QUANTIFYING PHYSICAL FUNCTIONAL PERFORMANCE IN OLDER ADULTS

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Determining physical function using performance tests can provide information about impairment and may be more responsive to change than self-report instruments. Many performance tests are designed to capture the functional limitations of severely limited persons (for example bed mobility, activities of daily living (ADL) tasks) and therefore have ceiling effects for persons with higher level function.[4] Older adults experience reduced cardiovascular fitness and strength. While still functioning independently, many older adults adjust their living status to accommodate their lower physical capacity.[1,2]

We developed an original instrument, the continuous-scale physical functional performance (PFP), based on the concept of integrating physiological capacity, physical performance, and psychosocial factors.[1] Performing a task, such as carrying groceries, reflects the person's ability to integrate neuromuscular and cardiovascular capabilities as influenced by the perception of those capabilities. Carrying groceries requires both upper and lower body strength, balance, and coordination. The weight carried reflects functional strength, and the time taken to complete a standard task reflects balance and coordination. Functioning on a daily basis, however, is the performance of many tasks serially and requires the integration of several separate domains of strength, flexibility, balance and coordination, and endurance.

To maintain an independent lifestyle, a person may adapt or compensate in one domain to overcome an insidious impairment in another. A person's success or lack of success in adaptation may affect performance in the form of confidence, fear of falling, motivation, and so forth. While interventions that are holistic in nature, e.g., exercise, may not demonstrate changes at the cellular level, they may still bring about improvement in functional performance of daily tasks. Conversely, interventions that are successful in changing muscle chemistry may fail to translate into improved functional performance.

The physical functional performance (PFP) test was developed to quantify whole-body physical functional performance and determine the contribution of several physical domains. The PFP instrument was validated in older men and women with a broad spectrum of abilities who did not require assistance on basic activities of daily living.[1] The PFP score is derived from a battery of 15 everyday tasks that sample from five physical domains: upper and lower body strength, upper body flexibility, balance and coordination, and endurance. Because participants perform common activities, essential to independent living, effects of learning or strategizing are minimized. Each task reflects one primary physical domain, which minimizes reliance on other domains to accomplish the task. Participants perform real, not simulated, tasks; e.g., sweeping a floor, carrying groceries. The 15 tasks are ordered from easy to most difficult and range from those requiring little strength or endurance to those demanding greater stamina. In addition, the tasks are performed serially because this approach closely mimics the real demands of everyday physical function, for example, getting dressed, cooking breakfast, taking the bus, going shopping and doing laundry. The cumulative time of the timed tasks is one measure of endurance. A person must pace his or her performance to complete as many tasks as possible. The instruction for each task is to perform it safely but to work at maximal effort, e.g., reaching as high as possible, carrying maximal weight, and working as quickly as possible. Instructions and measurement protocols were standardized. Depending on the level of ability, the time required to complete the entire test may range from 45 minutes for persons with a lot of vigor to 75 minutes for people with some dependency.[1]

A detailed description of the tasks and the

CCC 0148-639X/97/S50S17-04

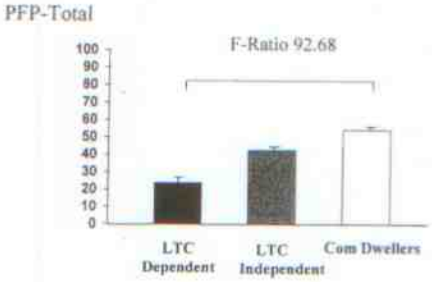

FIGURE 1. PFP-total Community Dwellers (n=78) (open bar); Long-term Care/Independent (n=31) (cross-hatched bar); Long-term Care/Dependent (n=39) (solid bar). Groups are significantly different (F-ratio=92.68).

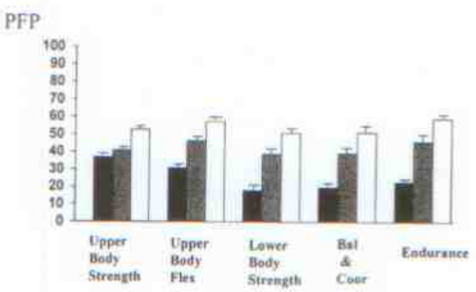

FIGURE 2. PFP-domains: upper body strength, upper body flexibility, lower body strength, balance and coordination, endurance. All domains were significantly different (F-ratio range=50-86). (Community Dwellers=open bar; Long-term Care/Independent= cross-hatched bar; Long-term Care/Dependent=solid bar.)

distribution of these measures across the physical domains is given elsewhere.[1] (A detailed description of the tasks and procedure dialog is also available from the author.) A brief description of the tasks follows. Tasks that are quantified using both weight and time include: carrying a pan of water; carrying and pouring water; carrying sandbags in a luggage bag on and off a 3-stair platform; carrying groceries. Tasks that are quantified by time alone include: transferring laundry from a washer to a dryer; donning and removing a jacket and a seat-belt; floor sweeping; vacuuming; making a bed; climbing a set of stairs; getting into and out of a bath-tub. Tasks that are quantified by distance include: 6-minute walk; placing a sponge on an adjustable shelf. Only one task is quantified with weight alone: pulling on a spring scale to simulate the opening of a fire door. Each score is allocated to a domain (upper body strength, upper body flexibility, lower body strength, balance and coordination, endurance) based upon consensus agreement of nine judges.[1] A subscale score is determined for each domain and these scores are averaged to determine the total score. The first ten tasks administered reflect all physical domains to make it possible to gather the most information on a person who may not have the stamina to complete all tasks. In addition, tasks were selected so that several tasks contributed to one domain score. For example, carrying a pan of water, carrying and pouring water, carrying groceries, and carrying weight on public transportation all reflect upper body strength. Tasks reflective of upper body strength and balance and coordination are included at all three levels of difficulty. Tasks requiring lower body strength were moderate or difficult. The PFP-total and 5 domains have good internal consistency (Cronbach's Range from 0.83-0.97); inter-rater and test-retest reliability range from 0.85-0.99.[1]

We administered the PFP to 148 older adults from three different living status situations: community dwellers (CD; n=78; age=72.0±5 years), long-term care residents who were independent (LTC/I; n=31; age=80.6±6 years), and long-term care residents reporting mild limitation (LTC/D; n=39; age=84.6±6 years).[1] As expected, these subjects had a broad range of physical capabilities. The CD (68±11 kg) group were slightly but significantly ($p<0.05$) heavier than the LTC/I (64±9 kg) and LTC/D (63±5 kg) group. In both isokinetic knee extension strength at 60°/s (KES) and maximal oxygen consumption (VO_2-max) the CD (KES=100±34 Nm; VO_2-max=1.52±5 L/min) were more significantly fit ($p<0.05$) than the LTC/I (KES=74.7±20 Nm; VO_2-max=1.22±4 L/min) which in turn were significantly more fit ($p<0.05$) than the LTC/D group (KES=59.5±16 Nm; VO_2-max=0.79±3 L/min) group.[1] In spite of these significant physical capacity differences, the groups did not report significantly different limitations on instrumental ADL (IADL) tasks.[1] The PFP scaling has been refined from a 0-to-12 scale as previously described[1] to a 0-to-100 scale. We empirically established lower and upper performance limits based on the performance of each task. Time was converted to speed ($1/t$) so that higher numbers reflect higher function for each unit of measure (weight, distance, and speed). Each task is scaled 1-to-100 according to the following formula:

Observed score = (observed score - lower limit)/(upper limit - lower limit) x 100.

FIGURE 3. PFP-total change in a randomized controlled exercise trial. Control (n=20), Strength (n=9), Endurance (n=9), Combined strength/endurance (n=13). * Indicates significantly different from control ($p<0.001$).

If the observed score was less than or equal to the lower limit or greater than or equal to the upper limit, the observed score was set at the appropriate limit. Unattempted tasks receive a score of 0.

The PFP can detect functional differences not distinguished using the IADL scale. The physical ability of the 3 groups of older adults is distinguished by the PFP-total score and the 5 domains (Figs. 1 and 2). Each physical domain of the PFP was significantly correlated ($p<0.01$) with the maximal physical measure it reflects: upper body strength and isometric elbow flexion strength at 90°/s (r=0.63); lower body strength domain and isokinetic knee extension at 60°/s (r=0.69); upper body flexibility and shoulder flexion (r=0.26); balance and coordination domain and step reaction time (r=-0.57); endurance domain and maximal oxygen consumption (r=0.65).[1] The PFP is capable of distinguishing differences in whole-body physical function among groups and providing information on the physical domains that comprise the whole-body performance.

Table 1. Exercise Intervention Effect Size on PFP-total and Selected PFP-domains

PFP Total & Domains	Strength Training	Endurance Training	Combined
PFP-total	0.78	1.00	1.30
Upper body strength	1.17	1.31	1.06
Lower body strength	1.15	2.00	1.60
Endurance	0.39	0.60	0.93

Ability to change physical function or track the time-course of change in physical function prior to disability is a primary concern for programs targeting prevention of disability. Preliminary data indicate that the PFP-total and domain scores are sensitive to detecting change. To test the instrument's sensitivity to change, we randomized healthy community dwelling men and women (age 73±5 years) to either a usual-activity control group (n=20), endurance training (n=9), strength training (n=9), or combined endurance/strength training (n=13). The intervention period was 6 months. Exercise training was performed 3 times/week for 60 minutes with a 10-minute warm-up and cool-down. Training equipment was Stairmaster Sport/Medical Product L. P. (Kirkland, Washington). Endurance training intensity was 75-80% of the heart-rate reserve.[3] Endurance training equipment included a recumbent stepper (Stairmaster Crossrobics 1650) and a body torso-trainer (Stairmaster Kayak). Strength training intensity was set at 75-80 % of the weight a subject could lift through four repetitions while holding to good form (4 RM). Strength training equipment included a Stairmaster Gravitron 2000 and Stairmaster leg press. Free-weights were used for deltoid strengthening or in shoulder rotator cuff or wrist limitation. In the combined strength/endurance training group, the time for training was divided equally between the two modalities.

The PFP is sensitive to change in physical function in 6-months. The PFP was sensitive to change in all exercise groups as illustrated in Figure 3. The effect of the intervention expressed as effect size is presented in Table 1. Effect size is calculated as follows:

Effect size = (delta intervention group - delta control)/mean standard deviation.

Table 1 indicates the effects of the interventions on the PFP-total and those domains corresponding to the interventions (strength and endurance). All interventions were successful at achieving increases in excess of the standard deviation of the PFP in both the upper and lower body strength domains (Effect size>1). Only the combined training showed significant ($p<0.05$) increases in the endurance domain. The control group which increased by 3.27 PFP units inadvertently may have increased endurance activities during the intervention period. Interestingly, the control group also lost 4.24 PFP units in the upper body strength domain. As upper body strength activities are less readily incorporated into daily life, this domain may be less likely to show a Hawthorne effect.[5] Change in function was not found in the domains of balance and coordination or flexibility, the two domains that did not receive a targeted intervention.

In summary, the PFP is a continuously scaled instrument that is administered under standard conditions with trained personnel. It offers valid and reliable quantification of whole-body physical functional performance, as well as, assessment of 5 physical domains: upper and lower body strength, upper body flexibility, balance and coordination, and endurance. In the 199 subjects tested, the PFP has no floor effects for older adults without deficiencies in ADL tasks or ceiling effects in these highly active community dwellers. The PFP-total and the domains are sensitive to change. This instrument offers promise as a method to evaluate function, functional impairment and tracking the time-course of change in function in higher functioning older adults.

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Acknowledgments: This work was performed at University of Washington and supported by NIH, R29AG10267; NIH, R01AG10853; NIH, AGR010943; Centers for Disease Control U48-CCU009654. Northwest Rehabilitation Hospital of Seattle, WA contributed the use space in Easy Street for the PFP testing. Stairmaster Sport/Medical Product L. P., Kirkland, Washington donated the use of their exercise equipment and facility.

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