VU Research Portal

Walking with a rollator and the level of physical intensity in adults 75 years of age or older.

Eggermont, L.H.P.; van Heuvelen, M.J.G.; van Keeken, B.L.; Hollander, A.P.; Scherder, E.J.A.

published in

Archives of Physical Medicine and Rehabilitation
2006

DOI (link to publisher)

[10.1016/j.apmr.2006.02.008](https://doi.org/10.1016/j.apmr.2006.02.008)

document version

Publisher's PDF, also known as Version of record

[Link to publication in VU Research Portal](#)

citation for published version (APA)

Eggermont, L. H. P., van Heuvelen, M. J. G., van Keeken, B. L., Hollander, A. P., & Scherder, E. J. A. (2006). Walking with a rollator and the level of physical intensity in adults 75 years of age or older. *Archives of Physical Medicine and Rehabilitation*, 87(5), 733-6. <https://doi.org/10.1016/j.apmr.2006.02.008>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

E-mail address:

vuresearchportal.ub@vu.nl

BRIEF REPORT

Walking With a Rollator and the Level of Physical Intensity in Adults 75 Years of Age or Older

Laura H. Eggermont, MSc, Marieke J. van Heuvelen, PhD, Brenda L. van Keeken, MSc, Arie P. Hollander, PhD, Erik J. Scherder, PhD

ABSTRACT. Eggermont LH, van Heuvelen MJ, van Keeken BL, Hollander AP, Scherder EJ. Walking with a rollator and the level of physical intensity in adults 75 years of age or older. *Arch Phys Med Rehabil* 2006;87:733-6.

Objective: To determine whether walking with a rollator by persons 75 years of age or older is of sufficient intensity to improve aerobic fitness.

Design: A cross-sectional cohort study.

Setting: University movement laboratory.

Participants: Fifteen subjects 75 years of age or older (mean age, 83.7y) who could only walk by using a rollator.

Interventions: Not applicable.

Main Outcome Measures: During 6 minutes of self-paced treadmill walking using a rollator at a mean walking speed of 0.6m/s, oxygen uptake ($\dot{V}O_2$), carbon dioxide production, and heart rate were determined. Respiratory exchange ratio (RER) and energy expenditure were calculated. The energy expenditure was expressed as the number of metabolic equivalents (METS), the percentage of estimated maximal $\dot{V}O_2$ ($\dot{V}O_{2max}$), the percentage of estimated $\dot{V}O_{2max}$ reserve, and the percentage of estimated maximal heart rate.

Results: Mean $\dot{V}O_2$ was .718L/min. Mean RER was .93 (95% confidence interval [CI], .89–.97). Thirteen participants showed an RER below 1.0, which indicates a negligible contribution of anaerobic expenditure. Walking with a rollator required a mean of 2.8 (95% CI, 2.4–3.2) METS, 71.9% of $\dot{V}O_{2max}$ (95% CI, 65.2%–78.6%), 50.5% (95% CI, 39.4%–61.5%) of $\dot{V}O_2$ reserve, and 75.2% (95% CI, 67.6%–82.8%) of estimated maximal heart rate.

Conclusions: For people 75 years of age or older, walking with a rollator is an activity of moderate to high level of intensity, with the capacity of improving aerobic fitness.

Key Words: Aerobic exercise; Energy expenditure; Frail elderly; Rehabilitation.

© 2006 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

THERE IS INCREASING EVIDENCE of a positive relation between physical activity, physiologic parameters such as blood pressure, functional abilities, balance, flexibility,

muscle strength, and cognitive functioning in older adults.¹⁻⁶ Cognitive functions are particularly vulnerable to aging⁷ and are crucial for independent living.⁸

Older adults with a decrease in physical activity caused by poor cardiorespiratory condition have experienced greater cognitive decline over a period of 6 years compared with older adults showing high cardiorespiratory fitness.⁹ In healthy, sedentary older subjects, aerobic activities resulted in a significant improvement in the maximal oxygen uptake ($\dot{V}O_{2max}$) and to benefit executive functions such as inhibition and planning.¹⁰ These studies, however, involved high-intensity physical activity such as running.¹⁰ This type of physical activity is usually not appropriate for people of advanced age.¹¹ It is known that physical fitness (eg, muscle strength, balance) decreases with age.¹² Consequently, many of the oldest old (age >75y) can only stay mobile by the use of a walking aid¹³ and are unable to run. In 1 study,¹⁴ more than half of the 599 subjects aged 75 or over who were surveyed owned 1 or more walking devices. In sum, for frail older people, walking with a device like a rollator is a much more appropriate activity than activities such as running.

In view of the effects of aerobic activity on for instance executive functions, it is important to know the exact amount of energy expended when walking with a rollator and does this constitute adequate aerobic activity. This has not been examined before. According to the guidelines of the American College of Sports Medicine (ACSM),¹⁵ activities with an intensity of 55% to 65% of maximal heart rate or 40% to 50% of $\dot{V}O_{2max}$ reserve ($\dot{V}O_{2max}$ minus resting $\dot{V}O_2$) are appropriate to increase or maintain cardiorespiratory fitness of relatively unfit persons provided that the frequency is at least 3 times a week and the duration at least 30 minutes per occasion. We studied this treatment frequency and duration in a recent pilot study¹⁶ in which the effects of walking with a rollator on executive functions were examined in persons with mild cognitive impairment. After a treatment period of 6 weeks, verbal fluency, a task that relies on executive control functions,¹⁷ improved. Firm conclusions about the effectiveness of walking with a rollator on executive functions can, however, not be drawn. First, the range of executive functions examined in that study was restricted (only 2 tasks). Second, it was not examined whether walking with a rollator is intense enough to increase aerobic activity. The objective of the present study was to determine the physical intensity of walking with a rollator.

METHODS

Participants

The study sample consisted of 15 subjects 75 years or older (12 women, 3 men) who lived in a residential home (n=13) or at home (n=2). The mean age was 83.7±4.6 years. The level of cognitive functioning was assessed by means of the Mini-Mental State Examination (MMSE).¹⁸ Mean MMSE score was 25.21±2.6. Mean body weight was 75.0±15.2kg. All participants signed informed consent.

From the Department of Clinical Neuropsychology, Vrije Universiteit, Amsterdam, The Netherlands (Eggermont); Institute of Human Movement Sciences, Rijksuniversiteit Groningen, Groningen, The Netherlands (van Heuvelen, Scherder); and Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam, The Netherlands (van Keeken, Hollander).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the author(s) or upon any organization with which the author(s) is/are associated.

Reprint requests to Laura H. Eggermont, MSc, Dept of Clinical Neuropsychology, Vrije Universiteit, Van der Boechorststraat 1, 1081 BT Amsterdam, The Netherlands, e-mail: LHP.Eggermont@psy.vu.nl.

0003-9993/06/8705-10719\$32.00/0
doi:10.1016/j.apmr.2006.02.008

Inclusion and exclusion criteria. Medical staff of the residential home and the general practitioner were consulted and participants were included in the study if (1) they were 75 years or older, (2) they were able to walk only by means of a rollator, (3) they had a normal mental status by using norms of a sample of cognitively unimpaired older persons controlling for age,¹⁹ and (4) they were able to walk 20m to determine walking speed. Participants were excluded from the study if they were suffering from a neurodegenerative disease that would cause motor impairment such as Parkinson's disease.²⁰

Comorbidity. Participants' medical history showed: cardiac problems (n=8), diabetes mellitus (n=2), cerebral ischemic attack (n=5), exanthema (n=2), diverticulosis (n=3), rheumatic arthritis (n=8), osteoporosis (n=5), gout (n=2), hernia nuclei pulposi (n=4), radiculopathy (n=2), spondylodosis (n=2), polymyalgia rheumatica (n=1), pulmonary disease (n=5), cholecystectomy (n=1), tumors (n=1), appendectomy (n=3), cystitis (n=1), pyelitis (n=1), hypercholesterolemia (n=1), hyperthyroidism (n=1), and visual disturbances (n=5). The comorbidities in our sample were representative of the general population of this age.²¹

Procedure

The participants walked with their rollator for 6 minutes on a treadmill.^a Each participant's walking velocity was determined by measuring the time needed to walk 20m on a regular flat surface at his/her comfortable speed. Because walking speed was determined over a short distance, the speed of the treadmill was set at a 10% reduction of the initially determined speed. Participants were asked to practice on the treadmill for a short period of time to get accustomed to the treadmill. Participants walked at a mean walking speed of $.64 \pm .10$ m/s.

Measurement

Oxygen consumption during walking was determined by use of Oxycon Alpha.^b This system consists of a soft mask to sample exhaled air and a sensor system that continuously measures expired ventilation, oxygen use ($\dot{V}O_2$), and carbon dioxide production ($\dot{V}CO_2$). From the 6-minute walk, the averages of the last 2 minutes were used to determine the outcome parameters in a steady-state condition.

Oxygen uptake. $\dot{V}O_2$ (in L/min) and $\dot{V}O_2$ per kilogram of body weight (in $\text{mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$) were determined. Percentage of estimated $\dot{V}O_{2\text{max}}$ ($\% \dot{V}O_{2\text{max}}$) was determined by using predicted values from the literature. These values were derived from regression equations of the relation between age and $\dot{V}O_{2\text{max}}$ for men and women aged 55 to 86 years.²² These equations include the following: for men: $\dot{V}O_{2\text{max}}$ (L/min) = $-0.034 \times \text{age} + 4.142$ or $\dot{V}O_{2\text{max}}$ ($\text{mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$) = $-0.31 \times \text{age} + 44.23$ and for women: $\dot{V}O_{2\text{max}}$ (L/min) = $-0.019 \times \text{age} + 2.518$ or $\dot{V}O_{2\text{max}}$ ($\text{mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$) = $-0.25 \times \text{age} + 36.63$. In addition, percentage of estimated $\dot{V}O_{2\text{max}}$ reserve was calculated by the following formula: $(\dot{V}O_2 - \text{resting } \dot{V}O_2) / (\dot{V}O_{2\text{max}} - \text{resting } \dot{V}O_2) \times 100\%$, using resting $\dot{V}O_2 = 3.5 \text{ mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$.

Respiratory exchange ratio. The respiratory exchange ratio (RER) was calculated by dividing $\dot{V}CO_2$ by $\dot{V}O_2$ to determine whether walking with a rollator is an aerobic activity. An RER of 1.0 or below 1.0 indicates aerobic expenditure with a negligible contribution of anaerobic expenditure.²³ In aerobic activity, the aerobic metabolic pathways are sufficient to meet the energy demands of the muscles and the participant can sustain the activity for a prolonged time period without exhaustion.²⁴ When exercise is performed at higher work rates, anaerobic pathways are increasingly used to meet energy demands, decreasing the length of time that activity can be

sustained. These anaerobic processes go together with the accumulation of lactate. The buffering of the lactate adds extra carbon dioxide to the expired air and the RER will exceed 1.0.²⁴

Energy expenditure. The energy expenditure (in J/s) was determined by the following formula: $\dot{V}O_2$ (L/s) $\times (16,040 + \text{RER} \times 4940)$.²⁵ Energy expenditure per meter and energy expenditure per meter per kilogram of body weight (in $\text{J} \cdot \text{m}^{-1} \cdot \text{kg}^{-1}$) were determined as well. The intensity of the activity was also expressed as the number of metabolic equivalent units (METs). One MET is generally assumed to be $3.5 \text{ mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$.²⁶

Heart rate. Measurement of heart rate (with a 5-second interval) was determined by use of a sports tester.^c Percentage of maximal heart rate was determined by the following formula: $\text{heart rate} / (220 - \text{age}) \times 100\%$.

RESULTS

Oxygen Uptake

The mean $\dot{V}O_2$ was $.718 \text{ L/min}$. Mean $\dot{V}O_2$ per kilogram of body weight was $9.89 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ (table 1). By using the linear regression equations from the literature,²² participants walked on average at 61.2% (95% confidence interval [CI], 52.5%–69.9%) of the estimated $\dot{V}O_{2\text{max}}$ expressed in $\text{mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ and 71.9% (95% CI, 65.2%–78.6%) of the estimated $\dot{V}O_{2\text{max}}$ expressed in liters per minute (for means and standard deviations, see table 1). Expressed as a percentage of $\dot{V}O_{2\text{max}}$ reserve, the participants walked at 50.5% (95% CI, 39.4%–61.5%).

Energy Expenditure

The mean energy expenditure and energy expenditure per meter were 246.73 J/s and 395.76 J/m , respectively. Mean energy expenditure per kilogram of body weight was $5.39 \text{ J} \cdot \text{m}^{-1} \cdot \text{kg}^{-1}$. Mean intensity was 2.8 (95% CI, 2.4–3.2) METs (see table 1).

Respiratory Exchange Ratio

Mean RER was .93 (95% CI, .89–.97). Thirteen participants showed an RER below 1.0. Two participants had an RER above 1.0 (1.02, 1.10).

Heart Rate

On average, participants reached a heart rate of 75.2% (95% CI, 67.6%–82.8%) of the estimated maximal heart rate.

DISCUSSION

The goal of this study was to determine the amount of energy expended when walking with a rollator. We found that this group of subjects, 75 years of age or older, consumed an average of 2.8 METs when walking; this corresponds to a moderate level of intensity according to the ACSM scale for the very old.¹⁵ Compared with activities taken from the Compendium of Physical Activities,²⁷ walking with a rollator is a somewhat higher-intensity activity than vacuum cleaning and a somewhat lower-intensity activity than walking down stairs. In our study, we did not measure the resting $\dot{V}O_2$; therefore, an MET was considered to be $3.5 \text{ mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$.²⁶ However, for older people this may be an overestimate.²⁶

Thirteen participants showed an RER below 1.0, indicating aerobic expenditure. Two participants had an RER above 1.0. One of them showed more exertion and walked at the highest speed of all participants. The other participant appeared very anxious during the walk on the treadmill and did not finish the

Table 1: Raw Data for Each Subject

Subjects	Walking Speed (m/s)	$\dot{V}O_2$ (L/min)	$\dot{V}O_2$ (mL·min ⁻¹ ·kg ⁻¹)	$\dot{V}CO_2$ (L/min)	RER	% $\dot{V}O_2$ max (L/min)	% $\dot{V}O_2$ max (mL·min ⁻¹ ·kg ⁻¹)	% $\dot{V}O_2$ Reserve	Energy Expenditure (J/s)	Energy Expenditure (J/m)	Energy Expenditure (J·m ⁻¹ ·kg ⁻¹)	METS	HR (beats/min)	%HRmax
1	0.65	0.95	14.03	0.81	0.86	71.58	75.82	70.18	319.49	491.52	7.34	4.01	95	69.34
2	0.61	0.50	5.44	0.48	0.96	56.79	35.94	16.66	173.74	284.82	3.10	1.55	119	88.81
3	0.61	0.53	8.47	0.59	1.10	67.64	61.04	47.91	190.92	312.98	4.97	2.42	127	98.45
4	0.72	0.95	10.71	0.89	0.94	70.07	56.96	47.12	327.23	454.48	5.11	3.06	95	68.84
5	0.45	0.97	11.02	0.97	0.99	101.35	68.32	59.55	339.78	755.06	8.58	3.15	81	58.70
6	0.67	0.57	10.88	0.50	0.88	75.08	81.33	74.72	191.70	286.11	5.50	3.11	86	67.72
7	0.68	0.72	14.03	0.59	0.82	76.78	88.38	85.09	241.76	355.53	6.84	4.01	98	71.53
8	0.51	0.57	9.50	0.50	0.87	68.32	66.07	55.16	191.45	375.40	6.26	2.71	114	87.02
9	0.75	0.69	8.15	0.65	0.95	72.90	51.35	37.60	237.14	316.19	3.76	2.33	87	63.50
10	0.85	0.75	13.77	0.75	1.02	74.66	82.78	78.19	261.59	307.75	5.70	3.93	132	94.29
11	0.65	0.59	7.01	0.55	0.94	62.51	44.15	28.36	202.64	311.75	3.71	2.00	82	59.85
12	0.50	0.75	9.41	0.70	0.94	77.71	58.31	46.76	257.01	514.02	6.51	2.69	85	61.59
13	0.62	0.79	9.34	0.73	0.94	71.95	52.24	40.61	270.96	437.03	5.20	2.67	115	79.31
14	0.65	0.69	8.07	0.61	0.89	47.36	40.87	28.13	234.61	360.94	4.20	2.31	132	93.62
15	0.70	0.78	8.49	0.65	0.85	84.00	54.31	41.13	260.94	372.78	4.10	2.43	89	65.44
Mean*	0.64±0.10	0.72±0.15	9.89±2.56	0.67±0.15	0.93±0.07	71.91±12.08	61.19±15.79	50.48±19.92	246.73±52.29	395.76±123.49	5.39±1.52	2.83±0.73	102.47±18.74	75.20±13.77

*Values are mean ± standard deviation of the measurements during the 6-minute walk.

Abbreviations: HR, heart rate; %HRmax, percentage of maximal heart rate.

6 minutes because of this anxiety. For this participant, the high RER may be related to hyperventilation. Combining this with the fact that all other participants had an RER lower than 1.0 suggests that walking with a rollator is an aerobic activity of a moderate- to high-intensity level.

According to the ASCM guidelines,¹⁵ activities with an intensity corresponding to 55% to 65% of maximal heart rate or 40% to 50% of $\dot{V}O_2$ max reserve are appropriate for increasing or maintaining cardiorespiratory fitness in relatively unfit older persons. Walking with a rollator yields an intensity corresponding to 75% of the maximal heart rate and 50% of the $\dot{V}O_2$ max reserve and therefore meets these criteria. However, the criteria further stipulate that activity of this intensity must be performed at least 3 times a week for at least 30 minutes a session.¹⁵ In the aforementioned pilot study,¹⁶ this treatment frequency and duration were successfully applied to subjects 75 years and older who walked with a rollator. Training with a rollator is inexpensive and widely feasible. As well, self-paced walking has been reported to be preferred over activities such as bicycling and swimming in this age group.²⁸

Energy expenditure during walking with assistive devices such as crutches or a walker has, so far, been examined only in younger people, and the results are inconsistent. One study²⁹ showed that walking with crutches resulted in lower $\dot{V}O_2$ compared with walking with a rollator or a standard walker. Compared with unassisted walking, walking with a wheeled walker resulted in more oxygen use.²⁹ In another study,³⁰ however, there was no difference in $\dot{V}O_2$ between walking with or without a rollator. Comparison between those 2 studies and our study is difficult because the studies included younger participants, walking speed differed, and participants did not use a rollator in their daily life.

The previously mentioned finding of an energy expenditure of 2.8 METS may be an underestimation of the intensity of walking with a rollator. For future research, it is recommended that resting $\dot{V}O_2$ is measured to provide more accurate estimates of the intensity expressed in METS as well as the $\dot{V}O_2$ max reserve. A second limitation of this study is that we estimated the $\dot{V}O_2$ max by using predicted values from the literature²² instead of participant scores of $\dot{V}O_2$ max obtained from direct or indirect measurement. However, in this frail population, it may be difficult or even impossible to determine the $\dot{V}O_2$ max directly. In 1 study,³¹ less than 50% of a representative sample of older subjects aged 57 to 78 years succeeded in reaching their $\dot{V}O_2$ max. As far as we know, exercise tests to determine or estimate the $\dot{V}O_2$ max of the oldest old have not been developed yet. Another limitation of the study is the small sample size yielding wide CIs on the main outcome measures. Further research in a larger sample would yield more precise estimates and greater confidence in our conclusions.

Because walking with a rollator might improve executive functions in older people,¹⁶ there is a need for further exploration of the applicability and possible benefits of this form of exercise. A broad range of cognitive indicators as well as functional outcomes need to be studied.

CONCLUSIONS

For people 75 years or older, walking with a rollator is an activity of a moderate to a high level of intensity, with sufficient capacity to improve aerobic fitness.

References

- Churchill JD, Galvez R, Colcombe S, Swain RA, Kramer AF, Greenough WT. Exercise, experience and the aging brain. *Neurobiol Aging* 2002;23:941-55.

2. Puggaard L, Larsen JB, Stovring H, Jeune B. Maximal oxygen uptake, muscle strength and walking speed in 85-year-old women: effects of increased physical activity. *Aging (Milano)* 2000;12:180-9.
3. DiBrezzo R, Shadden BB, Raybon BH, Powers M. Exercise intervention designed to improve strength and dynamic balance among community-dwelling older adults. *J Aging Phys Act* 2005;13:198-209.
4. Lazowski DA, Ecclestone NA, Myers AM, et al. A randomized outcome evaluation of group exercise programs in long-term care institutions. *J Gerontol A Biol Sci Med Sci* 1999;54:M621-8.
5. de Carvalho Bastone A, Filho WJ. Effect of an exercise program on functional performance of institutionalized elderly. *J Rehabil Res Dev* 2004;41:659-68.
6. Van Gelder BM, Tijhuis MA, Kalmijn S, Giampaoli S, Nissinen A, Kromhout D. Physical activity in relation to cognitive decline in elderly men: the FINE Study. *Neurology* 2004;63:2316-21.
7. Braver TS, Barch DM. A theory of cognitive control, aging cognition, and neuromodulation. *Neurosci Biobehav Rev* 2002;26:809-17.
8. Pugh KG, Lipsitz LA. The microvascular frontal-subcortical syndrome of aging. *Neurobiol Aging* 2002;23:421-31.
9. Barnes DE, Yaffe K, Satariano WA, Tager IB. A longitudinal study of cardiorespiratory fitness and cognitive function in healthy older adults. *J Am Geriatr Soc* 2003;51:459-65.
10. Colcombe S, Kramer AF. Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychol Sci* 2003;14:125-30.
11. DiPietro L. Physical activity in aging: changes in patterns and their relationship to health and function. *J Gerontol A Biol Sci Med Sci* 2001;56:13-22.
12. Buchner DM, Wagner EH. Preventing frail health. *Clin Geriatr Med* 1992;8:1-17.
13. Brandt A, Iwarsson S, Stahl A. Satisfaction with rollators among community-living users: a follow-up study. *Disabil Rehabil* 2003;25:343-53.
14. Edwards NI, Jones DA. Ownership and use of assistive devices amongst older people in the community. *Age Ageing* 1998;27:463-8.
15. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Med Sci Sports Exerc* 1998;30:975-91.
16. Scherder EJ, Paasschen J, Deijen JB, et al. Physical activity and executive functions in the elderly with mild cognitive impairment. *Aging Ment Health* 2005;9:272-80.
17. Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. *J Child Psychol Psychiatry* 1996;37:51-87.
18. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189-98.
19. Dufouil C, Clayton D, Brayne C, et al. Population norms for the MMSE in the very old: estimates based on longitudinal data. *Mini-Mental State Examination. Neurology* 2000;55:1609-13.
20. Marras C, Rochon P, Lang AE. Predicting motor decline and disability in Parkinson disease: a systematic review. *Arch Neurol* 2002;59:1724-8.
21. Bayliss EA, Ellis JL, Steiner JF. Subjective assessments of comorbidity correlate with quality of life health outcomes: initial validation of a comorbidity assessment instrument. *Health Qual Life Outcomes* 2005;3:51.
22. Paterson DH, Cunningham DA. The gas transporting systems: limits and modifications with age and training. *Can J Appl Physiol* 1999;24:28-40.
23. McArdle WD, Katch FI, Katch VL. Exercise physiology: exercise, nutrition and human performance. Baltimore: Lippincott, Williams & Wilkins; 2001. p 185.
24. Waters RL, Lunsford BR, Perry J, Byrd R. Energy-speed relationship of walking: standard tables. *J Orthop Res* 1988;6:215-22.
25. Garby L, Astrup A. The relationship between the respiratory quotient and the energy equivalent of oxygen during simultaneous glucose and lipid oxidation and lipogenesis. *Acta Physiol Scand* 1987;129:443-4.
26. Kwan M, Woo J, Kwok T. The standard oxygen consumption value equivalent to one metabolic equivalent (3.5 ml/min/kg) is not appropriate for elderly people. *Int J Food Sci Nutr* 2004;55:179-82.
27. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc* 1993;25:71-80.
28. Gill TM, DiPietro L, Krumholz HM. Role of exercise stress testing and safety monitoring for older persons starting an exercise program. *JAMA* 2000;284:342-9.
29. Holder CG, Haskvitz EM, Weltman A. The effects of assistive devices on the oxygen cost, cardiovascular stress, and perception of nonweight-bearing ambulation. *J Orthop Sports Phys Ther* 1993;18:537-42.
30. Foley MP, Prax B, Crowell R, Boone T. Effects of assistive devices on cardiorespiratory demands in older adults. *Phys Ther* 1996;76:1313-9.
31. White AT, Fehlauser CS, Hanover R, Johnson SC, Dustman RE. Is $\text{VO}_{2\text{max}}$ an appropriate fitness indicator for older adults? *J Aging Phys Act* 1998;6:303-9.

Suppliers

- a. Bonte Technology, Ampèrestraat 25B, 8013 PT Zwolle, The Netherlands.
- b. Jaeger, VIASYS Healthcare GmbH, Leibnizstr 7, D-97204 Hoechberg, Germany.
- c. Polar Electro Oy, Professorintie 5, FIN-90440 Kempele, Finland.