Journals of Gerontology: MEDICAL SCIENCES
Cite journal as: J Gerontol A Biol Sci Med Sci 2014 October;69(10):1260–1268
doi:10.1093/gerona/glu033

Advance Access publication March 10, 2014

Are Estimates of Meaningful Decline in Mobility Performance Consistent Among Clinically Important Subgroups? (Health ABC Study)

Subashan Perera,[1] Stephanie Studenski,[1] Anne Newman,[2] Eleanor Simonsick,[3] Tamara Harris,[3] Ann Schwartz,[4] and Marjolein Visser[5]; for the Health ABC Study

[1]Division of Geriatric Medicine and
[2]Department of Epidemiology, University of Pittsburgh, Pennsylvania.
[3]Intramural Research Program, National Institute on Aging, Bethesda, Maryland.
[4]Department of Epidemiology, University of California-San Francisco.
[5]Department of Epidemiology and Biostatistics, Vrije Universiteit, Amsterdam, The Netherlands.

Address correspondence to Subashan Perera, PhD, Division of Geriatric Medicine, University of Pittsburgh, 3471 Fifth Avenue, Suite 500, Pittsburgh PA 15213. Email: ksp9@pitt.edu

Background. Meaningful change criteria help determine if function has improved or declined, but their magnitudes may vary across clinically relevant subgroups. We estimate meaningful decline in four common measures of physical performance in subgroups of older adults based on initial performance, demographics, chronic conditions, and health status.

Methods. We used baseline (Year 1) and Year 4 data from the Health, Aging and Body Composition (Health ABC) study, a well-functioning cohort at baseline of white and black men and women (age 70–79), to evaluate the magnitude of meaningful decline in performance (6 m gait speed, 400-m walk time (400MWT), Short Physical Performance Battery, and Health ABC Physical Performance Battery (PPB), based on self-reported perceived mobility anchors (climbing 10 steps and walking ¼ mile). Estimates were stratified by initial performance, demographics, health status, chronic conditions, and body mass index, and compared across strata.

Results. For all four measures, small and substantial decline estimates were generally consistent among subgroups based on initial performance, demographics, health status, and chronic conditions. The only exception was for 400MWT, where men had greater estimates than women. For PPB, small change was 0.12 points, and substantial change was 0.22 points.

Conclusions. Estimates of small and substantial meaningful decline resemble those previously reported for gait speed, 400MWT, and SPPB. Magnitudes of meaningful performance decline appear to be generally consistent across strata of initial performance, demographics, health status, body mass index, and chronic conditions.

Key Words: Balance—Epidemiology—Functional performance—Gait.

Received July 23, 2013; Accepted February 7, 2014

Decision Editor: James Goodwin, MD

PHYSICAL performance deficits, detected by performance measures, have been consistently associated both cross-sectionally and longitudinally with falls, disability, hospitalization, institutionalization, functional decline, and mortality (1–10). Because physical performance measures are strongly associated with many clinically relevant current and future outcomes, they are increasingly being used as outcomes in observational studies and clinical trials in aging. To promote interpretation, criteria for meaningful change have been developed for many commonly used performance measures. Meaningful change is typically determined based on anchors, where perceptions of change are elicited from individuals, providers, or caregivers, or it can be determined statistically as change relatively larger than the variability among participants adjusted for test–retest reliability. Estimates of meaningful change in performance can be used in clinical care and research to help determine if an individual has had an important change in function. In clinical trial planning, such magnitudes help determine projected sample size and study power. Initial estimates of meaningful change have been reported for gait speed, the Short Physical Performance Battery (SPPB) and 400-m walk (11–13). All studies to date have created estimates over short time periods, based on the sample as a whole, without differentiating by potential factors that might influence meaningful change.

It is reasonable to evaluate whether the magnitude of meaningful change might differ among subpopulations based on initial performance, demographics, health or disease status, or over longer time periods. Conceivably,

persons with worse initial performance perceive change differently than those with better performance, or men and women may perceive change differently (14). Gradual decline might be perceived differently from more rapid decline. For use in clinical care and clinical trials that exclusively target populations other than older adults in general, it is essential to know whether published meaningful change estimates still apply. Because the Health ABC study is large enough to allow estimates and comparisons among subgroups based on initial performance, demographics, health, and disease, we estimated meaningful change in multiple potentially influential subgroups. Because Health ABC was designed to detect incident functional limitations over time, the initial population was quite well functioning, and thus, this study is limited to estimates of meaningful decline. In addition, we provide the first estimates of meaningful change in the Health ABC Physical Performance Battery, which was designed specifically to better detect change among healthy older people and examine change over a longer time period (15).

Methods

Parent Study

The detailed methods of the Health, Aging and Body Composition (Health ABC) study have been published elsewhere (16). Briefly, the Health ABC cohort consists of 3,075 black and white older adults aged 70–79 with no self-reported difficulty in walking a ¼ mile, climbing 10 steps, or performing activities of daily living that were recruited from the greater metropolitan areas of Pittsburgh, Pennsylvania, and Memphis, Tennessee, during the years 1997–1998. Participants were followed annually with clinic, in-home, and/or phone assessments. Mobility performance data were collected at baseline (Year 1) and at Year 4 (approximately 3 years after baseline), which we use in the present study, along with concurrent self-ratings of mobility difficulty.

Mobility Performance

Mobility performance measures from Years 1 (baseline) and 4 include a 6-m usual pace gait speed (m/s), the 400-m walk time (s), the SPPB, and the Health ABC Physical Performance Battery (PPB). The 400-m walk consisted of a 2-min warm up and repeated laps in an unobstructed 20-m hallway (17). The SPPB consists of balance, walking, and repeated chair rise components each scored on a 0–4 ordinal scale and summed to yield an overall integer score with the range 0–12 (7). The Health ABC PPB additionally contains more challenging tasks such as a one-foot stand and a narrow walk specifically to facilitate discrimination among higher functioning older adults, and is scored on a 0–4 scale including decimal fractions (15).

Mobility Anchors

Self-reported mobility from Years 1 (baseline) and 4 included difficulty/ease walking ¼ mile and climbing 10 steps. Each was based on separate Likert scales for difficulty and ease, which allowed us to construct a composite rating ranging from 1 (*unable*) to 7 (*very easy*).

Distribution-Based Estimation

In order to compare our estimates with others, we applied two distribution-based approaches. First, the effect size for change over time is typically defined as $\delta = (\mu_4 - \mu_1)/\sigma_1$, where μ_1 and μ_4, respectively, are the Year 1 (baseline) and Year 4 means, and σ_1 is the baseline standard deviation of each performance measure (18). An effect size of 0.2 is considered small and treated operationally as corresponding to a small but meaningful change, whereas 0.5 is considered moderate and treated as corresponding to a substantial change (19). Therefore, effect size–based criteria for small and substantial meaningful change were computed as $0.2 \times \sigma_1$ and $0.5 \times \sigma_1$, respectively. Second, we used standard error of measurement (SEM), given by $\text{SEM} = \sigma_1\sqrt{1-r}$, where r is the test–retest reliability of the measure, to obtain an alternative estimate for small but meaningful change (20). Test–retest reliabilities were applied as previously reported (0.904, 0.93, 0.72, and 0.72, respectively, for 400-m walk time, gait speed, SPPB, and Health ABC PPB (2,11)).

Anchor-Based Estimation

We operationally defined "no change" as no change in the 7-level self-reported item. A decline of 1–2 levels was considered a "small decline," whereas a decline of 3 or more levels was considered a "substantial decline." Next, we took mean differences in performance measures between those with no change and small decline to be anchor-based estimates of small meaningful change and between those with no change and substantial decline to be anchor-based estimates of substantial decline. This approach has been used for meaningful change in Chronic Heart Failure Questionnaire and Chronic Respiratory Questionnaire (21), as well as many mobility performance measures (11,12,22,23).

Statistical Analysis

First, we used appropriate descriptive statistics (means, standard deviations, frequencies, and percentages) to summarize participant characteristics. We stratified our anchor-based analyses for each mobility performance measure by participant characteristics such as "median" performance, age "midrange," race, gender, body mass index (BMI, normal ≤ 25, overweight 25–30, obsese ≥ 30), and self-reported global health and diseases (arthritis, cancer, diabetes, heart disease, and hypertension) at baseline. Because stratification artificially reduces baseline performance standard

deviation, distribution-based analyses were performed only using the unstratified sample. We fit a linear model with each measure of performance change as the dependent variable, and change in each anchor (no change/small decline/substantial decline), each stratification criterion and their interaction as independent factors of interest with appropriately constructed contrasts for obtaining statistical significance for differences in meaningful change estimates across strata. We used the false discovery rate methodology for obtaining *p* values adjusted for multiplicity due to many stratification criteria (24). This correction led to several situations in which between-strata differences in estimates of meaningful change had substantial magnitudes but were not statistically significant. Therefore, we mainly used multiplicity-uncorrected *p* values in order to apply a more sensitive standard to the evaluation of potentially important differences between strata. SAS software (SAS Institute, Cary, NC) was used for all statistical analyses.

Results

At baseline, participants had a mean age of 74, 52% were female and 42% were black. Participants entered the study with excellent self-reported mobility (Table 1). About 20%–25% of participants did not have data for one or more of the key variables at Year 4 due to death, disability or drop out, and their change could not be ascertained. Those without Year 4 data tended to be older, were more likely to be black, and report poorer global health and more chronic conditions at study entry. There were 173 (8.1%) participants who reported improved ability to walk ¼ mile and 145 (6.7%) participants who reported improved ability to climb 10 steps. These samples sizes were too small to stratify into subgroups and were excluded from the anchor-based analyses.

Unstratified Analyses

Using effect size and [SEM] techniques, estimates for small and substantial change were 0.05 and 0.12m/s [0.06] for gait speed, 0.31 and 0.78 points [0.83] for SPPB, and 12.3 and 30.7s [18.9] for 400MWT. For the PPB effect size, estimates of small and substantial change were 0.11 and 0.28 points [0.29]. Anchor-based small and substantial change estimates were 0.03 and 0.06–0.07 m/s for gait speed; 5.5–11.5 and 20.9–22.1s for 400MWT, 0.27–0.30 and 0.54–0.65 for SPPB; and 0.08 and 0.14–0.17 for PPB.

Baseline Performance Effect

Anchor-based estimates did not significantly differ between low and high baseline performance for gait speed or 400MWT (Table 2). For SPPB, 3/4 comparisons were not significant, whereas substantial decline estimate with respect to climbing 10 steps anchor was smaller in persons with SPPB < 10 (0.57 vs 1.14). For PPB, 3/4 estimates did not differ, whereas substantial decline estimate with respect to walking ¼ mile anchor was larger in persons with PPB < 2.34 (0.29 vs 0.14). None of the estimates differed across strata with multiplicity correction (not shown).

Demographics Effect

With uncorrected *p* values, there were no age or race differences. Men had greater estimates in 400MWT than women for 3/4 estimates. Men showed larger gait speed declines than women in ¼ comparisons. Women had a greater SPPB decline in ¼ comparisons. None of the estimates differed across strata with multiplicity correction, except in 400MWT with small decline estimate with respect to walking ¼ mile anchor, where men had larger estimates.

Health and Disease Effects

The only significant difference was effect of BMI on SPPB, where substantial decline estimate with respect to walking ¼ mile anchor was larger in BMI >30 (Table 2). With uncorrected *p* values, 3/4 measures showed at least one subgroup difference for arthritis, but no consistency by anchor or direction. No differences were observed for other diseases. Multiplicity-corrected *p* values did not show any differences in a consistent pattern (not shown).

Discussion

Among high-functioning older adults, meaningful decline estimates are "generally consistent" across relevant subgroups based on "initial" performance, demographics, health, and diseases. The only consistent suggestive trend was for gender, where men had larger 400MWT declines than women in 3/4 estimates. Where we found other subgroup differences, we did not observe any pattern across measure, subgroup, or anchor. To our knowledge, this is the first study to evaluate subgroup effects on meaningful change estimates in physical performance, despite having been identified as an agenda item for future work some time ago (14).

We confirmed estimates for gait speed and SPPB and obtained preliminary estimates for 400MWT and PPB. It appears that the results for gait speed are consistent with prior published estimates of 0.05 m/s for small change and 0.10 m/s for substantial change; and SPPB is consistent with the published estimate of 1 point for a substantial change (11,12). Estimates of 5–19s for a small change in 400MWT and 21–31s for a substantial change suggest that overall estimates are approximately 12s for a small change and 28s for a substantial change. 400MWT estimates were slightly smaller than published estimates from Lifestyle Interventions and Independence of Elders Pilot participants (11) and potentially greater in men. Based on associations between greater 400MWT and incident 6-year outcomes in the same cohort (10), our estimate of 28s corresponds to a 13% and 24% (adjusted hazard ratio = 1.13 and 1.24)

Table 1. Participant Characteristics: [*N*] Mean ± *SD* or *n* (%)

	Year 1 (Baseline) All	Year 1 Those without Follow-up Data† (Excluded)	Those With Complete Data† (Included)	
			Year 1	Year 4
Age ***				
70–74	1,928 (62.7)	410 (57.3)	1,501 (64.4)	—
75–79	1147 (37.3)	306 (42.7)	830 (35.6)	
Gender	[3,075]	[716]	[2,331]	—
Female	1584 (51.5)	364 (50.8)	1,211 (52.0)	
Race ***	[3075]	[716]	[2,331]	—
Black	1281 (41.7)	381 (53.2)	884 (37.9)	
Body mass index**				
<25	990 (32.2)	246 (34.4)	736 (31.6)	—
25–30	1301 (42.3)	272 (38.0)	1,016 (43.6)	
>30	784 (25.5)	198 (27.7)	579 (24.8)	
Self-reported health***	[3,071]	[714]	[2,329]	—
Excellent/very good	1350 (44.0)	234 (32.8)	1,108 (47.6)	
Good/fair/poor	1721 (56.0)	480 (67.2)	1,221 (52.4)	
Arthritis	[3,035]	[703]	[2,304]	—
	1719 (56.6)	402 (57.2)	1,304 (56.6)	
Cancer*	[3,068]	[714]	[2,326]	—
	579 (18.9)	118 (16.5)	456 (19.6)	
Diabetes***	[3,072]	[715]	[2,329]	—
	460 (15.0)	135 (18.9)	318 (13.7)	
Heart disease***	[2,985]	[691]	[2,268]	—
	658 (22.0)	194 (28.1)	458 (20.2)	
Gait speed (m/s)***	[3,047]	[716]	[2,331]	[2,331]
	1.18 ± 0.23	1.10 ± 0.22	1.20 ± 0.23	1.12 ± 0.23
400-m walk time (s)***	[2,317]	[890]	[1,427]	[1,427]
	332 ± 61	354 ± 69	319 ± 52	328 ± 58
SPPB (points)***	[3,037]	[810]	[2,227]	[2,227]
Range 0–12	10.1 ± 1.6	9.5 ± 1.9	10.3 ± 1.4	10.0 ± 1.7
PPB (points)***	[3,028]	[808]	[2,220]	[2,220]
Range 0–4	2.17 ± 0.55	1.93 ± 0.61	2.26 ± 0.50	2.10 ± 0.55
Climbing 10 steps***	[2,844]	[697]	[2,147]	[2,147]
Unable	0 (0.0)	0 (0.0)	0 (0.0)	24 (1.1)
A lot of difficulty	0 (0.0)	0 (0.0)	0 (0.0)	93 (4.3)
Some difficulty	0 (0.0)	0 (0.0)	0 (0.0)	126 (5.9)
A little difficulty	2 (0.1)	1 (0.1)	1 (0.1)	75 (3.5)
Not that easy	143 (5.0)	49 (7.0)	94 (4.4)	87 (4.1)
Somewhat easy	672 (23.6)	201 (28.8)	471 (21.9)	571 (26.6)
Very easy	2,027 (71.3)	446 (64.0)	1,581 (73.6)	1,171 (54.5)
Walking a ¼ mile***	[2,835]	[668]	[2,167]	[2,167]
Unable	0 (0.0)	0 (0.0)	0 (0.0)	48 (2.2)
A lot of difficulty	0 (0.0)	0 (0.0)	0 (0.0)	115 (5.3)
Some difficulty	1 (0.0)	0 (0.0)	1 (0.1)	171 (7.9)
A little difficulty	1 (0.0)	0 (0.0)	1 (0.1)	108 (5.0)
Not that easy	124 (4.4)	45 (6.7)	79 (3.7)	51 (2.4)
Somewhat easy	649 (22.9)	202 (30.2)	447 (20.6)	484 (22.3)
Very easy	2,060 (72.7)	421 (63.0)	1,639 (75.6)	1,190 (54.9)

Notes: PPB = Health ABC Physical Performance Battery; SD = standard deviation; SPPB = Short Physical Performance Battery.
†For nonperformance measures, the numbers are based on availability of gait speed.
*.05 ≤ p < .10; **.01 ≤ p < .05; *** p < .01 for comparing those included and excluded.

increases mortality and mobility disability risk. Estimates of 0.08–0.29 point for a small change in PPB and 0.17–0.28 for substantial change suggest overall estimates of approximately 0.12 point for a small change and 0.22 for a substantial change. We are not aware of other published estimates for PPB. Ours should be considered preliminary.

This study has several strengths. To our knowledge, this study contained the largest number of participants of all meaningful change in mobility performance reports to date. The cohort size permitted the important stratified analysis. Second, four commonly used performance measures and two relevant anchors were available in this cohort. Third,

Table 2. Anchor-Based Meaningful Change Estimates: [*N*] Mean Change Difference ± SE (*p* value)

	Walking ¼ Mile		Climbing 10 Steps	
Stratification and Measure	No Change vs Small Decline	No Change vs Substantial Decline	No Change vs Small Decline	No Change vs Substantial Decline
Unstratified				
Gait speed	[1,622] 0.03 ± 0.01	[1,519] 0.06 ± 0.01	[1,677] 0.03 ± 0.01	[1,425] 0.07 ± 0.01
400MWT	[1,115] −11.5 ± 2.6	[949] −22.1 ± 4.2	[1,107] −5.5 ± 2.5	[907] −20.9 ± 4.3
SPPB	[1,582] 0.30 ± 0.09	[1,459] 0.65 ± 0.10	[1,623] 0.27 ± 0.08	[1,363] 0.54 ± 0.11
PPB	[1,575] 0.08 ± 0.02	[1,457] 0.17 ± 0.03	[1,618] 0.08 ± 0.02	[1,357] 0.14 ± 0.03
Baseline performance				
Gait speed				
Slow (<1.2 m/s)	[735] 0.07 ± 0.01	[731] 0.13 ± 0.02	[796] 0.06 ± 0.01	[692] 0.11 ± 0.02
Fast (≥1.2 m/s)	[887] 0.04 ± 0.02	[788] 0.10 ± 0.02	[881] 0.04 ± 0.02	[733] 0.12 ± 0.02
	p = .2281	*p* = .2435	*p* = .3235	*p* = .6731
400MWT				
Slow (>312s)	[546] −15.3 ± 3.3	[438] −23.7 ± 4.9	[543] −3.1 ± 3.3	[434] −20.3 ± 4.9
Fast (≤312 s)	[569] −11.2 ± 4.5	[511] −32.0 ± 8.7	[564] −11.4 ± 3.9	[473] −33.6 ± 10.1
	p = .4017	*p* = .4370	*p* = .1351	*p* = .2718
SPPB				
Lower (≤10)	[769] 0.43 ± 0.11	[726] 0.92 ± 0.12	[800] 0.36 ± 0.11	[671] 0.57 ± 0.13
Higher (>10)	[813] 0.46 ± 0.13	[733] 0.81 ± 0.17	[823] 0.39 ± 0.12	[692] 1.14 ± 0.20
	p = .8792	*p* = .6089	*p* = .8572	*p* = .0159
PPB				
Low (≤2.34)	[720] 0.14 ± 0.03	[682] 0.29 ± 0.03	[765] 0.13 ± 0.03	[640] 0.23 ± 0.04
High (>2.34)	[855] 0.13 ± 0.04	[775] 0.14 ± 0.05	[853] 0.10 ± 0.03	[717] 0.20 ± 0.06
	p = .8403	*p* = .0165	*p* = .6223	*p* = .7691
Age				
Gait speed				
<75	[1,048] 0.03 ± 0.01	[972] 0.07 ± 0.02	[1,069] 0.03 ± 0.01	[910] 0.08 ± 0.02
75+	[557] 0.03 ± 0.02	[528] 0.05 ± 0.02	[592] 0.03 ± 0.02	[501] 0.04 ± 0. 02
	p = .7558	*p* = .4162	*p* = .7820	*p* = .2766
400MWT				
<75	[724] −7.4 ± 3.3	[623] −24.2 ± 5.0	[722] −7.8 ± 3.1	[601] −20.9 ± 5.0
75+	[378] −18.2 ± 4.4	[314] −18.1 ± 7.7	[374] −0.8 ± 4.2	[296] −24.0 ± 8.5
	p = .2265	*p* = .5301	*p* = .0720	*p* = .7869
SPPB				
<75	[1,028] 0.21 ± 0.11	[933] 0.63 ± 0.13	[1,045] 0.27 ± 0.10	[880] 0.64 ± 0.14
75+	[537] 0.46 ± 0.15	[507] 0.68 ± 0.16	[562] 0.25 ± 0.14	[469] 0.36 ± 0.19
	p = .1566	*p* = .7756	*p* = .9002	*p* = .2329
PPB				
<75	[1,025] 0.06 ± 0.03	[931] 0.16 ± 0.04	[1,042] 0.08 ± 0.03	[876] 0.11 ± 0.04
75+	[533] 0.12 ± 0.04	[507] 0.18 ± 0.04	[560] 0.06 ± 0.04	[467] 0.17 ± 0.05
	p = .2131	*p* = .7253	*p* = .8249	*p* = .2980
Gender				
Gait speed				
Male	[849] 0.04 ± 0.02	[769] 0.07 ± 0.02	[870] 0.04 ± 0.02	[747] 0.10 ± 0.02
Female	[773] 0.03 ± 0.02	[767] 0.07 ± 0.02	[807] 0.02 ± 0.02	[678] 0.05 ± 0.02
	p = .8085	*p* = .9588	*p* = .4369	*p* = .0474
400MWT				
Male	[620] −15.7 ± 3.6	[527] −33.4 ± 6.5	[620] −11.4 ± 3.5	[512] −32.5 ± 7.1
Female	[495] −7.1 ± 3.8	[422] −14.3 ± 5.6	[487] 0.3 ± 3.6	[395] −14.4 ± 5.5
	p = .0089	*p* = .0393	*p* = .0017	*p* = .0622
SPPB				
Male	[836] 0.34 ± 0.12	[744] 0.56 ± 0.16	[851] 0.17 ± 0.12	[723] 0.23 ± 0.18
Female	[746] 0.27 ± 0.12	[715] 0.71 ± 0.13	[772] 0.36 ± 0.11	[640] 0.75 ± 0.15
	p = .6990	*p* = .4611	*p* = .2793	*p* = .0239
PPB				
Male	[831] 0.08 ± 0.03	[742] 0.19 ± 0.04	[847] 0.08 ± 0.03	[719] 0.19 ± 0.05
Female	[765] 0.10 ± 0.03	[765] 0.17 ± 0.04	[771] 0.08 ± 0.03	[638] 0.12 ± 0.04
	p = .6971	*p* = .7494	*p* = .8729	*p* = .3039

Table 2. (*Continued*)

Stratification and Measure	Walking ¼ Mile		Climbing 10 Steps	
	No Change vs Small Decline	No Change vs Substantial Decline	No Change vs Small Decline	No Change vs Substantial Decline
Race				
Gait speed				
White	[1,046] 0.03 ± 0.01	[931] 0.07 ± 0.02	[1,070] 0.03 ± 0.01	[892] 0.07 ± 0.02
Black	[576] 0.04 ± 0.02	[588] 0.07 ± 0.02	[607] 0.03 ± 0.02	[533] 0.07 ± 0.02
	p = .8917	p = . 8255	p = .7659	p = .8978
400MWT				
White	[765] −13.7 ± 3.2	[644] −21.6 ± 5.9	[752] −6.0 ± 3.1	[622] −12.3 ± 6.0
Black	[350] −7.1 ± 4.6	[305] −22.4 ± 6.2	[355] −4.8 ± 4.2	[285] −30.4 ± 6.4
	p = .0910	p = .9475	p = .4948	p = .0618
SPPB				
White	[1,030] 0.27 ± 0.11	[906] 0.50 ± 0.14	[1,044] 0.31 ± 0.11	[863] 0.39 ± 0.16
Black	[552] 0.35 ± 0.14	[553] 0.77 ± 0.14	[579] 0.18 ± 0.13	[500] 0.60 ± 0.16
	p = .6898	p = .1918	p = .4240	p = .3518
PPB				
White	[1,029] 0.09 ± 0.03	[907] 0.17 ± 0.04	[1,042] 0.07 ± 0.03	[860] 0.11 ± 0.05
Black	[546] 0.07 ± 0.04	[550] 0.18 ± 0.04	[576] 0.08 ± 0.04	[497] 0.18 ± 0.05
	p = .7501	p = .8946	p = .7623	p = .2991
Body mass index				
Gait speed				
<25	[556] 0.04 ± 0.02	[505] 0.04 ± 0.03	[556] 0.01 ± 0.02	[461] 0.07 ± 0.03
25–30	[696] 0.02 ± 0.02	[645] 0.07 ± 0.02	[732] 0.04 ± 0.02	[628] 0.07 ± 0.02
>30	[353] 0.04 ± 0.02	[350] 0.08 ± 0.02	[373] 0.02 ± 0.02	[322] 0.05 ± 0.02
	p = .7203	p = .5476	p = .4317	p = .8294
400MWT				
<25	[388] −13.9 ± 4.8	[350] −16.3 ± 8.4	[390] 0.7 ± 4.5	[324] −8.6 ± 9.8
25–30	[500] −12.0 ± 3.9	[424] −22.4 ± 6.0	[513] −4.5 ± 3.6	[419] −28.4 ± 6.4
>30	[204] −4.5 ± 5.5	[163] −23.7 ± 8.7	[193] −13.1 ± 5.4	[154] −15.2 ± 7.9
	p = .0921	p = .8404	p = .7003	p = .2444
SPPB				
<25	[546] 0.41 ± 0.16	[494] −0.02 ± 0.21	[545] 0.15 ± 0.15	[448] 0.45 ± 0.27
25–30	[685] 0.35 ± 0.13	[624] 0.63 ± 0.15	[714] 0.43 ± 0.12	[604] 0.34 ± 0.17
>30	[334] 0.05 ± 0.17	[322] 0.90 ± 0.18	[348] 0.01 ± 0.16	[297] 0.59 ± 0.19
	p = .2494	p = .0033	p = .1070	p = .6199
PPB				
<25	[544] 0.08 ± 0.05	[495] 0.08 ± 0.06	[543] 0.07 ± 0.04	[447] 0.13 ± 0.07
25–30	[682] 0.08 ± 0.04	[622] 0.19 ± 0.04	[712] 0.09 ± 0.04	[600] 0.15 ± 0.05
>30	[332] 0.09 ± 0.05	[321] 0.20 ± 0.05	[247] 0.05 ± 0.05	[296] 0.11 ± 0.05
	p = .9744	p = .2148	p = .7815	p = .8921
Global health				
Gait speed				
Excellent/very good	[852] 0.04 ± 0.02	[772] 0.07 ± 0.02	[862] 0.05 ± 0.02	[733] 0.10 ± 0.03
Good/fair/poor	[770] 0.03 ± 0.02	[747] 0.07 ± 0.02	[815] 0.01 ± 0.01	[692] 0.05 ± 0.02
	p = .6398	p = .7425	p = .0968	p = .0857
400MWT				
Excellent/very good	[638] −14.9 ± 3.9	[563] −27.0 ± 7.0	[627] −9.4 ± 3.6	[536] −23.2 ± 6.7
Good/fair/poor	[477] −8.2 ± 3.7	[386] −18.5 ± 5.4	[480] −0.9 ± 3.5	[371] −17.6 ± 5.8
	p = .2101	p = .3681	p = .0910	p = .5495
SPPB				
Excellent/very good	[839] 0.47 ± 0.13	[755] 0.36 ± 0.18	[844] 0.29 ± 0.13	[720] 0.59 ± 0.20
Good/fair/poor	[743] 0.23 ± 0.12	[704] 0.79 ± 0.12	[779] 0.27 ± 0.11	[643] 0.53 ± 0.14
	p = .1593	p = .0478	p = .9101	p = .8157
PPB				
Excellent/very good	[836] 0.12 ± 0.04	[751] 0.09 ± 0.05	[839] 0.07 ± 0.04	[713] 0.17 ± 0.06
Good/fair/poor	[739] 0.06 ± 0 .03	[706] 0.20 ± 0.03	[779] 0.07 ± 0.03	[644] 0.12 ± 0.04
	p = .2940	p = .0724	p = .9477	p = .5060
Arthritis				
Gait speed				
No	[758] 0.01 ± 0.02	[686] 0.04 ± 0.02	[785] 0.02 ± 0.02	[649] 0.07 ± 0.03
Yes	[847] 0.05 ± 0.02	[814] 0.08 ± 0.02	[876] 0.03 ± 0.01	[762] 0.06 ± 0.02
	p = .1487	p = .1451	p = .5811	p = .8097

Table 2. (*Continued*)

Stratification and Measure	Walking ¼ Mile		Climbing 10 Steps	
	No Change vs Small Decline	No Change vs Substantial Decline	No Change vs Small Decline	No Change vs Substantial Decline
400MWT				
No	[558] −15.5 ± 4.2	[470] −18.4 ± 8.2	[555] −3.9 ± 4.0	[450] −32.9 ± 9.2
Yes	[547] −0.7 ± 3.9	[468] −21.7 ± 5.7	[544] −1.5 ± 3.7	[448] −16.8 ± 5.6
	$p = .0104$	$p = .7444$	$p = .6661$	$p = .1364$
SPPB				
No	[750] 0.20 ± 0.13	[675] 0.55 ± 0.17	[769] 0.01 ± 0.12	[633] 0.76 ± 0.20
Yes	[815] 0.33 ± 0.12	[765] 0.67 ± 0.13	[838] 0.45 ± 0.11	[716] 0.44 ± 0.14
	$p = .4662$	$p = .5796$	$p = .0075$	$p = .1875$
PPB				
No	[746] 0.05 ± 0.04	[674] 0.19 ± 0.05	[767] 0.03 ± 0.04	[632] 0.24 ± 0.06
Yes	[812] 0.10 ± 0.03	[764] 0.16 ± 0.04	[835] 0.11 ± 0.03	[711] 0.09 ± 0.04
	$p = .2611$	$p = .6198$	$p = .0940$	$p = .0308$
Cancer				
Gait speed				
No	[1,293] 0.05 ± 0.01	[1,219] 0.07 ± 0.01	[1,346] 0.03 ± 0.01	[1,138] 0.06 ± 0.02
Yes	[325] −0.03 ± 0.03	[297] 0.06 ± 0.03	[327] 0.01 ± 0.03	[284] 0.09 ± 0.03
	$p = .0128$	$p = .8776$	$p = .5139$	$p = .3677$
400MWT				
No	[881] −8.7 ± 3.3	[758] −23.6 ± 5.1	[882] −3.0 ± 3.0	[718] −23.1 ± 5.2
Yes	[237] −7.4 ± 6.0	[192] −16.4 ± 11.5	[228] −3.0 ± 6.3	[190] −11.9 ± 11.3
	$p = .8489$	$p = .5646$	$p = .9986$	$p = .3705$
SPPB				
No	[1,261] 0.36 ± 0.10	[1,174] 0.66 ± 0.11	[1,301] 0.28 ± 0.09	[1,088] 0.54 ± 0.12
Yes	[317] 0.10 ± 0.20	[282] 0.61 ± 0.24	[318] 0.17 ± 0.19	[272] 0.55 ± 0.27
	$p = .2322$	$p = .8601$	$p = .5995$	$p = .9737$
PPB				
No	[1,254] 0.09 ± 0.03	[1,171] 0.18 ± 0.03	[1,297] 0.10 ± 0.03	[1,083] 0.15 ± 0.03
Yes	[317] 0.04 ± 0.05	[283] 0.14 ± 0.07	[317] −0.03 ± 0.05	[271] 0.07 ± 0.08
	$p = .4018$	$p = .5812$	$p = .0305$	$p = .2963$
Diabetes				
Gait speed				
No	[1,430] 0.03 ± 0.01	[1,325] 0.06 ± 0.01	[1,468] 0.02 ± 0.01	[1,243] 0.07 ± 0.02
Yes	[190] 0.03 ± 0.03	[193] 0.07 ± 0.03	[207] 0.05 ± 0.03	[180] 0.06 ± 0.03
	$p = .8658$	$p = .7823$	$p = .4873$	$p = .7720$
400MWT				
No	[1,003] −9.2 ± 3.1	[857] −21.3 ± 5.0	[997] −3.0 ± 2.9	[817] −21.0 ± 5.2
Yes	[114] −2.1 ± 8.2	[92] −26.5 ± 12.8	[112] −0.7 ± 8.1	[90] −19.0 ± 12.2
	$p = .4196$	$p = .7058$	$p = .7917$	$p = .8798$
SPPB				
No	[1,399] 0.27 ± 0.09	[1,282] 0.61 ± 0.11	[1,425] 0.20 ± 0.09	[1,196] 0.53 ± 0.13
Yes	[181] 0.45 ± 0.23	[176] 0.73 ± 0.24	[196] 0.50 ± 0.22	[165] 0.46 ± 0.26
	$p = .4731$	$p = .6727$	$p = .2129$	$p = .8247$
PPB				
No	[1,393] 0.07 ± 0.03	[1,279] 0.17 ± 0.03	[1,418] 0.06 ± 0.03	[1,190] 0.16 ± 0.04
Yes	[180] 0.09 ± 0.07	[177] 0.10 ± 0.07	[198] 0.09 ± 0.06	[165] 0.01 ± 0.07
	$p = .8094$	$p = .3095$	$p = .7049$	$p = .0840$
Heart disease				
Gait speed				
No	[1,298] 0.03 ± 0.01	[1,179] 0.07 ± 0.02	[1,321] 0.03 ± 0.01	[1,098] 0.05 ± 0.02
Yes	[289] 0.04 ± 0.03	[292] 0.05 ± 0.03	[318] 0.03 ± 0.02	[290] 0.10 ± 0.03
	$p = .6722$	$p = .5602$	$p = .9165$	$p = .1773$
400MWT				
No	[927] −10.2 ± 3.2	[785] −27.3 ± 5.4	[910] −4.5 ± 3.1	[754] −22.9 ± 5.2
Yes	[169] −1.9 ± 7.0	[143] −5.7 ± 9.9	[180] 3.7 ± 6.5	[138] −6.0 ± 13.0
	$p = .2769$	$p = .0557$	$p = .2535$	$p = .2286$
SPPB				
No	[1,266] 0.26 ± 0.10	[1,135] 0.80 ± 0.12	[1,279] 0.30 ± 0.09	[1,055] 0.50 ± 0.13
Yes	[281] 0.48 ± 0.19	[280] 0.34 ± 0.19	[307] 0.21 ± 0.19	[275] 0.70 ± 0.21
	$p = .2902$	$p = .0431$	$p = .6778$	$p = .4241$

Table 2. (*Continued*)

Stratification and Measure	Walking ¼ Mile		Climbing 10 Steps	
	No Change vs Small Decline	No Change vs Substantial Decline	No Change vs Small Decline	No Change vs Substantial Decline
PPB				
No	[1,260] 0.07 ± 0.03	[1,134] 0.19 ± 0.03	[1,276] 0.07 ± 0.03	[1,051] 0.13 ± 0.04
Yes	[280] 0.14 ± 0.05	[280] 0.11 ± 0.05	[306] 0.07 ± 0.05	[274] 0.15 ± 0.06
	p = .2410	p = .2261	p = .9707	p = .8406
Hypertension				
Gait speed				
No	[877] 0.03 ± 0.02	[821] 0.07 ± 0.02	[881] 0.03 ± 0.02	[735] 0.09 ± 0.02
Yes	[708] 0.04 ± 0.02	[690] 0.06 ± 0.02	[786] 0.02 ± 0.02	[680] 0.06 ± 0.02
	p = .5773	p = .7455	p = .7644	p = .2867
400MWT				
No	[652] −6.1 ± 4.0	[614] −33.5 ± 7.4	[628] −2.1 ± 3.7	[515] −23.1 ± 7.1
Yes	[461] −9.0 ± 4.1	[382] −13.0 ± 6.0	[476] −3.2 ± 4.1	[388] −18.4 ± 6.4
	p = .6211	p = .0317	p = .8336	p = .6268
SPPB				
No	[857] 0.35 ± 0.13	[794] 0.48 ± 0.16	[853] 0.31 ± 0.12	[708] 0.50 ± 0.19
Yes	[715] 0.21 ± 0.12	[657] 0.63 ± 0.13	[760] 0.19 ± 0.12	[645] 0.48 ± 0.14
	p = .4116	p = .4898	p = .4450	p = .9333
PPB				
No	[854] 0.06 ± 0.04	[793] 0.19 ± 0.05	[848] 0.08 ± 0.03	[704] 0.16 ± 0.05
Yes	[711] 0.09 ± 0.03	[656] 0.14 ± 0.04	[760] 0.06 ± 0.03	[643] 0.11 ± 0.04
	p = .5907	p = .3575	p = .6303	p = .3999

Notes: 400MWT = 400-m walk time; m/s = meters per second; [*N*] = number of participants used to obtain estimate; p = interaction p value representing between-stratum comparison of no change vs decline differences; PPB = Health ABC Physical Performance Battery; s = seconds; SE = standard error of no change vs decline means difference; SPPB = Short Physical Performance Battery.

prior studies had been conducted over shorter periods of time, whereas ours was 3 years. Our findings were largely consistent, suggesting criteria for meaningful change may be time-period invariant. Finally, this high-functioning cohort allowed the use of the PPB. A frailer cohort would have precluded challenging mobility tasks in PPB.

This study has limitations. First, as expected, we had a smaller number of self-reported substantial decliners than participants in other groups. Thus, our substantial change criteria are subject to a greater level of noise. Second, self-reported improvement was not common, and we were unable to obtain estimates of performance improvement. Third, those with lower baseline performance were more likely to have data missing at Year 4, thereby creating a dropout bias. This is common in longitudinal aging studies, where the dropouts are the weakest. It is not immediately apparent how to overcome this limitation, especially in a secondary analysis. Fourth, a substantial proportion of participants did not complete 400MWT, resulting in potentially greater bias. Fifth, the baseline high-functioning nature of our cohort may cause our findings to be less generalizable to frailer populations. Lower baseline performance stratum partially mitigates this limitation. Finally, although our anchors have strong face validity for self-perception of own mobility and have been used in prior work, it is possible that results might be different with other anchors such as those representing health care provider perception.

Meaningful decline estimates in performance appear largely robust in many subgroups of elders, which provides for the desirable measurement characteristic of one criterion for change even in a heterogeneous population. We recommend 0.05 m/s, 12 s, and 0.12 point as criteria for a small but meaningful decline for gait speed, 400MWT, and PPB, respectively, and believe SPPB integer scoring makes it insensitive to small change. We recommend 0.10 m/s, 28 s, 1 point, and 0.22 point as criteria for a substantial decline for gait speed, 400MWT, SPPB, and PPB, respectively. These criteria could be potentially used to assess whether an elderly patient has had a meaningful decline between clinic visits or to estimate sample size and number needed to treat in intervention trials.

Funding

This research was supported by National Institute on Aging contracts and grants (N01-AG-6-2101, N01-AG-6-2103, N01-AG-6-2106, R01-AG028050, P30-AG024827), NINR grant (R01-NR012459), and Intramural Research Program of the NIH, National Institute on Aging.

References

1. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. *JAMA*. 2011;305:50–58. doi:10.1001/jama.2010.1923
2. Studenski S, Perera S, Wallace D, et al. Physical performance measures in the clinical setting. *J Am Geriatr Soc*. 2003;51:314–322. doi:10.1046/j.1532-5415.2003.51104.x
3. Reuben DB, Siu AL, Kimpau S. The predictive validity of self-report and performance-based measures of function and health. *J Gerontol*. 1992;47:M106–M110. doi:10.1093/geronj/47.4.M106
4. Williams ME. Identifying the older person likely to require long-term care services. *J Am Geriatr Soc*. 1987;35:761–766.

5. Guralnik JM, Branch LG, Cummings SR, Curb JD. Physical performance measures in aging research. *J Gerontol*. 1989;44:M141–M146. doi:10.1093/geronj/44.5.M141
6. Gill TM, Williams CS, Tinetti ME. Assessing risk for the onset of functional dependence among older adults: the role of physical performance. *J Am Geriatr Soc*. 1995;43:603–609.
7. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49:M85–M94. doi:10.1093/geronj/49.2.M85
8. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med*. 1995;332:556–561. doi:10.1056/NEJM199503023320902
9. Penninx BW, Ferrucci L, Leveille SG, Rantanen T, Pahor M, Guralnik JM. Lower extremity performance in nondisabled older persons as a predictor of subsequent hospitalization. *J Gerontol A Biol Sci Med Sci*. 2000;55:M691–M697. doi:10.1093/gerona/55.11.M691
10. Newman AB, Simonsick EM, Naydeck BL, et al. Association of long-distance corridor walk performance with mortality, cardiovascular disease, mobility limitation, and disability. *JAMA*. 2006;295:2018–2026. doi:10.1001/jama.295.17.2018
11. Kwon S, Perera S, Pahor M, et al. What is a meaningful change in physical performance? Findings from a clinical trial in older adults (the LIFE-P study). *J Nutr Health Aging*. 2009;13:538–544. doi:10.1007/s12603-009-0104-z
12. Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful change and responsiveness in common physical performance measures in older adults. *J Am Geriatr Soc*. 2006;54:743–749. doi:10.1111/j.1532-5415.2006.00701.x
13. Alley DE, Hicks GE, Shardell M, et al. Meaningful improvement in gait speed in hip fracture recovery. *J Am Geriatr Soc*. 2011;59:1650–1657. doi:10.1111/j.1532-5415.2011.03560.x
14. Beaton DE, Boers M, Wells GA. Many faces of the minimal clinically important difference (MCID): a literature review and directions for future research. *Curr Opin Rheumatol*. 2002;14:109–114. doi:10.1097/00002281-200203000-00006
15. Simonsick EM, Newman AB, Nevitt MC, et al.; Health ABC Study Group. 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*. 2001;56:M644–M649. doi:10.1093/gerona/56.10.M644
16. Newman AB, Haggerty CL, Kritchevsky SB, Nevitt MC, Simonsick EM; Health ABC Collaborative Research Group. Walking performance and cardiovascular response: associations with age and morbidity–the Health, Aging and Body Composition Study. *J Gerontol A Biol Sci Med Sci*. 2003;58:715–720. doi:10.1093/gerona/58.8.M715
17. Simonsick EM, Montgomery PS, Newman AB, Bauer DC, Harris T. Measuring fitness in healthy older adults: the Health ABC Long Distance Corridor Walk. *J Am Geriatr Soc*. 2001;49:1544–1548. doi:10.1046/j.1532-5415.2001.4911247.x
18. Kazis LE, Anderson JJ, Meenan RF. Effect sizes for interpreting changes in health status. *Med Care*. 1989;27(3 suppl):S178–S189.
19. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum; 1988.
20. McHorney CA, Tarlov AR. Individual-patient monitoring in clinical practice: are available health status surveys adequate? *Qual Life Res*. 1995;4:293–307. doi:10.1007/BF01593882
21. Wyrwich KW, Wolinsky FD. Identifying meaningful intra-individual change standards for health-related quality of life measures. *J Eval Clin Pract*. 2000;6:39–49. doi:10.1046/j.1365-2753.2000.00238.x
22. Brach JS, Perera S, Studenski S, Katz M, Hall C, Verghese J. Meaningful change in measures of gait variability in older adults. *Gait Posture*. 2010;31:175–179. doi:10.1016/j.gaitpost.2009.10.002
23. Oh-Park M, Perera S, Verghese J. Clinically meaningful change in stair negotiation performance in older adults. *Gait Posture*. 2012;36:532–536. doi:10.1016/j.gaitpost.2012.05.015
24. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc Series B Stat Methodol*. 1995;57:289–300. doi:10.2307/2346101