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Assessment of Impairments That Limit Exercise and Use of Impairment Information to Generate an Exercise

Mirja Hannele Hirvensalo, Jiska Cohen-Mansfield, Shlomit Rind, and Jack Guralnik

Prescribing the correct exercise program is a challenge for older adults with multiple physiological impairments. The authors evaluated an assessment instrument that incorporates results of multiple categories of impairment, including strength, balance, gait, vision, and cognitive function. The physical therapist made judgments on the relative impact of 9 different impairments on specific exercises and on the total impact of all impairments on particular exercises. In a cohort age 75–85 y, functional limitations, impaired balance, pain, and low physical endurance were estimated to have the largest impact on the ability to carry out exercise activities, primarily walking, stair climbing, balance exercises, and stationary bicycling. The assessments revealed that the ability to exercise was related to objective measures of function, indicating that the therapist incorporated such objective measures into the impairment-impact rating. The impairment-impact assessment facilitates creating individualized exercise prescriptions for individuals with impairments.

Key Words: functional limitation, exercise counseling, recommendations, functional tests

Higher levels of exercise and physical activity are strongly related to decreased risk of disability in older adults (Stuck et al., 1999) and have been suggested as a potential way to prevent mobility limitation and disability (Brandon, Gaasch, Boyette, & Lloyd, 2003; Fiatarone et al., 1994; Hirvensalo, Rantanen, & Heikkinen, 2000; LaCroix, Guralnik, Berkman, Wallace, & Satterfield, 1993; Leveille et al., 1999; Rantanen, Guralnik, Ferrucci, Leveille, & Fried, 1999). Older adults who are not yet disabled but are at risk for disability might benefit the most from exercise prescriptions tailored for their individual needs and abilities that account for factors such as chronic conditions, impairments, and functional limitations (Heath & Stuart, 2002: King, Rejeski, & Buchner, 1998).

The impact of multiple impairments on exercise potential can be difficult to estimate when an older adult has chronic conditions or disability. To ensure safety

Hirvensalo is with the Dept. of Sport Sciences, University of Jyväskylä, Jyväskylä, 40014 Finland. Cohen-Mansfield is with the Hebrew Home of Greater Washington, Research Institute on Aging, Rockville, MD 20825. Rind is with the Outpatient Center, Adventist Rehabilitation Hospital, Silver Spring, MD 20903. Guralnik and Hirvensalo are with the National Institute of Aging, National Institute of Health, Bethesda, MD 20892.

and an appropriate exercise prescription, a complete evaluation of chronic conditions and functional assessment are recommended (American College of Sports Medicine, 1998, 2000, 2004). Important aspects of physical function that require assessment have been identified by epidemiologic research. These include lower extremity function, gait speed, balance, and endurance, which have been demonstrated to be predictors of incident disability, fall risk, and loss of independence (Chang et al., 2004; Guralnik et al., 2000; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995; Shumway-Cook, Brauer, & Woollacott, 2000). Along with this functional evaluation, the actual impact of physiologic impairments on exercise activities needs to be evaluated and prioritized. For example, individuals who have impaired balance might be wary of falling and as a result require an exercise program that accounts for this impairment. Older adults with reduced levels of lower extremity strength, reaction time, standing and leaning balance, and vision or those who suffer from chronic pain might have impairments that necessitate major modifications to their exercise regimen.

The "Guide to Physical Therapist Practice, Second Edition" (American Physical Therapy Association, 2001) identifies diagnosis as a keystone in the process of maximizing patient outcomes. Examination and evaluation processes culminate in diagnosis that directs subsequent decisions related to prognosis, including the plan of care and interventions such as physical activity. The therapist makes clinical judgments based on data gathered during the screening or examination to plan the most efficient and safe interventions necessary to reach the goals. There is an evident need, however, for an instrument that gathers the information required to facilitate the clinician's diagnosis. Screening-suitable exercise activities are an especially essential part of the decision-making process in prevention and in health promotion.

The aim of this article is to outline a systematic approach to assessing the impact of various impairments on specific exercise activities and to using this information to formulate the most suitable exercise prescription. The impact of nine specific impairments on walking, stationary bicycling, upper and lower extremity exercises, and balance exercises was estimated using an evaluation scale called the Global Impairment Impact Rating scale. This scale was developed in the Hebrew Home Study of Impairment and Exercise, in which older adults with impairments were assessed to recruit them into an exercise intervention. The aim of this study was to evaluate the consistency of a physical therapist's ratings with multiple objective measures of function that were available when she was making these ratings. The research question was how the physical therapist's impairment-impact rating was associated cross-sectionally and longitudinally with performance tests and assessments. Finally, we present exercise recommendations based on the use of the scale and analyze the association between the recommended exercise-intensity level and the impairment-impact rating in walking.

Methods

Participants

This study uses data from the Hebrew Home Study of Impairment and Exercise, a longitudinal community-based study of adults age 75–85 years who were not currently disabled but were at risk for future disability and did little or no physical exercise. The study design and the screening process of the participants have been described in detail elsewhere (Guralnik, Leveille, Volpato, Marx, & Cohen-Mansfield, 2003; Marx, Cohen-Mansfield, & Guralnik, 2003). The study was conducted in the years 1999–2000 and 21 months later in collaboration with the Laboratory of Epidemiology, Demography, and Biometry of the National Institute on Aging and the Hebrew Home of Greater Washington Research Institute on Aging. The aim of this research project was to develop a system for screening a nondisabled population of older adults to identify those who are at high risk for disability so that they could be preferentially recruited into an exercise intervention.

Participants were from the Hebrew Home housing facility in Rockville, MD, and the surrounding community. Initially, 441 people who were recruited through a wide variety of recruiting processes agreed to complete a telephone screening interview. Of these, 306 participants met eligibility criteria because they were living in the community; reported they were able to walk without a walker, walk two to three blocks without help, and walk up and down stairs without help; and had not engaged in strenuous sports or recreational activities over the preceding 7 days. These people were evaluated at home or at the Research Institute on Aging at the Hebrew Home of Greater Washington by a trained research assistant. In all, 111 met the final criteria for study entry because they had a score on a short physical-performance battery (SPPB, described below) of 4–9 and a score on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) of 18 or more. Summary scores of lower extremity function in the range of 4 to 9 have been shown to predict subsequent disability (Guralnik et al., 1995). Ultimately, 101 older adults came to the Research Institute's clinic for extensive evaluation by a trained physical therapist–researcher. Participants who completed the 400-m-walk test at baseline ($n = 81$) were eligible for a follow-up exam, and 63 were reassessed an average of 21 months later. The reasons for nonparticipation in the follow-up were refusal ($n = 9$), not located ($n = 5$), and died before the assessment ($n = 4$).

Measurements and Procedures

Health Questionnaire. At baseline, participants were mailed a health questionnaire about sociodemographic characteristics, health, and exercise habits that was to be completed and returned by mail or during an in-home visit. The presence of chronic conditions was determined by asking whether participants' doctors had ever told them that they had had a heart attack or myocardial infarction, angina pectoris, high blood pressure, congestive or chronic heart failure, a broken or fractured hip, arthritis or rheumatism, intermittent claudication, a compression fracture or collapsed or crushed vertebrae, Parkinson's disease, cancer, emphysema or chronic bronchitis, diabetes mellitus, cataract, stroke, chronic nervous or emotional problems, chronic foot trouble, or a hip or knee replacement (answer: yes or no). Presence of pain was determined by asking participants to rate their pain in the back, hip, knees, and feet when walking on a flat surface. For each item respondents were asked to rate their pain severity using a scale from 0 to 10. For the analyses, the mean of the pain-level severities in the back and knees was used.

Short Physical-Performance Battery. The short physical-performance battery (SPPB) used in this study has been described elsewhere in detail (Guralnik et al., 1994). The SPPB evaluates lower extremity function and uses tests of regularly paced gait speed over a 4-m course, standing balance, and time to rise from a chair five times. Each test was scored from 0 to 4 based on normative scores from a large, representative cohort. The three test scores were summed, yielding a range from 0 to 12.

Physical Therapist's Evaluation

A trained physical therapist-researcher (S.R.) carried out the examination at the Research Institute on Aging at the Hebrew Home of Greater Washington. A range of examinations and physical-performance tests—a performance-oriented assessment of balance (Tinetti 1986, 1988); manual muscle testing (Medical Research Council, 1975); muscle tests by handheld dynamometer (Bandinelli et al., 1999), described in the next section; and a 400-m-walk test—were carried out to provide a format for evaluating how a variety of different impairments affected the ability to participate in specific exercise activities.

Physical-Performance Tests. Tinetti's standardized performance-oriented assessment (Tinetti, 1986, 1988) of balance and gait was carried out. All items were scored as normal versus adaptive or abnormal. Manual muscle testing (Medical Research Council, 1975) was used to grade strength of extension and flexion in the hips, knees, and shoulders using a scale from 0 to 5 on which 0 = *no palpable or observable contraction;* 1 = *trace muscle contraction is palpable, no body part motion is observed;* 2 = *minimal range of motion is present against gravity;* 3 = *full range of motion with gravity eliminated;* 4 = *full range of motion is present against gravity with considerable resistance to motion provided by examiner;* and 5 = *full range of motion is present against gravity with strong resistance to motion provided by examiner*.

In addition, handgrip strength in the stronger hand was measured using a dynamometer (Model BK-7498, Fred Sammons, Inc., Burr Ridge, IL). Knee-extensor strength was measured using a Nicolas manual muscle tester (Model BK-7454, Fred Sammons, Inc.). Participants, seated in a hard chair, were asked to extend the right knee and push for 5 s as hard as they could against the dynamometer, which was positioned on the tibial plate proximal to the ankle. Strength was measured as the peak force that the examiner had to apply to break the isometric contraction. Hip flexion was measured by placing the dynamometer on the midpoint of the anterior surface of the distal femur, 10 cm above of the upper margin of the patella. Participants were asked to lift their knee as hard as they could against the dynamometer for 5 s. The hip and knee measurements were found to be reliable in an earlier study (Bandinelli et al., 1999). Participants were asked to walk 400 m at their usual pace on an indoor 20-m course. They were permitted to rest for up to 60 s in a standing position when they wanted to. If a participant's heart rate exceeded 135 beats/min or fell below 40 beats/min or if he or she reported chest pain, leg pain, tightness or pressure in the chest, shortness of breath, or feeling faint, lightheaded, or dizzy or needed to stop walking and sit down, the test was stopped.

The Global Impairment Impact Rating. After completing the examination, the physical therapist estimated the impact that specific impairments had on the participant's ability to perform certain exercises using the Global Impairment

Impact Rating scale developed in the Research Institute on Aging at the Hebrew Home of Greater Washington, which assessed older adults with impairments that put them at risk for future disability (see the appendix). The scale was modified from a clinical assessment by the physical therapist (S.R.). Impairments included cognitive impairment; impaired vision, motor control, balance, range of motion, and physical endurance; hypertonicity; muscle weakness; and pain. The ratings were made separately for 15 different exercise activities: walking 5 min; walking 20 min; stair climbing; raising arms above the head; hip, knee, ankle, and shoulder exercises with and without resistance; exercises with ankle weights; and stationary bicycling. For each exercise, the impact of impairments was estimated by the physical therapist using a scale from 0 to 4, where 0 indicated *no impact;* 1, *minimal reduction in ability or efficacy to perform the activity (up to 25%);* 2, *major reduction (25–50%);* 3, *substantial reduction (50–75%);* and 4, *impairment virtually prevented performance of the activity*. For validity analyses, Ratings 2 (major), 3 (substantial), and 4 (prevented) were combined to indicate a major reduction, because of the specific impairment, in the ability or efficacy to perform the activity. The Global Impairment Impact Rating was the overall impact that the combination of all the impairments had on certain exercises.

Exercise Recommendations. After estimating the impairment impact on different exercise activities, the physical therapist recommended the intensity level (very low, low, medium, or high) of stretching exercises, balance exercises, upper and lower extremity strength training, and walking. The physical therapist also recommended the program type appropriate for each participant: either a classroom program or a personally supervised program.

Statistical Analysis

To evaluate the systematic work of the physical therapist, her ratings of impairment impact on ability to exercise (no impact, minimal reduction, and major reduction) were compared with the results of multiple objective measures of function in cases of impaired balance, impaired endurance, and weakness. The impact of pain was compared with pain levels reported in the health questionnaire. Chi-square tests for categorical variables and one-way analyses of variance in continuous variables were used. First, ratings of the impact of impaired balance were compared with the proportions of abnormal results in Tinetti's performance-oriented assessment of balance in turning while walking and in ascending four stairs. Second, ratings of the impact of impaired physical endurance were compared with the time to complete the 400-m-walk test. Third, pain-impact ratings were compared with self-reported pain levels, and finally weakness-impact ratings were compared with the manual muscle-testing assessments, muscle-strength tests, and SPPB scores. General linear models (ANCOVA) were used to evaluate the longitudinal association of the physical therapist's baseline impairment-impact ratings for impaired balance, impaired physical endurance, and weakness with SPPB and 400-m-walk time at 21 months. The models were adjusted for age, gender, number of chronic conditions, and baseline performance scores on the SPPB or 400-m-walk test. Participants who did not complete the 400-m-walk test at follow-up were assigned the second-worst actual time of those who had (788 s). The association between the recommended exercise-intensity level and the physical therapist's global impact rating in walking was analyzed by cross-tabulation followed by chi-square test. The SPSS 11.0 software package was used to carry out the analyses (SPSS Inc., Chicago).

Results

The average age of the 101 participants at baseline was 79.1 ± 2.8 years, 72% were women, and most had at least a high school education. They had approximately four chronic conditions; 9% reported history of fracture, 18% heart attack, 21% hip or knee replacement, and 23% cancer; 70% had high blood pressure; and 77% had arthritis. Over half (52%) had moderate to severe pain in the back or lower extremities, of whom 15% had pain in at least two sites. About half (55%) of the participants reported difficulty in walking a mile, and one fourth (29%) had difficulty climbing one flight of stairs.

The physical therapist's ratings of nine specific impairments' minimal or major impact on the ability to perform 15 different exercises are shown in Tables 1A and 1B. In general, impaired balance, pain, and impaired physical endurance were estimated to have the largest impact on exercise activities, primarily walking, stair climbing, balance exercises, and stationary bicycling. The greatest impact was for impaired physical endurance, which was rated as limiting 20 min of walking in 31% of the participants at a minimal reduction level and 51% of participants at a major reduction level. Impaired balance was rated as limiting balance exercises, with the corresponding percentages of 48% and 42%. Weakness was estimated to have an impact on ability to perform strength training with resistance: hip exercises with resistance in 79% of participants, knee exercises with resistance in 42% of participants, and shoulder exercises in 33% of participants at a minimal or major reduction level. In this population, vision, cognitive impairment, motor control, hypertonicity, and limited range of motion were estimated to limit exercising in only a few people (1–5%). The Global Impairment Impact Rating indicated that the overall impact of all impairments limited ability to engage in 20 min of walking in 87% of the participants, stair climbing in 79%, hip exercise with resistance in 80%, balance training in 90%, and stationary bicycling in 71%.

The impairments (impaired balance, impaired endurance, pain, and weakness) that were estimated to have the greatest impact on exercise activities were compared with other assessments and tests performed by participants (Tables 2A, 2B, and 3). Tables 2A and 2B show that the level of the physical therapist's impaired-balance-impact rating for four tasks was highly in accordance with the results of Tinetti's performance-oriented assessment of balance (for turning while walking and ascending four stairs) and the SPPB. Participants who were rated as having a major reduction in the ability to perform an exercise often showed corresponding abnormalities in performance assessments or lower scores in performance tests than those with minor limitation and those with no limitation. For example, those who were rated as having a major reduction in the ability to walk 20 min because of impaired balance were all assessed as having abnormalities in Tinetti's standardized performance-oriented assessment of gait (turning while walking), but only 63% of those who were rated as having minimal reduction and 25% of those who were rated as having no limitation were assessed as having this abnormality. Participants rated as having major limitations in exercise activities because of

Table 1A Percentage of Participants With Physical Therapist's Impairment-Impact Ratings on Different Exercises

	Impairment-Impact Rating for Specific Impairments and Global Impairment									
	Vision, *n* = 96–101		Cognitive impairment, *n* = 100–101		Motor control, *n* = 100–101		Hypertonicity, *n* = 99–101		Impaired balance, *n* = 101	
Exercise	**Min**	**Maj**	**Min**	**Maj**	**Min**	**Maj**	**Min**	**Maj**	**Min**	**Maj**
Walking 5 min	1								8	1
Walking 20 min	4		2		3		1		27	12
Stair climbing	5						1		52	9
Raise arms above head										
Hip exercise										
Hip exercise with resistance										
Knee exercise										
Knee exercise with resistance										
Ankle exercise					1					
Ankle exercise with resistance										
Shoulder exercise										
Shoulder exercise with resistance										
Balance exercise			1						48	42
Ankle weight									2	
Stationary bicycle					1				16	3

Note. Blank cells indicate <1%. Min = impairment results in minimal reduction in ability to do the activity; Maj = impairment results in major, substantial reduction in ability to do the activity, or it prevents exercising.

Table 1B Percentage of Participants With Physical Therapist's Impairment-Impact Ratings on Different Exercises

Exercise	Impairment-Impact Rating for Specific Impairments and Global Impairment									
	Limited ROM, $n = 100–101$		Weakness, $n = 101$		Impaired physical endurance, $n = 101$		Pain, $n = 100–101$		Global impairment impact, $n = 101$	
	Min	Maj	Min	Maj	Min	Maj	Min	Maj	Min	Maj
Walking 5 min	1		2		28	13	18		38	9
Walking 20 min	1	1	3	1	31	51	12	24	24	63
Stair climbing	2		5	2	20	24	12	8	44	35
Raise arms above head	3	1					1		3	1
Hip exercise	1		9		1		1		11	
Hip exercise with resistance	1		43	36	1		8	1	44	36
Knee exercise	1		5		1		2		9	
Knee exercise with resistance	1		32	10	1		6	4	33	13
Ankle exercise		2			1				3	1
Ankle exercise with resistance		2	5	2	1				8	1
Shoulder exercise	1	1	2	1	1		1		5	1
Shoulder exercise with resistance	1	2	24	9	1		4	1	24	11
Balance exercise				3	2	1	5		48	42
Ankle weight	2				1		1		2	
Stationary bicycle			1	1	27	27	15	4	42	29

Note. Blank cells indicate <1%. ROM = range of motion; Min = impairment results in minimal reduction in ability to do the activity; Maj = impairment results in major, substantial reduction in ability to do the activity, or it prevents exercising.

Table 2A Association Between Balance, Endurance, and Pain Tests and Assessment With Physical Therapist's Impaired-Balance, Impaired-Endurance, and Pain-Impact Ratings on Walking 20 min and Stair Climbing

	Physical Therapist's Impairment-Impact Rating on Exercise Activities at Baseline							
	Walking 20 min, Impact Level [a]				Stair Climbing, Impact Level			
Test or assessment	No	Min	Maj	*p*	No	Min	Maj	*p*
Impaired-balance impact, *n*	62	27	12		39	52	10	
Tinetti,[a] %, χ^2								
turning while walking	25	63	100	<.001	15	24	100	<.001
climb 4 stairs	74	89	100	.039	62	90	100	.001
SPPB mean score (*SD*)	8.0 (1.0)	7.6 (1.5)	6.4 (1.2)	<.001	8.1 (0.7)	7.7 (0.8)	6.5 (0.9)	.002
Decline in SPPB score, *n* units, *M* (*SD*) at follow-up[b]	37, 0.7 (1.7)	22, 1.4 (2.3)	4, 3.0 (1.4)	.076	27, 0.8 (1.8)	30, 0.9 (2.0)	6, 3.7 (2.3)	.006
Impaired-physical-endurance impact, *n*	19	31	51		57	20	24	
Failed 400-m test	0	7	30	.003	5	15	58	.001
400-m-walk test[c] (s)	390	437	470	.014	424	466	480	.103
Failed 400-m test at follow-up (%)[d]	9	35	46	.105	32	33	50	.678
400-m-walk test at follow-up (s)[e]	511	620	645	248	603	616	646	.695
Pain impact, *n*	65	11	24		80	12	8	
Self-reported pain level (1–10) in back, *M* (SD)	1.2 (0.4)	1.3 (0.5)	1.4 (0.5)	.080	1.2 (0.4)	1.3 (0.5)	1.6 (0.5)	.023
Self-reported pain level (1–10) in knees, *M* (SD)	1.2 (0.4)	1.4 (0.5)	1.4 (0.5)	.427	1.2 (0.4)	1.5 (0.5)	1.5 (0.5)	.069

Note. Cells are blank if comparison is not relevant. No = no impact on exercise activity; Min = minimal reduction in ability or efficiency, up to 25%; Maj = major or substantial reduction in ability or efficiency, >25%; SPPB = short physical-performance battery.

[a]Percentage of participants with adaptive or abnormal balance evaluated by Tinetti's performance-oriented assessment of balance, %, χ^2. [c]63 participants were available for SPPB tests at follow-up; general linear model is adjusted with age, gender, and number of chronic conditions. [d]81 participants completed 400-m test at baseline. [f]62 participants were available for the 400-m test. [g]Those who failed the test at follow-up got the second-worst time of the completed test (788 s); general linear model is adjusted for age, gender, the number of chronic conditions, and baseline walking time.

Table 2B Association Between Balance, Endurance, and Pain Tests and Assessment With Physical Therapist's Impaired-Balance, Impaired-Endurance, and Pain-Impact Ratings on Balance Exercise and Stationary Bicycle

	Physical Therapist's Impairment-Impact Rating on Exercise Activities at Baseline							
	Balance Exercise, Impact Level				Stationary Bicycle, Impact Level			
Test or assessment	**No**	**Min**	**Maj**	***p***	**No**	**Min**	**Maj**	***p***
Impaired-balance impact, *n*	11	48	42		82	16	3	
Tinetti,[a] %, χ^2								
turning while walking	18	17	81	<.001	35	81	100	<.001
climb 4 stairs	64	69	98	.001	77	94	100	.204
SPPB mean score (*SD*)	8.0 (1.0)	8.1 (1.2)	7.1 (0.9)	<.001	7.9 (0.9)	6.8 (1.1)	7.0 (1.0)	.003
Decline in SPPB score, *n* units, *M* (*SD*) at follow-up[b]	7, 0.1 (1.3)	3, 0.5 (1.6)	26, 2.1 (2.3)	.005	54, 0.9 (1.9)	8, 1.6 (2.3)	1, 6.0 (0)	.036
Impaired-physical-endurance impact, *n*	98	2	1		47	27	27	
Failed 400-m test					11	15	41	.006

400-m-walk test[c] (s)					421	444	482	.092
Failed 400-m test at follow-up (%)[d]					29	32	55	.295
400-m-walk test at follow-up (s)[e]					598	604	657	.874
Pain impact, *n*	95	5			80	15	4	
Self-reported pain level (1–10) in back, *M* (*SD*)	1.2 (0.4)	1.8 (0.4)		.003	1.2 (0.4)	1.5 (0.5)	1.5 (0.6)	.047
Self-reported pain level (1–10) in knees, *M* (*SD*)	1.3 (0.5)	1.4 (0.5)		.583	1.3 (0.4)	1.5 (0.5)	1.3 (0.5)	.086

Note. Cells are blank if comparison is not relevant. No = no impact on exercise activity; Min = minimal reduction in ability or efficiency, up to 25%; Maj = major or substantial reduction in ability or efficiency, >25%; SPPB = short physical-performance battery.

[a]Percentage of participants with adaptive or abnormal balance evaluated by Tinetti's performance-oriented assessment of balance, %, χ^2. [c]63 participants were available for SPPB tests at follow-up; general linear model is adjusted with age, gender, and number of chronic conditions. [d]81 participants completed 400-m test at baseline. [f]62 participants were available for the 400-m test. [g]Those who failed the test at follow-up got the second-worst time of the completed test (788 s); general linear model is adjusted for age, gender, the number of chronic conditions, and baseline walking time.

Table 3 Association Between Muscle and Performance Tests and Physical Therapist's Weakness-Impact Rating on Hip, Knee, and Shoulder Exercises, *M* (*SD*)

	Weakness-Impact Rating At Baseline											
	Hip Exercise With Resistance, *n* = 100, Impact Level				Knee Exercise With Resistance, *n* = 101, Impact Level				Shoulder Exercise With Resistance, *n* = 101, Impact Level			
Test	No, *n* = 22	Min, *n* = 43	Maj, *n* = 36	*p*	No, *n* = 59	Min, *n* = 32	Maj, *n* = 10	*p*	No, *n* = 68	Min, *n* = 24	Maj, *n* = 9	*p*
Manual muscle test												
hip extension, kg, sum of both sides	8.0 (0.4)	7.7 (0.8)	6.5 (0.7)	<.001								
hip flexion, kg, sum of both sides	8.3 (0.5)	7.9 (0.7)	6.7 (0.7)	<.001								
knee extension, kg, sum of both sides					8.9 (0.9)	7.9 (0.7)	7.4 (0.6)	<.001				
knee flexion, kg, sum of both sides					9.0 (0.9)	7.9 (0.6)	7.3 (0.7)	<.001				
shoulder extension, kg, sum of both sides									8.6 (0.8)	7.6 (0.7)	7.3 (0.6)	<.001
shoulder flexion, kg, sum of both sides									9.0 (0.9)	8.3 (0.8)	7.7 (1.1)	<.001
Muscle strength tests												
grip, kg, mean of 3 trials	23.2 (9.0)	21.1 (7.8)	15.0 (3.4)	<.001	22.3 (8.1)	15.7 (4.8)	13.8 (4.7)	<.001	21.2 (7.8)	15.9 (6.5)	15.1 (4.9)	.002
knee extension, kg, mean of 3 trials	16.5 (6.2)	15.1 (5.7)	13.4 (4.4)	.084	16.4 (5.6)	13.1 (3.9)	11.1 (6.1)	.001	15.9 (5.4)	12.8 (4.8)	11.7 (5.3)	.011
hip flexion, kg, mean of 3 trials	15.3 (4.7)	12.1 (5.7)	11.2 (4.0)	.009	13.3 (5.5)	11.3 (3.5)	11.6 (6.5)	.179	13.4 (4.9)	11.2 (4.9)	9.4 (5.5)	.033
Decline in SPPB[a] score at follow-up, *n*, units	9, –0.3 (0.9)	29, –1.2 (1.8)	25, –1.4 (2.4)	.159	36, –0.9 (1.6)	20, –1.1 (2.1)	7, –2.7 (3.1)	.049	43, –0.7 (1.5)	13, –2.4 (2.7)	7, –1.9 (2.4)	.004

Note. No = no weakness impact on exercise; Min = minimal reduction in ability or efficiency, up to <25%; Maj = major or substantial reduction in ability or efficiency, >25%; SPPB = short physical-performance battery. [a]63 participants were available at follow-up to perform the SPPB. The general linear model (ANCOVA) is adjusted for age, gender, and number of chronic conditions.

balance problems had significantly lower performance scores on the SPPB than those rated as having minimal or no limitation (p = <.001 to .003) They also had greater decline in SPPB scores during the 21-month follow-up than those in the minimal- or no-limitation group.

Impaired-endurance-impact rating on 20 min walking was seen to be statistically significant when compared with the 400-m test times (p = .014) at baseline and with the percentage who failed the test (p = .003). Time to complete the 400-m-walk test at follow-up was best in participants who were rated as having no limitation in the ability to walk 20 min and worst in participants with major limitation after adjustment for age, gender, chronic conditions, and baseline 400-m-walk time, although these differences did not reach statistical significance. Self-reported pain levels corresponded to the physical therapist's pain-impact ratings. This was statistically significant for the relationship of the physical therapist's assessment of the impact of pain on stair climbing (p = .023), balance exercises (p = .003), and stationary bicycling (p = .047) and the participants' self-report of back pain.

Manual muscle testing was used to grade strength of extension and flexion in the hips, knees, and shoulders. These results were compared with the physical therapist's ratings of the impact of weakness on hip, knee, and shoulder exercises. In addition, handgrip, knee-extensor, and hip-flexion strength were measured using dynamometers. Table 3 shows that the assessed impact of weakness in specific joints on exercise was strongly related to measured strength in those joints, either by manual muscle testing or by dynamometry. It is interesting that handgrip strength, as measured via dynamometer, was related to the physical therapist's ratings of the impact of weakness on hip, knee, and shoulder exercises. After adjustment for age, gender, baseline SPPB score, and number of chronic conditions, the physical therapist's weakness-impact ratings for knee (p = .049) and shoulder (p = .004) exercises with resistance were significantly associated with a greater reduction in SPPB score at follow-up.

After estimating the impact of specific impairments on the ability to perform exercises, the physical therapist prescribed the intensity level for exercise activities and recommended either a classroom program or personal supervision (Table 4). Participants were prescribed mainly classroom programs, but for 15% personal supervision for stretching and balance training was recommended. For 86% of participants in walking, 44% in balance, 28% in upper extremity strength, and 45% in lower extremity strength training, very-low- or low-intensity exercise was prescribed (Table 4). For walking, 44% were advised to begin at less than 10 min on level ground and 42% were advised to walk 10–20 min on level ground. The Global Impairment Impact Rating on walking was strongly associated with the walking-exercise-intensity recommendation (Figure 1). In those whose overall impairments were judged to have a major impact on their ability to walk, a very-low-level or low-level walking intensity and duration were recommended, and for those who were rated as having no limitation, a moderate level of walking was recommended.

Discussion

Currently, there is a need for a tool that gathers information on limitations in exercising that can help to individualize intervention programs. A structured assessment, the Global Impairment Impact Rating scale, enabled us to identify systematically

Table 4 The Level of Supervision and Recommendations for Exercise Intensity, % ($N = 101$)

	Level of Supervision		Intensity Level			
Training	Classroom	Requires personal supervision	Very low	Low	Medium	High
Stretching	85	15				
Balance[a]	85	15		44	45	11
Upper extremity strength	99	1	7	21	44	28
Lower extremity strength[b]	100		18	27	44	12
Walking[c]			44	42	3	12

[a]Balance: Low = balance exercises with at least one upper extremity support and minimum shoulder-width lower extremities base of support; medium = balance exercises with no upper extremity support and minimum shoulder-width lower extremities base of support; high = balance exercises with no upper extremity support and narrow lower extremities base of support. [b]Strength-training intensity: Very low = movement only, no resistance; low = <50% of 1RM or ≥15 repetitions to fatigue; medium = 60–70% of 1RM or 10 repetitions to fatigue; high = unlimited intensity, could work at ≥75% of 1RM. [c]Walking levels: Very low = customary walking speed, <10 min, level ground; low = customary walking speed, 10–20 min, level ground; medium = customary walking speed, 21–30 min, level ground; high = brisk 10–20 min level walking.

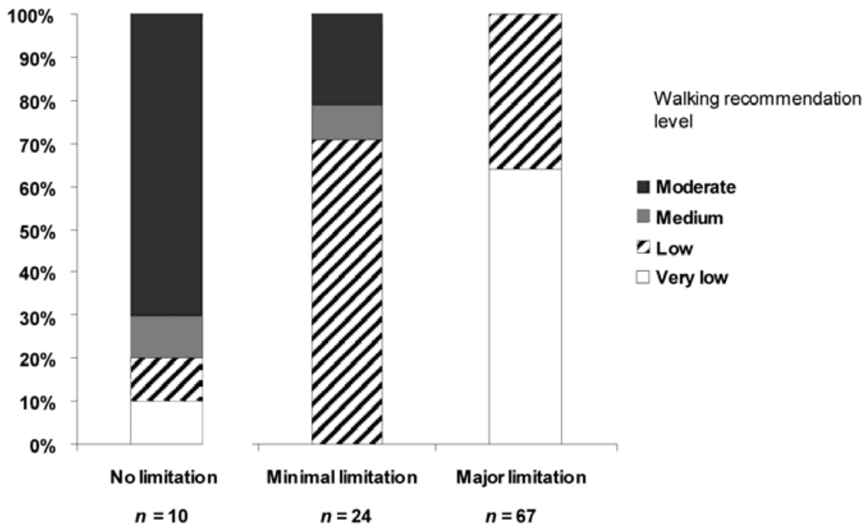

Figure 1 — Recommended walking intensity according to Global Impairment Impact Rating on walking.

the impact of a broad range of specific impairments and the total impact of all impairments on exercise activities in older adults with impairments. A trained physical therapist–researcher who carried out the examinations found the assignment of impairment-impact ratings easy to perform and an appropriate basis for exercise prescriptions. Older people with functional limitations in this study had multiple impairments that caused reductions in their ability to exercise, and therefore recommended exercise levels for these people were initially very low. The results of this study can be valuable in planning further intervention programs and studies on exercise promotion among older adults with functional limitations.

The Global Impairment Impact Rating showed that there were several exercise activities in which most participants had impairments that limited these activities: 20 min of walking was limited in 87% of the participants, stair climbing in 79%, hip exercise with resistance in 80%, balance training in 90%, and shoulder exercises in 35%. These exercises are all important components of an exercise prescription that will help an older adult perform daily activities (American College of Sports Medicine, 2006). The first step in designing an exercise program is to understand how a person's impairments limit the ability to perform certain exercise. Using the Global Impairment Impact Rating scale, the therapist, clinician, or exercise specialist can see the level of the impact, from 0 (*no effect*) to 4 (*large effect*), that various impairments can have on the ability to perform specific exercise activities. Based on the systematic assessment of individuals, related to various impairments, accurate images or representations of these individuals can inform the development of a viable exercise prescription. For example, a study participant had impaired balance and endurance that were both rated as having a major impact on walking, reduced upper extremity range of motion that was rated as limiting raising arms above head, and weakness that was rated as affecting shoulder exercises at a minimal reduction level. The physical therapist designed an exercise prescription for this individual that included personal supervision of stretching and balance training and recommended very low-level walking (less than 10 min walking on level ground at customary speed) and low-intensity upper and lower extremity strength training. In another case the physical therapist had rated a person as having a minimal reduction in ability to walk because of impaired balance and endurance, and the recommended level of balance training was medium intensity in a classroom program and recommended walking level was low (10–20 min walking on level ground at customary speed).

Impaired balance, impaired physical endurance, and pain were estimated to have the largest impact on exercise activities. The intensity of the recommended exercise was very low or low for half of the participants for balance exercises and for 86% of participants in walking. The balance and endurance recommendations were in accordance with the American College of Sports Medicine's (1998, 2006) and best-practice standards (Cress et al., 2004), which recommend for older adults low-level balance training, initially, that progressively requires more difficult postures and low-level aerobic exercise such as walking. In older people the impact of impaired balance and endurance on exercise can be quite substantial, with consequences such as falls and cardiovascular events in those who receive the wrong prescription. There are, however, examples of effective programs in which balance and endurance have been facilitated and maintained, even in very old people (mean 83 years). Binder et al. (2002) showed that even higher level aerobic exercise, when it follows flexibility, strength, and balance training, can be done safely. The program was an appropriate intervention for sedentary, community-dwelling older adults, mean age 83 years. Pain was found to affect walking in one third of the participants and stair climbing and stationary bicycling in one fifth. An earlier study by Leveille, Cohen-Mansfield, and Guralnik (2003) with the same participants found that participants who had two to four pain sites had more negative exercise attitudes, beliefs, and self-efficacy than those with one or no pain sites. Pain relief has also been recommended as an incentive to start exercising (American Geriatrics Society Panel on Exercise and Osteoarthritis, 2001; Ettinger et al., 1997).

As expected, weakness was determined to have an impact on the ability to perform strength training with resistance. One fifth of the participants were given an exercise prescription that included lower extremity movement only with no resistance, and one fourth were advised to exercise at an intensity under 50% of their one-repetition maximum (the maximum amount of weight that can be safely lifted one time) or 15 repetitions to fatigue. These recommendations are lower than those of the American College of Sports Medicine (1998) and other current exercise prescriptions (Mazzeo & Tanaka, 2001) that recommend high-intensity progressive resistance training (60–100% of the one-repetition maximum, with increases over time). On the other hand, the exercise prescription for older adults with osteoarthritis pain is clearly lower: 40–60% of one-repetition maximum, 10–15 repetitions (American Geriatrics Society Panel on Exercise and Osteoarthritis, 2001). In more detailed analyses of our study population, the frequency of any chronic condition or pain did not differ between those who got lower level exercise prescriptions for resistance training and those who got higher level recommendations. The main differences in the lower and higher level recommendation groups were the results of performance tests and the current physical activity. Those who received very low-level recommendations had significantly lower performance scores on the SPPB, manual strength tests with handheld dynamometer, and manual muscle testing, and they reported significantly less light sport involvement ($p = .038$) than those who received higher level recommendations.

Impaired vision, cognition, motor control, and range of motion and hypertonicity were estimated to limit exercising in only a few people. An explanation for cognitive functioning's having a slight impact is that those who had problems had been excluded from the study during the home visits. Hypertonicity was an uncommon impairment and thus had little impact on exercise. Insufficient motor control had an impact on 3% of participants' walking and stair-climbing ability. It is probable that the impact of motor control was mainly through impaired balance. Limited range of motion was rated as having an impact on the ability to engage in endurance and strength training in 7% of participants. In spite of the frequency of arthritis (70%), these participants only infrequently had range-of-motion limitations that had an impact on exercising. In fact, 1 participant expressed why her health was not an obstacle to exercising: "For people who have arthritis there are available exercise groups in the local senior center, and in water, moving is so easy."

The physical therapist's impairment-impact rating was associated cross-sectionally and longitudinally with performance tests and assessments. The assessments made for the Global Impairment Impact Rating scale were shown to have good construct validity when compared with multiple aspects of lower extremity function, gait speed, balance, and lower and upper extremity strength and endurance and good predictive validity using follow-up outcomes related to lower extremity function and endurance. Participants who were rated as having major balance problems affecting ability to climb stairs or weakness problems affecting knee or shoulder exercises had the lowest performance-test and assessment scores at baseline and the greatest reduction in SPPB scores during the 21 months of follow-up. Overall, a comparison of the impairment-impact ratings with objective functional tests revealed that the physical therapist rated the impact impairments in a manner that was consistent with the tests.

The fact that there was only one physical therapist carrying out the tests and assessing the impact of impairments, based on the knowledge from the health questionnaires and the performance tests, might be seen as a limitation of this study. The aim of this article, however, was to outline a systematic approach from determining the impact of various impairments on specific exercise activities to outlining the most suitable exercise prescription.

The main limitation of the Global Impairment Impact Rating scale is that it focuses on physiological impairments. There are other factors that affect the ability to exercise, such as psychological and social factors (unwillingness, self-efficacy to perform exercise activity, lack of company, etc.) and many chronic conditions (Cohen-Mansfield, Marx, Biddison, & Guralnik, 2004). Social and psychological factors can have a large impact on people's attitudes toward exercise and their motivation to exercise. Nonetheless, this Global Impairment Impact Rating scale, when it is performance oriented and the professional relies on a broad range of tests and assessments, might reflect the impact of psychological status, cognitive status, specific disease, and other factors that affect the ability to exercise.

Many health care professionals do not feel adequately prepared to design and prescribe exercise programs for their patients. The Global Impairment Impact Rating scale might provide a useful instrument for creating appropriate individualized interventions by identifying domains that need particular attention in the program. More studies need to focus on the use of multidimensional assessments of factors that can limit exercising and that can be translated into a specific exercise prescription for individual needs.

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Appendix: The Global Impairment Impact Rating Scale

GLOBAL IMPAIRMENT IMPACT RATINGS Rate each activity using the Impairment Impact Scale. Enter scores for current levels of functioning.		IMPAIRMENT IMPACT RATINGS Indicate the degree to which each impairment negatively impacts on function using the Impairment Impact Scale. Leave box blank if there are no impairments in the category.									
(Global impairment must be at least 1 if there is any impairment in an activity.) ACTIVITIES	Global Impairment Impact	Vision	Cognitive impairment	Impaired motor control/ coordination	Hypertonicity	Impaired balance	Limited ROM	Weakness	Impaired physical endurance	Pain	

1. Walking 5 minutes										
2. Walking 20 minutes										
3. Stair climbing										
4. Raise arms above head										
5. Hip exercises - no resistance										
6. Hip exercises - resistance										
7. Knee exercises - no resistance										
8. Knee exercises - resistance										
9. Ankle exercises - no resistance										
10. Ankle exercises - resistance										
11. Shoulder exercises - no resistance										
12. Shoulder exercises - resistance										
13. Balance exercises										
14. Applying ankle weight										
15. Stationary bike										

Impairment Impact Scale:

0 No Impact

1 Minimal reduction in ability/efficiency (up to 25%)

2 Major reduction in ability/efficiency (25-50%)

3 Substantial reduction in efficiency (50-75%)

4 Virtually prevents performance of activity

9 Not assessed

Study ID ____________

Date ____/____/_______

PT Initials ____________