

ORIGINAL ARTICLE

Measures of Physical Functioning Predict Self-Reported Performance in Self-Care, Mobility, and Domestic Life in Ambulatory Persons With Multiple Sclerosis

Jaana Paltamaa, MSc, PT, Taneli Sarasoja, MD, Esko Leskinen, PhD, Juhani Wikström, PhD, MD, Esko Mälkiä, PhD, PT

ABSTRACT. Paltamaa J, Sarasoja T, Leskinen E, Wikström J, Mälkiä E. Measures of physical functioning predict self-reported performance in self-care, mobility, and domestic life in ambulatory persons with multiple sclerosis. *Arch Phys Med Rehabil* 2007;88:1649-57.

Objective: To determine the associations between clinically measured physical functioning variables and self-reported performance in mobility, self-care, and domestic life in ambulatory persons with multiple sclerosis (MS), using the *International Classification of Functioning, Disability and Health* (ICF) as a framework.

Design: Survey study.

Setting: Community setting in Finland.

Participants: A population-based sample of 120 ambulatory persons with MS (30 men, 90 women) with mean age 45.0 ± 10.8 years (range, 20–71y), mean disease duration from symptom onset 12.3 ± 8.8 years (range, 1–39y), and mean Expanded Disability Status Scale 2.8 ± 2.0 (range, 0–6.5).

Interventions: Not applicable.

Main Outcome Measures: The primary dependent variables were self-reported performance in self-care, mobility, and domestic life from the Functional Status Questionnaire. The physical functioning variables were drawn from the ICF activities ($n=9$) and body functions ($n=14$) categories. Age- and sex-adjusted odds ratios from multinomial logistic regression were estimated for the physical functioning variables associated with activities of daily living (ADL) performance.

Results: Overall, of this cohort 31% reported difficulties or dependence in self-care, 52% in mobility, and 68% in domestic life. The most significant predictors of perceived difficulties or dependence in ADL performance were: (1) lower scores in the Box and Block Test; (2) lower Berg Balance Scale scores; (3) greater velocity moment when standing with eyes open; (4) slower ten-meter walk test times and shorter stride length at normal speed; and (5) shorter distance in the six-minute walk test.

Conclusions: Perceived difficulties and dependence were most prominent in domestic life. In particular, measures of

activities predicted difficulties in ADL performance. Monitoring of physical functioning should be extended to those independent MS persons reporting difficulties in ADL performance.

Key Words: Activities of daily living; Cross-sectional studies; Multiple sclerosis; Odds ratio; Outcome assessment (health care); Physical therapy (specialty); Rehabilitation.

© 2007 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

MULTIPLE SCLEROSIS (MS), despite its relatively limited prevalence, is a chronic, progressive, and potentially disabling disorder. The problems experienced vary depending on the type, duration, and extent of the disease and are often complex, interdependent, and difficult to manage.¹ Even in the initial stage of MS, when neurologic deficits are relatively minor and mental health is relatively unaffected, subjects experience limitations in daily functioning.²

As the disease progresses, the ability to perform activities of daily living (ADLs) is reduced, thus leading to dependence.³⁻⁵ About one fourth of MS subjects in population-based studies required assistance in personal care such as bathing, dressing, and feeding.⁶⁻⁸ In a recent population-based study in Finland, 53% of subjects were independent in domestic life, but a considerable number of them (35%–62%) reported difficulties in performing various domestic tasks.⁸ About three fourths of MS subjects have some degree of ambulatory impairment^{9,10} and 38% to 45% of MS subjects use assistive devices to facilitate their mobility.^{10,11}

The clinical presentation of MS is highly variable and is characterized by various physical, emotional, and cognitive changes.⁹ Previous studies indicate that MS causes a range of symptoms including, but not limited to, muscle weakness, autonomic dysfunction, abnormal gait mechanism, and poor balance.^{1,9} These symptoms typically contribute to reduced ADL performance in persons with MS^{4,7,12-14} and have a considerable impact on the social roles of MS subjects and on the well-being of their families.¹⁵ It remains unclear how the documented symptoms relate to ADL performance, because symptoms and performance have often been examined separately. Therefore, greater knowledge of the factors that reliably predict ADL performance in MS persons could improve physiotherapy (PT) strategies, thereby enhancing such persons' daily functioning and helping them to maintain their ability to live independently in society.

Assessments of both personal and instrumental ADL are advocated in MS.⁵ In addition, declines in functional mobility are associated with loss of social connections, reduced participation, and altered abilities to perform self-care, productivity, and leisure activities.³ ADLs have been categorized in many ways.¹⁶ For this study, we used the domains "self-care," "mobility," and "domestic life" of the World Health Organization's

From the Departments of Physical Medicine and Rehabilitation (Paltamaa) and Neurology (Sarasoja), Central Hospital, Jyväskylä, Finland; Departments of Mathematics and Statistics (Leskinen) and Health Sciences (Paltamaa, Mälkiä), University of Jyväskylä, Finland; and Department of Neurology, University of Helsinki, Helsinki, Finland (Wikström).

Supported in part by the Central Finland Health Care District, the Finnish MS Society, and the Social Insurance Institution of Finland.

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

Reprint requests to Jaana Paltamaa, MSc, PT, Dept of Health Sciences, University of Jyväskylä, PO Box 35 (Viv), FI-40014 Jyväskylä, Finland, e-mail: jaana.paltamaa@sport.jyu.fi.

0003-9993/07/8812-0005\$32.00/0

doi:10.1016/j.apmr.2007.07.032

*International Classification of Functioning, Disability and Health (ICF)*¹⁷ to identify ADL content. The ICF classification also guided the selection of the performance-based tests (described later) that became the operational definitions of physical functioning in this study.

Disability can be assessed as a level of dependence on personal help or as perceived difficulty in ADLs.¹⁸ As Jette¹⁸ pointed out, the rating of perceived difficulty can be considered the primary assessment of disability, whereas the rating of actual dependence on assistance is an assessment of the consequence of disability. In this study, we describe self-reported restrictions on performance in the domains of self-care, mobility, and domestic life in ambulatory subjects with MS, as perceptions of restrictions in everyday life indicate a need for interventions to prevent overload and increased dependence in ADL performance.

The purpose of this study was to identify which of the physical functioning factors in the ICF components, activities and body functions, predict self-reported performance in mobility, self-care, and domestic life in ambulatory persons with MS. Because age, sex, and the disease itself are assumed to impact on performance, the relationships between ADL performance and personal factors, and between ADL performance and disease-related variables were also examined. Our main interest was to identify the most important determinants of ADL performance, in order to find clinical measures relevant to persons with MS.

METHODS

Participant Selection

The participants for this study were obtained from a population-based database in the Central Finland Health Care District containing 277 clinically definite MS subjects in 2000.¹⁹ The potential participants for this study were subjects from the previous questionnaire study,⁸ whose MS diagnosis had been confirmed prior to August 2000 by a neurologist (N=199). Subjects were included if they were able to walk at least 20m with or without walking aids and had no concurrent diseases that could interfere with the measures. Forty-six subjects were ineligible because they were not functionally ambulatory (ie, were essentially confined to a wheelchair and thus unable to perform the measures) and 10 because of a concurrent disease such as a major musculoskeletal disorder.

A plain language statement inviting participation and outlining the aims and test requirements of the study was mailed to all the 143 subjects who fulfilled the inclusion criteria. Subjects who were willing to participate returned a form to the hospital in a prepaid envelope. On this form they gave their contact information and the best days and times to reach them. A total of 120 subjects volunteered to participate in the study, but 23 subjects refused or did not return the form. A written informed consent was obtained from each of the participants. The study was approved by the local ethics committee.

Procedures

In this study, we used cross-sectional data obtained from the first testing session in 2000. At the time of testing, participants had to be stable in their MS with no ongoing relapse. Physical functioning was assessed by measures of the ICF activities and body functions categories, and by ADL self-reports. Figure 1 provides a description of the ICF framework of the study.

All the measures as well as interviews were conducted in the PT department at the hospital of Central Finland by 2

physiotherapists, one of whom was the researcher, and both of whom had participated in the earlier interrater reliability study.²⁰

Health condition variables of MS were confirmed by a neurologist. Disease severity was assessed using the Expanded Disability Status Scale (EDSS).²¹ The clinical course of the disease was defined as relapsing remitting MS and primary progressive MS. Information on disease duration from symptom onset and from diagnosis was obtained. The interval from previous relapse was recorded according to participants' self-reports.

Personal factors (sex, age, body mass index [BMI], other diseases), obtained by the questionnaire and face-to-face interview, were used as descriptive variables and as independent variables when necessary. In addition, we used 2 questionnaires to assess the impact of MS-related fatigue (Modified Fatigue Impact Scale [MFIS]²²; scale range, 0–84) and depressive symptoms (Center of Epidemiologic Studies Depression Scale [CES-D]²³; scale range, 0–60). As the present study focus was on physical functioning, fatigue, and depressive symptoms were used as covariates.

Measures

ADL performance on the level of activities and participation. The primary dependent variables in this study were self-reported ADL performance using the physical function subscale of the Functional Status Questionnaire (FSQ).²⁴ The aim of the FSQ is to describe what persons do in their current environment, that is, to describe restrictions in ADL performance within the component activities and participation. The FSQ items were reclassified to enable the results to be linked to the ICF categories. A 4-item scale for self-care (washing oneself, d510; toileting, d530; dressing, d540; eating, d550), a 5-item scale for mobility (moving around within the home, d4600; climbing, d4551; walking short distances, d4500; driving, d475; using transportation, d470), and a 5-item scale for domestic life (preparing meals, d630; washing and drying clothes and garments, d6400; cleaning living area, d640; acquisition of goods and services, d620; taking care of plants, indoors and outdoors, d6505) was constructed.

In the FSQ, subjective difficulty during the past month was assessed on the scale: usually did with no difficulty, usually did with some subjective difficulty, usually did with much difficulty (ie, require some aid or assistance), usually did not because of MS, and usually did not do for other reasons. The calculation of each FSQ score was transformed according to published algorithms.²⁴ The FSQ score ranges between 0 (representing fully dependent) and 100 (fully independent ADL performances). The reliability of the original FSQ has been found to be high across a wide range of settings and populations.^{24–26}

Activities (capacity). The aim of the measures in activities was to indicate the highest probable level of physical functioning that a subject may attain in a given domain at a given moment (capacity). Participants underwent the following previously reported²⁰ objective, performance-based measures: Box and Block Test (BBT), Berg Balance Scale (BBS), Kela Coordination test, postural stability tests (ie, standing with feet 20cm apart with eyes open and with eyes closed) performed on a Good Balance force platform,^a ten-meter walk test (10MWT) times at normal and maximal speed measured by Newtest photocells,^b and distance covered in the six-minute walk test (6MWT). The different variables used in the study are shown in figure 1.

Body functions. The following previously reported²⁰ measures of the physiologic body functions of the body were

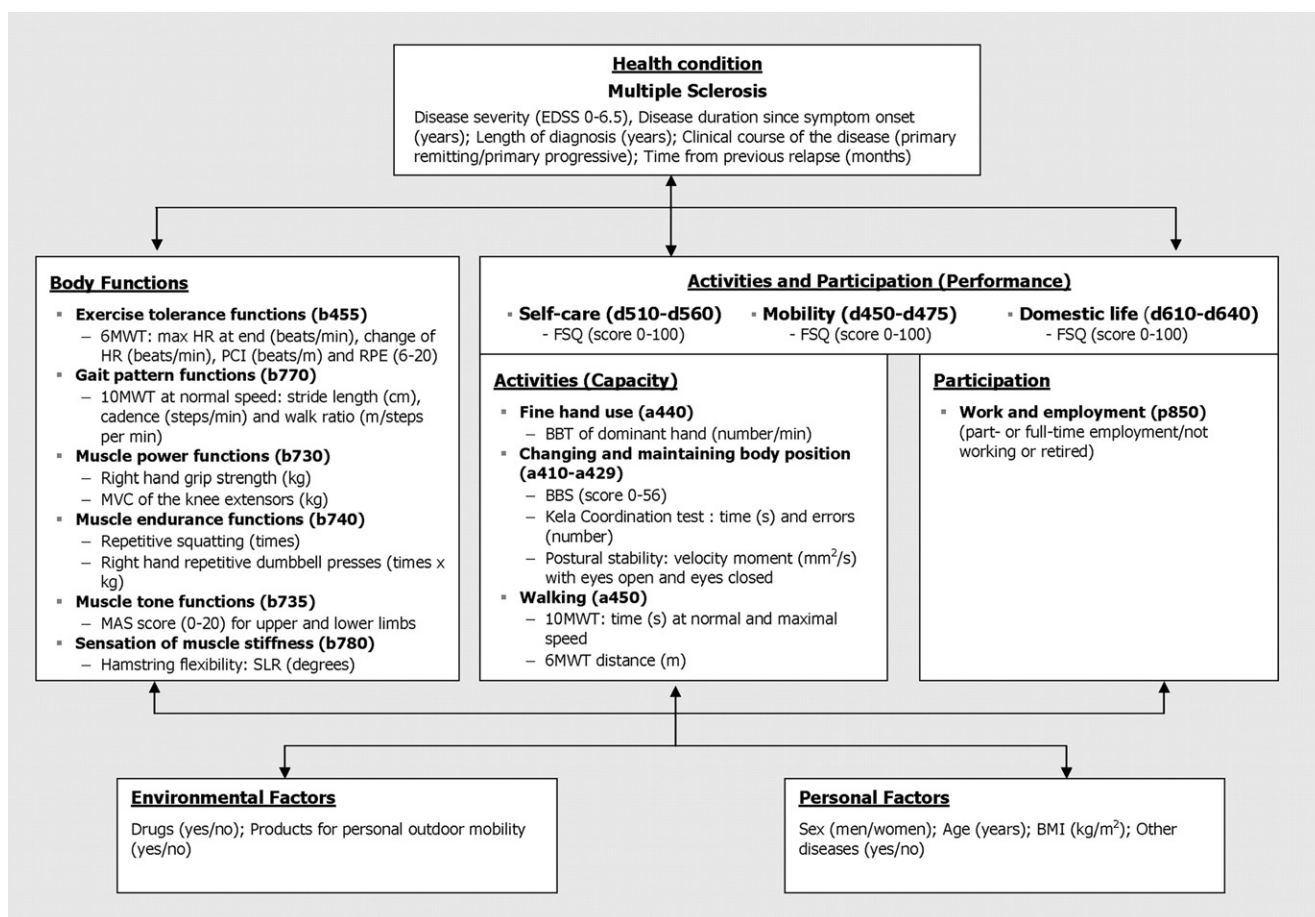


Fig 1. Data used in this study displayed using the ICF as a framework. Abbreviations: BBS, Berg Balance Scale; BBT, Box and Block Test; BMI, body mass index; EDSS, Expanded Disability Status Scale; FSQ, Functional Status Questionnaire; HR, heart rate; MAS, Modified Ashworth Scale; MVC, maximal voluntary contraction; PCI, Physiological Cost Index; RPE, rating of perceived exertion; 6MWT, six-minute walk-test; SLR, straight-leg raise test; 10MWT, ten-minute walk test.

conducted: heart rate measured by Polar Heartwatch,^c Physiological Cost Index (PCI) and rating of perceived exertion (RPE) during the 6MWT, spatiotemporal parameters of the 10MWT, grip strength measured by a Jamar dynamometer,^d maximal isometric force of the knee extensors measured by a Newtest Force Isometric Strength Testing System^b and David 200 dynamometer,^e muscle endurance tests according to the Invalid Foundation of Finland, Modified Ashworth Scale (MAS), and the passive straight-leg raise (SLR) test. The different variables used in the study are shown in figure 1.

Statistical Methods

For self-care, mobility, and domestic life we classified the participants into 3 groups: “independent,” (FSQ score 100), “independent with perceived difficulties,” (FSQ score 66.6–99.9), and “dependent” (FSQ score 0–66.5). Because of the reclassification of the FSQ, the original warning zones²⁴ could not be used. The cutoff scores were determined to indicate important functional change. An FSQ score of 100 represents fully independent performance without any subjective difficulty in any FSQ item. A cutoff score of 66.5 was chosen to differentiate participants who perceived difficulties in 1 or more FSQ items, but were independent, from those who were dependent (ie, needed assistance and/or assistive devices).

Frequencies and descriptive statistics (means, standard deviations [SDs], ranges) were used to obtain the baseline demographic data on the participants. Descriptive statistics (not included here) on all outcome variables were calculated to organize and describe the data. The normal distribution of the outcome variables was evaluated using the Kolmogorov-Smirnov test. Analyses included construction of side-by-side boxplots to explore the distribution of the physical functioning measures in relation to the groups of ADL performance. Extreme values for a variable within a group were excluded from the analyses. Of 23 variables, 8 had no extreme values, 12 had 1 to 4 extreme values, and 3 had more than 4 extreme values for each analysis. These 3 variables and number of excluded cases were: MAS lower-limb scores (n=9 for self-care), velocity moment with eyes open (n=9 for self-care), and velocity moment with eyes closed (n=9 for self-care; n=9 for domestic life). All data were analyzed using SPSS.^f

We used a multinomial logistic regression for modeling. To investigate which factors explained ADL performance, 3 analyses were performed initially by using the FSQ subscales of self-care, mobility, and domestic life, respectively, as dependent measures. The 9 variables in activities and 14 variables in body functions shown in figure 1 were independent variables. All of the calculations were conducted using primary sampling units except the PCI (beats/min × 100) and walk ratio (m/steps

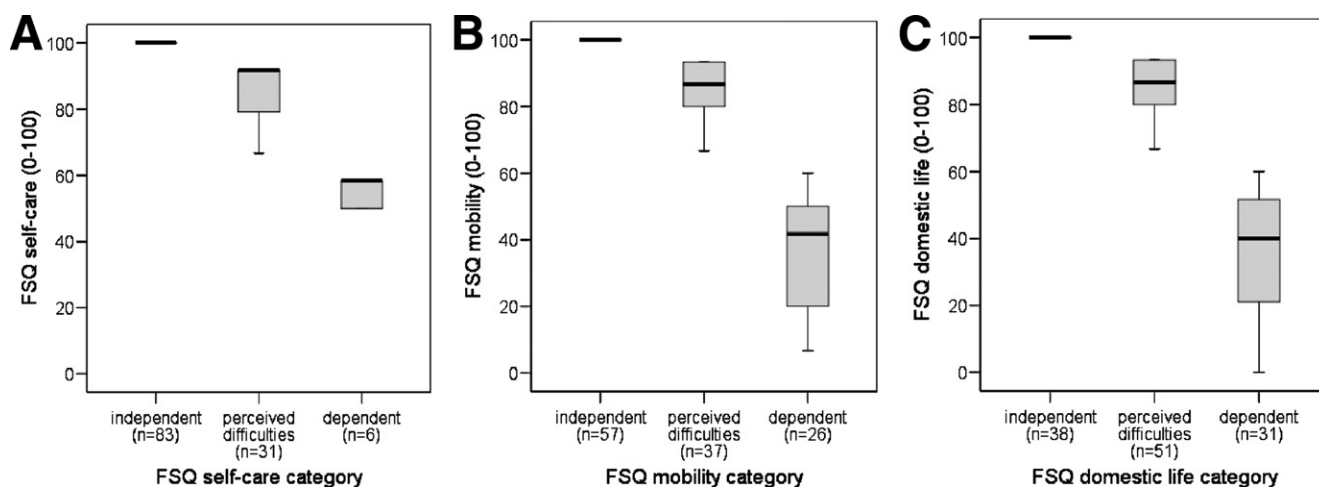


Fig 2. Performance in ADL obtained from FSQ: (A) self-care, (B) mobility, and (C) domestic life. Boxplots are 25%–75% quartiles; whiskers are 10%–90% percentiles; solid lines are median value. All scales showed statistically significant differences between fully independent, independent with perceived difficulties, and dependent group (Kruskal-Wallis test, $P < .001$).

per min \times 1000). In addition, a multinomial logistic regression was performed using the ICF personal factors (sex, age, BMI, other diseases than MS), ICF health condition variables (disease severity measured by EDSS, disease duration since symptom onset, length of diagnosis, clinical course of the disease, time from previous relapse), the impact of MS-related fatigue (MFIS), and depressive symptoms (CES-D) as independent background variables.

The variables associated with ADL performance were identified using odds ratios (ORs) with a 95% confidence interval (CI) for being “fully independent” versus “independent with perceived difficulties,” and for being “dependent” versus “independent with perceived difficulties,” adjusted for age and sex. The associations between dependent and independent with perceived difficulties in self-care performance were excluded from results because of the small number of participants in the dependent group ($n=6$). The level of significance was set as .05.

RESULTS

Participant Characteristics

The participants ($N=120$) ranged in age from 20 to 71 years, but only 1 participant was over 65 years old. The mean age \pm SD was 45 ± 10.8 years. The majority were women (75% [$n=90$]). Fifty-two participants were retired, 55 were working full- or part-time (including students), and the rest of 13 were either unemployed or otherwise not working. Forty participants reported having an additional disease.

With respect to the clinical course of the disease, 88% had relapsing remitting MS, 11% had primary progressive MS, and 1% had unknown clinical course. The average disease duration from symptom onset was 12.3 ± 8.8 years (range, 1–39y) and from diagnosis 7.1 ± 6.2 years (range, 0–26y). Approximately half of the participants ($n=62$) had had MS symptoms over 10 years. The mean EDSS was 2.8 ± 2 (range, 0–6.5). Overall 40 participants had no disability (EDSS, 0–1.5), 47 had mild disability (EDSS, 2–3.5), and 33 had moderate disability, that is, had limited walking ability (EDSS, 4–6.5). Permanent use of a walking aid outdoors was reported by 27 participants. Self-reported time from previous relapse was over 1 month in all cases and in most cases over 6 months (79%). Sixty-two

participants did not use any medication for MS, and 38 used immunomodulative drugs.

Restrictions in self-reported performance were substantially more prevalent in the mobility and domestic life domains than in the self-care domain. On average, participant’s FSQ scores for self-care, mobility, and domestic life were 93.8 ± 11.9 (range, 50–100), 81.8 ± 26.4 (range, 7–100), and 76.9 ± 28.3 (range, 0–100), respectively. The FSQ scores for the fully independent, independent with perceived difficulties, and dependent groups in self-care, mobility, and domestic life are presented graphically in figure 2.

Personal Factors and ADL Performance

We used a multinomial logistic regression to analyze the relationships between ADL performance and personal factors (age, sex, BMI, other diseases). Among these variables, the only significant associations were between age and mobility (OR=1.06; 95% CI, 1.00–1.18 for dependent vs perceived difficulties) and between age and domestic life (OR=.95; 95% CI, .91–.99 for independent vs perceived difficulties).

Health Condition and ADL Performance

We used multinomial logistic regression to analyze the relationships between ADL performance and health condition. Mild disease severity (EDSS < 4.0) was significantly associated with independent performance in self-care (OR=11.39; 95% CI, 4.21–30.76 for independent vs perceived difficulties), and with dependency in mobility and in domestic life (OR=.03; 95% CI, .01–.14; OR=.16; 95% CI, .00–.07, respectively, for dependent vs perceived difficulties). In addition, relapsing remitting MS was associated with dependency in mobility (OR=6.42; 95% CI, 1.25–32.86 for dependent vs perceived difficulties). Disease duration from symptom onset, disease duration from diagnosis, and relapse during the preceding 6 months were not significantly related to performance in any of the 3 ADL domains.

Measures of Physical Functioning and ADL Performance

Tables 1 and 2 present age- and sex-adjusted ORs and their CIs for the association between the activities (capacity) variables and ADL performance. The BBS was the strongest pre-

Table 1: ORs and 95% CIs From Multinomial Logistic Regression Analyses: Associations of "Independent" Versus "Perceived Difficulties" With Changes in Activities (capacity)

| Activities (capacity) | Self-Care Independent (n=83) vs Perceived Difficulties (n=31) OR (95% CI) | Mobility Independent (n=57) vs Perceived Difficulties (n=37) OR (95% CI) | Domestic Life Independent (n=38) vs Perceived Difficulties (n=51) OR (95% CI) |
|---|--|---|--|
| BBT of dominant hand (n/min) | 1.07 (1.03–1.12) | 1.05 (1.01–1.10) | 1.07 (1.02–1.12) |
| BBS score (0–56) | 1.24 (1.11–1.38) | 2.15 (1.45–3.14) | 1.68 (1.13–2.49) |
| Kela Coordination test: time (s) | 0.99 (0.97–1.01) | 0.98 (0.96–0.99) | 0.98 (0.96–1.01) |
| Kela Coordination test: faults (n) | 0.99 (0.91–1.07) | 0.90 (0.83–0.98) | 0.95 (0.87–1.03) |
| Postural stability eyes open (mm ² /s) | 0.95 (0.91–0.99) | 0.86 (0.80–0.93) | 0.85 (0.76–0.94) |
| Postural stability eyes closed (mm ² /s) | 0.97 (0.95–0.99) | 0.97 (0.95–0.99) | 0.98 (0.95–1.01) |
| 10MWT time at normal speed (s) | 0.72 (0.60–0.87) | 0.50 (0.34–0.74) | 0.53 (0.34–0.81) |
| 10MWT time at maximal speed (s) | 0.52 (0.37–0.73) | 0.38 (0.21–0.67) | 0.63 (0.39–1.02) |
| 6MWT distance (m) | 1.01 (1.00–1.01) | 1.01 (1.00–1.01) | 1.01 (1.00–1.01) |

NOTE. Values in bold are statistically significant ($P < .05$). Values are adjusted for age and sex.

dicator for perceived difficulties in self-care, mobility, and domestic life. In addition, the BBT of the dominant hand, postural stability with eyes open, 10MWT time at normal speed and 6MWT distance had independent effects in all 3 ADL domains.

Participants who were independent had a higher BBS score (OR=2.15), decreased velocity moment in standing with eyes open (OR=.86), faster 10MWT times at normal speed (OR=.50) and at maximal speed (OR=.38), and longer distance in the 6MWT (OR=1.01) compared with those who perceived difficulties in mobility. In fact, as can be seen in table 1, all the activities variables were significantly associated with mobility. Because the calculations were made using primary sampling units, these effects are quite large. For example, an OR of 1.01 for the 6MWT distance means that participants who walked 1m longer were 1% more likely to be independent than those perceiving difficulties in the mobility domain. The likelihood of being independent rather than perceiving difficulties in mo-

bility increased over 2-fold if the participant had 1-point better score in the BBS (OR=2.15). Participants having 1-point better BBT result within the age- and sex-adjusted reference values given by Mathiowetz et al²⁷ had over 2-fold likelihood of being fully independent rather than perceiving difficulties in domestic life (OR=2.87; 95% CI, 1.12–7.38). 10MWT time at normal speed was inversely associated with independence in mobility (OR=.50), which means that a 1-second faster walking time at normal speed represents a 50% likelihood of being fully independent rather perceiving difficulties in mobility.

The variables strongly associated with dependence in mobility and domestic life (see table 2) included the BBS (OR=.67 for mobility; .66 for domestic life), 10MWT time at normal speed (OR=1.87 for mobility; 1.52 for domestic life), and 10MWT time at maximal speed (OR=2.43 for mobility; 1.79 for domestic life). For example, an OR of .66 for the BBS means that a 1-point lower BBS increased the likelihood of being dependent approximately one third.

Tables 3 and 4 present age- and sex-adjusted ORs and their CIs for the association between the body functions variables and ADL performance. Among the body functions variables, repetitive squatting was the only one that had independent effects on all the self-reported performances when the independent participants were compared with those who perceived difficulties. When the dependent participants were compared with those who perceived difficulties, the most significant predictors of mobility and domestic life were change in heart rate during the 6MWT, stride length and cadence of the 10MWT, maximal isometric force of knee extensors, right hand repetitive dumbbell presses, and spasticity score (MAS) for the lower limbs.

Effect of Depressive Symptoms and Fatigue on ADL Performance

Overall 40% (n=49) of the participants had a clinically significant level of depressive symptoms when a CES-D cutoff score²³ of 16 was used. The average CES-D score was 14.9±11.6 (range, 0–47). When assessed as a continuous measure, the only significant association with the CES-D and ADL performance was in domestic life when the independent participants were compared with those who perceived difficulties (OR=2.69; 95% CI, 1.09–6.77).

Almost 50% of the participants (n=57) had an MFIS score of over 38, which has been proposed as a cutoff value for significant fatigue.²⁸ The average level of MS-related fatigue measured by the MFIS was 35.0±16.5 (range, 0–84). In domestic life, those who were independent had significantly less

Table 2: ORs and 95% CIs From Multinomial Logistic Regression Analyses: Associations of Dependent Versus Perceived Difficulties With Changes in Activities (capacity)

| Activities (capacity) | Mobility* Dependent (n=26) vs Perceived Difficulties (n=37) OR (95% CI) | Domestic Life* Dependent (n=31) vs Perceived Difficulties (n=51) OR (95% CI) |
|---|---|--|
| BBT of dominant hand (n/min) | 0.93 (0.89–0.98) | 0.93 (0.89–0.98) |
| BBS score (0–56) | 0.67 (0.54–0.83) | 0.66 (0.55–0.80) |
| Kela Coordination test (time) | 0.97 (0.92–1.02) | 1.02 (1.00–1.05) |
| Kela Coordination test (faults) | 0.90 (0.74–1.09) | 1.03 (0.92–1.16) |
| Postural stability eyes open (mm ² /s) | 1.04 (1.01–1.07) | 1.09 (1.03–1.14) |
| Postural stability eyes closed (mm ² /s) | 1.01 (1.00–1.02) | 1.03 (1.01–1.05) |
| 10MWT time at normal speed (s) | 1.87 (1.29–2.69) | 1.52 (1.22–1.89) |
| 10MWT time at maximal speed (s) | 2.43 (1.41–4.21) | 1.79 (1.31–2.45) |
| 6MWT distance (m) | 0.99 (0.98–0.99) | 0.99 (0.99–0.99) |

NOTE. Values in bold are statistically significant ($P < .05$). Values are adjusted for age and sex.

*Self-care were omitted because of the small number of the participants in the dependent group (n=6).

Table 3: ORs and 95% CIs From Multinomial Logistic Regression Analyses: Associations of Independent Versus Perceived Difficulties With Changes in Body Functions

| Body Functions | Self-Care Independent (n=83) vs Perceived Difficulties (n=31) OR (95% CI) | Mobility Independent (n=57) vs Perceived Difficulties (n=37) OR (95% CI) | Domestic Life Independent (n=38) vs Perceived Difficulties (n=51) OR (95% CI) |
|--|--|---|--|
| 6MWT HRmax at end (beats/min) | 1.02 (1.00–1.05) | 1.01 (0.99–1.04) | 1.02 (0.99–1.05) |
| 6MWT HR chance (beats/min) | 1.05 (1.02–1.08) | 1.02 (0.99–1.05) | 1.02 (0.99–1.04) |
| 6MWT PCI (beats/m × 100) | 1.01 (0.98–1.03) | 1.00 (0.98–1.02) | 1.00 (0.98–1.03) |
| 6MWT RPE (6–20) | 0.78 (0.62–0.98) | 0.78 (0.60–1.02) | 0.64 (0.46–0.88) |
| 10MWT stride length (cm) | 1.04 (1.02–1.06) | 1.05 (1.02–1.08) | 1.04 (1.01–1.08) |
| 10MWT cadence (steps/min) | 1.06 (1.03–1.09) | 1.05 (1.01–1.09) | 1.02 (0.98–1.06) |
| 10MWT walk ratio (m/steps per min × 1000) | 0.86 (0.60–1.23) | 1.36 (0.87–2.12) | 1.27 (0.83–1.94) |
| Right hand grip strength (kg) | 1.02 (0.96–1.09) | 1.02 (0.95–1.09) | 0.99 (0.93–1.06) |
| MVC of the knee extensors (kg) | 1.03 (1.01–1.05) | 1.01 (0.99–1.04) | 1.00 (0.98–1.02) |
| Repetitive squatting (times) | 1.12 (1.05–1.20) | 1.10 (1.04–1.17) | 1.07 (1.03–1.12) |
| Right hand repetitive dumbbell presses (kg by times) | 1.03 (1.01–1.04) | 1.00 (1.00–1.01) | 1.00 (1.00–1.01) |
| MAS score for upper limbs (0–20) | 0.38 (0.21–0.69) | 0.18 (0.05–0.67) | 0.41 (0.11–1.55) |
| MAS score for lower limbs (0–20) | 0.44 (0.29–0.67) | 0.17 (0.05–0.52) | 0.35 (0.12–1.00) |
| Hamstring flexibility (SLR deg) | 1.02 (0.99–1.05) | 1.02 (0.99–1.05) | 1.02 (0.99–1.04) |

NOTE. Values in bold are statistically significant ($P < .05$). Values are adjusted for age and sex. Abbreviations: HRmax, maximal heart rate; MVC, maximal voluntary contraction.

MS-related fatigue compared with the participants who perceived difficulties or were dependent (MFIS, 20.9 ± 12 , 39 ± 14.3 , and 45.7 ± 12.8 , respectively). Fatigue was an independent predictor in self-care (OR=.94; 95% CI, .91–.97), mobility (OR=.95; 95% CI, .93–.98), and domestic life (OR=.90; 95% CI, .87–.94) when the independent participants were compared with those who perceived difficulties, but it was an independent predictor only in domestic life (OR=1.04; 95% CI, 1.00–1.08) when the dependent participants were compared with those who perceived difficulties.

Because of the substantial level of fatigue, we conducted additional multinomial logistic regression analyses between ADL performance and physical functioning adjusted for age, sex, and fatigue (MFIS). We found only minor changes in the significant associations. In activities (see table 1), the BBT of the dominant hand no longer showed a significant association with mobility (OR=1.04; 95% CI, 1.00–1.09 for

the independent participants vs those who perceived difficulties; $P=.064$). In body functions, when comparing the independent participants with those who perceived difficulties (see table 3), the ORs between the 6MWT RPE and performance in self-care (OR=.85; 95% CI, 0.66–1.10; $P=.208$) and between the 6MWT RPE and performance in domestic life (OR=.69; 95% CI, 0.47–1.02; $P=.062$) became nonsignificant, whereas the ORs between the walk ratio of the 10MWT and performance in self-care became significant (OR=.65; 95% CI, .43–.98; $P=.038$). When the dependent participants were compared with those who perceived difficulties (see table 4), the OR between the change in heart rate during the 6MWT and performance in mobility became nonsignificant (OR=.96; 95% CI, 0.93–1.00; $P=.056$), whereas the OR between the 6MWT PCI and performance in domestic life became significant (OR=1.03; 95% CI, 1.00–1.05; $P=.021$).

Table 4: ORs and 95% CIs From Multinomial Logistic Regression Analyses: Associations of Dependent Versus Perceived Difficulties With Changes in Body Functions

| Body Functions | Mobility* Dependent (n=26) vs Perceived Difficulties (n=37) OR (95% CI) | Domestic Life* Dependent (n=31) vs Perceived Difficulties (n=51) OR (95% CI) |
|--|--|---|
| 6MWT HRmax at end (beats/min) | 0.97 (0.94–1.00) | 0.98 (0.95–1.01) |
| 6MWT HR chance (beats/min) | 0.96 (0.92–1.00) | 0.95 (0.91–0.98) |
| 6MWT PCI (beats/m × 100) | 1.04 (1.01–1.07) | 1.02 (1.00–1.04) |
| 6MWT RPE (6–20) | 1.33 (0.99–1.78) | 1.32 (1.03–1.70) |
| 10MWT stride length (cm) | 0.94 (0.91–0.97) | 0.94 (0.91–0.97) |
| 10MWT cadence (steps/min) | 0.93 (0.89–0.96) | 0.88 (0.83–0.94) |
| 10MWT walk ratio (m/steps per min × 1000) | 1.52 (0.94–2.46) | 1.19 (0.80–1.76) |
| Right hand grip strength (kg) | 1.00 (0.92–1.08) | 0.96 (0.89–1.02) |
| MVC of the knee extensors (kg) | 0.94 (0.91–0.97) | 0.94 (0.91–0.97) |
| Repetitive squatting (times) | 0.93 (0.84–1.03) | 0.90 (0.83–0.99) |
| Right hand repetitive dumbbell presses (kg by times) | 0.93 (0.90–0.97) | 0.94 (0.91–0.97) |
| MAS score for upper limbs (0–20) | 1.51 (0.98–2.31) | 2.82 (1.51–5.28) |
| MAS score for lower limbs (0–20) | 1.47 (1.13–1.91) | 2.32 (1.54–3.50) |
| Hamstring flexibility (SLR deg) | 0.99 (0.96–1.02) | 0.98 (0.95–1.01) |

NOTE. Values in bold are statistically significant ($P < .05$). Values are adjusted for age and sex.

*Self-care were omitted because of the small number of the participants in the dependent group (n=6).

DISCUSSION

In this study, we were able to examine a representative, population-based sample of ambulatory persons with MS (EDSS \leq 6.5) and to determine the strength of the independent associations found between clinically measured physical functioning variables and self-reported performance in mobility, self-care, and domestic life. An important strength of this study is the simultaneous assessment of several physical functioning measures. Our categories, activities and body functions, contain almost the same ICF items as those considered relevant in or influenced by PT in a neurologic community health care situation in the study by Finger et al.²⁹ It is only in more severely disabled MS subjects that there is an obvious need to assess respiratory functions.

Some studies of MS have focused on the relation between measures of functional ability and measures of global cognitive status.³⁰⁻³² However, to our knowledge, the specific of association between physical functioning and ADL performance studied here has not been reported earlier in subjects with MS. We used OR to determine the strongest predictors of difficulties in ADL performance. We have reported the results of the univariate model only, because there was considerable multicollinearity between the factors. The ORs were presented using primary sampling units, thus allowing clinically meaningful implications. Our results show some clear associations, which persist after controlling for the effect of age and sex.

Overall, the participants' ADL performance was on a high level. In the present study group, 69% were fully independent reporting no difficulties in self care, 48% were independent in mobility, and 32% independent in domestic life. In contrast, only 5% were dependent in self-care, 22% dependent in mobility, and 26% dependent in domestic life. The proportion of dependent participants is relatively small considering that approximately half of the participants had had MS symptoms for over 10 years and that the average disease duration from symptom onset was 12 years. Earlier studies have indicated that MS tends to progress over time, but that the course of the disease is unpredictable and individual.³³ This was confirmed by our study; thus dependence or perceived difficulties in ADL performance was not associated with either disease duration since symptom onset or time since diagnosis.

In a previous study by Provinciali et al,³⁴ age and disability in MS were not related, but other studies^{33,35} have found a higher prevalence of physical limitations among older than younger MS subjects. In our study, older age was associated with dependence in mobility (OR=1.06) and, inversely, with independence in domestic life (OR=.95), compared to those with perceived difficulties. That means that a change in age of a year corresponds to a 5% to 6% probability for being dependent in mobility or perceiving difficulties in domestic life. Age was the only personal ICF factor that predicted ADL performance in our study. Despite the fact that there were no significant associations between sex and ADL performance, we conducted analyses adjusted by sex and age because of the considerable sex bias in our study group and because a significant age by sex interaction effect has previously been found for ADL.^{33,36,37}

Our study found associations between the FSQ, which is a self-report instrument describing what MS subjects do in their current environment, and objective performance-based measures in ICF activities and body functions categories. A previous study by Goverover et al,¹³ however, found no significant relationship between objective and subjective assessments of everyday life activities. We agree with them that objective performance-based measures and subjective self-reports both

provide information of value in the assessment of physical functioning in MS subjects, and that 1 method should not be used as a substitute for the other. In the context of the ICF, performance-based measures contain items that only concern the motor aspects of actual performance (ie, they measure ICF capacity), but self-report instruments provide useful subjective information on issues such as fatigue, motivation, and environmental factors (ie, they measure ICF performance).

The importance in rehabilitation of identifying restrictions individually in different ADL domains has been highlighted in previous studies showing that MS subjects can be independent in self-care, while still being limited in instrumental ADL.^{3,5} The previous personal and instrumental ADL both included mobility items.¹⁶ In our study, the FSQ was reclassified to link the results to the ICF categories, and thus we were able to assess mobility performance separately from the self-care and domestic life items. Consistent with earlier results,^{3,5} we found that only a few subjects (n=6) were dependent in self-care, whereas about one fourth of the participants were dependent in mobility and one fourth in domestic life. The main rationale underlying the reclassification was to put together items that have the same general functional goal. However, the reclassification of the FSQ item questions according to the ICF needs further study.

For a physical functioning measure to be consistent with and sensitive to the goal of maintaining ADL performance, it should capture meaningful domains of functioning. Our study drew the physical functioning variables from 2 components of the ICF, activity (capacity) and body functions. When evaluating the role of physical functioning in relation to ADL performance, several factors were found to be important. Among the variables of activities, the BBT of the dominant hand, BBS, velocity moment when standing with eyes open, 10MWT time at normal speed, and 6MWT distance were significant predictors of ADL performance (see tables 1, 2). However, in body functions the associations were less obvious and 10MWT stride length at normal speed was the only variable that had independent effects on all 3 ADL performance groups studied (see tables 3, 4). Motor weakness is a major symptom of MS,⁹ and grip strength has been found to associate with reduced quality of life in older men and women.³⁸ In our study, grip strength did not appear to be relevant in ADL performance. Future work is needed to study the associations between the components of activities and body functions.

In the present study, we investigated the underlying factors in participants who reported being independent and being dependent separately from those participants who reported being independent with perceived difficulties. We believe that there was an advantage in using the group with perceived difficulties as the comparison group in this study, because minor differences in physical functioning between the groups were more readily found. These minor declines in physical functioning precede and often predict the onset of clinically detectable dependence in ADL performance. It is important to identify this early decline in order to plan delay in progression. Our results show the value of the use of physical functioning measures in detecting such changes.

The results showed that the influence of underlying factors, that is, the results of the objective measures of activities and body functions, was dissimilar in these 3 groups of participants. Significant associations with ADL performance were found even when independent participants were compared with those who were independent but reported having perceived difficulties. The relationship was strong, especially between mobility and the covariates of activities, in which all 9 variables (see table 1) significantly predicted performance in mobility. Given

that mobility is the paramount aim of PT, it is important to know that these measures of balance and walking can predict perceived limitations in mobility. The significant OR for the PCI in mobility revealed that energy consumption was associated with reduced walking capacity in the dependent group, that is, in those who need assistance and/or assistive devices. This might have implications for community walking and should be considered in the assessment and rehabilitation of ambulatory MS subjects who use assistive devices. Mobility limitations are thought to be the main factor contributing to physical disability.³⁹ Altered mobility can also have a range of psychosocial implications, including decreased opportunity to perform self-care and tasks in domestic life.^{7,15}

Intervention studies have shown that self-management programs and energy-conservation courses can produce significant reductions in MS-related fatigue.⁴⁰ Our findings contribute to the importance of fatigue targeting in such interventions, because the 50% of participants reporting significant fatigue corresponds to the numbers found in previous studies of fatigue prevalence. On the other hand, fatigue showed only minor significant associations with physical functioning, these mainly appearing in exercise tolerance functions (heart rate, PCI, RPE). Physical functioning measures and the MFIS seem to assess different aspects of functioning. A clear definition of fatigue is lacking, as is a generally approved fatigue measurement scale.^{22,28} We suggest that the FSQ score "usually did with some subjective difficulty" contains an aspect of fatigue. In the clinical setting it might be sufficient to assess perceived difficulties in ADL performance to identify subjects who have significant fatigue.

Mental health is a potentially important risk factor for rehabilitation outcome and an independent association between depressive symptoms and limitations in activities in subjects with MS has been described.⁴¹ This was not, however, clearly shown in our study. We found that depressive symptoms were a determinant of performance in domestic life in independent participants with perceived difficulties. It might be that the effort required to participate in domestic life increases, causing depressive symptoms. Depression can also hinder a person's ability to develop coping strategies. Surprisingly, we observed no effect of depressive symptoms on domestic life in dependent participants compared with those who were independent with perceived difficulties. In addition, our study did not confirm that good mental health is of importance in self-care or mobility in subjects reporting perceived difficulties or dependence. The effect of the associations between fatigue and depressive symptoms on ADL performance needs further investigation.

Study Limitations

This study has some possible limitations. Restrictions in ADL performance are not necessarily a consequence of activity limitations or impairments in body functions only, but may also be an effect of properties of the physical environment.^{17,37} However, in the present study, we did not evaluate the impact of the environmental factors included in the ICF. In clinical practice, it is important to ensure that rehabilitation efforts include measures to improve the physical environment of MS subjects. The reliability and the validity of the FSQ have been shown to be good in previous articles.²⁴⁻²⁶ However, reliability studies are lacking in the case of the Finnish version. This study focused on ambulatory persons with MS. Thus the proportion of dependent participants could be expected to be small compared with the general MS population. In addition, because of the small number of dependent participants in self-care we were not able to analyze the associations between "dependent" and "independent with perceived difficulties" in self-care per-

formance. It should be emphasized that the previous study was an exploratory analysis conducted to obtain further insight into the discrepancy between ADL performance and the factors underlying it.

CONCLUSIONS

Our study identifies the most relevant factors underlying ADL performance with respect to activity limitations and impairments in body functions in subjects with MS, and shows the complexity of the interactions between different categories within the ICF. The findings have significant implications for the measurement of PT outcomes, suggesting that the most significant predictors of difficulties in ADL performance include: (1) lower scores for the BBT of the dominant hand; (2) lower BBS; (3) greater velocity moment when standing with eyes open; (4) slower 10MWT times and shorter stride length at normal speed; and (5) shorter 6MWT distance.

The finding that performance-based measures in activities in particular predicted poor outcomes in ADL performance is important for clinicians. From a clinical perspective, using the self-report FSQ may facilitate the detection of impaired functioning that would otherwise go unrecognized and may help physical therapists to value patients' priorities, particularly in terms of rehabilitation goals. Traditionally, interventions have targeted MS subjects with definite and more severe limitations in physical functioning. However, such interventions need to be extended to those whose are independent but perceive difficulties in ADL performance, thereby enabling them to enhance their ADL performance and independent living in society.

References

1. Kesselring J, Beer S. Symptomatic therapy and neurorehabilitation in multiple sclerosis. *Lancet Neurol* 2005;4:643-52.
2. de Groot V, Beckerman H, Lankhorst GJ, Polman CH, Bouter LM. The initial course of daily functioning in multiple sclerosis: a three-year follow-up study. *Mult Scler* 2005;11:713-8.
3. Finlayson M, Winkler Impey M, Nicolle C, Edwards J. Self-care, productivity and leisure limitations of people with multiple sclerosis in Manitoba. *Can J Occup Ther* 1998;65:299-308.
4. Gulick EE. Symptom and activities of daily living trajectory in multiple sclerosis: a 10-year study. *Nurs Res* 1998;47:137-46.
5. Månsson E, Lexell J. Performance in activities of daily living in multiple sclerosis. *Disabil Rehabil* 2004;26:576-85.
6. McDonnell GV, Hawkins SA. An assessment of the spectrum of disability and handicap in multiple sclerosis: a population-based study. *Mult Scler* 2001;7:111-7.
7. Einarsson U, Gottberg K, Fredrikson S, von Koch L, Widén Holmqvist L. Activities of daily living and social activities in people with multiple sclerosis in Stockholm County. *Clin Rehabil* 2006;20:543-51.
8. Paltamaa J, Sarasoja T, Wikström J, Mälkiä E. Physical functioning in subjects with multiple sclerosis: a population-based study in Central Finland. *J Rehabil Med* 2006;38:339-45.
9. LaBan MM, Martin T, Pechur J, Sarnacki S. Physical and occupational therapy in the treatment of patients with multiple sclerosis. *Phys Med Rehabil Clin N Am* 1998;9:603-14.
10. Hobart JC, Lamping DL, Fitzpatrick R, Riazi A, Thompson AJ. The multiple sclerosis impact scale (MSIS-29): a new patient-based outcome measure. *Brain* 2001;124:962-73.
11. Finlayson M, Guglielmello L, Liefer K. Describing and predicting the possession of assistive devices among persons with multiple sclerosis. *Am J Occup Ther* 2001;55:545-51.
12. Freeman JA. Improving mobility and functional independence in persons with multiple sclerosis. *J Neurol* 2001;248:255-9.

13. Goverover Y, Kalmar J, Gaudino-Goering E, et al. The relation between subjective and objective measures of every-day activities in persons with multiple sclerosis. *Arch Phys Med Rehabil* 2005; 86:2303-8.
14. Finlayson ML, Peterson EW, Cho CC. Risk factors for falling among people aged 45 to 90 years with multiple sclerosis. *Arch Phys Med Rehabil* 2006;87:1274-9.
15. Hakim EA, Bakheit AM, Bryant TN, et al. The social impact of multiple sclerosis—a study of 305 patients and their relatives. *Disabil Rehabil* 2000;22:288-93.
16. Coster WJ, Haley SM, Andres PL, Ludlow LH, Bond TL, Ni PS. Refining the conceptual basis for rehabilitation outcome measurement: personal care and instrumental activities domain. *Med Care* 2004;42(Suppl 1):62-72.
17. World Health Organization. International classification of functioning, disability and health. Geneva: WHO; 2001.
18. Jette AM. Introduction: physical disability. *Phys Ther* 1994;74: 379-86.
19. Sarasoja T, Wikström J, Paltamaa J, Hakama M, Sumelahti ML. Occurrence of multiple sclerosis in central Finland: a regional and temporal comparison during 30 years. *Acta Neurol Scand* 2004; 110:331-6.
20. Paltamaa J, West H, Sarasoja T, Wikström J, Mälkiä E. Reliability of physical functioning measures in ambulatory subjects with multiple sclerosis [published erratum in: *Physiother Res Int* 2006; 11:123]. *Physiother Res Int* 2005;10:93-109.
21. Kutzke JF. Rating neurological impairment in multiple sclerosis: an expanded disability status scale (EDSS). *Neurology* 1983;33: 1444-52.
22. Multiple Sclerosis Council for Clinical Practice Guidelines. Fatigue and multiple sclerosis: evidence-based management strategies for fatigue in multiple sclerosis. Washington (DC): Paralyzed Veterans of America; 1998. p 1-33.
23. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas* 1977;1: 385-401.
24. Jette AM, Davies AR, Cleary PD, et al. The Functional Status Questionnaire: reliability and validity when used in primary care. *J Gen Intern Med* 1986;1:143-9.
25. Murphy N, Confavreux C, Haas J, et al. Quality of life in multiple sclerosis in France, Germany, and the United Kingdom. *J Neurol Neurosurg Psychiatry* 1998;65:460-6.
26. Cleary PD, Jette AM. Reliability and validity of the Functional Status Questionnaire. *Qual Life Res* 2000;9:747-53.
27. Mathiowetz V, Volland G, Kashman N, Weber K. Adult norms for Box and Block Test for manual dexterity. *Am J Occup Ther* 1985;39:386-91.
28. Flachenecker P, Kümpfel T, Kallmann B, et al. Fatigue in multiple sclerosis: a comparison of different rating scales and correlation to clinical parameters. *Mult Scler* 2002;8:523-6.
29. Finger ME, Cieza A, Stoll J, Stucki G, Huber EO. Identification of intervention categories for physical therapy, based on the international classification of functioning. Disability and health: a Delphi exercise. *Phys Ther* 2006;86:1203-20.
30. Beatty WW, Blanco CR, Wilbanks SL, Paul RH, Hames KA. Demographic, clinical, and cognitive characteristics of multiple sclerosis patients who continue to work. *Neurorehabil Neural Repair* 1995;9:167-73.
31. Rao SM, Leo GJ, Ellington L, Nauertz T, Bernardin L, Unverzagt F. Cognitive dysfunction in multiple sclerosis. II. Impact on employment and social functioning. *Neurology* 1991;41:692-6.
32. Kessler HR, Cohen RA, Lauer K. The relationship between disability and memory dysfunction. *J Neurosci* 1992;6:17-34.
33. Confavreux C, Vukusic S, Adeleine P. Early clinical predictors and progression of irreversible disability in multiple sclerosis: an amnesic process. *Brain* 2003;126:770-82.
34. Provinciali L, Ceravolo MG, Bartolini M, Logullo F, Danni M. A multidimensional assessment of multiple sclerosis: relationships between disability domains. *Acta Neur Scand* 1999; 100:156-62.
35. DiLorenzo T, Halper J, Picone MA. Comparison of older and younger individuals with multiple sclerosis: a preliminary investigation. *Rehabil Psychol* 2004;49:123-5.
36. Duran L, Fisher AG. Male and female performance on the assessment of motor and process skills. *Arch Phys Med Rehabil* 1996; 77:1019-24.
37. Iezzoni LI. Risk adjusting rehabilitation outcomes: an overview of methodologic issues. *Am J Phys Med Rehabil* 2004;83:316-26.
38. Sayer A, Syddall H, Martin H, Dennison E, Roberts H, Cooper C. Is grip strength associated with health-related quality of life? Finding from the Hertfordshire Cohort Study. *Age Ageing* 2006; 35:409-15.
39. Chan A, Heck CS. Mobility in multiple sclerosis: more than just a physical problem. *Int J MS Care* 2000;3:35-40.
40. Neill J, Belan I, Reid K. Effectiveness of non-pharmacological interventions for fatigue in adults with multiple sclerosis, rheumatoid arthritis, or systemic lupus erythematosus: a systematic review. *J Adv Nurs* 2006;56:617-35.
41. Gottberg K, Einarsson U, Fredrikson S, von Koch L, Widén Holmqvist L. A population-based study of depressive symptoms in multiple sclerosis in Stockholm County. Association with functioning and sense of coherence. *J Neurol Neurosurg Psychiatry* 2007;78:60-5.

Suppliers

- a. Metitur Ltd, Heinämäentie 7, FIN-40250, Jyväskylä, Finland.
- b. Newtest Ltd, Kiviharjuntie 11, FIN-99220 Oulu, Finland.
- c. Polar Electro Oy, Professorintie 5, FIN-90440 Kempele, Finland.
- d. Sammons Preston, PO Box 5071, Bolingbrook, IL 60440.
- e. David Industries Ltd, Tutkijankatu 2, FIN-83500 Outokumpu, Finland.
- f. Version 14.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.