Does Physical Activity Affect the Predictive Value of Health-Related Fitness Tests on Walking Difficulty?

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Abstract

Background: Low level of physical activity (PA) and poor fitness tend to predict decline in mobility. The present study investigated whether PA modifies predictive value of health-related fitness (HRF) tests on difficulty in walking 2-km (WD).

Methods: PA was assessed by self-reported questionnaires in 1990 and 1996. Subjects aged 55-69 years and free of self-reported WD participated in assessment of HRF in 1996. Occurrence of WD was assessed by questionnaire in 2002 (n=537).

Results: There were no statistically significant interactions between PA and HRF tests, thus PA and HRF were both independent predictors of WD. Regardless of the PA level the subjects in the poorest
performing third in each HRF test had higher risk of WD than the subjects in the best performing third.

Conclusions: PA and HRF seemed to be independent predictors of WD, although the association of PA with WD was weaker than the association of HRF. Thus, PA did not modify the predictive value of HRF on WD.

Introduction

Previous population studies have shown that the amount and intensity of physical activity (PA) decrease with increasing age. Consequently, sedentary lifestyle increases the risk of functional disabilities, health and social service use, chronic disease morbidity, and mortality. There is strong scientific evidence that PA can promote health and physical functioning throughout life, even among the oldest persons.

Malmberg et al. reported that low level of PA predicts the occurrence of mobility difficulties among middle-aged and older adults. According to Hirvensalo et al. PA can protect mobility-impaired persons against further disability and all-cause mortality. Randomized controlled trials have shown that exercise, especially resistance training, is effective in improving physical performance and functioning among older populations.

Physical fitness deteriorates with advancing age. In follow-up studies low fitness has been reported to be associated with poor mobility and physical functioning. Recent reviews and consensus statements reported that low fitness is associated with poor health outcomes and mortality, even with steeper gradient than PA. Our recent studies indicated that health-related fitness (HRF) tests predict self-reported mobility difficulties among older adults. Many components and factors of fitness are also associated with PA, and a dose response between PA and fitness has been identified.
Body composition can be regarded as one factor of HRF. Body mass index (BMI) is a proxy measure of body composition that indicates overweight and obesity. Higher BMI is associated with poorer physical functioning. Recently Stenholm et al. reported that high BMI (>30 kg/m²) predicted walking limitations among a representative sample of older Finnish adults. It is agreed that PA is beneficial for weight control, but dose-response relationship is still unclear.

The Toronto model on PA, HRF and health specifies the interrelationships between activity, fitness and health. According to the model health and PA can influence each other either through HRF of straight forward without fitness effects. The present study focuses on predictive value of HRF tests among high-functioning older adults on walking difficulty. Self-reported walking difficulty (WD) is an important outcome variable since mobility function can be seen as a prerequisite for functional independence and health. Since previous studies have indicated associations between PA and fitness, PA and mobility difficulties as well as between fitness and mobility function, the present study aims at analysing whether level of PA modifies predictive value of selected HRF items on WD among high-functioning older adults.

Methods

Subjects

The study forms a part of the Kainuu Study on Living Habits and Health. A systematic and regionally representative sample of community-based residents between the ages of 19 and 63 years was drawn from the 1979 census data of a medium-sized industrial town and two rural municipalities in northeast Finland. The initial sample included 6,787 men and women, of whom 5,259 (77.5%) answered the baseline questionnaire in 1980. The cohort was followed-up by postal questionnaires in 1981, 1985, 1990, 1996 and 2002. In 1996 respondents aged 55 years and older were invited to the assessment of HRF in their home municipalities. The sample of the present study consisted of all the men and women who were born between 1927 and 1941 (subjects aged 55 to 69 years in 1996), who participated in the HRF assessment.
and did not report WD in 1996 (baseline) (n=672). During the six years follow-up time 135 (20%) subjects were lost to follow-up because they could not be contacted (n=62), refused to respond to the follow-up questionnaire (n=67), or had severe health restrictions (n=6) 22. Our previous study 17 showed that poorer baseline (1996) performance in HRF tests increased the risk for non-response at follow-up (2002). The analyses of the present study included 537 subjects who responded to the questionnaire in 2002.

**Procedures**

Postal questionnaires were sent to the cohort members in 1990, 1996 and in 2002. The respondents’ readiness to participate in the assessment of HRF in 1996 was pre-screened on the basis of their answers to the questionnaire. The exclusion criteria were “living in an institution” or "having severe difficulty or inability to walk independently outdoors and on stairs”. Each participant signed a statement of informed consent before participation.

A team of six trained health and fitness professionals, all of whom had a degree in sport or health sciences, screened and tested the participants individually at a local gymnasium in each of the three target municipalities in 1996 (baseline). Using a validated pre-testing health screening, 29,30 the testers applied a systematic safety procedure to exclude non-eligible participants from selected tests. The study was approved by the ethics committee of the UKK Institute for Health Promotion Research in 1995 and by the Ethical Committee of Pirkanmaa Hospital District in 2002.

**Assessment of physical activity**

Self-reported questionnaires were used to assess respondents’ level of PA. The following question was used in 1990 and 1996: “Which of the following categories best describes your PA during the past 12 months? Consider all types of leisure-time PA, including walking and cycling, if activity takes at least 15-
20 minutes at time”. The original response alternatives describing PA levels were 1) vigorous activity at least twice a week, 2) vigorous activity at least once a week and in addition other light activities, 3) some activity each week, but less than above, 4) no regular weekly activity. Vigorous activity was described in the instructions as intense enough to cause perspiration or breathlessness. For the analysis PA levels in 1990 and 1996 were combined and categorized in two groups. Subjects reporting activity level 1 in both 1990 and 1996 and subjects reporting activity level 1 in one year and level 2 in the other year were regarded as vigorously active. All the other subjects were regarded as having no regular vigorous activity.

Assessment of health-related fitness

Assessment of HRF, in 1996, was conducted by selected test items of validated HRF tests targeted at high-functioning older adults. The original test battery includes measurements of all main components of HRF. The time requirement for one person to complete all tests is relatively high, taking about 60 minutes. To improve the feasibility of the tests, only three items that represent the most important fitness factors for mobility function i.e. balance, muscle strength and walking speed were included in the present study. The selected tests were backwards walk for dynamic balance, one-leg squat functional leg muscle strength and 1-km walk for walking ability and aerobic fitness. Among all the test items in the original HRF test battery these three test items were previously reported to have the highest predictive value on WD. The descriptions of HRF tests and test specific exclusion criteria have been presented in Appendix 1.

For the analyses performance in each three test was divided into three fitness categories based on the gender and age group specific thirds of the test scores. The best performing third of the subjects in each test was given score 2, mid third was given score 1 and the poorest third was scored as 0. Those who were eligible to participate in the HRF assessment, but could not complete a specific test according to test instructions, were included in the poorest third. A HRF summary score was calculated by adding the
individual scores of the tests together. The summary scores 5 and 6 were regarded as high fit, scores 3 and 4 were regarded as fit and scores 0 to 2 were regarded as low fit.

Body weight and height were measured in the same occasion as HRF test items. Measurements were conducted with light sport clothing without shoes. BMI was calculated by dividing weight in kilograms by the square of height in meters. For the analyses BMI was categorized into two groups: BMI lower than 27 kg/m² was regarded as normal for older adults and BMI equal to or over 27 kg/m² was regarded as overweight.

Assessment of self-reported walking difficulty
Self-reported walking difficulty was used to assess participants’ perceived mobility function in their everyday life. The assessment of WD in the present study was based on similar questionnaire information in 1996 and 2002. The subjects reported how well they were able to walk 2 kilometres without a rest. The response alternatives were 4= “able without difficulty”, 3= “able with some difficulty”, 2= “able with severe difficulty” and 1= “not able”. Only the subjects who did not report any difficulty in 1996 (response alternative 4) were included in the study. The response to the 2002 questionnaire was the outcome variable. Subjects reporting difficulty (response alternative 1-3) were regarded as having WD.

Statistical analysis
General characteristics of the study sample were analysed by cross-tabulations and chi-square test of independence. At baseline (1996) cross-sectional associations between PA groups and individual HRF test performance, and between PA groups and BMI were assessed by the analysis of covariance. Logistic regression analyses were used as statistical method in estimating odds ratios of these baseline factors (HRF tests, BMI, PA) for occurrence of WD six years later (2002). The modifying effect of baseline PA level on the predictive value of individual HRF test items on WD was assessed by test specific analyses.
including an interaction term (PA*HRF test) in logistic regression model. Correspondingly, the effects of baseline PA on predictive values of HRF summary score and BMI on WD were assessed by interaction terms. In the final analyses HRF summary score, BMI and PA variables were entered into the same model. Gender, age group, gender-age-interaction, marital status, vocational education, and smoking were included as confounders in all models since preliminary analysis showed that these variables were associated with HRF test performance and BMI at baseline (1996). All analyses were conducted by SPSS software, version 14.0 (SPSS Inc, Chicago IL).

Results

The subjects who answered to follow-up questionnaire in 2002 were younger and they perceived their health status better than the subjects who were lost to follow-up. The younger subjects and subjects who had better perceived health status in 1996 were also less likely to report WD at follow-up than older and less healthy subjects. Table 1 presents the general characteristics of the study population.

Place table 1 here.

Over one fourth (28%, n=68) of the men and one third (36%, n=108) of the women reported vigorous physical activity at baseline. Walking was the most typical type of activity among both genders: 75% of the subjects reported walking to be their most typical type of activity. At baseline subjects who reported vigorous PA at least twice a week walked the 1-km distance faster than the non-vigorously active subjects. Vigorously active women performed also the one-leg squat test better and had lower BMI than the non-vigorously active women (table 2). Normal weight subjects walked the 1-km distance on average faster than the overweight subjects. The group difference was on average 34 seconds (p=0.001) among the men and 40 seconds (p<0.001) among the women. Normal weight women performed also the one-leg
squat test on average 2.0 points (p<0.001) and backwards walk on average 3.8 seconds (p=0.008) better than the overweight women.

In prospective logistic regression analyses non-vigorously active subjects had higher risk of WD in all fitness categories and in both BMI groups than the vigorously active subjects (figure 1). The risk of WD was highest among the non-vigorously active subjects who belonged to the poorest fitness third in each individual HRF test, who had low fitness in terms of HRF summary score or who were overweight. Smoking was the only background factor that was clearly associated with increased risk of WD [odds ratios (OR) ranging from 2.1 to 3.0].

Regardless of the PA level the subjects in the poorest performing third in each HRF test had higher risk of WD than the subjects in the best performing third. The confounder-adjusted OR associated with risk of WD between HRF summary score categories were higher than the respective OR in individual test items. Correspondingly, the overweight subjects (BMI ≥ 27 kg/m^2), regardless of their PA level, had greater risk of WD than the vigorously active normal weight subjects. No statistically significant interactions between PA and HRF test performance or between PA and BMI were found.

Both PA (non-vigorous vs. vigorous activity OR = 2.04; 95% CI 1.11-3.75) and BMI (overweight vs. normal weight OR=2.75; 95% CI 1.60-4.72) were predictive for WD when HRF summary score was not included in the model. Correspondingly, PA (non-vigorous vs. vigorous activity OR = 2.04; 95% CI 1.08-3.85) and HRF summary score (low vs. high fit OR = 7.12; 95% CI 3.15-16.08, fit vs. high fit OR=2.93,
95% CI 1.30–6.61) were both independent predictors of WD. When BMI was included into the same logistic regression model as a third independent predictor, the predictive value of PA on WD rose slightly over the level of statistical significance (p-value=0.053) (table 3). Low fit score of HRF and overweight were both associated with higher risk of WD regardless of PA.

Place table 3 here.

Discussion

The purpose of the present study was to analyse whether PA modifies the predictive value of selected HRF tests and BMI on WD among high-functioning older adults. The main findings of the study showed that both HRF and BMI were independent predictors of WD regardless of the PA level. The risk of WD was highest among the non-vigorously active subjects who belonged to the poorest fitness third or who were overweight.

The HRF tests of the study were selected to represent the most important fitness factors for mobility function among older adults: balance, muscle strength and walking ability. \(^{18,21,22,31,32}\) The HRF summary score (as combined from three separate HRF tests) was more predictive for WD risk than any of those three tests singly. Brill et al. \(^{36}\) reported a corresponding association between summary score of muscle strength and self-reported physical function during on average five years follow-up among 30-82-year-old persons. Rantanen et al. \(^{32}\) showed that the risk of severe walking disability was markedly higher among the persons who had both poor balance and poor muscle strength when compared to the persons who had poor fitness only in one or none of these factors. Thus, co-impairments are more powerful predictors of underlying causes of dependence than single impairments.
The results of the present study complement previous findings about the associations between PA, fitness and health in terms of mobility function. 25 Self-reported walking ability (WD) was regarded as an indicator of health, and both activity and fitness were independently associated with that outcome when BMI was included in the analysis. OR for WD risk were higher with HRF tests than with PA which indicates that fitness may be a more powerful predictor for WD than activity. This is in line with Huang et al. 3 who reported an inverse gradient for both PA and fitness for functional limitations, but the gradient for fitness was steeper.

There is evidence that PA can lead to biological and psychological benefits without changes in fitness. 37,38 Blair et al. 39 suggested that any activity that has capacity to change either health or fitness will change both. They stated that fitness is developed by activity, although the magnitude of response to exercise stimulus is genetically determined. Rantanen et al. 40 suggested that physical fitness has a mediating role between PA and functional disability. Thus, disability is associated with inactivity, which correlates with lower strength which in turn is associated with greater degree of disability. According to Blair et al. 39 it is not possible to conclude whether activity or fitness is more important for health, but from a public health perspective, it is clear that recommendations and programs should be designed to promote PA rather than fitness.

Haskell et al. 37 stated that health benefits of PA are relatively greatest among previously sedentary persons. Even light, regular PA has been reported to be associated with better functional ability than sedentary lifestyle. 41 In a three year follow-up study by Visser et al. 42 stable activity patterns indicated the smallest decline in mobility performance. Rantanen and Heikkinen 43 stated that starting activity in old age may restore muscle strength close to that of a lifelong activity pattern. Thus, it is never too late to start PA. 7
The assessment of PA forms one limitation for the present study. The activity question covered all daily PA and exercise that lasts at least 15-20 minutes at time, but we were not able to estimate energy expenditure during these activities. Studying middle-aged adults Suni et al. classified activities into muscular type activities, aerobic activities and lifestyle activities. Since walking was clearly the most typical type of PA among the present study sample, we were not able to make corresponding classification and were thus unable to analyse effects of different types of activity on the occurrence of WD. Visser et al. reported that subjects, who performed sport activities and had higher total PA level showed less decline in mobility after three years than the subjects, who reported no sports activities and had lower level of total activity. Conversely, LaCroix et al. found in a 4-year-follow-up study that regular PA was associated with decreased risk of losing mobility regardless of the type of activity. Walking and gardening conveyed similar benefit as more vigorous forms of activity.

The other limitation of the present study is that self-reported walking ability was used as the outcome. Stenholm et al. used measured walking speed (≤1.2 m/s) or inability to finish a 6.1-m gait speed test as a primary indicator of walking limitation. Our previous study among the present study sample showed that optimal cut-off value for walking speed predicting WD was 1.8 m/s among men and 1.6 m/s among women. In the present study the mean walking speeds were also higher (1.8 m/s at baseline and 1.7 m/s at follow-up) than previously used cut point (1.2 m/s). Based on our previous report the follow-up sample is highly selected, and mean walking speeds at follow-up may underestimate true changes in walking ability. Thus, the commonly used cut point (1.2 m/s) for walking speed would not have been appropriate among the present high-functioning study population.

The subjects were selected from the original study cohort in 1980. The subjects of the present study were physically more active, perceived their health status better and smoked less than the original cohort. Our previous study indicated that the subjects who were lost to follow-up during six years performed the
baseline (1996) HRF assessment more poorly than those who remained in the study. Poor baseline
performers were also more likely to be excluded from follow-up assessment than better performers.
Selection bias typically seen in follow-up studies\(^4\) may lead to underestimations of true associations
between fitness, PA and mobility.

To conclude, PA did not modify predictive value of HRF and BMI on WD among high-functioning older
adults. Non-vigorous PA, poor fitness and overweight were all independent predictors of WD. PA in
general seem to be beneficial for physical functioning. It appears that exercise aimed at improving fitness
and interventions for weight management may provide a safety margin towards mobility difficulties, and
thus protect against development of WD.

Acknowledgments

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Table 1. General characteristics of the study sample in 1996 according to whether the subjects reported self-reported walking difficulty in 2002 or not.

<table>
<thead>
<tr>
<th>Baseline variable (1996)</th>
<th>No WD*</th>
<th>WD*</th>
<th>p-value†</th>
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<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>women</td>
<td>296</td>
<td>82</td>
<td>18</td>
</tr>
<tr>
<td>men</td>
<td>241</td>
<td>83</td>
<td>17</td>
</tr>
<tr>
<td>Age group</td>
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<tr>
<td>55-59</td>
<td>229</td>
<td>90</td>
<td>10</td>
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<tr>
<td>60-64</td>
<td>172</td>
<td>85</td>
<td>15</td>
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<td>65-69</td>
<td>136</td>
<td>68</td>
<td>32</td>
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<td>Marital status</td>
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<td>79</td>
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<tr>
<td>married</td>
<td>456</td>
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<td>widowed</td>
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<td>58</td>
<td>42</td>
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<td>73</td>
<td>27</td>
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<td>Education</td>
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<tr>
<td>no vocational training or education</td>
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<td>79</td>
<td>21</td>
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<tr>
<td>vocational training (preparatory courses)</td>
<td>197</td>
<td>81</td>
<td>19</td>
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<tr>
<td>secondary education (middle or high school/ vocational institute)</td>
<td>150</td>
<td>88</td>
<td>12</td>
</tr>
<tr>
<td>higher education (university/ college)</td>
<td>40</td>
<td>90</td>
<td>10</td>
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<td>Smoking</td>
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<td>83</td>
<td>17</td>
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<td>current smoker</td>
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<tr>
<td>past smoker</td>
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<td>86</td>
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<td>Perceived health status</td>
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<td>good</td>
<td>79</td>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>fairly good</td>
<td>218</td>
<td>88</td>
<td>12</td>
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<tr>
<td>average</td>
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<tr>
<td>fairly poor</td>
<td>14</td>
<td>50</td>
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*WD* = self-reported difficulty in walking 2-km without a rest in 2002.

† p-value from the Chi-square test of independence.
Table 2. Cross-sectional associations between level of physical activity and health-related fitness test results, health-related fitness summary score and body mass index at baseline (1996).

<table>
<thead>
<tr>
<th>Health-related fitness at baseline</th>
<th>Physical activity at baseline</th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th>p-value*</th>
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<tr>
<td></td>
<td>Vigorous activity &gt; 2 x week vigorous activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>Mean (SE)</td>
<td>n</td>
<td>Mean (SE)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Backwards walk (s) men</td>
<td>61</td>
<td>23.8 (1.1)</td>
<td>155</td>
<td>25.1 (0.7)</td>
<td>0.339</td>
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</tr>
<tr>
<td>women</td>
<td>91</td>
<td>32.6 (1.2)</td>
<td>157</td>
<td>32.8 (0.9)</td>
<td>0.909</td>
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<td></td>
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<tr>
<td>One-leg squat men</td>
<td>68</td>
<td>11.2 (0.5)</td>
<td>171</td>
<td>10.6 (0.3)</td>
<td>0.277</td>
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<tr>
<td>(points, 0-13) women</td>
<td>106</td>
<td>8.4 (0.4)</td>
<td>186</td>
<td>6.8 (0.3)</td>
<td>0.001</td>
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<tr>
<td>1-km walk (min:s) men</td>
<td>68</td>
<td>9:24 (0:09)</td>
<td>167</td>
<td>9:48 (0:06)</td>
<td>0.037</td>
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<tr>
<td>women</td>
<td>108</td>
<td>10:06 (0:07)</td>
<td>188</td>
<td>10:37 (0:05)</td>
<td>&lt;0.001</td>
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<tr>
<td>HRF summary score men</td>
<td>68</td>
<td>3.9 (0.2)</td>
<td>168</td>
<td>3.5 (0.1)</td>
<td>0.108</td>
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<tr>
<td>(points, 0-6) women</td>
<td>106</td>
<td>3.7 (0.2)</td>
<td>186</td>
<td>3.1 (0.1)</td>
<td>0.001</td>
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<tr>
<td>Body mass index (kg/m²) men</td>
<td>68</td>
<td>26.7 (0.4)</td>
<td>173</td>
<td>27.0 (0.2)</td>
<td>0.528</td>
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<td></td>
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<tr>
<td>women</td>
<td>108</td>
<td>26.8 (0.4)</td>
<td>188</td>
<td>28.0 (0.3)</td>
<td>0.009</td>
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SE= standard error

*p-value from the univariate analysis of covariance, adjusted for age group
Table 3. The final confounder adjusted* logistic regression analysis to predict self-reported walking difficulty (n = 502).

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Physical activity</td>
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<tr>
<td>vigorously active ref.</td>
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<tr>
<td>non-vigorously active</td>
<td>1.90</td>
<td>1.00-3.56</td>
<td>0.053</td>
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<td>normal weight ref.</td>
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<tr>
<td>overweight</td>
<td>2.08</td>
<td>1.17-3.71</td>
<td>0.013</td>
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<tr>
<td>HRF summary score</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>high fit ref.</td>
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<tr>
<td>fit</td>
<td>2.55</td>
<td>1.12-5.81</td>
<td></td>
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<tr>
<td>low fit</td>
<td>5.79</td>
<td>2.52-13.32</td>
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</table>

* adjusted for gender, age group, gender*age group, marital status, vocational education and smoking

OR= odds ratio

CI = confidence interval
Appendix 1. Description of the health-related fitness tests for high-functioning older adults and test-specific exclusion criteria.

Test: Backwards walking, to measure postural control in movement.  
Method: Subject walks backwards along a marked 6.1-m (20-ft) line with tandem steps (toes touching heel at every step) as quickly as possible. After a 2-meter practice trial, subject performs three trials.  
Outcome: Walking times of three trials as measured by a stopwatch (s) from standing position to end of line. Best time is final result.  
Exclusion criteria: Severe dizziness, severe symptoms of spine or lower extremities which may be aggravated by test.

Test: One-leg squat with increasing weight, to assess functional strength restrictions of leg extensors.  
Method: Subject takes a short step forward, first with right leg, squats down until knee of tracking leg lightly touches mat, then rises immediately, and steps back to starting position. Squat is repeated with left leg.  
Outcome: Load limit for a successful squat task measured as maximum weight relative to subject’s body weight, up to 125% (1-13 points). Test starts with body weight (i.e., no added weight) and 5% increments of body weight are added at 4 successive steps of 10%, 15%, 20% and 25%, using a weight vest.  
Exclusion criteria: Dizziness, severe diseases or symptoms of cardiovascular system, moderate or severe symptoms of spine, hip and knee which may be aggravated by test movement.

Test: 1-km walk, to assess sub-maximal aerobic capacity.  
Method: Subject walks as fast as possible on a flat surface using normal walking style.  
Outcome: Walking time (min) measured by a stopwatch.
Exclusion criteria: Severe diseases or symptoms of cardiovascular system, severe dizziness, severe symptoms of spine, hip and knee which may be aggravated by test.
Figure 1. Odds ratios (with 95% confidence intervals) of association between self-reported walking difficulties and health-related fitness tests and body mass index. Logarithmic scale. The odds ratios are adjusted for gender, age group, gender*age group, marital status, vocational education and smoking. Vigorously active subjects with the best test performance or normal weight were used as a reference group.