A Health-Related Fitness and Functional Performance Test Battery for Middle-Aged and Older Adults: Feasibility and Health-Related Content Validity

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ABSTRACT. Malmberg JJ, Miilunpalo SI, Vuori IM, Pasanen ME, Oja P, Haapanen-Niemi NA. A health-related fitness and functional performance test battery for middle-aged and older adults: feasibility and health-related content validity. Arch Phys Med Rehabil 2002;83:666-77.

Objective: To evaluate the feasibility and health-related content validity of 6 health-related fitness (HRF) and 3 functional performance (FP) tests among middle-aged and older persons.

Design: Cross-sectional methodologic study.

Setting: Field laboratories in 3 communities of northeast Finland.

Participants: A regionally representative, community-based cohort of 55- to 79-year-old men (n=501) and women (n=632).

Interventions: Not applicable.

Main Outcome Measures: Health-related test exclusion rates (%) by age groups and odds ratios (ORs) of subjective health outcomes by fitness categories (least 20%, next 40%, most fit 40%).

Results: The health-related test exclusion rates increased with age, mainly because of musculoskeletal health limitations among the women and cardiovascular and musculoskeletal health limitations among the men. With the exception of dynamic back extension, 1-leg squat, 1-leg standing balance, and the 1-km walk among the women 75 years and older, 85% or more of the subjects qualified for the HRF tests and 95% or more for the FP tests. Strong and graded associations were found for cardiorespiratory and musculoskeletal fitness and the FP test levels with perceived health and functional ability status among both the men and the women (OR range, 2–31). The motor fitness test level was primarily associated with functional ability status.

Conclusions: All the HRF and FP tests showed health-related content validity, and 4 of 6 of the HRF tests and all of the FP tests proved to be safe, with minor health-related test exclusions for middle-aged and older adults. The findings may help to target physical activity intervention toward persons at high risk for declining health and functional ability.

Key Words: Exercise test; Physical fitness; Rehabilitation; Reproducibility of results.

AN INCREASE IN THE NUMBER of individuals 65 years and over has been projected.[1] Because of this projected increase, problems related to declining health and functional ability have grown in importance. In addition, the physical activity level of the aging population is becoming an important health promotion issue. Physical activity and exercise recommendations have extended the traditional approach of structured exercise to lifestyle activity in promoting the health and functional ability of the elderly.[2,3] From a public health perspective, knowledge of the health and functional status of the aging population is of critical importance if physical activity intervention is to be targeted toward those at high risk of declining health[4] and functional ability.[5,6] It is also imperative to examine more quantifiable outcomes of habitual physical activity if the contribution of physical activity to the health and functional ability of the aging population is to be better understood.

Physical fitness can be defined as an outcome of habitual physical activity. The scientific evidence indicates that aerobic exercise and fitness can improve cardiovascular and metabolic health[7-9] and that increasing motor and musculoskeletal fitness can improve the ability of older persons to perform daily tasks.[3,10,11] Better motor and musculoskeletal fitness also may prevent falls,[12] decrease the risk for osteoporotic fractures related to falls,[13-15] and reduce nursing home admissions.[16]

Based on the known relationships between physical activity, fitness, and health, a new fitness concept, ie, health-related fitness (HRF), has recently been introduced.[17] HRF refers to the components of fitness (eg, cardiorespiratory, motor, musculoskeletal, morphologic, metabolic factors) that are affected by habitual physical activity and are related to various health outcomes. The health outcomes can be characterized on a continuum beginning with the capacity to enjoy life and withstand challenges and ending with morbidity or, in the extreme, mortality. Functional performance (FP) is related to the components of HRF, and it refers to the ability to perform tasks for independent living and overall well-being.

By assessing relevant aspects of HRF and FP, researchers can provide useful information for targeting physical activity intervention toward individuals or populations at risk for declining health and functional ability. Several attempts have already been made to develop field methods for assessing the physical fitness and FP of middle-aged and elderly people (ie, the Evergreen Project,[18] Groningen Fitness Test for the Elderly,[19] Functional Fitness Assessment for adults over 60 years,[20] Functional Fitness Assessment for Older Adults,[21] Continuous-Scale Physical Function Performance,[22] Fitness Canada,[23] Eurofit,[24] UKK Institute's HRF Test Battery [HR-

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FTB] for adults[25]). To our knowledge, only the UKK Institute's field-based HRFTB for middle-aged adults has been designed for physical activity promotion for health and has been evaluated systematically for its reliability,[25] safety and feasibility,[26] health-related validity,[27] and physical activity–related validity.[28] The validity, safety, and feasibility of the HRFTB's motor and musculoskeletal fitness test items were established in 2 consecutive studies,[25-28] and the reliability and criterion validity[29,30] and feasibility[31] of the cardiorespiratory fitness test item were assessed in a series of earlier studies.

Because the HRFTB[25] was developed and validated for adults under the age of 60 years, the purpose of the present study was to determine the appropriateness of the HRFTB for older adults by investigating its feasibility and health-related content validity in this respect in the cross-sectional part of a 16-year follow-up study. The hypothesis for feasibility was that applying the safety procedure would cause health-related test exclusion rates to increase systematically with age, mainly because of self-reported musculoskeletal and cardiovascular health limitations, but that no severe injuries or symptoms requiring medical treatment would result from participation in the tests. Based on the HRF concept,[32] the hypotheses for health-related content validity were (1) that body composition, cardiorespiratory fitness, musculoskeletal fitness, and FP would be associated with perceived health and functional ability and (2) that motor and musculoskeletal fitness would be associated primarily with functional ability in the study population.

METHODS

Study Population

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-size industrial town and 2 rural municipalities in northeast Finland.[33] The result was a target population of 6787 men and women, of whom 5259 (77.5%) answered the baseline survey in 1980. According to national census data from the Central Statistical Office of Finland, a total of 340 men and 150 women (9.3% of the cohort) died between the baseline survey on March 1, 1980, and the follow-up survey on September 30, 1996.

The study population consisted of all the men and women who were both alive and between the ages of 55 and 79 years in 1996. A total of 1682 of the 1969 survivors (85.4%) responded to the follow-up survey in 1996. Of the 287 nonrespondents, 133 (6.7% of the alive cohort in 1996) failed to return the questionnaire after 2 requests, 109 (5.5%) did not return the survey in due time, 29 (1.5%) refused to respond, 7 (0.3%) did not respond because of health restriction, and 9 (0.5%) could not be contacted. In addition, 57 (2.9%) of the respondents had moved to areas outside the 3 target communities and were excluded from the study. The response rate for the women at or over the age of 70 years was somewhat lower than for the younger women (86% vs 92.5%), but no difference existed in the response rate between the men and women (91.5% vs 90.5%). A short supplementary telephone interview survey made by the health care personnel in one of the study communities indicated that the proportion of persons living alone was higher among the 29 nonrespondents (93.1%) than among the 364 respondents (21.3%) but that no difference existed between the 2 groups with respect to the proportion able to move around independently outdoors or on stairs (90.4% vs 89.7%, respectively).

The respondents' readiness to participate in the HRF and FP assessment was prescreened on the basis of their self-rated ability to walk outdoors and on stairs (fig 1). The exclusion

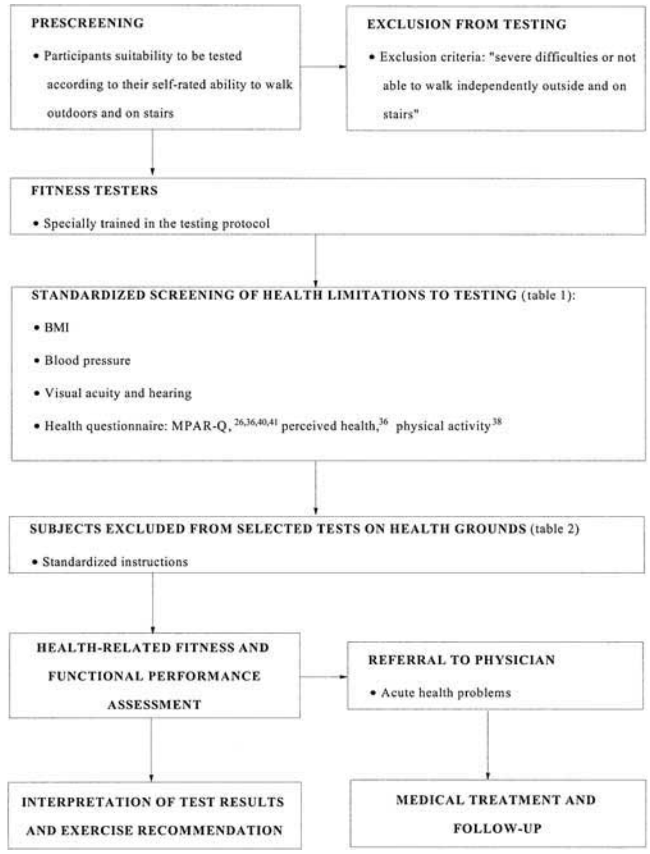

Fig 1. Safety procedure for HRF and FP assessment in middle-aged and older adults. Abbreviation: MPAR-Q, Modified Physical Activity Readiness Questionnaire.

criterion for the assessment was "severe difficulties or unable to walk independently outdoors and on stairs." Of the 1625 respondents who resided in the 3 target communities, 213 (10.8%) persons, mostly women 70 years and older, were excluded. A total of 1412 persons met the eligibility criteria and were invited for testing, and 1133 (80.2%) of those invited finally participated in the HRF and FP assessment.

Procedures

A self-administered, postal survey provided data on sociodemographic status, perceived health, chronic conditions, functional ability, physical activity, and smoking and alcohol consumption. The survey items have been related to the existence of chronic diseases,[34] prediction of coronary heart disease risk,[35] use of physician[36] and hospital services,[37] and decreased risk of all-cause[36,38,39] and cardiovascular disease[38,39] mortality among middle-aged and elderly adults.

A team of 6 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 3 study communities. The health screening included the measurement of body weight and height for body mass index (BMI), the measurement of systolic (SBP) and diastolic blood pressure (DBP) at rest (auscultation method by mercury sphygmomanometer after 5min of rest in the sitting position), and tests of visual acuity (standardized vision card, 0–2.0) and hearing accuracy (understanding of conversation over a distance of 5m or 16ft, able/not able). The use of spectacles and

Table 1: Descriptive Results of the Health Screening: Percentage of Subjects With a High BMI, Elevated Blood Pressure, Reduced Visual and Hearing Ability, Poor Perceived Health,[36] Low Physical Activity Level,[38] or Diseases and Symptoms Reported in the MPAR-Q[26,36,40,41]

Health Screening Measure	Age Groups for Men (y)						Age Groups for Women (y)					
	55–59 (n=161)	60–64 (n=122)	65–69 (n=114)	70–74 (n=74)	75–79 (n=30)	Total (n=501)	55–59 (n=187)	60–64 (n=158)	65–69 (n=154)	70–74 (n=87)	75–79 (n=46)	Total (n=632)
BMI ≥30kg/m^2	17	20	18	20	10	18	30	32	29	41	37	32
Blood pressure												
DBP ≥100mmHg	9	14	10	15	0	11	8	10	9	3	9	8
SBP ≥160mmHg	17	30	40	47	27	31	20	21	36	39	50	29
Visual acuity, 5m <0.3 (0–2.0)‡	1	0	0	1	0	1	0	1	0	1	0	1*
Hearing accuracy, 5m (difficulty or not able)	0	2	3	20	20	5*	2	0	1	5	15	2
Perceived health (rather poor or poor)	7	9	7	15	14	9*	2	5	7	6	2	5*
Weekly physical activity (some or none)	46	43	47	63	63	49*	42	42	54	72	76	51*
MPAR-Q questions (yes)§												
1. Have you had a heart attack or heart surgery?	12	16	16	30	23	17	4	6	8	7	9	6*
2. Do you have pain in your heart and chest during physical exertion?	29	41	41	52	43	39†	32	34	43	49	51	39†
3. Do you often feel faint or have spells of severe dizziness?	13	20	13	25	30	18*	23	32	34	29	31	29†
4. Has your physician ever told you that you have a joint problem such as arthritis?	7	15	7	22	20	12*	12	21	19	21	27	18*
5. Do you have back or other frequent or chronic musculoskeletal problems?	58	58	59	69	47	59*	60	58	63	59	59	60*
6. Is there any other health reason, not mentioned here, why you should not follow a physical activity program, even if you wanted to?	12	13	16	23	21	15†	16	11	21	21	29	18†
7. Are you taking medications?	42	65	60	81	73	59*	56	60	70	70	72	63

* Fewer than 10 missing cases.
† More than 10 but less than 30 missing cases.
‡ Standardized vision card.
§ Information was cross-checked with participant reports of chronic diseases in the follow-up survey.

hearing aids was permitted in the visual and hearing tests. The health screening also included a Modified Physical Activity Readiness Questionnaire[26,36,40,41] (MPAR-Q) a question on perceived health,[36] and a single-item self-assessment of leisure-time physical activity that covered the intensity, frequency, and duration of any type of exercise during the past 12 months (rated "vigorous activity twice or more times a week," "vigorous activity once a week and some light-intensity activity," "some activity each week," "no regular weekly activity").[38] The descriptive results of the health screening are in table 1.

By using information from the health screening, the testers applied the safety procedure to exclude noneligible participants from the various HRF and FP tests (fig 1). The testers were trained to administer and score the tests. In addition, testers with first-aid skills and equipment were available during the testing to treat potential health problems, and they were instructed to refer the participants to a physician at the local health care center, if necessary.

The participant's invitation to the testing session contained information about the purpose of the study and the possibility of interrupting the test at any time. Each participant signed the statement of informed consent before taking part in the assessment. The study was approved by the ethics committee of the UKK Institute for Health Promotion Research.

HRF and FP

The HRF and FP assessment included the determination of body composition (BMI), 6 HRF tests, and 3 FP tests (table 2). One motor fitness test was used to assess balance.[25] Four musculoskeletal fitness tests concentrated on flexibility of the trunk,[25] flexibility of the lower extremities,[25,a] muscular endurance of the trunk,[42,b] and muscular strength of the lower extremities.[25] Three FP tests assessed mobility during a 6.1-m (20ft) walk,[10] chair stand (43cm),[5] and stair climb and descent[43] (3 times a set of 8 steps each 17cm high).[44,45] The tests were administered in a standard order, followed by a 10-minute rest before the cardiorespiratory fitness test.[29] The participants were consistently encouraged to achieve their best or "usual" test performance. They were asked to perform the test as fast as possible without risking their health to obtain their best test performance, or they were asked to perform the test at their own pace to obtain their usual test performance.

Table 2 describes each test and the test-specific exclusion criteria. Table 3 lists the diseases and symptoms that led to subject exclusions. Detailed descriptions of the reliability[10,23,29,30,42,44,46,47] and feasibility[26,31] of the tests have been given elsewhere. In brief, the interrater intraclass correlation coefficients were good, and the mean test-retest differences ranged between small and moderate for the 1-leg squat, trunk side bending, and 1-leg standing balance tests of the middle-aged adults.[25] In addition, the test-retest correlation coefficients were high for the knee extension range of motion (ROM),[47] dynamic back extension,[42,b] and the 2-km walk time[29] of the middle-aged adults, and they ranged between moderate and high for the 6.1-m walk,[10] the chair stand,[46] and the stair climb and descent[43-45] of the middle-aged and older adults.

The interrelationships between the HRF and FP test items were assessed with age-adjusted partial correlation coefficients.

Table 2: Description of the HRF and FP Tests and the Test-Specific Exclusion Criteria

Body Composition

Test: BMI for the assessment of obesity.
Method: standard measures of weight and height.
Outcome: BMI (kg/m^2).

Motor Fitness

Balance

Test: 1-leg standing balance for assessing static postural control while the area of support is reduced.[25]
Method: subject stands as still as possible on the preferred leg wearing sport shoes. The opposite foot is placed at knee level along the inner side of the supporting leg with the thigh rotated outward and arms relaxed to the side.
Outcome: duration of balance task up to 60 seconds as measured by a stopwatch.
Exclusion criteria: severe dizziness, severe symptoms of the spine or lower extremities that may be aggravated by the test.

Musculoskeletal Fitness

Trunk flexibility

Test: trunk side-bending to the right and left for measuring the average ROM in lateral flexion of the thoracic and lumbar spine and pelvis.[25]
Method: subject stands on marked lines (15cm apart) with the back against the wall and arms straight at the sides of the body. Subject slides the middle finger along the lateral thigh to the right and then to the left as far as possible, keeping shoulders and buttocks in contact with the wall and heels in contact with the floor.
Outcome: the average distance (cm) between the maximal right and left side-bending ROM measured by a cloth tape measure.
Exclusion criteria: severe dizziness and severe spinal symptoms that may be aggravated by the test movement.

Lower-Extremity Flexibility

Test: knee extension ROM for assessing hamstring muscle extensibility.[25]
Method: subject lies supine with the knee and hip to be measured in 90° flexion. The opposite leg rests extended. The inclinometer[a] is attached to the medial side of the ankle.
Outcome: the average scores (deg) between the maximal left and right knee ROM.
Exclusion criteria: severe symptoms of the lumbar spine or lower extremities that hinder the subject from getting on or up from the floor or that may be aggravated by the test movement.

Trunk Muscular Endurance

Test: dynamic back extension for assessing trunk extensor muscle endurance.[42]
Method: subject lies in a semi-inclined body position (50°) in a standing hyper extensor[b] with hips and lower legs supported and fingers crossed behind the neck. Subject raises the upper body off the table to a straight back level and returns to the starting position at a self-selected pace.
Outcome: maximum number of repetitions in 30 seconds.
Exclusion criteria: moderate to severe diseases or symptoms of the cardiovascular system (table 3) and severe spinal, hip, and knee symptoms that may be aggravated by the test movement.

Lower-Extremity Strength

Test: 1-leg squat for assessing functional leg extensor strength.[25]
Method: subject proceeds to take a short step forward, first with the right leg, squats down until the knee of the tracking leg lightly touches the mat, and then rises up immediately and steps back to the starting position. The squat is repeated with the left leg.
Outcomes: a successful chair stand (see below) and the load limit for a successful squat task measured as the maximal weight relative to the subject's body weight up to 140% (1–13 points). The test starts with the chair stand and body weight (ie, no added weight) and 5% increments of body weight are added at 4 successive steps of 10%, 15%, 20%, and 25% using a weight-belt system.
Exclusion criteria: dizziness, severe diseases or symptoms of the cardiovascular system (table 3), and moderate or severe symptoms of the spine, hip, and knee that may be aggravated by the test movement.

Functional Performance

Mobility

Test: 6.1-m (20ft) walk for assessing the ability to walk.[10]
Method: subject walks the course at his/her "usual" pace after starting from a standstill.
Outcome: performance time (s) measured by stopwatch.
Exclusion criteria: severe dizziness and severe symptoms of the spine, hip, and knee that may be aggravated by the test.
Tests: chair stand for assessing the ability to rise from chair.[5]
Method: subject folds arms across the chest and stands up from a straight-backed chair (43cm), first 1 time and, if successful, then 5 times at a self-selected pace.
Outcome: performance time (s) in the chair stand measured with stopwatch from the initial sitting position to the final standing position at the end of the fifth stand.
Exclusion criteria: severe dizziness, severe diseases or symptoms of the cardiovascular system (table 3), and severe symptoms of the spine, hip, and knee that may be aggravated by the test.
Test: stair climb and descent for assessing the ability to climb stairs.
Method: subject walks up and down a standard flight of stairs[43,44] 3 times at self-selected pace, using the handrail for support only if needed.
Outcome: performance time (s) measured by stopwatch from the initial standing position to the end of the third descent.
Exclusion criteria: severe dizziness, severe diseases or symptoms of the cardiovascular system (table 3), and severe symptoms of the spine, hip, and knee that may be aggravated by the test.

Cardiorespiratory Fitness

Test: 1-km walk for assessing submaximal aerobic capacity.[29]
Method: subject walks as fast as possible on a flat surface using his/her normal walking style.
Outcome: walk test time (min) measured by a stopwatch.
Exclusion criteria: severe diseases or symptoms of the cardiovascular system (table 3), severe dizziness, and severe symptoms of the spine, hip, and knee that may be aggravated by the test movement.

Table 3: Diseases or Symptoms for Which Subjects Were Excluded From Selected HRF and FP Tests

Disease or Symptom
Severe cardiovascular diseases or symptoms
Recent myocardial infarction (within 12mo)
Coronary heart disease with chest pain
Moderate or severe valvular disease, cardiomyopathy, or other cause of heart failure
Untreated or labile hypertension of ≥180/110
Severe anemia (hemoglobin level <110–100g/L)
Severe symptoms during physical effort
Undiagnosed pain in the chest, shoulders, or upper extremities
Susceptibility to arrhythmia during or after physical effort
Asthma
Dyspnea
Dizziness
Headache
Other severe chronic diseases of labile status
Juvenile diabetes
Hyperthyroid activity
Active diseases of the vertebral column or joints
Mental instability
Influenza or any generalized infection of the body
Recent major trauma
Recent surgery
Unusually severe tiredness or weakness
Intoxication (alcohol, drugs), hangover

Most of the coefficients (*r*) were below 40. However, cardiorespiratory fitness, as measured by the 1-km walk, and musculoskeletal fitness, as measured by dynamic back extension, correlated moderately for both the men and the women with the stair climb and descent (r=.64, .63; r=−.53, −.52, respectively, for the gender and fitness measure), the chair stand (r=.43, .50; r=−.58, −.61), and the 6.1-m walk (r=.47, .43; r=−.32, −.34).

Feasibility of the Tests

The exclusion rates for each HRF and FP test were recorded by age group separately for the men and women on the basis of health limitations and unwillingness or refusal to participate (fig 2). In terms of safety of the HRF and FP assessment, all the acute musculoskeletal injuries or symptoms and all the cardiovascular complications that required referral to a physician were recorded.

Health-Related Content Validity of the Tests

Perceived health and functional ability were assessed by a self-administered questionnaire as 2 distinct health outcomes in the HRF continuum.[17] Perceived health represented the individual integration of the physical, psychologic, and social dimensions of health,[48] whereas functional ability referred to the individual's perception of ability to perform socially defined tasks and roles of daily living. Perceived health has been shown to be associated with functional ability,[49] but it does not fully explain the differences in functional status among middle-aged and older adults.[50,51] Because the constructs that it represents have been linked to personal evaluations of health and well-being across different age, disease, and treatment groups, it provides a useful measure of overall health in independent population samples.[48]

A standard question was used for perceived health status: "How do you rate your current state of health? Good, rather good, average, rather poor, poor."[36] The question has been associated with risk factors and disease indicators for heart disease,[52] as well as with the use of outpatient physician services[36] and mortality.[36,52] The short-term (22d) reproducibility of perceived health status has been shown to be good (weighted κ=.67) in a representative population sample of middle-aged and older individuals,[53] and, in our study, its long-term (13mo) reproducibility proved to be moderate (weighted κ=.42–.47) in a population sample of middle-aged individuals.[36]

Functional ability was determined from the self-rated difficulties revealed by 3 mobility tasks.[54-57] These mobility tasks were chosen because of their less gender- and environment-specific nature, their logical basis for expressing multiple dimensions of HRF, and their direct linkage to FP in terms of lower-extremity functioning, which has been shown to have a substantial effect on the ability of older persons to remain independent.[5,6] The participants rated their current capacity according to 4 categories of difficulty (from "no difficulty" to "not able") with respect to climbing several flights of stairs without rest, walking 2km without rest, and running a distance of 100m. Self-ratings of mobility difficulties have been related to different chronic conditions and disabilities, particularly cardiovascular and musculoskeletal disease,[57-59] loss of independence,[57] and nursing home admission and premature mortality[5] among the elderly. The reproducibility of mobility self-ratings has been shown to range between fair and good (weighted κ=.57–.70) in a representative population sample of middle-aged and older individuals.[53]

Data Analysis

All the analyses were conducted separately for the men and the women. The age groups used in the analysis were 55 to 59 years, 60 to 64 years, 65 to 69 years, 70 to 74 years, and 75 to 79 years. The subjects were grouped into fitness categories and age- and gender-specific cut points according to their HRF and FP scores. The least fit 20% of the participants in each age-gender group were classified as having "low fitness," the next

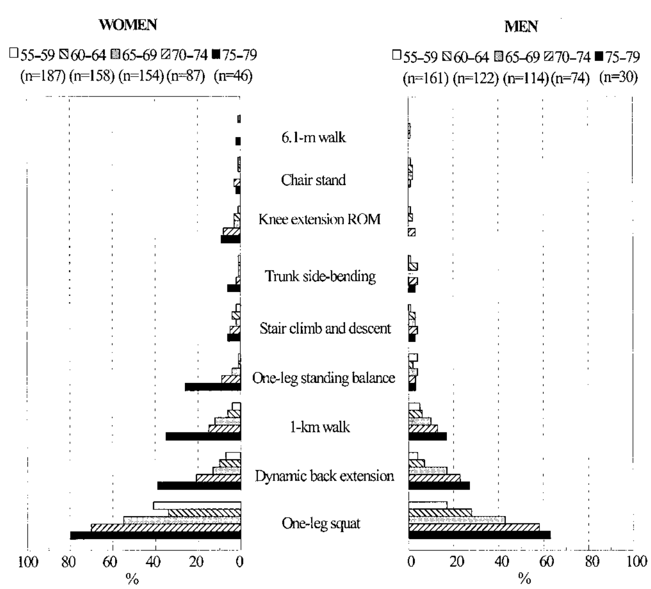

Fig 2. Percentage of men and women in each age group excluded from the HRF and FP tests because of health limitations, interruption, or refusal to participate.

40% were categorized as having "moderate fitness," and the remaining 40% were considered to belong to the "high fitness" category.[27,60] The corresponding cut points for the BMI were "high BMI," "moderate BMI," and "low BMI." Because the distribution of the 1-leg squat test scores were truncated and therefore skewed, the cut points for the 3 fitness categories were assigned differently among the women, and the 2 highest fitness categories were combined for the men according to Suni et al.[27] Eleven percent of the women and 46% of the men obtained the maximum score in the 1-leg squat test.

Multinomial logistic regression models with 3-level health outcomes were used to estimate the odds ratios (ORs) with 95% confidence intervals (CIs) of average and poor perceived health and average and poor self-rated running ability in the fitness categories. The high fitness and good perceived health category and the high fitness and good self-rated running ability category were used as reference, respectively. Because poor self-rated walking ability and poor self-rated stair climbing ability were used as exclusion criteria, logistic regression models with 2-level health outcomes were used to estimate the ORs of average or poor (combined) self-rated walking ability and average or poor self-rated stair climbing ability in the fitness categories. The high fitness and good self-rated walking and the high fitness and good self-rated stair climbing categories were used as references, respectively. When the 95% CI did not include 1.0, the results were considered statistically significant ($P<.05$). Age, living situation, education, and smoking status were included in all the models as possible confounding variables.

RESULTS

The demographic characteristics of the study sample are listed in table 4. The mean age ± standard deviation (SD) of the 1133 participants was 63±6.3 years, with 55.4% between 55 and 64 years, 38% between 65 and 74 years, and 6.6% between 75 and 79 years. Over half the participants were women (55.8%).

Most subjects reported at least 1 chronic condition (77.9%). A total of 26.6% of the persons under the age of 65 years and 25.7% of persons 65 years or older reported some form of cardiovascular disease (eg, ischemic heart disease, coronary heart disease, hypertension, heart insufficiency, cardiac arrhythmia, intermittent claudication). Correspondingly, 27.1% of the younger subjects and 23.5% of the older subjects reported some form of musculoskeletal disease (eg, hip or knee arthrosis, chronic back problem, arthritis), the corresponding values being 6.3% and 7.1% for some form of respiratory disease (eg, asthma, bronchitis, emphysema), 3.9% and 5.3% for diabetes, and 1.5% and 1.3% for some form of mental disease (eg, severe depression, mental instability). When rated according to a recent definition,[61] about 20% of the men and 30% of the women were classified as obese, with a BMI of $30kg/m^2$ or greater (see table 1). The distribution of the subjects with respect to perceived health and functional ability are presented in table 5 by age and gender.

Table 4: Demographic Characteristics of the Sample

	Men	Women	Total
N	501	632	1133
Age (y)			
Mean ± SD	63.8±6.3	64.1±6.4	64±6.3
Range	55–79	55–79	55–79
Education* (%)			
Higher education	4	5	4
Secondary education	22	22	22
Vocational training	42	39	41
No education	32	34	33
Living situation (%)			
Independent	13	31	22
Independent, with support	86	68	77
Home for the elderly	1	1	1
Weekly physical activity status† (%)			
Vigorous and light activity	51	48	50
Light activity	47	50	48
No activity	2	2	2
Smoking status (%)			
Never smoked	40	81	60
Past smoker	43	10	27
Current smoker	17	9	13

* Education in 1980; higher education (university, college), secondary education (middle or high school, vocational institute or college), vocational training (preparatory courses), no education (no professional training or education).
† Single-item self-assessment of leisure-time physical activity, including intensity, frequency, and duration of any type of weekly physical activity in the year preceding the survey.

Feasibility of the Tests

Less than 5% of the men and women in any of the 5 gender-specific age groups were excluded from the 6.1-m walk, the chair stand, and the stair climb and descent (see fig 2). Severe dizziness, angina pectoris, and intermittent claudication were the main health limitations to FP testing among the men (1%), and hip or knee arthrosis was the most prevalent among the women (2%).

No more than 15% of the subjects in any of the gender-specific age groups were excluded from the 1-leg standing balance test, the 1-km walk, the trunk side-bending test, and the knee-extension ROM test. However, the exclusion rates were somewhat higher for the 1-leg standing balance test (25%) and the 1-km walk (35%) in the oldest group of women. Arthrosis of the hip or knee (15%) and severe dizziness (7%) were the main health limitations to balance testing among these women, whereas arthrosis of the hip or knee (22%), severe dizziness (4%), and asthma (4%) were the main health limitations to their walk test.

A substantial proportion of persons 65 years and older were excluded from the dynamic back extension test. The exclusion rates for the 2 oldest age groups were 22% and 25% for the men and 20% and 40% for the women, respectively. The main health limitations to back extension testing in the 70- to 74-year-old age group were chronic back pain (7%) and angina pectoris (7%) among the men and joint arthrosis (11%) and back pain (6%) among the women. The main health limitations to dynamic back-extension testing in the 75- to 79-year-old age group were dizziness (10%) among the men and joint arthrosis (17%) and dizziness (7%) among the women.

The largest proportion of persons in any of the gender-specific age groups excluded from any test were those excluded from the 1-leg squat. Among the men, the exclusion rate increased from 15% in the youngest age group to 63% in the oldest group. Among the women, the rate went from 40% in the youngest group to 80% in the oldest group. The main health restrictions to squat testing were joint arthrosis (12%), chronic back pain (10%), and angina pectoris (6%) for the men and joint arthrosis (22%), chronic back pain (13%), and arthritis (3%) for the women.

One injury occurred during the testing. An older person sustained a lumbar compression fracture after losing balance and falling backward in the 1-leg squat test. The person was

Table 5: Distribution of the Subjects According to the Health Outcomes of Perceived Health and Functional Ability by Age and Gender

Health Outcome	Men (n=501) n	55–59* (n=161) %	60–64 (n=122) %	65–69 (n=114) %	70–74 (n=74) %	75–79 (n=30) %	Women (n=632) n	55–59 (n=187) %	60–64 (n=158) %	65–69 (n=154) %	70–74 (n=87) %	75–79 (n=46) %
Perceived health												
Poor	46	8	9†	7†	15	14	28	2	5	7†	6†	2
Average	254	51	55†	45†	53	52	323	52	51	43†	55†	67
Good	197	42	36†	48†	32	35	278	46	44	50†	39†	30
Functional ability												
Stair climbing												
Severe difficulty‡	32	4†	3†	5†	16†	18†	63	5†	11†	9†	19†	17†
Some difficulty	122	17†	26†	27†	37†	32†	229	30†	30†	45†	47†	61†
No difficulty	333	79†	70†	68†	47†	50†	313	65†	59†	46†	34†	22†
Walking												
Severe difficulty‡	30	4†	5†	4	15†	10†	47	2†	4†	6†	17†	35†
Some difficulty	108	17†	14†	26	31†	38†	137	17†	21†	24†	24†	37†
No difficulty	356	79†	81†	70	54†	52†	431	81†	75†	70†	59†	28†
Running												
Severe difficulty‡	120	12†	19†	24†	51†	53	176	16†	26†	28†	48†	62†
Some difficulty	179	32†	37†	47†	35†	27	251	38†	42†	51†	36†	33†
No difficulty	189	56†	44†	28†	15†	20	180	46†	32†	21†	16†	5†

* Age group (n).
† Fewer than 8 missing values in the respective age groups.
‡ Severe difficulty or not able.

referred to the physician at the local health center for diagnosis and subsequent medical treatment.

Associations With Perceived Health

The multinomial logistic regression models revealed strong and graded associations between cardiorespiratory and musculoskeletal fitness and the FP tests and perceived health among both the men and the women (fig 3). For the men, moderate and low fitness in the 1-km walk and low fitness in the dynamic back-extension, stair climb and descent, chair stand, and 6.1-m walk tests were associated with average (ORs=2.0–3.3) and poor (ORs=3.2–9.3) perceived health in comparison with the high fitness and good perceived health category. Moderate fitness in the chair stand test was associated with poor perceived health, whereas moderate fitness in the dynamic back-extension test and the stair climb and descent and low fitness in the 1-leg standing balance, trunk side-bending, and 1-leg squat tests were associated with average perceived health (ORs=1.8–3.2). No statistically significant associations were found between BMI and in the ROM in knee extension and perceived health among the men.

For the women, moderate and low fitness in the 1-km walk test, low fitness in the ROM in knee extension, dynamic back-extension, 1-leg squat, stair climb and descent, chair stand and 6.1-m walk tests, and a high BMI were associated with average (ORs=1.6–4.0) and poor (ORs=3.0–31) perceived health in comparison with the category of high fitness (low BMI) and good perceived health. Moderate fitness in the dynamic back-extension, chair stand, and stair climb and descent tests, and low fitness in the 1-leg standing balance and trunk side-bending tests were associated with average perceived health (ORs=1.7–2.0).

Associations With Functional Ability

The multinomial logistic regression models revealed strong and graded associations between the HRF and FP tests and the functional ability of the men and women (figs 4, 5). Among the men, moderate and low fitness in dynamic back-extension, stair climb and descent, chair stand, and 6.1-m walk tests; moderate fitness in the 1-km walk; and low fitness in the trunk side-bending, knee-extension ROM, and 1-leg squat tests were associated with average (ORs=2.5–4.8) and poor (ORs=3.0–5.7) self-rated running ability in comparison with the category of high fitness and good self-rated running ability. Moderate and high BMI values, moderate and low fitness in the 1-leg standing balance test, moderate fitness in the trunk side-bending test, and low fitness in the 1-km walk test were associated with poor self-rated running ability (ORs=1.9–23). Moderate and low fitness in all the HRF and FP tests, with the exception of moderate fitness in the knee-extension ROM test and a moderate BMI, were associated with average or poor self-rated stair climbing ability (ORs=1.7–8.3) and average or poor self-rated walking ability (ORs=1.9–8.8) in comparison with their respective categories of high fitness (low BMI) and good self-rated stair climbing ability and good self-rated walking ability.

Among the women, moderate and high BMI values and moderate and low fitness in the 1-km walk, 1-leg standing balance, stair climb and descent, chair stand, and 6.1-m walk tests and low fitness in the trunk side-bending, dynamic back-extension, and 1-leg squat tests were associated with average (ORs=1.8–4.2) and poor (ORs=2.0–26) self-rated running ability in comparison with the category of high fitness (low BMI) and good self-rated running ability. Moderate fitness in the trunk side-bending and 1-leg squat tests and low fitness in the knee-extension ROM test were associated with poor self-rated running ability, whereas moderate fitness in the dynamic back-extension test was associated with average self-rated running ability (ORs=2.0–5.0). Moderate and high BMI values and moderate and high fitness in all the HRF and FP tests, with the exception of moderate fitness in the knee-extension ROM, trunk side-bending, and dynamic back-extension tests, were associated with average or poor self-rated stair climbing ability (ORs=1.7–6.6) and average or poor self-rated walking ability

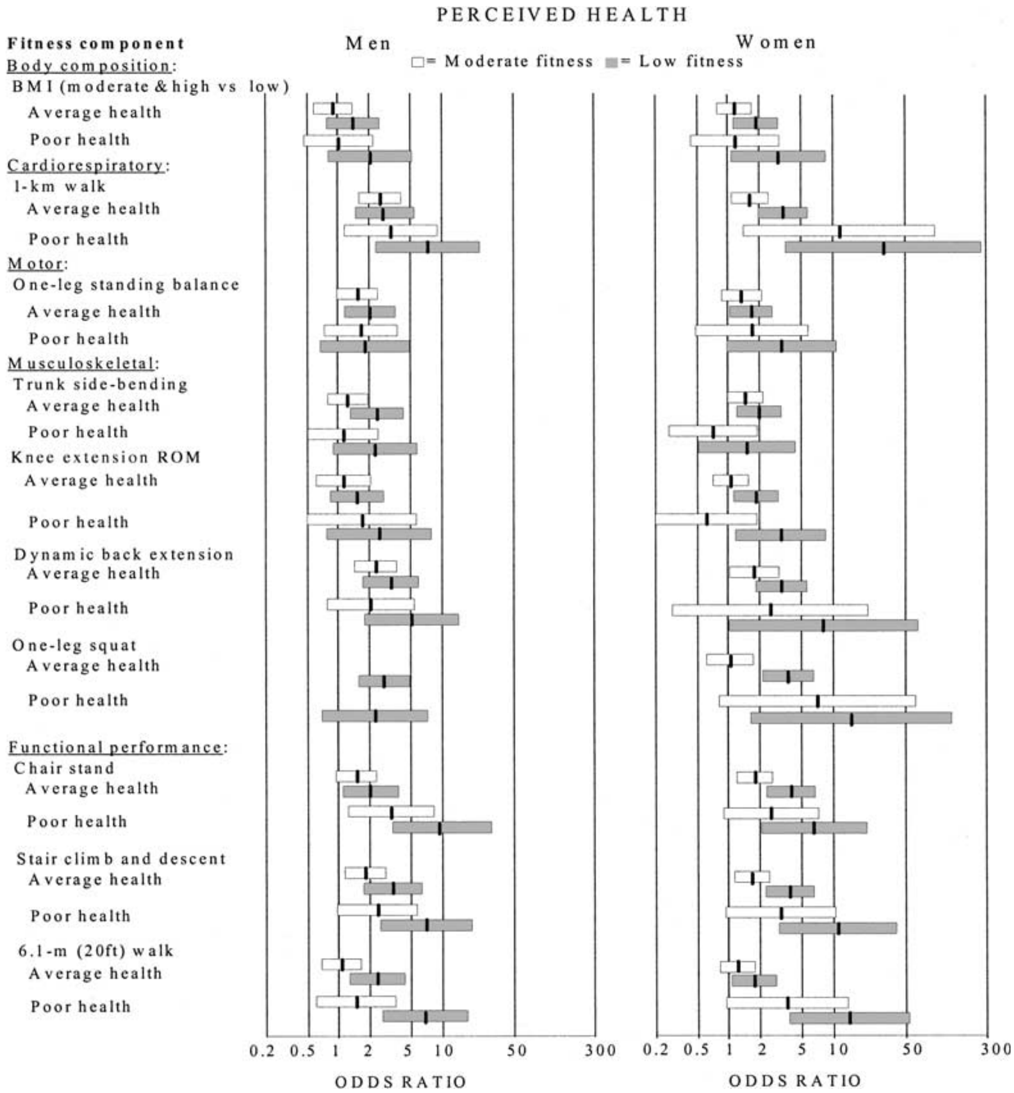

Fig 3. Associations between the HRF and FP tests and perceived health with high fitness and good perceived health as the reference category (OR with 95% CIs adjusted for age, education, living situation, smoking status). Because of the skewed distributions in the 1-leg squat test, the 3 fitness categories were assigned differently for the women and the 2 highest fitness categories were combined for the men.

(ORs=1.6–9.4) in comparison with their respective category of high fitness (low BMI) and good self-rated stair climbing ability and good self-rated walking ability.

DISCUSSION

Feasibility of the Tests

The results indicate that the HRF and FP tests of the HR-FTB, with the exception of 2 musculoskeletal fitness tests (dynamic back-extension, 1-leg squat), can be applied to middle-aged and older adults as long as minor health-related exclusions and physician participation are observed. As expected, the safety procedure led to a systematic increase in test-specific exclusion rates with age, mainly because of musculoskeletal health limitations among women and cardiovascular and musculoskeletal health limitations among men. Apart from the dynamic back-extension and 1-leg squat tests and the 1-leg standing balance and 1-km walk tests of the women 75 years and older, 85% or more of the subjects in each age group qualified for the HRF tests and 95% or more were able to participate in the FP tests. The low exclusion rates are in accordance with earlier Finnish population studies among middle-aged persons,[26,31] and they correlate with the rates reported in the Allied Dunbar National Fitness Survey[62] for middle-aged and older persons. However, the exclusion rates were lower in the present study than in the Mini-Finland Health Survey,[42] where 34% of the subjects between the ages of 55 and 59 years and 47% of the subjects between the ages of 60 and 65 years were excluded from simple muscular performance tests. Any comparison of the differences in the exclusion rates between these studies is limited because the studies used different methods. In the present study, as well as in the study by Suni et al,[26] a standardized screening of health limitations was performed by trained fitness testers before the HRF and FP testing (see fig 1). In the Mini-Finland Health Survey, a clinical evaluation of health limitations before fitness testing was performed by physicians.[42] Despite the safety procedure described in the present study, 1 of the 1133 participants was referred to

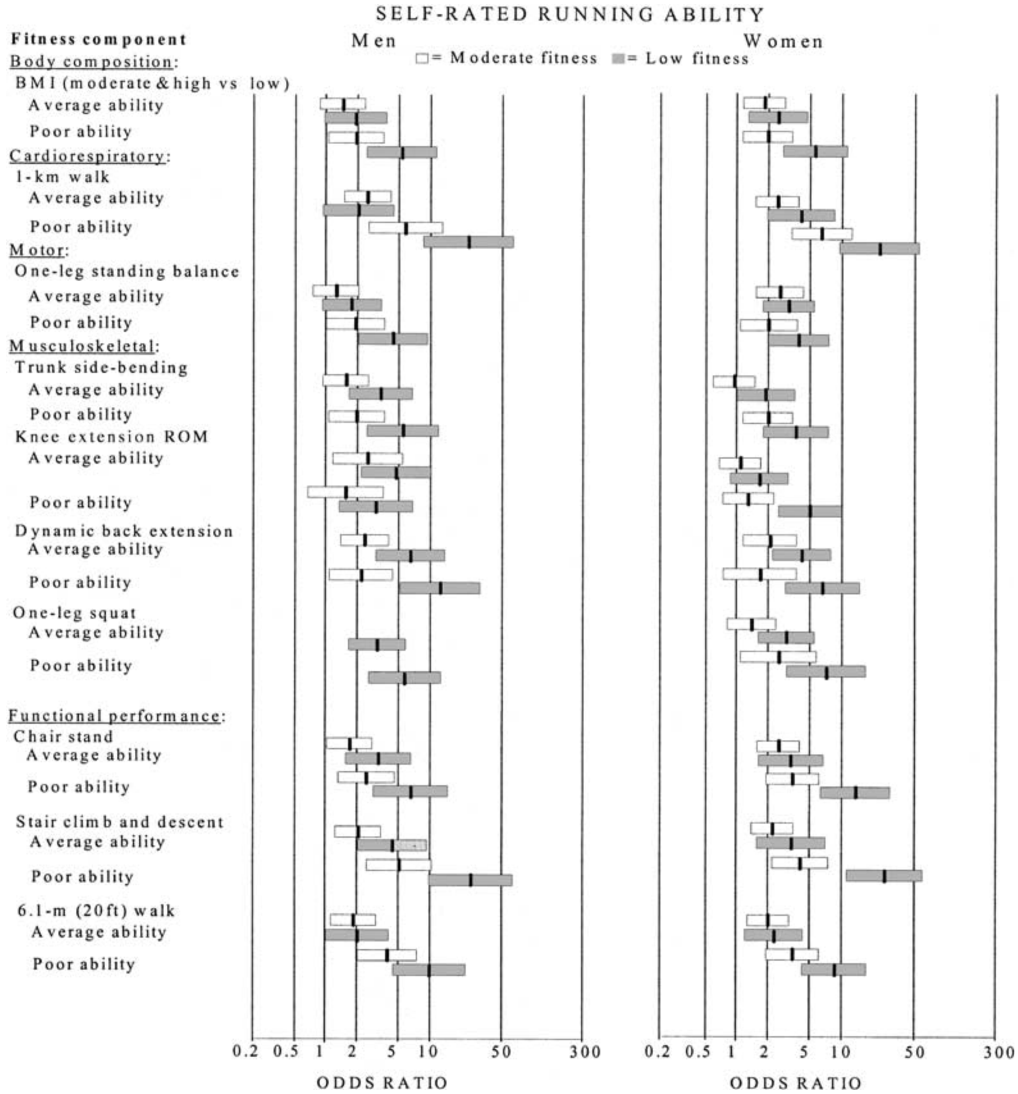

Fig 4. Associations between the HRF and FP tests and the self-rated running ability with high fitness and good self-rated running ability as the reference category (OR with 95% CIs adjusted for age, education, living situation, smoking status). Because of the skewed distributions in the 1-leg squat test, the 3 fitness categories were assigned differently for the women and the 2 highest fitness categories were combined for the men.

physician for clinical evaluation and medical treatment as a result of a fall-related injury in the 1-leg squat test. The accident could not be predicted because the 72-year-old woman had no health limitations to squat testing, and she reported that she engaged in weekly, vigorous, leisure-time physical activity.

Health-Related Content Validity of the Tests

As hypothesized, strong and graded associations were found for cardiorespiratory fitness (1-km walk), musculoskeletal fitness (dynamic back extension), and FP (stair climb and descent, chair stand, 6.1-m walk) with perceived health and functional ability. The similarity of the associations for the men and women supported the strength and consistency of these relationships. In the present study, body composition (BMI) was associated with functional ability among both the men and the women. Similar types of relationships have been found earlier in a cross-sectional study among middle-aged women[27] and in a longitudinal study among middle-aged and older women.[63] However, in the present study, BMI was related to perceived health only among the women, and this finding disagrees with the findings of the Cardiovascular Health Study.[64] Our present findings, together with those of other studies, suggest that weight control of middle-aged and older men and women would help prevent functional disability.

As hypothesized, motor (1-leg standing balance) and musculoskeletal fitness (trunk side bending, knee-extension ROM, 1-leg squat) were primarily associated with functional ability. This finding suggests that functional ability may be a better marker of motor and musculoskeletal fitness among middle-aged and older adults than perceived health is. This result is in line with the findings of earlier cross-sectional[5] and prospective[5,6] studies on poorer balance and lower-extremity muscular function and disability among the elderly. However, Suni et al[26] found no relation between balance and lower-extremity strength and self-rated stair climbing ability among middle-aged men. In addition, no relations were found between trunk

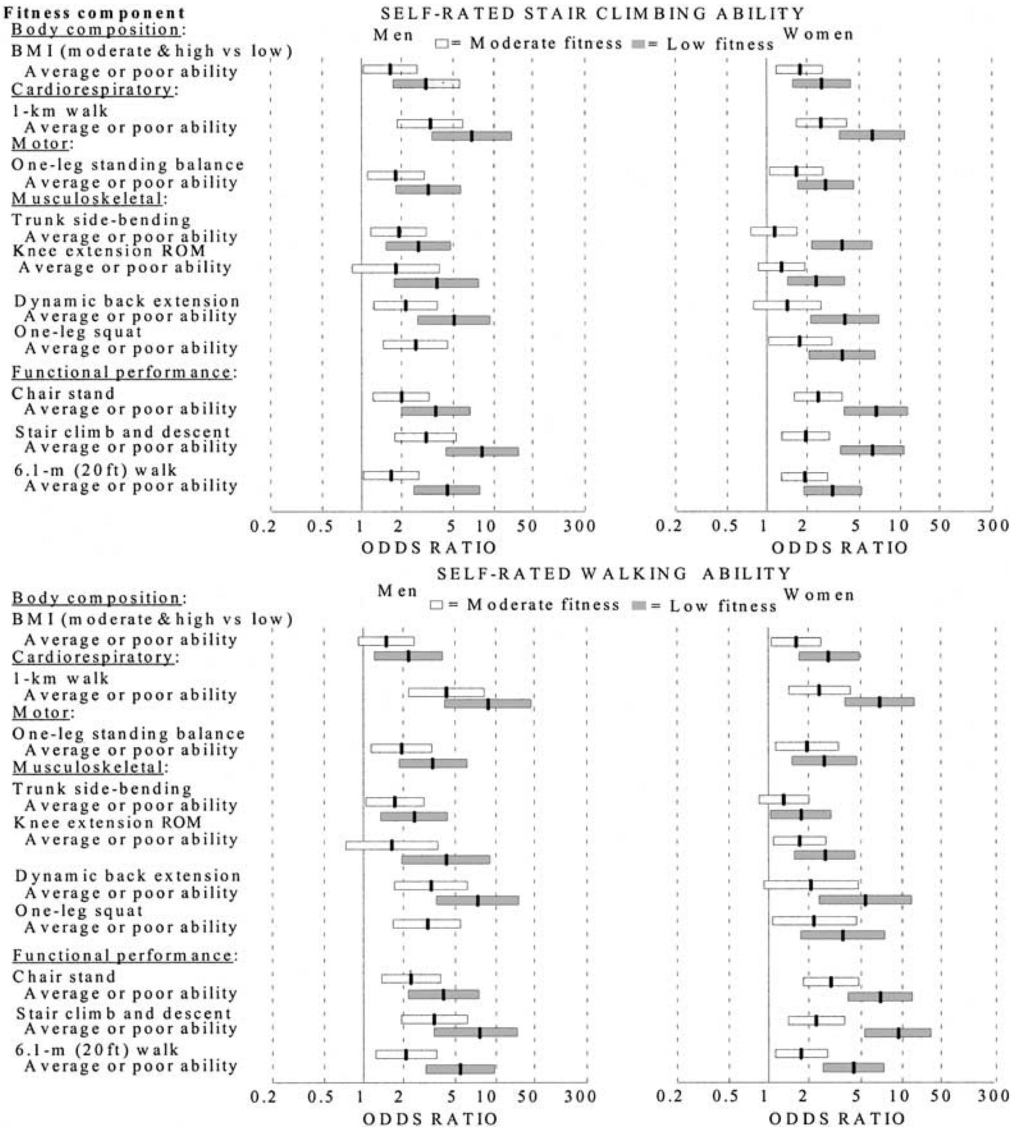

Fig 5. Associations between the HRF and FP tests and self-rated stair climbing and walking ability with the high fitness and good self-rated stair climbing and walking ability as the reference categories, respectively (OR with 95% CIs adjusted for age, education, living situation, smoking status). Because of the skewed distributions in the 1-leg squat test, the 3 fitness categories were assigned differently for the women and the 2 highest fitness categories were combined for the men.

flexibility and knee extensibility and self-rated stair climbing ability among men and women in the Suni study. The reason for this difference in the findings between our present study and the study by Suni et al[27] can possibly be explained by the age differences of the subjects. The postural control and lower-extremity strength of older men and the trunk flexibility and hamstring extensibility in older men and women may become increasingly more relevant for mobility in persons past middle age.

The present study has some limitations. It was subject to selection bias because a self-administered questionnaire was used to exclude persons with severe mobility difficulties (10% of the study population). This procedure may have caused the population estimates of fitness to be too high, especially if the fitness level of the nonparticipants was poorer than that of the participants, and may therefore limit the generalizability of the results to persons with some or no difficulty in walking independently outdoors and on stairs. However, in the present study, the effect of such bias is unlikely because no difference existed in the mobility status of the participants and nonparticipants in one of the study communities (Sotkamo), which was studied in more depth for mobility status. The present study was also subject to measurement bias because of the self-ratings of health and functional ability that were used to validate the HRFTB. Such bias may have affected the strength of the associations between fitness and the subjective health outcomes. The effect of such bias is unlikely because perceived health has been shown to be reliable[36,53] and valid in terms of predicting various subjective and objective health outcomes such as changes in physical functioning,[49,51] use of outpatient physician services,[36] coronary heart disease morbidity and mortality,[52] and overall mortality.[4,36,51] In addition, 2 of the 3 mobility self-ratings used in our study were cross-validated against other more objective measures. The mean time for the stair climb and descent and the 1-km walk decreased systematically as the level of self-rated difficulty in climbing several flights of stairs and walking 2-km without a rest decreased. Men who reported no difficulty in stair climbing and walking had an 18% and 15% lower mean time for the stair climb and descent and the 1-km walk, respectively, than did men reporting at least some difficulties, whereas the corresponding differences for the women were 24% and 13%. This result, in addition to the findings of earlier studies supporting the reliability[65] and construct validity[66,67] of mobility self-ratings among community-based elderly, suggests that validity of the self-rated information can be considered good for data from the present study. The most important limitation of the present study is its cross-sectional design. One may hypothesize that HRF and FP tests affect levels of perceived health and functional ability or vice versa. Obviously, additional prospective studies are needed to establish the predictive health-related validity of the HRF and FP tests in terms of health and functional ability.

Despite these limitations, the strength of this cross-sectional study, compared with that of other similar studies, is the assessment of a broad set of individual components of HRF and FP as they relate to standardized surveys of health and functional ability in a large population-based sample of middle-aged and older adults. Suni et al[27] along with Morey et al[68] found that a broad range of individual fitness components is related to various measures of health among middle-aged and elderly subjects. To our knowledge, only a few studies have investigated the components of HRF and FP within a wide age range.[69,70] To better understand the extent to which the components of HRF and FP contribute to various health outcomes, it is imperative to acknowledge the independent contributions of these components to the health of the aging population. The present study provides an important step in that direction.

CONCLUSIONS

The proposed test battery posseses content validity in relation to perceived health and functional ability and 4 of the 6 HRF tests (1-leg standing, trunk side-bending, knee-extension ROM, 1-km walk) and all of the FP tests (6.1-m walk, stair climb and descent, chair stand) can be safely applied to middle-aged and older adults when using the safety procedure for the HRF and FP test battery.

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Suppliers

a. Myrin goniometers; LIC Rehab, Svetsarvägen 4, S-17183 Solna, Sweden.
b. Standing Hyper Extensor; HUR Ltd, Patamäentie 4, 67100 Karleby, Finland.