval. A training HR was derived using the formula: $THR = P \times (HR_{max} - RHR) + RHR$, where "P" represents the percentage of HR_{max} that is desired and RHR stands for resting HR.[20]

Variables

The variables used to analyze the treadmill tests' results were: VO_2; carbon dioxide production (VCO_2); pulmonary ventilation (Ve); HR at the last stage of treadmill test (HRLSTA); HR at $VO_2 = 10$ ml.min^{-1}.kg^{-1} (HR10ML); HR at $VO_2 = 15$ ml.min^{-1}.kg^{-1} (HR15ML).

Given that not all volunteers completed the test's 10 stages, a variable was created to present the results related to the stage that all of them managed to do, that is, the seventh stage (HR7STA ≅45 Watts).

Additionally, seven indices were created to facilitate the analysis of HR and movement data:

1. DYNHOUR = total number of counts recorded divided by the number of hours of monitoring.
2. DYN40 = total time (in minutes per hour of monitoring) when the movement monitors indicated walking, that is, scores were equal to or greater than 40 counts.min^{-1}.[21]
3. HR30 = total time spent with a HR equal to or greater than 30% of predicted HR Reserve (HRR).
4. HR50 = total time spent with a HR equal to or greater than 50% of HRR.
5. CI30 = total time spent with a combination of the movement count indicating walking and the HR equal to or greater than 30% of HRR.
6. CI50 = total time spent with a combination of the movement count indicating walking and the HR equal to or greater than 50% of HRR.
7. HR110 = total time spent with a HR equal to or greater than 110 beats.min^{-1}.

Thirty percent of HRR was chosen because, although it is too low to bring about training effects, it may be enough to have health benefits, and 50% was chosen as the level at which an activity performed would result in training, if sustained for long enough.[22]

The combined indices (CI30 and CI50) were created to exclude periods when a high HR might not indicate raised energy expenditure.

The absolute HR index of 110 beats.min-1 was chosen because activities performed at this level and above would be considered to be of moderate intensity (≥50% of predicted HRR) and could possibly bring about training effect, if performed for long enough.[23]

Statistical analysis

The Statistical Package for Social Sciences (SPSS) was used for all analyses described. Significance was assumed to be at the $\alpha = 0.05$ level.

Data were tested for normality using the Shapiro-Wilks and/or the Kolmogorov-Smirnov statistic with a Lilliefors significance level. For the data not normally distributed in the sample non-parametric tests were used.

Comparisons involving data related to the activity indices were carried out with the Kruskal-Wallis one-way ANOVA; those involving age, anthropometric measures, treadmill tests, walking speeds and their correlates were analyzed with two-tailed unpaired t-tests. The interaction between time and group was investigated with a two-way ANOVA.

RESULTS

Characteristics at baseline

Baseline characteristics of subjects included in the study are presented in Table 1 and the baseline results for the HR and movement monitoring indices are displayed in Table 2. As can be seen in both tables, at baseline, controls and exercisers did not differ statistically in any of the variables analyzed, be it age, physical characteristics, or habitual activity measured by the absolute and relative indices created from the HR and movement monitoring.

Table 1. Baseline characteristics of the subjects in the Control and in the Exercise Group.

Variables	Control* n=12	Exercise* n=10	*p*
Age (years)	73.6 (1.7)	75.5 (2.9)	0.100
Height (cm)	157.6 (6.9)	158.3 (7.4)	0.826
Weight (kg)	64.2 (8.6)	63.2 (11.8)	0.824
Medication**	0.2 (0.4)	0.2 (0.4)	–
Chosen speed (km.h^{-1})	4.6 (0.5)	4.4 (0.7)	0.434
Chosen step length (cm)	65.7 (4.4)	62.6 (10.0)	0.383
Faster speed (km.h^{-1})	5.8 (0.5)	5.3 (0.8)	0.125
Faster step length (cm)	72.5 (4.8)	67.8 (10.7)	0.219
VO_2 (ml.min^{-1}.kg^{-1})***	21.0 (1.2)	22.8 (2.5)	0.255
VCO_2 (l.min^{-1})***	1.2 (0.2)	1.4 (0.4)	0.446
Ve (l.min^{-1})***	30.8 (4.0)	34.2 (9.1)	0.281
HRLSTA (beats.min^{-1})	127.1 (10.4)	132.5 (12.2)	0.283
HR7STA (beats.min^{-1})	113.2 (11.8)	117.6 (13.9)	0.444
HR10ML (beats.min^{-1})	88.3 (6.9)	95.5 (11.2)	0.311
HR15ML (beats.min^{-1})	104.0 (7.8)	109.7 (13.7)	0.487
RPE (Borg scale)	13 (11-19)	16 (12-18)	0.264

* Values given as means (standard deviation).
** Mean number of drugs taken at least once a week; Chosen speed: self-selected walking speed (km.h^{-1}); Chosen step length: step length at the self-selected walking speed (cm); Faster speed: walking speed faster than the self-selected; Faster step length: step length at the faster walking speed (cm).
*** n=6.
p: two-tailed unpaired t-tests; VO_2: oxygen consumption; VCO_2: carbon dioxide production; Ve: pulmonary ventilation; HRLSTA: heart rate at the last stage of treadmill test; HR7STA: heart rate at the 7th stage of treadmill test (≅45 Watts); HR10ML: heart rate at VO_2=10 ml.min^{-1}.kg^{-1}; HR15ML: heart rate at VO_2=15 ml.min^{-1}.kg^{-1}; RPE: rate of perceived exertion is given as median (inter-quartile range).

Table 2. Baseline comparison of habitual physical activity as measured by the indices related to heart rate and movement monitoring (absolute and relative), in the Control and in the Exercise Group.

Indices	Control* n=12	Exercise* n=10	*p*
DYNHOUR	1038 (626-2060)	1247 (607-1694)	0.359
DYN40	10.37 (6.2-26.4)	14.72 (6.7-19.8)	0.113
HR30	8.80 (4.2-32.4)	9.97 (2.0-20.6)	0.895
HR50	0.73 (0.1-8.2)	0.57 (0.0-3.2)	0.291
CI30	4.50 (1.8-10.9)	4.71 (1.4-9.2)	0.895
CI50	0.64 (0.0-3.0)	0.36 (0.0-1.8)	0.210
HR110	0.99 (0.1-13.1)	0.40 (0.0-2.9)	0.113

* Values are given as median (interquartile range).
p: Kruskal-Wallis one-way ANOVA; DYNHOUR: monitor counts per hour; DYN40: time spent walking; HR30: time spent with heart rate ≥30% of heart rate reserve; HR50: time spent with heart rate ≥50% of heart rate reserve; CI30: time spent walking with heart rate ≥30% of heart rate reserve; CI50: time spent walking with heart rate ≥50% of heart rate reserve; HR110: time spent with heart rate ≥110 beats.min^{-1}.

Before comparing change/lack of change within each group (exercise × control), a two-way analysis of variance was used to determine if there was a significant interaction between the group a subject had been randomized to, the period that the measurements took place and each of the different variables measured. Walking speeds and their respective step lengths, RPE, HR7STA, HRLSTA, HR10ML as well as HR15ML, all had a significant interaction between group and time. There was no interaction between group and time on VO$_2$, VCO$_2$, Ve or on any of the activity indices. Those variables that did not show an interaction between time of measurement and group of placement were not further analyzed statistically.

Walking and Treadmill tests

After training, in the exercise group all variables analyzed presented a significant reduction (Table 3): walking speeds and respective step lengths, HR7STA, HR10ML, HR15ML and RPE. Contrary to the exercisers, the controls showed no significant changes (Table 3).

At the pre-training period only one out of ten exercisers did not complete the treadmill test. She managed 7 of the 10 stages, but as all the other exercisers, completed the full test at the post-training measurement. Notwithstanding, all volunteers overcame objections to walking on a big, noisy, unfamiliar piece of equipment quite easily, after clear demonstration of how to walk on it.

Table 3. Difference between pre- and post-intervention variables in the Exercise and in the Control group.

Variables	Pre*	Post*	Diff**	*p*
Exercise Group (n=10)				
Chosen speed (km.h^{-1})	4.4 (0.7)	5.2 (0.4)	-0.8 (0.5)	0.001
Chosen step length (cm)	62.6 (9.9)	72.7 (6.5)	-10.1 (6.8)	0.001
Faster speed (km.h^{-1})	5.3 (0.8)	6.1 (0.5)	-0.8 (0.6)	0.002
Faster step length (cm)	67.8 (10.6)	78.0 (6.4)	-10.2 (7.2)	0.002
VO$_2$ (ml.min^{-1}.kg^{-1})	22.8 (2.5)	21.0 (2.1)	-1.8 (2.3)	–
VCO$_2$ (l.min^{-1})	1.4 (0.4)	1.2 (0.3)	-0.2 (0.1)	–
Ve (l.min^{-1})	34.3 (9.0)	28.1 (6.7)	-6.2 (6.5)	–
HRLSTA (beats.min^{-1})	132.5 (12.2)	108.9 (7.7)	-23.6 (7.9)	<0.001
HR7STA (beats.min^{-1})	117.6 (13.9)	97.2 (8.1)	-20.4 (7.7)	<0.001
HR10ML (beats.min^{-1})	95.5 (11.2)	79.5 (5.8)	-16.0 (6.5)	0.016
HR15ML (beats.min^{-1})	109.7 (13.7)	91.2 (5.9)	-18.5 (8.1)	0.019
RPE (Borg scale)	15 (12-18)	12 (9-19)	3.5 (-4-+7)	0.033
Control Group (n= 12)				
Chosen speed (km.h^{-1})	4.6 (0.5)	4.7 (0.4)	-0.1 (0.5)	0.411
Chosen step length (cm)	65.7 (4.4)	67.4 (6.2)	-1.7 (3.6)	0.127
Faster speed (km.h^{-1})	5.8 (0.5)	5.7 (0.6	0.1 (0.3)	0.334
Faster step length (cm)	72.5 (4.8)	72.0 (5.7)	0.5 (2.8)	0.583
VO$_2$ (ml.min^{-1}.kg^{-1})	21.0 (1.2)	20.0 (2.8)	1.0 (3.2)	–
VCO$_2$ (l.min^{-1})	1.2 (0.2)	1.2 (0.3)	0.0 (0.1)	–
Ve (l.min^{-1})	30.8 (4.0)	30.0 (5.6)	0.8 (3.3)	–
HRLSTA (beats.min^{-1})	127.1 (10.4)	128.1 (11.8)	-1.0 (6.0)	0.575
HR7STA (beats.min^{-1})	113.2 (11.8)	114.3 (11.3)	-1.1 (4.8)	0.452
HR10ML (beats.min^{-1})	88.3 (6.9)	88.8 (3.1)	-0.5 (6.3)	0.853
HR15ML (beats.min^{-1})	104.0 (7.8)	105.8 (7.7)	-1.8 (5.6)	0.456
RPE (Borg scale)	13 (11-19)	15 (10-19)	-2.0 (6-6)	0.477

* Values are given as mean (standard deviation). ** Pre-training value minus post-training value.
p: two-tailed unpaired t-tests; Chosen speed: self-selected walking speed (km.h^{-1}); Chosen step length: step length at the self-selected walking speed (cm); Faster speed: walking speed faster than the self-selected; Faster step length: step length at the faster walking speed (cm); VO$_2$: oxygen consumption; VCO$_{2,}$ carbon dioxide production; Ve: pulmonary ventilation; HRLSTA: heart rate at the last stage of treadmill test; HR7STA: heart rate at the 7th stage of treadmill test (≅45 Watts); HR10ML: heart rate at VO$_2$ = 10 ml.min^{-1}.kg^{-1}; HR15ML: heart rate at VO$_2$ = 15 ml.min^{-1}.kg^{-1}; RPE: rate of perceived exertion is given as median (interquartile range).

Two out of 12 controls managed 8 rather than 10 stages of the treadmill tests, both pre- and post-training. At the last test (post-training) a third subject managed two stages less (6 minutes) than her previous 10 stages (pre-training test). All other controls completed the full test on the treadmill.

When processing the pre-training treadmill test data, a malfunction in the gas analyzers was detected, in spite of no problems being detected in the calibrations carried out prior to every single test. As a result, data from 6 controls and 6 exercisers were excluded from the analysis.

Intervention: training mode and compliance

Two subjects did not allow the speed to be increased much beyond their faster walking speed, so the inclination was increased. For the other subjects it varied so that all of them had the inclination increased at some point, but for most of the time it was necessary to increase only the speed to reach the target exercise HR. The mean speed during the endurance part of training increased from 4.4±0.7 $km.h^{-1}$ with no inclination during the first week to 6.1±0.4 $km.h^{-1}$ with 6±3 degrees of inclination at the last session.

The exercisers showed high compliance: six women attended all 36 sessions; one attended 32, another one 31 and the last two attended 30. Without exception, sessions were missed due to engagements previous to enrolment in this study. Nevertheless, it was felt that the lowest attendance rate can be considered high compliance, as it meant being present in 83% of the total possible sessions.

Physical activity

As no significant interaction was found in any of the activity indices, no further statistical analysis was carried out.

DISCUSSION

Aerobic training by walking on a motorized treadmill for 12 weeks proved successful in increasing both walking speeds, as well as their respective step lengths. The increase in walking speed seen in the exercisers seems to be a direct result of increased step length, as no significant difference was found in step rates at either walking speed. Other researchers also managed to significantly increase step length and walking speed, with no significant changes in step rate, a group using a non-specific training program[24] and the other an specific one.[25] These studies and the present one show that walking speeds can be increased with training, even in healthy individuals with levels of habitual physical activity comparable to subjects some 40 years younger, as was the case of the women in the present study.[21] However, the training mode needs to be specific, as the lack of specificity may not bring about the desired and necessary improvements.[26]

Among other reasons, the importance of the findings above lies on the fact that increase in the self-selected walking speed can predict reduction in mortality even after 8 years,[13] as well as in the association between disability, institutionalization, hospitalization and mortality with slow walking speed,[27] and also on the fact that decreased walking speed and shorter steps are significant risk factors for falls in older people.[12] As such, the considerable detrimental consequences resulting from a fall warrant measures that can be easily implemented and adopted by an ever increasing elderly population, like the present's study training program. Notwithstanding, those who would most likely have falls are unlikely to go out on their own. It is perhaps for them that a very specific form of training such as the one carried out in the present study would most likely benefit. Possibly for the more frail individuals the use of the treadmill with a harness and rails to hold onto would allow them to overcome the fear of falling that might be associated with walking, give them more confidence as they managed to walk and would provide a more specific mode of training.

Indeed, even the exercisers in the present study, who were independent and physically active, improved significantly their walking speed and step length at easily tolerated levels. The reason behind the use of the treadmill for aerobically training the healthy women in the present study was the finding that the elderly take larger steps on the treadmill when repeating the same speed performed on the floor.[28] The more frail elderly subjects might benefit as much, if not more, from training on the treadmill to increase walking speed and step length as the present study's healthy, physically active subjects.

The mode of training used in the present study was well accepted, with no injuries reported. A similar mode of training has been reported by others, who used treadmills[29] or stationary bicycles[30] and showed that training led to significant improvements in VO_2 peak, peak HR, and economy of walking, concomitant with an increased exercise capacity. These findings agree with the results of the present study, where many of the physiological variables, walking speeds and step lengths showed improvement after training and the significant changes were found to lie in the exercise group, with no change in the controls (Table 3).

An undetected malfunction of gas analyzers which resulted in the elimination of data from about half of the sample undermined the cardio-respiratory assessment of volunteers in the present study. Nevertheless, a 17% decrease in HRs at VO_2 equal to 10 and 15 ml.min^{-1}.kg^{-1} demonstrates the increased fitness in the exercisers.[15] Mechanical efficiency was increased by about the same amount, as seen in the 17% mean decrease in HRs at the 7th stage of treadmill test. The perception of effort at the last stage of the treadmill test was also changed in the exercisers, who showed a 19% decrease in their rating on the Borg Scale. Again no significant change was observed in the controls. Thus, it can be assumed that there was an increase in cardiorespiratory fitness, rather than just increased mechanical efficiency.[2] Decreases in sub maximal HRs at the same work load have been reported by others.[31]

After a 12-week period, habitual physical activity showed no significant difference in either group. This would seem to indicate that for the exercisers becoming faster and fitter did not translate itself into a significant decrease in the strain of daily activities. The possibility that 3 months training was too short a time to cause a significant change in habitual physical activity cannot be discarded. It is likely that, in a group as healthy and active as the volunteers in the present study, a much longer period of time would be necessary to bring about changes in their lifestyle. Or even that the only way of bringing about such a change would be by permanently increasing the number of activities they take part in. One such a possibility would be making the training part of their routine.

Notwithstanding, one cannot overlook the need for a more multidimensional approach to the issue of increasing habitual physical activity in the elderly, given its importance for and links with health.[6,7,9] As researchers have pointed out, it is also necessary to develop behavioral skill-building during the training programs – particularly exercise self-efficacy and perceived exercise control, tailor them to suit the group it is intended to, including in terms of proximity to the subjects residence, offer follow up and specialist advice.[32,33]

Contrasting with the findings of the present study and those of other researchers,[31,34] there are studies that did find significant increases in objectively measured physical activity after training in elderly subjects.[35,36] However, the movement monitoring was carried out during the training period, while the subjects were attending the training sessions, which may account for the increased readings registered during that period.

Other studies that reported increased physical activity after training[32,37] used questionnaires to measure it, relying solely on the volunteers' answers to quantify increase/decrease of physical activity over time. As findings from questionnaires were not validated against objective and quantifiable measures and volunteers were aware of objectives of the studies, it is possible that their findings were biased.[38] This source of bias is particularly important in view of the results from a national general survey in England,[39] which showed that 80% of the elderly people interviewed believed that they were fit and the majority of them thought they exercised enough to keep fit. Even more worrying is the fact that about half of the elderly men and women classified as being sedentary, they believed themselves to be "very or fairly active".[39] Further support for the bias in the use of questionnaires comes from a study[33] in which the objective measurement of physical activity was carried out on a random sample of 560 community dwelling people over 65 years and showed that the levels were well below the recommended, with only 2.5% of participants achieving the recommended weekly amount of moderate intensity activity and 62% of them achieving none.

Based on the results presented and discussed, it is concluded that the three-month aerobic training program by treadmill walking resulted in significant increases in step length and self-selected walking speeds in healthy, independent, elderly women. This program, however, did not lead to increased habitual physical activity as measured by movement monitors. The length of the monitoring period was not enough to detect changes in the physical strain of daily activities in these women, as measured by the relative indices.

REFERENCES

1. Yasunaga A, Togo F, Watanabe E, Park H, Park S, Shephard RJ, Aoyagi Y. Sex, age, season, and habitual physical activity of older Japanese: the Nakanojo Study. J Aging Phys Act. 2008;16(1):3-13.
2. Huggett, DL; Connelly, DM; Overend, TJ. Maximal aerobic capacity testing of older adults: A critical review. J Gerontol A Biol Sci Med Sci. 2005; 60(1):57-66.
3. Samuel D, Rowe P, Hood V, Nicol A. The relationships between muscle strength, biomechanical functional moments and health-related quality of life in non-elite older adults. Age Ageing. 2012;41(2):224-230.
4. Duffy CR, Stewart D, Pecoraro F, Riches PE, Farina D, Macaluso A. Comparison of power and EMG during 6-s all-out cycling between young and older women. J Sports Sci. 2012;30(12):1311-1321.
5. Hollman JH, McDade EM, Petersen RC. Normative spatiotemporal gait parameters in older adults. Gait Posture. 2011;34(1):111-118.
6. Wanderley FA, Silva G, Marques E, Oliveira J, Mota J, Carvalho J. Associations between objectively assessed physical activity levels and fitness and self-reported health-related quality of life in community-dwelling older adults. Qual Life Res. 2011;20:1371-1378.

7. Avila-Funes J A, Pina-Escudero SD, Aguilar-Navarro S, Gutierrez-Robledo LM, Ruiz-Arregui L, Amieva H. Cognitive impairment and low physical activity are the components of frailty more strongly associated with disability. J Nutr Health Aging. 2011;15(8):683-689.
8. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise and physical fitness: definitions and distinctions for health-related research. Public Health Rep. 1985;100: 126-131.
9. Montoye HJ, Kemper HCG, Saris WHM, Washburn RA (eds). Measuring physical activity and energy expenditure. Champain: Human Kinetics; 1996.
10. Janssen TWJ, van Oers CAJM, Rozendaal EP, Willemsen EM, Hollander AP, van der Woude LHV. Changes in physical strain and physical capacity in men with spinal cord injuries. Med Sci Sports Exerc. 1996;28(5):551-559.
11. Bélanger M, Townsend N, Foster C. Age-related differences in physical activity profiles of English adults. Prev Med. 2011;52(3-4):247-249.
12. Montero-Odasso M, Schapira M, Soriano ER, et al. Gait velocity as a single predictor of adverse events in healthy senior aged 75 years and older. J Gerontol Med Sci. 2005; 60(10):1304-1309.
13. Hardy SE, Perera S, Roumani YF, Chandler JM, Studenski Stephanie A. Improvement in Usual Gait Speed Predicts Better Survival in Older Adults. J Am Geriatr Soc. 2007; 55:1727-1734.
14. Takata Y, Ansai T, Soh I, Kimura Y, Yoshitake Y, Sonoki K, Awano S, Kagiyama S, Yoshida A, Nakamichi I, Hamasaki T, Torisu T, Toyoshima K, Takehara T. Physical fitness and cognitive function in an 85-year-old community-dwelling population. Gerontology. 2008;54(6):354-360.
15. Greig CA, Young A, Skelton DA, Pippet E, Butler FMM, Mahmud SM. Exercise studies with elderly volunteers. Age Ageing. 1994;23:185-189.
16. American College of Sports Medicine. Guidelines for exercise testing and prescription. 3rd ed. Philadelphia: Lea & Febiger; 1986.
17. Cotes JE. Lung function - assessment and application in medicine. Oxford: Blackwell Scientific Publications; 1979.
18. Borg G. Perceived exertion as an indicator of somatic stress. Scand J Rehabil Med. 1970;2:92-98.
19. Hart TL, Swartz AM, Cashin SE, Strath SJ. How many days of monitoring predict physical activity and sedentary behaviour in older adults? Int J Behav Nutr Phys Act. 2011; 8:62. doi: 10.1186/1479-5868-8-62.
20. Hartley LH. Writing an exercise prescription for your cardiac patients. J Cardiovasc Med. 1983;8(1):31-40.
21. Resende TL. Análise de métodos de medidas de atividade física habitual em idosas hígidas [Tese]. Porto Alegre (RS): Pontifícia Universidade Católica do Rio Grande do Sul; 2004.
22. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA. 1995;273:402-407.
23. American College of Sports Medicine. The recommended quality and quantity of exercise for developing and maintaining fitness in healthy adults. Med Sci Sports Exerc. 1990;22:265-274.
24. Bean JF, Herman S, Kiely DK, Frey IC, Leveille SG, Fielding RA, Frontera WR. Increased Velocity Exercise Specific to Task (InVEST) training: a pilot study exploring effects on leg power, balance, and mobility in community-dwelling older women. J Am Geriatr Soc. 2004;52(5):799-804.
25. Tsaih P-L, Shih Y-L, Hu M-H. Low-intensity task-oriented exercise for ambulation-challenged residents in long-term care facilities: a randomized, controlled trial. Am J Phys Med Rehabil. 2012;91:616-624.
26. Freiberger E, Menz HB, Abu-Omar K, Rütten A. Preventing Falls in Physically Active Community-Dwelling Older People: A Comparison of Two Intervention Techniques. Gerontology. 2007;53:298-305.
27. Cesari M, Kritchevsky SB, Newman AB, Simonsick ES, Harris TB, Penninx BW, Brach JS, Tylavsky FA, Satterfield S, Bauer DC, Rubin SM, Visser M, Pahor M. Added value of physical performance measures in predicting adverse health-related events: results from the Health, Aging and Body Composition Study. J Am Geriatr Soc. 2009;57(2):251-259.
28. Greig C, Butler F, Skelton D, Mahmud S, Young A. Treadmill walking in old age may not reproduce the real life situation. J Am Geriatr Soc. 1993;41:15-18.
29. Morton RD, West DJ, Stephens JW, Bain SC, Bracken RM. Heart rate prescribed walking training improves cardiorespiratory fitness but not glycaemic control in people with type 2 diabetes. J Sports Sci. 2010;28(1):93-99.
30. Gass G, Gass E, Wicks J, Browning J, Bennett G, Morris N. Rate and amplitude of adaptation to two intensities of exercise in men aged 65-75 yr. Med Sci Sports Exerc. 2004; 36(10):1811-1818.
31. Meijer GAL, Janssen GME, Westerterp KR, Verhoeven F, Saris WHM, ten Hoor F. The effect of a 5-month endurance-training programme on physical activity: evidence for a sex-difference. Eur J Appl Physiol. 1991;62:11-17.
32. Jong J, Lemmink KAPM, King AC, Huisman M, Stevens M. Twelve-month effects of the Groningen active living model (GALM) on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55–65. Patient Educ Couns. 2007;66:167-176.
33. Harris TJ, Owen CG, Victor CR, Adams R, Cook DG. What factors are associated with physical activity in older people, assessed objectively by accelerometry? Br J Sports Med. 2009;43(6):442-450.
34. Westerterp KR, Plasqui G. Physical activity and human energy expenditure. Curr Opin Clin Nutr Metab Care. 2004; 7:607-613.
35. Koizumi D, Rogers NL, Rogers ME, Islam MM, Kusunoki M, Takeshima N. Efficacy of an accelerometer-guided physical activity intervention in community-dwelling older women. J Phys Act Health. 2009;6(4):467-474.
36. Rangan VV, Willis LH, Slentz CA, Bateman LA, Shields AT, Houmard JA, Kraus WE. Effects of an 8-Month Exercise Training Program on Off-Exercise Physical Activity. Med. Sci. Sports Exerc. 2011;43(9):1744-1751.
37. Hamdorf PA, Withers RT, Penhall RK, Plummer JL. A follow-up study on the effects of training on the fitness and habitual activity patterns of 60- to 70-year-old women. Arch Phys Med Rehabil. 1993;74:473-477.
38. Shephard RJ. Limits to the measurement of habitual physical activity by questionnaires. Source: Br J Sports Med. 2003; 37(3):197-206.
39. Anonymous: The Allied Dunbar National Fitness Survey: Main Findings. London: The Sports Council and Health Education Authority; 1992.