Eur Rev Aging Phys Act (2008) 5:97–105
DOI 10.1007/s11556-008-0037-2

ACADEMIC LITERATURE REVIEW

Batteries assessing health related fitness in the elderly: a brief review

S. Varela · C. Ayán · J. M. Cancela

Received: 24 April 2008 / Accepted: 27 July 2008 / Published online: 15 August 2008

Abstract Evaluation of physical functioning is a key issue in clinical geriatrics and in aging research. In recent years, different physical performance batteries in which individuals are asked to perform several tasks and are evaluated using different criteria have been designed and used in elderly populations. These batteries include different types of test which range from basic motor abilities to relevant everyday activities, depending on the construct area in the domain of physical function that must be measured. This paper reviews and classifies the main physical functioning batteries that can be found in the scientific field of aging research in order to provide knowledge on selection, administration, and interpretation of this indispensable assessment tools.

Keywords Battery · Test · Health · Fitness · Elderly

Introduction

During the past three decades, physical clinicians and researchers have struggled to determine the most appropriate methods to assess the ability of elder individuals to maintain their independence in activities of daily living (ADLs) [6] in order to get an objective measure of their functional status. Given that this level of autonomy relies on the effective combination of several physical capacities (mainly endurance, strength, and flexibility) and selected motor abilities (such as balance, coordination, or agility) [38], standardized methods for the assessment of physical performance and functional ability have been developed, and their reliability and validity have been demonstrated [12]. Moreover, in an attempt to enhance the ability to quantify the functional status of the elderly, direct physical performance measures (defined as a series of tasks that the individual must perform in a standardized manner and are assessed using a priori criteria) [16] have been developed and gathered under the structure of performance batteries.

This paper reviews the most relevant performance batteries that have been specifically designed to assess the functional status of the elderly in order to provide knowledge on selection, administration, and interpretation of this indispensable assessment tools.

S. Varela (✉) · C. Ayán · J. M. Cancela
Faculty of Education and Sport Sciences,
University of Vigo,
Campus A Xunqueira,
S/N 36005 Pontevedra, Spain

Functional fitness batteries

Functional fitness has been designed as having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue, so batteries must asses the physiologic attributes that support the behavioral functions necessary to perform activities of daily living [38]. Functional fitness is typically assessed using batteries that include a combination of health- and performance-related test (Table 1), including measurements of aerobic capacity, muscular strength and endurance, body weight and composition, flexibility, balance, and coordination [4] (Table 2).

American Alliance for Health, Physical Education, Recreation and Dance

One of the first attempts to create a specific battery to measure the physical fitness of the elderly was carried out by the American Alliance for Health, Physical Education,

Table 1 Batteries designed specifically for the elderly

Battery	Author	Year	Objective
AAHPERD	Osness, W.H. et al.	1990	Health-related fitness
SPPB	Guralnik, J.M et al.	1994	Health-related fitness
MacArthur battery	Guralnik JM, Seeman TE, Tinetti ME, Nevitt MC, Berkman LF	1994	Health-related fitness
Functional Fitness Battery	Nezt, Y; Argov, E.	1997	Health-related fitness
Fullertton Fitness Test	Rikli, R.; Jones, C.	1999	Health-related fitness
Groningen	Lemmink, K.	1996	Health-related fitness
Health ABC	Brach J, Simonsick E, Kritchevsky S, Yaffe K, Newman B.	2004	Health-related fitness
PPT	Reuben, D.B.; Siu, A.L.	1990	ADL
PPME	Winograd, C.H. et cols.	1994	ADL
Time Movement Battery	Creel, G.L.; Light, K.E.; Thigpen, M.T.	2001	ADL
Health-related fitness, PF	Suni, J.H.; Oja, P.; Laukkanen, R. et al.	1996	Comprehensive batteries
IADL/FFA	Shigematsu, R.; Tanaka, K. et cols.	2001	Comprehensive batteries
ADAP Test	de Vreede, P.L.,et cols.	2006	Comprehensive batteries
CS-PFP	Crees, M.E. et cols.	1996	Comprehensive batteries
PFP-10	Crees, M.E.; Petrella, J.K.; Moore, T.L.; Schenkman, M.L.	2005	Comprehensive batteries
WHAS	Guralnik J, Fried L, Simonsick E, Kasper J, Lafferty M	1995	Comprehensive batteries

Recreation and Dance (AAHPERD) [5]. This battery, also known as Functional Fitness Assessment Battery [3], having been subjected to several reliability and validity examinations [4] and once established the pertinent normative parameters [30], has become one of the most popular batteries and one of the most useful databank tools. However, certain weak points have been detected, such as the absence of some lower body muscle function tests or the fact that some of the exercises (flexibility and aerobic endurance) may be difficult to perform for many elderly people, as well as the verification of a learning effect [40]. Besides, it is worth mentioning that the protocol in two of the exercises (coordination and strength) should undergo some modifications in order to improve its reproducibility [3].

All in all, the AAHPERD is a battery which can be easily administered due to its low cost and its minimal space and equipment requirements, and it also includes a large number of reference parameters and a user's manual to apply it. Only the learning effect needs to be controlled, especially as far as the agility, flexibility, and coordination exercises are concerned. This fact makes of it a useful instrument to evaluate the underlying physical parameters associated with daily activities.

Short physical performance battery

This battery, known as SPPB or Nacional Institute on Aging (NIA battery) was derived from the adaptation of different functional tests created during the 1980s with the objective of being administered by one single person, in any home, regardless of any spatial constraints. The resulting battery was focused on assessing the lower extremity function and was able to classify a large number of elderly people across a broad spectrum of functional status, predicting mortality in an efficient way [17]. That may be the reason why this is one of the most widely used batteries in longitudinal studies seeking to evaluate elderly people (whether they are sedentary [33] or affected by certain pathologies [22]) or to assess the effects of training in these populations (the physical exercise programmes [18]). The SPPB battery is characterized by the short period of time involved in its performance (10–15 min) and by the fact that it predicts mobility disability and activities of daily living disability independently, mainly through the assessment of strength, balance, and gait speed. Nevertheless, significant ceiling or floor effects on some of the items limit their ability to provide measurement data on a continuous scale across a wide range of ability levels [38]. Probably due to this fact, some researchers have included a 0 level (performance level between 0 and 5) which refers to people who cannot perform the exercises, to those individuals who are not able to walk, or to those situations in which it is self-evident that there is a risk of injury if the candidates take the test [31]. Some other tests are generally added to this battery (such as the ability to walk 400 m or the 6-min walking test) in order to make a more thorough assessment.

Mac Arthur battery

The MacArthur Study of Successful Aging investigated factors that influence physical and cognitive functioning among relatively highly functional volunteers between the ages of 70 and 79, with the main objective of identifying the key factors that seem to contribute to healthy aging [36].

The measures included in the battery represent several major domains of physical performance, and the test used derives from previous studies. Because of that, these measures have generally good reliability [41].

Table 2 Physical capacities assessed by the different health related fitness batteries

Health-related fitness	Battery	Task
Flexibility	AAHPERD	Sit and reach
	Functional Fitness Battery	Upper extremity flexibility
	Functional Fitness Battery	Lower extremity flexibility
	FFT	Sit and reach
	FFT	Back Scratch
	Groningen	Sit and Reach
Strength	AAHPERD	Muscle strength/endurance
	SPPB	Chair stands
	Mac Arthur	Hand grip strength
	Functional Fitness Battery	Arm streght
	Functional fitness battery	Lower strength
	FFT	Chair stand
	FFT	Arm curl
	Groningen	Grip strength
	ABC	Isokinetic strength
	ABC	Chair stands
Endurance	AAHPERD	Half mile walk
	Functional fitness battery	Walking
	FFT	6-min walk
	FFT	2′ step in place
	Groningen	Walking endurance
	ABC	400-m walk
Speed	SPPB	Walking speed
	Groningen	Simple reaction time
	ABC	6-m walk (gait speed)
Balance	AAHPERD	Dynamic balance
	SPPB	Standing balance
	Mac Arthur	Balance
	Mac Arthur	10-ft walk
	Functional fitness battery	Balance
	FFT	8-ft up and go
	Groningen	Balance board
	ABC	Feet in parallel
	ABC	Semi-tandem
	ABC	Tandem
	ABC	Single leg stance
	ABC	20-cm narrow walk
Coordination	AAHPERD	Soda pop
	Mac Arthur	Tapped a foot
	Mac Arthur	Sing the name
	Mac Arthur	Switching back and forth between 2″ circles 1 ft apart while in a seated position
	Functional fitness battery	Coordination
	Groningen	Block transfer
Agility	Functional fitness battery	Agility

While the battery presents performance measures of functioning as true measures of physical health status in non-disabled old persons, it must be noted that some important domains, such as proximal upper extremity strength and shoulder range of motion, are not included, so further methodological work is needed in order to establish a more comprehensive battery [16].

The Groningen fitness test for the elderly

The Groningen fitness test for the elderly (GFE) is a field-based motor fitness assessment designed to research the interrelationship between motor fitness, physical activity, health, and daily functioning [49]. This battery includes manual dexterity and reaction time tests, identified as

important features of physical aptitude [13]. In addition, it is combined with a questionnaire to assess the subjective self-evaluation of health, and therefore, it has been used in longitudinal studies seeking to analyze the correlation between fitness level perceived through questionnaires and that proved in field tests [50]. The reliability, inter-rater, intra-rater, and internal consistency of the GFE has been demonstrated [23], which makes of it a very useful tool to measure basic motor abilities such as strength, endurance, and coordination. Although "passing" the GFE does not take long (each test takes 4 min and the endurance test 15) and its items are simple to perform and easily transportable, it does require specific equipment; thus, it might not be easily administered in all situations. In addition to this, it should be noted that the circumduction test lacks objectivity, that including a suitable warming up before the sit and reach test has been suggested, and that some previous practice before the block-transfer exercise would be advisable in order to avoid the learning effect. Furthermore, the endurance exercise (walking test) may not be selective enough, given the fact that some people are able to finish it without reaching their maximum level of effort [23]. Lastly, it must be stressed that because this battery consists of simple exercises and it is easy to administer, it is used to assess the fitness level of sedentary populations and of people affected by different pathologies [25].

Functional fitness

With the aim to develop a field test to assess various components of daily activities, the battery functional fitness was developed [28]. This battery consists of eight subtest components which try to reproduce daily activities, measuring the fitness level at the same time. Three of these components have been taken from the AAHPERD, while the rest are completely new.

This battery does not require special equipment, it is a low-cost battery easy to perform, and it does not involve too much time (50 people can be tested in 3 h). Its strong point is that it is easy to administer and does not need a doctor's permission. However, it is only useful to assess independent individuals (which is a limitation) and large populations. It might not be a good choice if the purpose is to carry out clinical studies or pre–post over a short period of time.

Fullerton fitness test

With the purpose of developing a series of tests to assess the key physiologic parameters that support functional mobility, the Fullerton fitness test (FFT) was created the [38], also known as Senior Fitness Test [11]. This battery focuses on the evaluation of those physical abilities which allow the functional independence of the elderly, and it includes the body mass index as well. The FFT is relatively easy to perform, the exercises are safe, it has almost no ceiling and floor effects, and there are "normative scores" for each exercise [39], which makes of it a very useful battery to assess the functional fitness. Besides, if it is organized as a circuit, it is possible to evaluate up to 24 people in 90 min [19]. It is worth mentioning that in spite of the fact that the construct validity of the FFT has been confirmed, some kind of learning effect has been detected, and therefore, one or two previous practice sessions are advisable prior to the final assessment session [26]. Lastly, it must be taken into consideration that the FFT has been created and validated upon the score of voluntary elderly people, with ambulatory independence and generally active; consequently, the extrapolation of these scores should be done with caution.

Health Aging and Body Composition Study

The Health Aging and Body Composition Study (Health ABC) is "a prospective investigation of interrelationships between health conditions, body composition, social behavioral factors, and change in physical function" [2]. To measure a wider range of function in this population, the SPPB battery was expanded to create the Health ABC performance battery [48]. Because of that, the hold times on the standing balance items were increased to 30 s, and two additional balance tests were added. Besides, walking endurance is usually assessed by means of the 400-m walk test [47]. Although this battery includes a large reference database to compare scores, it is important to point out that the selective criteria for joining the ABC study are being able to walk a quarter of a mile, climbing up ten steps, or performing basic daily life activities. Additionally, the fact that strength, mobility, and flexibility tests are not included leaves this battery somehow incomplete. In spite of this, the Health ABC battery has been described as a set of effective exercises to identify functional limitation in a discriminatory and concise way [2].

Batteries assessing activities of daily living

The extent to which an individual can live independently depends largely on his or her ability to perform daily functional tasks known as ADLs. ADLs are the tasks that define an individual's daily functional competence: basic (self-care, hygiene, etc.) and instrumental (household, shopping, etc.) [11]. The batteries reviewed in this section (Table 3) include ADL tests focused on the ability to reproduce complex, real-life tasks rather than on specific physiologic abilities. Thus, these measures are closer to the concept of disability than are the tests of more basic abilities. To avoid repetition data, several classic batteries that assess ADLs are not mentioned here, since they have been fully reviewed elsewhere [14].

Table 3 Comprehensive batteries

Battery	Task
PPT	Writing a sentence
	Simulated eating
	Lifting a book and putting it on a shelf
	Putting on and removing a jacket
	Picking up a small object from the floor
	Turning 360°
	Walking 15.2 m (PPT-7)
	Climbing one flight of stairs
	Counting the number of flights of stairs (PPT-9)
Time movement battery	Lie to sit
	Sit to lie
	Sit to stand
	6-m (20 ft) forward walk
	3-m (10 ft) back walk
	Figure-8 walk
	Stepping over obstacles while walking
	Supine floor to stand
	Stairs: up 4 steps
	Stairs: down 4 steps
PPME	Bed mobility
	Transfer skills
	Multiple stands from chair
	Standing balance
	Step up
	Ambulation

Physical performance and mobility examination

The physical performance and mobility examination (PPME) was developed to fill the need for a performance measure of physical functioning and mobility appropriate for hospitalized and frail elders [51]. Tasks were selected that could be safely and reliably administered at the bedside, office, or home by non-professionals after brief training. The tests have been designed to screen (1) from gross level of function and to detect clinically relevant changes in mobility. The PPME has been proven to be reliable and valid when used with healthy older people especially with those who have suffered a hip fracture [44].

Physical performance test

The battery physical performance test (PPT) was created with the idea of obtaining an objective quantifiable measure of functional capabilities. The PPT assesses multiple components of the physical function through the performance of different daily life activities of various degrees of difficulty [37]. This test has been confirmed as an independent predictor of death or institutionalization [35], and it is presented in several shortened versions (nine, eight, or seven items) which enable the completion of the test in less than 10 min. Although this battery constitutes in itself an objective way to assess the functional level, it is normally used together with another tests such as the "Tinetti gait score" or the "6-min walking test", with which it is perfectly correlated, obtaining a more complete assessment at the same time [21]. Furthermore, it is not unusual (in studies seeking a more thorough physical and functional assessment) to administer this battery in coordination with the SPPB, since they are also perfectly correlated [43]. The PPT seems to be an appropriate way of assessing those daily life activities involving strength, balance, and flexibility, although it has also been used successfully to evaluate the effects of training programs [20] or the level of autonomy of sick populations [32].

Timed movement battery

The timed movement battery (TMB) is a battery designed to assess the range of mobility in elderly people ("mobility" meaning their ability to manage their own body in order to face different situations in an autonomous way); therefore, it includes tests related to the basic and instrumental activities of daily living [34]. Unlike most tests, TMB tasks are performed at two speeds (self-selected speed and maximum movement), which facilitate the elimination of the "ceiling effects". In spite of the fact that its construct validity has been verified, that it is perfectly correlated with other classic elderly fitness tests (such as Up & Go test [6]), and that it is being used in current clinic research [1], it is noticeable that some kind of accurate coordination test is missing in order to fully evaluate the mobility upon which daily life autonomy rests. Besides, performing some of the tasks may be difficult for those people suffering from certain mobility problems, hence the need for more research in order to evaluate its sensitivity and specificity.

Comprehensive batteries

There are some batteries that include several tests to assess health-related fitness (HRF) as well as to measure functional performance (FP). In this context, HRF refers to the components of fitness (cardiorespiratory, motor, musculoskeletal, morphologic, etc.) that are affected by habitual physical activity and are related to various health outcomes. FP, which is related to the components of HRF, refers to the ability to perform tasks for independent living and overall well-being.

The comprehensive test batteries presented here (Table 4) generally include motor skills (coordination, kinesthetic differentiation, or sense of rhythm) and some performance measures (flexibility, strength or endurance, among others).

Table 4 Batteries that measure activities of daily living

Battery	Task
WHAS	Measured walk
	Side-by-side
	Semi-tandem
	Tandem
	Functional reach
	Chair stands
	Grip Strength
	Pinch Strength
	Overhead lifting ability
	Shoulder range of motion
	Purdue pegboard
	Opening a lock with a key
	Putting on and buttoning a blouse
	Telephone use
CS-PFP	Carry a weighted pan a distance of 1 m
	Pouring water from a jug into a cup
	Donning and removing a jacket
	Place a sponge on and remove it from an adjustable shelf
	Floor sweeping with broom and dustpan (floor sweep)
	Transfer clothes from washer to dryer (laundry 1); transfer clothes from dryer to basket (laundry 2)
	Open and pass through a fire door (door pull)
	Making a bed
	Vacuuming
	Place a strap over a shoe (shoe strap)
	Pick up 4 scarves from the floor
	Carry weighted bag up and down simulated bus stop
	Carry groceries 70 m
	Sit and stand up from the floor (floor sit/rise)
	Climb stairs
	6 min walk
PFP-10	Carry a weighted pan a distance of 1 m
	Donning and removing a jacket
	Place a sponge on and remove it from an adjustable shelf
	Floor sweeping with broom and dustpan (floor sweep)
	Transfer clothes from washer to dryer (laundry 1); transfer clothes from dryer to basket (laundry 2)
	Pick up 4 scarves from the floor
	Carry groceries 70 m
	Sit and stand up from the floor (fllor sit/rise)
	Climb stairs
	6 min walk
IADL	Hand gripping
	Arm curl
	Keeping a half-squat position
	Hand tapping
	Foot tapping
	Reaction to a dropped bar
	Walking around two cones
	Moving beans with chopsticks
	Manipulating pegs
	Stand-up from lying position
	Raising both arms
	Raising one leg
	Trunk flexion from a standing position
	Trunk flexion in a seated position (sit and reach)
	Single-leg balance with eyes open
	Single-leg balance with eyes closed
	Reaching arms forward in a standing position (functional reach)
ADAP test	Carrying a weighted pan between kitchen counters
	Pouring water from a jug into a cup
	Carrying weight in a luggage bag up and down a 3-stair bus platform
	Carrying groceries through a door, up and down a 3-stair platform and lifting groceries on a counter
	Transferring laundry from a dryer to a counter
	Putting on and taking off a jacket
	Floor sweeping
	Vacuuming
	Making a bed
	Climbing Stairs (13 steps)
	Getting down and up from the floor
	Opening a door
	Putting a hook-and-loop strap over a shoe
	Picking up four scarves from the floor
	6-min walk
	Functional reach
HRF-PF	Balance
	Trunk flexibility
	Lower extremity flexibility
	Trunk muscular endurance
	Lower extremity strength
	Cardiorespiratory fitness
	6.1-m (20 ft) walk assessing the ability to walk
	Chair stand for assessing the ability to rise from chair
	Stair climb and descent for assessing the ability to climb stairs

Continuous scale physical functional performance test

This battery, known as continuous scale physical functional performance (CS-PFP), was created with the intention of producing a measuring tool which avoided the ceiling and floor effects and which identified the causes of poor physical functional performance. As a result, it was obtained an instrument which uses a continuous scale to quantify the physical function performance of the whole body as well as across several physical domains [7]. Therefore, the CS-PFP is based on the performance of very common and simple daily life tasks, which minimizes the "learning effect" and assesses the levels of strength, balance, coordination, and endurance upon which these tasks rest. The fact that the battery is applicable to elderly people with different functional levels should be emphasized, although it was not designed to assess those individuals who need assistance in order to perform some of their daily tasks. Nevertheless, the battery has been used to assess people with specific disorders, such as cardiovas-

cular disease, pot-born injury, or Parkinson's disease [9]. There are several versions of this battery worth mentioning. The German version modifies the size of the furniture where the tests are carried out and substitutes the "vertical reach task" with the "functional reach test". Thus, the flexibility is evaluated by a combination of a forward standing reach and sit and reach task (putting a Velcro-closed strip across the shoe). It was estimated that the battery had changed in more than 30%, so a new one was defined, the daily activity performance [10]. Besides, in order to overcome the difficulties in the application of the CS-PFP (a fixed laboratory space and approximately 1 h were necessary to administer the test), a shortened version, "physical function performance 10 test" (PFP-10), was created, which requires less room and equipment and which is applied in 30 min [9]. Lastly, the CS-PFP has also been adapted to elderly wheelchair users [8].

Health-related fitness and functional performance test

The health-related functional test battery (HR-FTB) is a battery comprising several motor and musculoskeletal fitness tests which has been widely used in adults. Due to its success, it was decided to test its efficiency in assessing the level of fitness in people over 60, and as a result, a battery including six HRF tests and three FP tests was originated [24]. This battery has a great correlation with the perceived level of health, although two of the tests (dynamic back extension and one-leg extension) may cause safety problems. However, this battery was validated with people who do not show mobility problems, so more research should be done in order to determine the possible applicability of the HR-FTB to a wider range of elderly populations.

Instrumental activities of daily living

With the objective of creating an index to correlate chronological age with the level of functional decline, the instrumental activities of daily living (IADL) was designed, which consists of 17 tests related to instrumental daily life activities [44]. This battery can be completed in 40 min, and it only requires an examiner and minimum equipment. Although the IADL includes different exercises which have been developed and validated in different studies [45], it must be taken into account that the capability of the exercise "functional reach" to assess the dynamic balance has been questioned [50] and that this battery has only been used in Japanese populations [27]. Therefore, more studies confirming its reliability in different geographical contexts would be necessary.

Women's Health and Aging Study

The Women's Health and Aging Study (WHAS) is a longitudinal study designed to identify the factors related to progressive physical disability in impaired elderly women over 65 [15]. The WHAS battery consists of fitness exercises and other tests which assess the efficiency of the performance of certain daily life tasks; therefore, it has been pointed out as a very effective method to predict and calculate the risk of developing progressive disabilities [29]. Besides, a remarkable feature of the WHAS battery is that it can be safely performed in home setting [46]. Although the use of the battery in a longitudinal study has provided a significant amount of reference data, we have to bear in mind that the women who were selected to participate in WHAS had to show some kind of difficulty in performing certain tasks which assess the functional autonomy; consequently, this results are not applicable to healthy populations, nor to men, of course [42].

Conclusion

The batteries which have been designed to assess the healthy physical condition of the elderly and which are used nowadays in clinical relevant studies present some inclusion and exclusion criteria as well as some normative values which are clear enough and which enable a good replicability of the tests. However, new applications of these batteries need to be carried out for the current level of health of elderly people to become clear. On the other hand, a better explanation of the performance protocols on which those batteries which asses daily life activities are based is necessary in order to facilitate their application in different contexts as well as the comparison of the obtained data.

References

1. Bastille J, Gill-body K (2004) A yoga based exercise program for people with chronic poststroke hemiparesis. Phys Ther 84:33–48
2. Brach J, Simonsick E, Kritchevsky S, Yaffe K, Newman B (2004) The association between physical function and lifestyle activity and exercise in the Health, Aging and Body Composition Study. J Am Geriatr Soc 52:502–509
3. Bravo G, Gauthier P, Roy P, Tessier D, Gaulin P, Dubois M, Péloquin L (1994) The functional fitness assessment battery: reliability and validity data for elderly women. J Aging Phys Act 2:67–79
4. Capranaica L, Tiberi M, Figura F, Osness W (2001) Comparison between American and Italian older adult performances on the AHHPERD functional fitness test battery. J Aging Phys Act 9:11–19
5. Clark B (1989) Test for fitness in older adults. AAHPERD Fitness Task Force. JOPRD March, pp 66–71
6. Creel G, Light K, Thigpen M (2001) Concurrent and construct validity of scores on the timed movement battery. Phys Ther 81:790–798
7. Cress M, Buchner D, Quesead K, Esselman P, deLateur B, Schwartz R (1996) Continuous-scale functional performance in healthy older adults: a validation study. Arch Phys Med Rehab 77:1243–1250

8. Cress M, Kinne S, Patrick D, Maher E (2002) Physical functional performance in persons using a manual wheelchair. J Orthop Sports Phys Ther 32:104–113
9. Cress M, Petrella J, Moore T, Schenkman M (2005) Continuous-scale physical functional performance test: validity, reliability, and sensitivity of data for the short version. Phys Ther 85:323–335
10. de Vreede PL, Samson MM, van Meeteren NL, Duursma SA, Verhaar HJ (2006) Reliability and validity of the assessment of daily activity performance (ADAP) in community-dwelling older women. Aging Clin Exp Res 18:325–333
11. Dobek J, White K, Gunter K (2006) The effect of a novel ADL based training program on performance of activities of daily living and physical fitness. J Aging Phys Act 15:13–25
12. Ferrucci L, Guralnik JM, Salive ME, Fried LP, Bandeen-Roche K, Brock DB, Simonsick EM, Corti MC, Zeger SL (1996) Effect of age and severity of disability on short term variation in walking speed. J Clin Epidemiol 49:1089–1096
13. Greene L, Williams H, Macera C, Carter J (1993) Identifying dimensions of physical (motor) functional capacity in healthy older adults. J Aging Phys Act 5:163–178
14. Guralnik J, Branch L, Cummings S, Curb D (1989) Physical performance measures in aging research. J Gerontol 5:M141–M146
15. Guralnik J, Fried L, Simonsick E, Kasper J, Lafferty M (eds) (1995) The Women's Health and Aging Study: health and social characteristics of older women with disability. Bethesda, MD, National Institute on Aging, (NIH publ. no. 95-4009). Available from http://www.nih.gov/nia/health/pubs/whasbook/title.htm
16. Guralnik J, Simonsick E, Ferruci L, Glynn R, Berkman L, Blazer G, Scherr P, Wallace R (1994a) A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol 49:M85–M94
17. Guralnik JM, Seeman TE, Tinetti ME, Nevitt MC, Berkman LF (1994b) Validation and use of performance measures of functioning in a non-disabled older population: MacArthur studies of successful aging. Aging (Milano) 6:410–419
18. Herman T, Giladi N, Gruendlinger L, Hausdorff JM (2007) Six weeks of intensive treadmill training improves gait and quality of life in patients with Parkinson's disease: a pilot study. Arch Phys Med Rehabil 88:1154–1158
19. Jones C, Rikli R (2000) The application of Fullertons's functional fitness test for older adults in a group setting. Sci Sport 15:194–197
20. Katzman WB, Sellmeyer DE, Stewart AL, Wanek L, Hamel KA (2007) Changes in flexed posture, musculoskeletal impairments, and physical performance after group exercise in community-dwelling older women. Arch Phys Med Rehabil 88:192–199
21. King M, Judge J, Whipple R, Wolfson L (2000) Reliability and responsiveness of two physical performance measures examined in the context of a functional training intervention. Phys Ther 80:8–16
22. Landi F, Russo A, Cesari M, Pahor M, Bernabei R, Onder G (2007) HDL-cholesterol and physical performance: results from the ageing and longevity study in the sirente geographic area (ilSIRENTE Study). Age Ageing 36:514–520
23. Lemmink K, Han K, de Greef M, Rispens P, Stevens M (2001) Reliability of the Groningen fitness test for the elderly. J Aging Phys Act 9:194–212
24. Malmberg JJ, Miilunpalo SI, Vuori IM, Pasanen ME, Oja P, Haapanen-Niemi NA (2002) A health-related fitness and functional performance test battery for middle-aged and older adults: feasibility and health-related content validity. Arch Phys Med Rehabil 83:666–677
25. Marieke C, van Vilsteren A, de Greef M, Huisman R (2005) The effects of a low-to-moderate intensity pre-conditioning exercise programme linked with exercise counselling for sedentary haemodialysis patients in The Netherlands. Results of a randomized trial. Nephrol Dial Transplant 20:141–146
26. Miotto J, Chodzko-Zajko W, Reich J, Supler M (1999) Reliability and validity of the Fullerton functional fitness test: an independent replication study. J Aging Phys Act 7:339–335
27. Nakamura Y, Tanaka K, Yabushita N, Sakai T, Shigematsu R (2007) Effects of exercise frequency on functional fitness in older adult women. Arch Gerontol Geriat 44:163–173
28. Netz J, Argot E (1997) Assessment of functional fitness among independent older adults: a preliminary report. Percept Mot Skills 84:1059–1074
29. Onder G, Penninx B, Ferrucci L, Fried L, Guralnik J, Pahor M (2005) Measures of physical performance and risk for progressive and catastrophic disability: results from the Women's Health and Aging Study. J Gerontol A Biol Sci Med Sci 60:74–79
30. Osness W, Adrian M, Clark B, Hoeger W, Raab D, Wisweel R (1996) Functional fitness assessment for adults over 60 years. Kendall/Hunt, Dubuque, IA
31. Ostir GV, Ottenbacher KJ, Fried LP, Guralnik JM (2007) The effect of depressive symptoms on the association between functional status and social participation. Soc Indic Res 80:379–392
32. Paschal K, Oswald A, Siegmund R, Siegmund S, Threlkeld AJ (2006) Test–retest reliability of the physical performance test for persons with Parkinson disease. J Geriatr Phys Ther 29:82–86
33. Patel KV, Coppin A, Manini T, Lauretaini F, Bandinelli S, Ferruci L, Guralnik J (2006) Midlife physical activity and mobility in older age: the InChianty Study. Am J Prev Med 31:217–224
34. Rehm S, Light K, Freund J (1997) Reliability of timed-functional movements for clinical assessment of a frail elderly population. Phys Occup Ther Geriatr 15:1–19
35. Reuben D, Siu A, Kimpau S (1992) The predictive validity of self-reported and performance-based measures of function and health. J Gerontol 47:M106–M110
36. Reuben DB, Judd-Hamilton L, Harris TB, Seeman TE (2003) MacArthur Studies of Successful Aging. The associations between physical activity and inflammatory markers in high-functioning older persons: MacArthur Studies of Successful Aging. J Am Geriatr Soc 51:1125–1130
37. Reuben DB, Siu AL (1990) An objective measure of physical function of elderly outpatients. The physical performance test. J Am Geriatr Soc 38:1105–1112
38. Rikli R, Jones C (1999a) Development and validation of a functional fitness test for community residing older adults. J Aging Phys Act 7:129–161
39. Rikli R, Jones C (1999b) Functional fitness normative scores for community residing older adults, age 60–94. J Aging Phys Act 7:162–181
40. Rikli R, Jones C (1997) Physical performance in independent older adults. J Aging Phys Act 5:244–261
41. Seeman TE, Charpentier PA, Berkman LF, Tinetti ME, Guralnik JM, Albert M, Blazer D, Rowe JW (1994) Predicting changes in physical performance in a high-functioning elderly cohort: MacArthur Studies of Successful Aging. J Gerontol 49:M97–M108
42. Semba R, Varadhan R, Bartali B, Ferruci L, Ricks M, Blaum C, Fried L (2007) Low serum carotenoids and development of severe walking disability among older women living in the community: the Women's Health and Aging Study I. Age Ageing 36:62–67
43. Sheerman S, Reuben D (1998) Measures of functional status in community dwelling elders. J Gen Intern Med 13:817–823
44. Sherrington C, Lord SR (2005) Reliability of simple portable tests of physical performance in older people after hip fracture. Clin Rehabil 19:496–504
45. Shigematsu R, Kim HK, Kim HS, Tanaka K (1998) Reliability and objectivity of the test items to assess functional fitness

required for performing activities of daily living in older adult Japanese women. Jpn J Physiol Anthropol 3:13–18
46. Simonsick E, Maffeo C, Rogers S, Skinner E, Davis D, Guralnik J, Fried L (1997) Methodology and feasibility of a home based examination in disabled older women: the Women's Health and Aging Study. J Gerontol A Biol Sci Med Sci 52:M264–M274
47. Simonsick EM, Montgomery PS, Newman AB, Bauer DC, Harris T (2001b) Measuring fitness in healthy older adults: the Health ABC Long Distance Corridor Walk. J Am Geriatr Soc 49:1544–1548
48. Simonsick EM, Newman AB, Nevitt MC, Kritchevsky SB, Ferrucci L, Guralnik JM, Harris T, Health ABC Study Group (2001a) Measuring higher level physical function in well-functioning older adults: expanding familiar approaches in the Health ABC study. J Gerontol A Biol Sci Med Sci 56:M644–M649
49. University of Groningen, Department of Human Movement Sciences (1995) The Groningen fitness test for the elderly: field based motor fitness assessment for adults over 55 years. University of Groningen, Groningen, The Netherlands
50. Van Heuvelen M, Kempen G, Ormel J, de Greef M (1997) Self-reported physical fitness of older persons: a substitute for performance-based measures of physical fitness? J Aging Phys Act 5:298–310
51. Winograd CH, Lemsky CM, Nevitt MC, Nordstrom TM, Stewart AL, Miller CJ, Bloch DA (1994) Development of a physical performance and mobility examination. J Am Geriatr Soc 42:743–749