Qual Life Res (2013) 22:1213–1223
DOI 10.1007/s11136-012-0267-7

Health-related quality of life in relation to walking habits and fitness: a population-based study of 75-year-olds

Helena Hörder · Ingmar Skoog · Kerstin Frändin

Accepted: 7 September 2012 / Published online: 22 September 2012

Abstract
Purpose To assess health-related quality of life (HRQL) in relation to walking habits and fitness status in older persons. A second aim was to examine fitness status as a mediator in the relation between walking habits and HRQL.
Methods A cross-sectional population-based sample of 75-year-olds from Gothenburg, Sweden, was examined ($n = 698$, response rate 61 %). Walking habits were assessed as weekly frequency and duration. HRQL was assessed with the Short Form-36 (SF-36) and fitness with maximal and self-selected gait speed, chair-stand, stair-climbing capacity, grip strength and one-leg stance.
Results The proportion of 75-year-olds who attained recommended levels of moderate physical activity ($\geq$ 150 min/week), described as walking, was 60 %. This was positively associated with most subscales of SF-36 and with all fitness tests except grip strength. Maximal gait speed was the fitness test with the highest correlations to all SF-36 subscales. Fitness, described with maximal gait speed, was a partial mediator in most relations between walking habits and SF-36. After adjustment for confounders, associations between regular walking and SF-36 were no longer significant, except for Role Physical, General Health and Role Emotional in women.
Conclusions Attaining recommended levels of walking, as well as a high fitness status, is positively associated with several aspects of HRQL in older persons. Fitness, described with maximal gait speed, seems to have a partial role in the relation between walking habits and HRQL, suggesting that other mechanisms are also involved.

H. Hörder (✉) · I. Skoog · K. Frändin
Gothenburg, Sweden
e-mail: helena.horder@vgregion.se

Keywords Aged · Physical activity · Quality of life · Physical function · Gait speed · Mediator

Abbreviations

BMI	Body Mass Index
DSM	Diagnostic and Statistical Manual of Mental Disorders
HRQL	Health-related quality of life
OR	Odds Ratio
QoL	Quality of Life
SF-36	Short Form-36
WHO	World Health Organization

Introduction

The remarkable increase in life expectancy in the twentieth century implies a need to focus on factors capable of promoting a high quality of life (QoL) into old age. In fact, older persons seem to prefer a high QoL rather than longevity [1]. One important aspect of QoL, and the focus of this study, is health status or health-related quality of life (HRQL), which has become a key outcome in interventions in older adults [2]. It represents self-reported multiple outcomes, conceptualized as two broad categories: function (physical, mental and social) and well-being [3].

Physical activity (i.e. “any bodily movement produced by skeletal muscles that results in energy expenditure”) [4] is a behavior with extensive health benefits, both as prevention of and rehabilitation from several chronic diseases, such as cardiovascular disease, diabetes and cancer [5]. The health benefits of physical activity might even be greater in older persons compared with younger populations, as inactivity and related outcomes, that is, falls, osteoporosis, functional limitations and disability, are more common in the elderly [6]. The World Health Organization (WHO) recommends at least 150 min of moderate-intensity aerobic physical activity per week in adults above age 65 years. For additional health benefits, 300 min/week is recommended [6]. Walking is one of the most recommended, preferred and prevalent activities, being easily incorporated into everyday life and sustained into old age [7].

Physical activity has been generally found to be positively related to several aspects of HRQL in older persons, both in cross-sectional studies and in randomized controlled trials [2, 8, 9]. The type, frequency, duration and intensity of physical activity in relation to HRQL are, however, not known. Further, a focus on possible mediators in the pathway between physical activity and HRQL could give a deeper understanding of this relation [2]. Psychological constructs, especially self-efficacy, have been identified as mediators in this relation, in terms of physically active persons having a higher self-efficacy which, in turn, was positively associated with HRQL, which was directly related to global QoL, assessed as life satisfaction [10].

The relation between physical activity and HRQL is complex and probably not due to a single mechanism. Another possible mediator in this relation is fitness, which is often increased in physical activity interventions, especially walking, in older persons [11]. Fitness (i.e. "a set of attributes that people have or achieve", like cardiorespiratory endurance, muscle strength and balance") [4] in older persons is often assessed with objective tests of functional capacity. One such common test is gait speed, which exerts demands on heart, lung, circulatory, nervous and musculoskeletal systems, and has been suggested to serve as a marker for physiological reserve [12]. Moreover, gait speed has been identified as a global indicator of self-perceived physical function [13]. Objective capacity and self-perceived physical function are related but somewhat different constructs. The International Classification of Functioning (ICF) [14] distinguishes between capacity (can do in standardized environment), on the one hand, and performance (actually do in own environment), on the other. The latter is most often self-reported and is represented as one aspect of HRQL. Fitness status and several aspects of HRQL have been shown to be associated in older persons [15–19]. However, it is suggested that fitness per se is not the pathway from physical activity to QoL [2]. To address the lack of research on the role of fitness in the relation between physical activity and QoL, we hypothesized that fitness could have at least a partial role in the relation between physical activity and HRQL, especially physical aspects. The *aim* of this paper was therefore to assess HRQL in relation to walking habits and fitness in older persons. A second aim was to examine fitness as a mediator in a hypothetical relation between walking habits and HRQL.

Methods

Study population

As part of the multidisciplinary repeated cross-sectional and longitudinal Gerontological and Geriatric Population Studies in Gothenburg (H70) [20], 75-year-olds born in 1930 and living in Gothenburg, Sweden, on September 1, 2005, were invited to undergo a health examination in the period 2005–2006. The sample was obtained systematically, based on birth date, from the Swedish Population Register, and included persons living both in private households and in institutions. Selected individuals were invited by mail to participate in the study. Among those selected ($N = 1{,}250$), 10 died before they could be examined, 2 had emigrated, 18 could not be traced and 32 could not speak Swedish, leaving an effective sample of 1,188 individuals. Among these, 758 accepted to take part in the examinations (response rate 61 %). In the present paper, 45 individuals with dementia according to DSM-IV criteria were excluded [21]. Out of the remaining participants, 698 answered questions about walking habits and were included in this paper. Only those able to visit the outpatient department ($n = 637$) took part in tests of fitness. Examinations were carried out by health professionals, such as nurses and physiotherapists.

Non-responders did not differ from responders regarding gender, living area or number of hospitalizations in the period 2000–2004, but the 4-year mortality within 4 years of the study start in 2005 was higher (21 vs 9 %) and fewer of the men were married.

The Ethics Review Board of the Faculty of Medicine at the University of Göteborg approved the study (diary number T453-04). All participants gave their written informed consent to participate.

Measures

The general examination included physical, psychiatric and neuropsychological examinations, laboratory tests and extensive semi-structured interviews on health-related aspects. The design, procedures and methods of data collection have been reported elsewhere [20]. For this paper, background data such as marital status, education level, smoking habits, body mass index (BMI), self-reported medical conditions (ischemic heart disease, diabetes mellitus, cerebrovascular disease, bronchitis, arthritis) and medication were used. Major depression was diagnosed according to DSM-IV criteria [21]. The total level of physical activity was estimated according to a scale made up of 6 levels, ranging from hardly any physical activity to hard exercise several times a week [22].

The 36-Item Short Form Health Survey (SF-36) was used to assess HRQL. It is the most widely used instrument for measuring self-perceived physical and mental health status worldwide. It includes 36 items and generates a health profile with eight subscales (Physical Function, Role Physical, Bodily Pain, General Health, Vitality, Social Function, Role Emotional and Mental Health) [23]. Each domain is transformed into a scale ranging from 0 (worse) to 100 (best). The reliability of the questionnaire when tested in older persons has been shown to be comparable to that in younger age groups [24]. It has been translated into Swedish and validated in a representative sample of the population and has normative Swedish data for different age groups [25]. The SF-36 was sent by mail to participants, who were asked to complete it at home and bring it to the examination.

Data concerning general behavior of walking, without a specific recall period, were collected at interviews conducted by a physiotherapist. The questions used were the following: "Do you take a daily walk?" Response alternatives: yes or no. If you do not take a daily walk, how many times a week do you walk? Response alternatives: never, almost never, 1–2 days, 3–4 days, almost daily. How long does your walk generally last? Response alternatives: 0–15, 15–30, 30–60 min, 1–2 h, >2 h [26]. Walking time in minutes per week was calculated by multiplying lowest level of days with lowest level of minutes for each response alternative. The participants were classified into four groups according to recommended levels of moderate physical activity [6]: <75 min/week, 75 to <150 min/week, 150 to <300 min/week and $\geq$ 300 min/week.

Tests of fitness

- *Self-selected and maximum gait speed* for 20-meter indoors with standing start (meter/second) [22]. The type of walking aids was recorded. The walking test has shown good intra- and inter-rater reliability [27].
- *Timed chair-stand*, the ability to stand up and sit down from a chair five times in a row as quickly as possible. The total time (seconds) was used as outcome. Participants were asked to stand up without support of their arms, from a chair with a seat height of 43 cm and with armrests [22]. The timed chair-stand test has been shown to have high test–retest reliability and is considered to be a sensitive test for evaluating effects of exercise [28]. It also displays discriminative and concurrent validity properties [29].
- *Stair Climbing*, that is, the ability to climb onto boxes of varying heights (10, 20, 30, 40 and 50 cm) without support [22]. The height from the best leg was used for analysis.
- *Balance* was tested by the ability to stand on one leg without shoes, for a maximum of 30 s [30]. The hip joint of the non-weight-bearing leg was in a neutral position, the knee flexed to approximately 90 degrees, and hands behind the back and looking straight ahead. The test was interrupted if the subject moved from the standardized position. Three trials for each leg were allowed, and the best result from the best leg was used for analysis (seconds).
- *Grip strength* was tested with a Jamar dynamometer at an elbow angle of 90 degrees and with the shoulder joint in a neutral position. The test was repeated three times for each hand, and the highest value of the best hand was used as outcome (kg). The method has been shown to have high intra- and inter-test reliability [31] and validity [32].

Statistical analysis

Data are presented as means and standard deviations (SD) for continuous variables and relative frequencies for categorical variables. Ordinal data and continuous data where fixed levels were analyzed (i.e. max 30 s in one-leg stance) are presented as median and interquartile range. Background data were analyzed with Student′s *t* test for continuous data, Mann–Whitney′s tests for ordinal data and chi-square tests for proportions (Fishers exact test for 2 $\times$ 2 tables).

The SF-36 is an ordinal scale, but by convention, it is usually treated as an interval scale. In order to allow comparisons with other studies, we choose to describe mean values. For SF-36, tests of difference between groups, classified by walking habits, were analyzed with the nonparametric Kruskal–Wallis test, as some of its subscales were positively skewed, and also with the parametric one-way ANOVA. As the *p* value in parametric and nonparametric tests for SF-36 did not differ, only the parametric one is reported. Parametric one-way ANOVA was used to analyze group differences in walking speed, chair-stand and grip strength, and nonparametric Kruskal–Wallis tests for one-leg stance. Tukey′s post hoc analyses with adjustment for multiple comparisons were then performed to detect group differences. A power calculation showed that 63 individuals per group were needed to detect a suggested clinically significant difference of 5–10 points in SF-36 [33], with a power of 80 % for a $p < 0.05$.

Clinical relevance of differences between walking groups is also presented as effect sizes (ES). They are expressed as the standardized mean change, calculated from a linear regression model, for each higher level of walking group divided by the standard deviation in the total group for the dependent variable. Magnitude of standardized effects was interpreted according to Cohen's [34] guidelines: 0.20 small, 0.50 medium and 0.80 large.

Due to the ordinal scale and skewed results in SF-36, the following analyses were done with nonparametric tests. Spearman's rank correlation was used to analyze bivariate associations between fitness and SF-36 subscales. Correlations were interpreted according to Munro [35]; 0.00–0.25 little if any, 0.26–0.49 low, 0.50–0.69 moderate, 0.70–0.89 high and 0.90–1.00 very high. The fitness test with the highest correlation to SF-36 was chosen to represent fitness in the following analysis, that is, maximal gait speed.

Logistic regression models were performed to estimate the Odds Ratio (OR) for scoring in the highest sex-specific quartile of SF-36 subscales (dependent variable).

1. Bivariate analyses with walking habits as a hypothesized predictor of SF-36
2. Bivariate analyses with maximal gait speed as a hypothesized predictor of SF-36
3. To test the hypothesis of fitness as a mediator in the relation between walking habits and SF-36, maximal gait speed was added to the model with walking habits as predictor. Tests of mediational effect were performed according to the bootstrapping procedure for Sobel′s test [36]. The size of the mediational effect was measured as the change in the model (OR) before and after the mediator was added. To test whether the mediation effect was significant, a bootstrap procedure was performed with a number of samples set to 8,000. In men, 2.9 % of the bootstrap models failed, indicating a reliability problem due to small sample size.
4. Multivariate analyses were then performed for mediated models with adjustment for education level, living alone, number of medical conditions, number of medications, BMI and current smoker. All confounders included were associated with the majority of the SF-36 subscales (dichotomized by upper quartile) on a level of $p < 0.20$ in bivariate analyses, with number of medications, number of medical conditions and BMI, showing the strongest associations with most subscales. All confounders were entered simultaneously into a total model. Number of medical conditions, medications and BMI were included as continuous variables, all others dichotomized as presented in Table 1. To separate walking as a type of physical activity, preliminary analyses also included adjustment for physical exercise ≥ 3 h/week [22], as regular walkers have been shown to be more likely to participate in other and more vigorous physical activities [37]. It did not, however, influence the results and was therefore not included in the final analyses.

Individuals who did not respond to a question or were unable to perform a test were excluded from analyses that included that specific variable. For example, 3.9 % of the women and 5.5 % of the men who visited the outpatient department were unable to perform the test of maximal gait speed. For SF-36, missing questions were substituted according to the manual.

All data were analyzed using the SPSS (Statistical Package for the Social Sciences, Chicago IL) version 16.0 for Microsoft Windows, except tests of mediation which were analyzed with SAS procedure LOGISTIC (version 9.2 for Windows). As SAS is relatively inefficient for drawing a large number of repeated bootstrap samples, an external program was written for fast generation of a large number of randomly drawn samples with replacement. Two-tailed p values ≤ 0.05 were considered to be statistically significant.

Results

Men had better results than women in all subscales of SF-36 and in most tests of fitness. Recommended levels of walking (≥ 150 min/week) were attained by 59.5 % of the women and 59.1 % of the men, whereas walking ≥ 300 min/week was attained by 17.3 % of the women and 18.5 % of the men. No gender differences were found in walking habits (Table 1).

Weekly duration of walking was positively related to all subscales of SF-36, except Mental Health in women and Role Emotional in men. The trend for mean difference between the walking groups ranged from 5 to 10 points in physical domains of SF-36, effect size ranging from 0.24 to 0.39. The difference in mental domains ranged from 2 to 6 points, effect size 0.11–0.28. Walking was also positively related to all tests of fitness, except grip strength. The effect size for difference in fitness ranged from 0.13 to 0.26, with the highest scores for gait speed (Tables 2, 3).

In general, those who walked 75 to <150 min/week did not differ significantly compared to those who did <75 min/week of walking, but those who walked ≥150 min/week did. In women, higher scores were also seen for ≥300 min/week compared to 75–150 min/week of walking in SF-36 subscales of Physical Function, Role Physical, Body Pain, General Health and Vitality, and also in some tests of fitness. This was not seen in men (Tables 2, 3).

All tests of fitness were positively correlated to all SF-36 subscales, although on a low to moderate level. Maximal gait speed was the test with the highest correlations to all subscales (ranging from 0.24 to 0.58, $p < 0.001$), while grip strength was the test with lowest correlations (ranging from 0.15 to 0.30) (Table 4). Maximal gait speed was chosen to represent fitness in the following analyses.

Table 1 Characteristics of the 75-year-old study population, by gender ($n = 698$)

	Women $n = 427$	Men $n = 271$
Living alone (%)	54.0	24.0***
Education level; more than basic (%)	41.2	44.1
Smoking habits (%)		
Never	58.2	33.7***
Former	30.6	50.6***
Current	9.1	9.2
Body mass index (kg/m2, mean, (SD))	26.6 (4.5)	26.8 (3.7)
Medical conditions (%)		
Angina pectoris	3.3	1.2
Ischemic heart disease	21.2	28.4*
Cerebrovascular disease	7.0	11.4
Diabetes	10.0	15.4*
Arthritis	45.5	29.2***
Chronic bronchitis	7.3	8.2
Major depression	15.0	7.8**
Number of medical conditions, (%)		
0	42.6	38.7
1	39.1	43.2
2	13.8	13.3
≥ 3	4.5	4.8
Number of daily medications (mean,(SD))	4.3 (3.1)	3.6 (3.2)**
Regular exercise ≥ 3 h/week (%)	2.7	6.9*
SF-36 subscales (mean,(SD))		
Physical function	69 (24)	76 (22)***
Role physical	66 (40)	73 (38)*
Body pain	64 (26)	76 (24)***
General health	64 (20)	70 (19)***
Vitality	65 (22)	70 (20)***
Social function	84 (22)	91 (18)***
Role physical	77 (36)	84 (32)*
Mental health	78 (19)	83 (18)**
Walking habits (%)		
< 75 min/week	26.5	25.8
75–150 min/week	14.1	15.1
150–300 min/week	42.2	40.6
300 min/week	17.3	18.5
Fitness		
Maximal gait speed (m/s, mean (SD))	1.56 (0.30)	1.78 (0.32)***
Regular gait speed (m/s, mean (SD))	1.16 (0.2)	1.21 (0.2)***
Timed chair-stand (sec, mean (SD))	13.6 (5.2)	12.5 (3.7)
Stair climbing, reaching 50 cm (%)	24.7	72.0***
One-leg stance (sec, median (iq range))	20 (17–23)	30 (24–30)
Grip strength (kg, mean (SD))	22.9 (5.1)	38.6 (7.1)***

More than basic education: ≥ 8 years of school

*Significant gender difference of a level of $p < 0.05$, **$p < 0.01$, ***$p < 0.001$

In women, those who attained recommended levels of walking were more likely to score in the upper quartile of all SF-36 subscales except Mental Health, and those with a high maximal gait speed were more likely to score in the upper quartile of all SF-36 subscales. Maximal gait speed was a partial mediator in most relations between walking habits and SF-36 with a mediation effect of OR −0.2 to −0.6. After adjusting the mediated analyses for confounders as described previously, significant associations remained between walking habits and Role Physical, General Health and Role Emotional (Table 5).

In men, those who attained recommended levels of walking were more likely to score in the upper quartile of Physical Function, Role Physical, Vitality and Role Emotional, and those with a high maximal gait speed were more likely to score in the upper quartile of Physical Function, Role Physical, Vitality and Social Function. Maximal gait speed partially mediated the relation between walking habits and Role Physical (mediation effect OR −0.2), and totally mediated the relation to Role Emotional (mediation effect OR −0.3). After adjusting the mediated analyses for confounders, significant associations between walking habits and SF-36 disappeared (Table 6).

When mediation was analyzed after adjustment for confounders instead, gait speed could not be confirmed as a mediator. Similar analyses with all other fitness tests showed results in the same direction, but mostly with lower ORs.

Discussion

Our results showed that older persons who attained recommended levels of walking, and also those with a high level of fitness, had better results in most aspects of HRQL. Maximal gait speed compared to other common tests of fitness had the highest correlations to all aspects of HRQL. Fitness, described with maximal gait speed, was a partial mediator in most relations between walking habits and HRQL.

The demonstrated relation between walking habits and HRQL is in accordance with global recommendations of ≥150 min/week of moderate physical activity for health benefits [5, 6], and in line with previously reported dose–response relations between physical activity and HRQL [38, 39]. However, these findings are in contrast to the relation between physical activity and all-cause mortality where any physical activity is better than none, with minor additional effects for higher doses [40]. Walking interventions among older persons have shown effects on both fitness [11] and physical and mental HRQL [41, 42]. On the other hand, in our paper, several associations, especially in men, were confounded by variables such as medical conditions, number of medications and BMI. Also, the effect sizes for both HRQL and fitness were small. However, one has to consider that HRQL is a complex

Table 2 Results in subscales of Short Form-36 and fitness in relation to walking habits in the 75-year-old study population, women

	n	<75 min/ week of walking	75 to <150 min/ week of walking	150 to <300 min/ week of walking	≥300 min/ week of walking	*p* value for trend[a]	Effect size (95 % CI) as trend value in SD-scale[b]	Multiple comparison[d]
SF-36, (mean (SD))								
Physical function	408	54 (28)	66 (22)	74 (20)	81 (16)	**<0.001**	0.39 (0.31–0.48)	a, b, c, e
Role physical	401	48 (42)	56 (41)	77 (35)	73 (40)	**<0.001**	0.26 (0.17–0.35)	b, c, d, e
Body pain	406	52 (24)	61 (23)	67 (25)	73 (25)	**<0.001**	0.28 (0.19–0.37)	b, c, e
General health	397	56 (21)	60 (18)	68 (19)	71 (17)	**<0.001**	0.27 (0.18–0.36)	b, c, d, e
Vitality	397	55 (23)	60 (22)	68 (21)	72 (18)	**<0.001**	0.28 (0.19–0.37)	b, c, e
Social function	407	74 (29)	86 (18)	97 (19)	90 (16)	**<0.001**	0.24 (0.15–0.33)	b, c
Role emotional	396	66 (43)	72 (38)	83 (32)	79 (35)	**<0.001**	0.15 (0.05–0.24)	b
Mental health	401	73 (20)	78 (17)	79 (18)	80 (18)	0.071	0.12 (0.03–0.22)	–
Fitness tests								
Max gait speed (m/s, mean,(SD))	368	1.44 (0.38)	1.51(0.27)	1.60 (0.28)	1.65 (0.25)	**<0.001**	0.23 (0.13–0.34)	b, c
Regular gait speed (m/s, mean,(SD))	369	1.08 (0.22)	1.14 (0.20)	1.17 (0.18)	1.23 (0.15)	**<0.001**	0.26 (0.16–0.36)	b, c, e
Timed chair-stand (sec, mean, (SD))	367	15.6 (9.0)	13.9 (5.3)	13.4 (5.5)	12.2 (2.8)	**<0.001**	–0.18 (–0.28 to −0.08)	b, c, e
Stair climbing, (50 cm, %)	373	15	12	28	35	**0.003**	1.6 (1.2–2.1)[c]	Not analyzed
Grip strength (kg, mean, (SD))	372	21.8 (4.6)	22.6 (4.6)	23.2 (5.6)	23.7 (4.6)	0.117	0.13 (0.02–0.23)	–
One-leg stance (sec, median,(iq range))	373	14 (30)	15 (24)	23 (20)	26 (19)	**0.015**	0.17 (0.07–0.27)	b, c

SF-36 = Short Form-36: scale score 0 (worst possible) to 100 (no limitations)

[a] Global linear trend test from one-way analysis of variance (ANOVA) for mean

[b] Effect sizes are expressed as the mean change, calculated from a linear regression model, for each higher level of walking group, divided by the standard deviation of the dependent variable

[c] One exception is the test of stair-climbing capacity which is a dichotomized variable (50 cm or not) and thereby presented with an odds ratio

[d] Tukey's post hoc for multiple comparison of mean (rank mean for one-leg stance) between walking groups, $p \leq 0.05$: a) < 75 versus 75 to <150, b) < 75 versus 150 to <300, c) < 75 versus ≥ 300, d) 75 to <150 versus ≥ 150 to <300, e) 75 to <150 versus ≥ 300, f)150 to <300 versus ≥ 300

construct, influenced by many other factors besides physical activity, and the fact that this was a mean difference between four groups.

Further, we found that fitness was positively associated with several aspects of HRQL with maximal gait speed having higher correlations in comparison with, for example, grip strength, chair-stand and one-leg stance. Slow gait speed has been identified as a predictor of adverse health outcomes, for example, disability, cognitive impairment, institutionalization, falls and mortality, and has been recommended as a possible "vital sign" [43]. Results in gait speed and other fitness tests such as chair-stand, grip strength and 6-min walk have also recently been associated with several aspects of HRQL in older persons [15–19]. In agreement with our findings, most consistent associations have been seen in relation to SF-36 subscales of Physical Function and Vitality [16]. In men, lower body physical function has been related to physical, but not mental, HRQL, while the opposite applied for upper body physical function [44]. A stronger relation between grip strength, as compared to lower extremity function, and mental HRQL was not confirmed in our study. As for walking habits, several associations, especially in women, were confounded by medical conditions, number of medications and BMI. This has also been demonstrated for relations between grip strength and HRQL in community-dwelling older persons, but here confounding was more prevalent among men [15]. Anyway, these findings support co-morbidity as an explanation for the relation between fitness status and aspects of HRQL.

Table 3 Results in subscales of Short Form-36 and fitness in relation to walking habits in the 75-year-old study population, men

	n	<75 min/week of walking	75 to <150 min/week of walking	150 to <300 min/week of walking	≥300 min/week of walking	*p*-value for trend[a]	Effect size (95 % CI) as trend value in SD-scale[b]	Multiple comparison[d]
SF-36, mean (SD)								
Physical function,	258	61 (26)	75 (19)	82 (18)	83 (16)	**<0.001**	0.36 (0.25–0.47)	a, b, c
Role physical	253	58 (43)	70 (38)	78 (34)	84 (31)	**<0.001**	0.23 (0.12–0.35)	b, c
Body pain	259	64 (29)	78 (22)	87 (22)	83 (19)	**<0.001**	0.24 (0.13–0.35)	a, b, c
General health	252	61 (23)	68 (18)	72 (16)	76 (16)	**<0.001**	0.26 (0.15–0.38)	b, c
Vitality	252	61 (23)	68 (18)	73 (18)	77 (20)	**<0.001**	0.27 (0.16–0.39)	b, c
Social function	257	83 (26)	91 (15)	93 (14)	95 (13)	**<0.001**	0.23 (0.11–0.34)	c
Role emotional	248	78 (37)	83 (33)	86 (30)	88 (29)	0.328	0.11 (−0.01–0.23)	–
Mental health	254	74 (22)	82 (16)	84 (16)	89 (12)	**<0.001**	0.27 (0.16–0.38)	b, c
Fitness tests								
Max gait speed (m/s, mean,(SD))	240	1.65 (0.34)	1.79 (0.35)	1.81 (0.30)	1.84 (0.25)	**0.013**	0.19 (0.07–0.31)	b, c
Regular gait speed (m/s, mean,(SD))	240	1.14 (0.19)	1.23 (0.20)	1.23 (0.17)	1.25 (0.15)	**0.014**	0.19 (0.06–0.31)	b, c
Timed chair-stand (sec, mean, (SD))	244	15.0 (8.3)	14.4 (8.1)	11.7 (3.5)	11.9 (2.5)	**0.001**	−0.22 (−0.34 to −0.10)	b, c, d
Stair-climbing (50 cm, %)	246	56	66	78	80	**0.019**	1.5 (1.2–2.0)[c]	Not analyzed
Grip strength (kg, mean (SD))	245	36.9 (7.8)	38.8 (7.3)	38.6 (6.7)	40.2 (6.6)	0.146	0.13 (0.01–0.26)	–
One-leg stance (sec, median, (iq range))	246	21 (30)	21 (23)	30 (18)	30 (12)	**0.041**	0.16 (0.04–0.28)	b, c, e

SF-36 = Short Form-36: scale score 0 (worst possible) to 100 (no limitations)

[a] Global linear trend test from one-way analysis of variance (ANOVA) for mean

[b] Effect sizes are expressed as the mean change, calculated from a linear regression model, for each higher level of walking group, divided by the standard deviation of the dependent variable

[c] One exception is the test of stair-climbing capacity which is a dichotomized variable (50 cm or not) and thereby presented with an odds ratio

[d] Tukey's post hoc for multiple comparison of mean (rank mean for one-leg stance) between walking groups, $p \leq 0.05$: a) < 75 versus 75 to <150, b) < 75 versus 150 to <300, c) < 75 versus ≥ 300, d) 75 to <150 versus ≥ 150 to <300, e) 75 to <150 versus ≥ 300, f)150 to <300 versus ≥ 300

Fitness, described with maximal gait speed, was a partial mediator in most relations between walking habits and SF-36. The effect of change in OR before and after mediation ranged from −0.4 to −0.6 in women and −0.1 to −0.3 in men, and the direct relation between walking habits ad SF-36 remained in most dimensions. The role of fitness in relations between physical activity and HRQL has been debated. It has been assumed to be a possible mediator, but, on the other hand, it has been argued that a person needs to be aware of a capacity to be able to perceive an increased quality [2]. As a consequence, self-efficacy has been in focus and also identified as a pathway between physical activity and HRQL [10]. Clinically, physical activity interventions aiming at improving HRQL might have to include both strengthening of actual lower body capacities and psychological constructs such as self-efficacy. Gait speed could be an outcome of interest if it is combined with assessment of, for example, self-efficacy.

Interestingly, there were indications that a stronger positive relation existed between weekly duration of walking and HRQL in women compared to men. This was also seen for fitness status in unadjusted analysis and for the mediating effect of maximal gait speed. Reasons may be that women have a different body composition from men, with a lower physical function and physiological reserve, and therefore are more vulnerable to decreasing physical activity and fitness levels. It might also be that women with a low self-perceived physical health and fitness avoid physical activities. As a result, women might benefit even more from physical activity than men if

Table 4 Correlations between physical fitness and SF-36 subscales in the 75-year-old study population ($n = 637$)

	Maximal gait speed	Self-selected gait speed	Timed chair-stand[a]	Stair-climbing capacity	One-leg stance	Grip strength
Physical function	0.58	0.55	−0.49	0.56	0.42	0.25
Role physical	0.38	0.37	−0.34	0.30	0.31	0.17
Bodily pain	0.33	0.28	−0.27	0.32	0.22	0.30
General health	0.35	0.33	−0.32	0.23	0.18	0.24
Vitality	0.42	0.38	−0.35	0.31	0.24	0.24
Social function	0.27	0.32	−0.27	0.30	0.24	0.20
Role emotional	0.24	0.24	−0.20	0.24	0.18	0.15
Mental health	0.26	0.24	−0.19	0.22	0.15	0.21

All correlations significant at a level of $p \leq 0.01$, Spearman′s rank correlation coefficient

When women and men were tested separately, the correlations were in the same magnitude

[a] A low result means a high fitness

Table 5 Odds Ratio (OR) and 95 % confidence intervals (CI) for scoring in the upper quartile of SF-36 in relation to walking habits and fitness unadjusted, mediated and adjusted models [women ($n = 364$)]

Dependent variables	Predictor[a]	Mediator[b]	Mediated model[c]		Adjusted[d]
	Walking habits OR (95 % CI)	Maximal gait speed OR (95 % CI)	OR (95 % CI)	Effect change in OR (95 % CI)	OR (95 % CI)
Physical function	2.3 (1.2–4.5)**	4.3 (2.5–7.5)***	1.9 (0.9–3.8)	−0.5 (0 to −1.4)	1.2 (0.6–2.5)
Role physical[e]	3.8 (2.4–6.1)***	2.7 (1.6–4.4)***	3.2 (1.9–5.3)***	−0.6 (−0.1 to −1.4)*	2.9 (1.7–4.9)***
Bodily pain	2.8 (1.5–5.0)***	1.9 (1.1–3.1)**	2.4 (1.3–4.5)**	−0.4 (−0.1 to −1.0)**	1.9 (1.0–3.6)
General health	2.5 (1.4–4.5)**	2.3 (1.4–3.8)***	2.1 (1.2–3.9)*	−0.4 (−0.1 to −1.0)*	1.9 (1.0–3.6)*
Vitality	2.3 (1.3–4.0)**	4.8 (2.9–8.0)***	1.8 (1.0–3.3)*	−0.5 (−0.1 to −1.1)*	1.7 (0.9–3.1)
Social function[e]	1.7 (1.1–2.7)*	3.4 (2.0–5.7)***	1.3 (0.8–2.1)	−0.4 (−0.2 to −0.8)***	1.4 (0.8–2.3)
Role emotional[e]	2.0 (1.3–3.2)**	2.4 (1.4–4.2)***	1.7 (1.0–2.8)*	−0.3 (−0.1 to −0.7)***	1.8 (1.1–3.0)*
Mental health	1.0 (0.6–1.8)	2.5 (1.4–4.3)***	0.8 (0.5–1.5)	−0.2 (−0.1 to −0.4)***	0.7 (0.4–1.4)

*$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$

[a] Bivariate analysis with walking habits (≥150 min/week with <150 min/week as reference) as predictor

[b] Bivariate analysis with maximal gait speed (performing in the upper sex-specific quartile with all others as reference) as predictor

[c] Max gait speed added to model with walking habits as predictor and observed change between unmediated and mediated model

[d] Mediated model adjusted for education level, living alone, number of medical conditions, number of medications, BMI and current smoker

[e] Scoring max (100 points) due to ceiling effects

HRQL is the focus. Further, the clinically relevant gender difference of 5–10 points in SF-36 in our sample is in line with data collected in a similar age group in Sweden in 1991–92 [25]. Fitness status and chronic conditions have been suggested to explain these gender differences [45]. However, somewhat higher scores in SF-36 were found in our sample compared to the normative values from 1991 to 1992, especially in physical subscales [25]. As physical HRQL has been shown to decrease to a higher degree than mental HRQL during the life course [23], physical health status might be responsive to actions in late life.

Among the strengths of this paper were the population-based design, the comprehensive examinations, the use of established tests for assessments of fitness and HRQL, the fact that all participants were examined by health professionals, that individuals with dementia were excluded, and that men and women were analyzed separately.

There are also several limitations. First, the data were cross-sectional making it difficult to assess the direction of causality. For example, individuals with high HRQL could tend to be more physically active and have a higher fitness level. The wording effect size might also be a bit

Table 6 Odds Ratio (OR) and 95 % confidence intervals (CI) for scoring in the upper quartile of SF-36 in relation to walking habits and fitness unadjusted, mediated and adjusted models [men ($n = 238$)]

Dependent variables	Predictor[a]	Mediator[b]	Mediated model[c]		Adjusted[d]
	Walking habits OR (95 % CI)	Maximal gait speed OR (95 % CI)	OR (95 % CI)	Effect change in OR (95 % CI)	OR (95 % CI)
Physical function	2.6 (1.3–5.0)**	4.1 (2.2–7.4)***	2.3 (1.1–4.6)*	−0.3 (0.4 to −1.2)	1.7 (0.8–3.7)
Role physical[e]	2.2 (1.3–3.8)**	2.9 (1.6–5.4)***	1.9 (1.0–3.4)*	−0.3 (0 to −0.9)*	1.4 (0.7–2.6)
Bodily pain	1.4 (0.8–2.3)	1.4 (0.8–2.4)	1.2 (0.7–2.2)	−0.1 (0 to −0.4) *	1.0 (0.6–1.8)
General health	1.5 (0.8–2.8)	1.3 (0.7–2.3)	1.4 (0.8–2.6)	−0.1 (0 to −0.3)	1.2 (0.6–2.4)
Vitality	2.4 (1.3–4.5)**	2.5 (1.4–4.4)***	2.1 (1.1–4.1)*	−0.3 (0 to −0.9)	2.0 (1.0–3.9)
Social function[e]	1.5 (0.9–2.7)	2.4 (1.3–4.7)**	1.2 (0.7–2.3)	−0.3 (−0.1 to −0.7)***	0.7 (0.4–1.5)
Role emotional[e]	1.9 (1.0–3.4)*	1.6 (0.8–3.0)	1.6 (0.8–3.2)	−0.2 (0 to −0.7)*	1.4 (0.7–2.8)
Mental health	1.8 (1.0–3.3)	1.6 (0.9–2.8)	1.6 (0.9–3.0)	−0.2 (0 to −0.6)**	1.5 (0.7–2.9)

*$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$

[a] Bivariate analysis with walking habits (≥150 min/week with <150 min/week as reference) as predictor

[b] Bivariate analysis with maximal gait speed (performing in the upper sex-specific quartile with all others as reference) as predictor

[c] Max gait speed added to model with walking habits as predictor and observed change between unmediated and mediated model

[d] Mediated model adjusted for education level, living alone, number of medical conditions, number of medications, BMI and current smoker

[e] Scoring max (100 points) due to ceiling effects

misleading in cross-sectional study. A longitudinal design or randomized controlled trial is needed for causal inferences. It is possible, however, that the direction of the causality is reciprocal. Secondly, physical activity level was measured with a global question about walking habits, which provides a general impression of physical activity habits and lack of information about intensity. The reason for not using a questionnaire tested for reliability and validity was the longitudinal and repeated cross-sectional nature of the original study, which not provides a possibility to change to new instruments tested for reliability and validity in later cohorts. Global questionnaires have a limited ability to identify whether individuals are fulfilling recommended levels of physical activity, and walking habits are in opposite to total physical activity often underreported [46]. The lack of a test of reliability of the walking question is a serious limitation and it is hard to consider seasonal influence with such a global question. Thirdly, there were ceiling effects in some subscales of SF-36, making it difficult to capture variance. Furthermore, persons with severe cognitive deficits cannot be included in self-assessed measures. Fourthly, the fitness tests do not capture aerobic capacity or flexibility. The 6-min walking test has been included in previous cross-sectional cohorts, but has been removed from the comprehensive examination battery. As walking is supposed to put demands on aerobic capacity in elderly persons, it would have been preferable to also have results in 6-min walking test. Fifthly, regarding generalizability to other populations, the participation rate in the study was 61 %, and persons who died within 4 years of the study start were overrepresented among non-participants. Since there were more women than men in this population-based sample and analyses were done separately by gender, the statistical power among men was lower. Also, in analyses including fitness variables, only persons who were able to visit the clinic and perform the tests were included, which probably led to a healthy population bias. One also has to consider that this was a Swedish urban population.

Further longitudinal research is required to examine the direction of the association between physical activity and fitness in relation to HRQL. Many of the variables, here treated as confounders, could instead be predictors or mediators, but as the focus of this paper was on the mediating effect of fitness, they are all treated as confounders. Analyses using structural equation modeling could be an alternative for a deeper understanding of causality and possible mediators. A qualitative design might also increase the understanding of possible mediating and moderating mechanisms in these relations.

In conclusion, the attainment of recommended levels of walking, and also fitness status, is related to HRQL in older persons. If improved HRQL is a goal when encouraging older persons to be physically active, fitness seems to be a partial pathway, suggesting that other mechanisms such as previously identified self-efficacy also play a role.

Acknowledgments The H70 studies have received support from the Swedish Council for Working Life and Social Research (no 2001-2835, 2001-2646, 2003-0234, 2004-0150, 2004-0145, 2006-0596, 2006-0020, 2006-1506, 2008-1111, 2010-0870), the

Alzheimer's Association Stephanie B. Overstreet Scholars (IIRG-00-2159, 2008-1229), the Alzheimer's Association Zenith Award (ZEN-01-3151), the Swedish Research Council (no. 11267, 2005-8460, 825-2007-7462), the Bank of Sweden Tercentary Foundation, Stiftelsen för Gamla Tjänarinnor and Handlanden Hjalmar Svenssons Forskningsfond. This specific study was supported by Swedbank Sjuhärad stiftelse, Alice Swenzons stiftelse, Stiftelsen Sigurd and Elsa Goljes Minne and FoU-rådet Södra Älvsborg. We are very grateful to the persons who consented to participate in this study. The authors also thank Valter Sundh for statistical support.

Conflict of Interest The authors have no conflict of interest to disclose.

References

1. Phelan, E. A., Anderson, L. A., LaCroix, A. Z., & Larson, E. B. (2004). Older adults' views of "successful aging"–how do they compare with researchers' definitions? *Journal of the American Geriatrics Society, 52*(2), 211–216.
2. Rejeski, W. J., & Mihalko, S. L. (2001). Physical activity and quality of life in older adults. *J Gerontol A Biol Sci Med Sci, 56*(Spec No 2), 23–35.
3. Stewart, A., & King, A. (1991). Evaluating the efficacy of physical activity for influencing quality of life outcomes in older adults. *Annals of Behavioral Medicine, 13*, 108–116.
4. Kaspersen, C., Powell, K., & Christensson, G. (1985). Physical activity, exercise and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports, 100*(2), 126–131.
5. Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., et al. (2007). Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise, 39*(8), 1435–1445.
6. World Health Organization. (2010). *Global recommendations on physical activity for health*. Geneva, Switzerland.
7. Morris, J. N., & Hardman, A. E. (1997). Walking to health. *Sports Medicine (Auckland, N. Z.), 23*(5), 306–332.
8. Rejeski, W. J., Brawly, L., & Shumaker, S. (1996). Physical activity and health-related quality of life. *Exercise and Sport Sciences Reviews, 24*, 71–108.
9. Taylor, A. H., Cable, N. T., Faulkner, G., Hillsdon, M., Narici, M., & Van Der Bij, A. K. (2004). Physical activity and older adults: A review of health benefits and the effectiveness of interventions. *Journal of Sports Sciences, 22*(8), 703–725.
10. Motl, R. W., & McAuley, E. (2010). Physical activity, disability, and quality of life in older adults. *Physical Medicine and Rehabilitation Clinics of North America, 21*(2), 299–308.
11. Keysor, J. J. (2003). Does late-life physical activity or exercise prevent or minimize disablement? A critical review of the scientific evidence. *American Journal of Preventive Medicine, 25*(3 Suppl 2), 129–136.
12. Cesari, M. (2011). Role of gait speed in the assessment of older patients. *JAMA, 305*(1), 93–94.
13. Cress, M. E., Schechtman, K. B., Mulrow, C. D., Fiatarone, M. A., Gerety, M. B., & Buchner, D. M. (1995). Relationship between physical performance and self-perceived physical function. *Journal of the American Geriatrics Society, 43*(2), 93–101.
14. World Health Organization. (2001). *International classification of functioning, disability and health: ICF*. Geneva: World health Organization.
15. Sayer, A. A., Syddall, H. E., Martin, H. J., Dennison, E. M., Roberts, H. C., & Cooper, C. (2006). Is grip strength associated with health-related quality of life? Findings from the Hertfordshire Cohort Study. *Age and Ageing, 35*(4), 409–415.
16. Wanderley, F. A., Silva, G., Marques, E., Oliveira, J., Mota, J., & Carvalho, J. (2011). Associations between objectively assessed physical activity levels and fitness and self-reported health-related quality of life in community-dwelling older adults. *Quality of Life Research, 20*(9), 1371–1378.
17. Takata, Y., Ansai, T., Soh, I., Awano, S., Yoshitake, Y., Kimura, Y., et al. (2010). Quality of life and physical fitness in an 85-year-old population. *Archives of Gerontology and Geriatrics, 50*(3), 272–276.
18. Garber, C. E., Greaney, M. L., Riebe, D., Nigg, C. R., Burbank, P. A., & Clark, P. G. (2010). Physical and mental health-related correlates of physical function in community dwelling older adults: A cross sectional study. *BMC Geriatrics, 10*, 6.
19. Olivares, P. R., Gusi, N., Prieto, J., & Hernandez-Mocholi, M. A. (2011). Fitness and health-related quality of life dimensions in community-dwelling middle aged and older adults. *Health and Quality of Life Outcomes, 9*, 117.
20. Rinder, L., Roupe, S., Steen, B., & Svanborg, A. (1975). Seventy-year-old people in Gothenburg. A population study in an industrialized Swedish city. *Acta Medica Scandinavica, 198*(5), 397–407.
21. Association, A. P. (Ed.). (Fourth edition1994). *Diagnostic and statistical manual of mental disorders*. Washington DC.
22. Frändin, K., & Grimby, G. (1994). Assessment of physical activity, fitness and performance in 76-year-olds. *Scandinavian Journal of Medicine and Science in Sports, 4*, 41–46.
23. Ware, J. E, Jr, & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Medical Care, 30*(6), 473–483.
24. Walters, S. J., Munro, J. F., & Brazier, J. E. (2001). Using the SF-36 with older adults: A cross-sectional community-based survey. *Age and Ageing, 30*(4), 337–343.
25. Sullivan, M., & Karlsson, J. (1998). The Swedish SF-36 health survey III. Evaluation of criterion-based validity: Results from normative population. *Journal of Clinical Epidemiology, 51*(11), 1105–1113.
26. Frandin, K., Grimby, G., Mellstrom, D., & Svanborg, A. (1991). Walking habits and health-related factors in a 70-year-old population. *Gerontology, 37*(5), 281–288.
27. Connelly, D.M., Stevenson T. J., & Vandervoort, A. A. (1996). Between- and within-rater reliability of walking tests in a frail elderly population. *Physiotherapy Canada* (58), 47–51.
28. Jette, A. M., Jette, D. U., Ng, J., Plotkin, D. J., & Bach, M. A. (1999). Are performance-based measures sufficiently reliable for use in multicenter trials? Musculoskeletal Impairment (MSI) Study Group. *Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 54*(1), M3–6.
29. Whitney, S. L., Wrisley, D. M., Marchetti, G. F., Gee, M. A., Redfern, M. S., & Furman, J. M. (2005). Clinical measurement of sit-to-stand performance in people with balance disorders: Validity of data for the five-times-sit-to-stand test. *Physical Therapy, 85*(10), 1034–1045.
30. Stones, M. J., & Kozma, A. (1987). Balance and age in the sighted and blind. *Archives of Physical Medicine and Rehabilitation, 68*(2), 85–89.
31. Peolsson, A., Hedlund, R., & Öberg, B. (2001). Intra- and intertester reliability and reference values for hand strength. *Journal of Rehabilitation Medicine, 33*(1), 36–41.
32. Bellace, J. V., Healy, D., Besser, M. P., Byron, T., & Hohman, L. (2000). Validity of the Dexter Evaluation System's Jamar dynamometer attachment for assessment of hand grip strength in a normal population. *Journal of Hand Therapy, 13*(1), 46–51.

33. Ware, J. E, Jr, Snow, K., Kosinski, M., & Gandek, B. (1993). *SF-36 health survey. Manual and interpretation guide*. Boston: The health Institute, New England Medical Center.
34. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd edn). New Jersey: Lawrence Erlbaum Associates.
35. Munro, B. (2005). *Statistical methods for health care research* (5th ed.). Philadelpia: Lippkott Williams & Wilkins.
36. Hayes, A. F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods, 41*(3), 924–936.
37. Lee, I. M., & Buchner, D. M. (2008). The importance of walking to public health. *Medicine and Science in Sports and Exercise, 40*(7), 508–512.
38. Vuillemin, A., Boini, S., Bertrais, S., Tessier, S., Oppert, J. M., Hercberg, S., et al. (2005). Leisure time physical activity and health-related quality of life. *Preventive Medicine, 41*(2), 562–569.
39. Martin, C. K., Church, T. S., Thompson, A. M., Earnest, C. P., & Blair, S. N. (2009). Exercise dose and quality of life: A randomized controlled trial. *Archives of Internal Medicine, 169*(3), 269–278.
40. Lollgen, H., Bockenhoff, A., & Knapp, G. (2009). Physical activity and all-cause mortality: An updated meta-analysis with different intensity categories. *International Journal of Sports Medicine, 30*(3), 213–224.
41. Cheng, S. P., Tsai, T. I., Lii, Y. K., Yu, S., Chou, C. L., & Chen, I. J. (2009). The effects of a 12-week walking program on community-dwelling older adults. *Research Quarterly for Exercise and Sport, 80*(3), 524–532.
42. Okamoto, N., Nakatani, T., Morita, N., Saeki, K., & Kurumatani, N. (2007). Home-based walking improves cardiopulmonary function and health-related QOL in community-dwelling adults. *International Journal of Sports Medicine, 28*(12), 1040–1045.
43. Abellan van Kan, G., Rolland, Y., Andrieu, S., Bauer, J., Beauchet, O., Bonnefoy, M., et al. (2009). Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) task force. *J Nutr Health Aging, 13*(10), 881–889.
44. Hall, S. A., Chiu, G. R., Williams, R. E., Clark, R. V., & Araujo, A. B. (2011). Physical function and health-related quality-of-life in a population-based sample. *Aging Male, 14*(2), 119–126.
45. Orfila, F., Ferrer, M., Lamarca, R., Tebe, C., Domingo-Salvany, A., & Alonso, J. (2006). Gender differences in health-related quality of life among the elderly: The role of objective functional capacity and chronic conditions. *Social Science and Medicine, 63*(9), 2367–2380.
46. Ainsworth, B. E. (2009). How do I measure physical activity in my patients? Questionnaires and objective methods. *British Journal of Sports Medicine, 43*(1), 6–9.