Stroke
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association | American Stroke Association

Improvements in Speed-Based Gait Classifications Are Meaningful

Arlene Schmid, Pamela W. Duncan, Stephanie Studenski, Sue Min Lai, Lorie Richards,
Subashan Perera and Samuel S. Wu

Stroke. 2007;38:2096-2100; originally published online May 17, 2007;
doi: 10.1161/STROKEAHA.106.475921
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628

Improvements in Speed-Based Gait Classifications Are Meaningful

Arlene Schmid, PhD; Pamela W. Duncan, PhD; Stephanie Studenski, MD, MPH; Sue Min Lai, PhD; Lorie Richards, PhD; Subashan Perera, PhD; Samuel S. Wu, PhD

Background and Purpose**—**Gait velocity is a powerful indicator of function and prognosis after stroke. Gait velocity can be stratified into clinically meaningful functional ambulation classes, such as household ambulation (<0.4 m/s), limited community ambulation (0.4 to 0.8 m/s), and full community ambulation (>0.8 m/s). The purpose of the current study was to determine whether changes in velocity-based community ambulation classification were related to clinically meaningful changes in stroke-related function and quality of life.

Methods**—**In subacute stroke survivors with mild to moderate deficits who participated in a randomized clinical trial of stroke rehabilitation and had a baseline gait velocity of 0.8 m/s or less, we assessed the effect of success versus failure to achieve a transition to the next class on function and quality of life according to domains of the Stroke Impact Scale (SIS).

Results**—**Of 64 eligible participants, 19 were initially household ambulators, and 12 of them (68%) transitioned to limited community ambulation, whereas of 45 initially limited community ambulators, 17 (38%) became full community ambulators. Function and quality-of-life SIS scores after treatment were significantly higher among survivors who achieved a favorable transition compared with those who did not. Among household ambulators, those who transitioned to limited or full community ambulation had significantly better SIS scores in mobility ($P=0.0299$) and participation ($P=0.0277$). Among limited community ambulators, those who achieved the transition to full community ambulatory status had significantly better scores in SIS participation ($P=0.0085$).

Conclusions**—**A gait velocity gain that results in a transition to a higher class of ambulation results in better function and quality of life, especially for household ambulators. Household ambulators possibly had more severe stroke deficits, reducing the risk of "ceiling" effects in SIS-measured activities of daily living and instrumental activities of daily living. Outcome assessment based on transitions within a mobility classification scheme that is rooted in gait velocity yields potentially meaningful indicators of clinical benefit. Outcomes should be selected that are clinically meaningful for all levels of severity. **(*Stroke*. 2007;38:2096-2100.)**

Key Words: functional recovery ■ gait velocity ■ quality of life ■ rehabilitation

Stroke, the primary cause of adult disability, leads to impairments in mobility and walking.[1,2] Decreased gait velocity reflects impaired mobility; is a reliable, valid, and sensitive measure of recovery of poststroke mobility[3–5] that discriminates the effects of stroke; and is related to the potential for rehabilitation recovery.[6] Gait velocity is also a widely used indicator in other health states and among older adults, in whom it predicts future health status and health care utilization.[7]

The relations between gait velocity and community ambulation have been reported in individuals after stroke. Previous work regarding ambulation classification was completed by Perry et al.[5] That group used a questionnaire to assess the current mobility of 147 stroke patients. Additional assessments included muscle strength, proprioception, walking velocity, and functional walking ability at home and in the community. Gait velocity was determined to be the most efficient in predicting ambulation classification. The authors condensed 6 original walking classifications into the 3 used in the current analysis: household, limited community, and full community ambulation. Perry et al[5] determined that household ambulation was equal to severe gait impairment and a velocity of <0.4 m/s; limited community ambulation was equivalent to moderate gait impairments and a walking speed of between 0.4 and 0.8 m/s; and full community ambulation

Received October 18, 2006; final revision received December 13, 2006; accepted January 22, 2007.

From the Department of Occupational Therapy (A.S.), Indiana University School of Health and Rehabilitation Sciences, and the Richard L. Roudebush VA Medical Center, Indianapolis, Ind; the Department of Community and Family Medicine (P.W.D.), Doctor of Physical Therapy Division, Duke Center for Clinical Health Policy Research, Duke University, Durham, NC; the Division of Geriatric Medicine (S.S.), University of Pittsburgh, and GRECC, VA Pittsburgh Healthcare System, Pittsburgh, Pa; the Theo and Alfred Landon Center on Aging (S.M.L.), University of Kansas Medical Center, Kansas City, Kan; the Department of Veteran Affairs (L.R.), and the Department of Occupational Therapy, University of Florida, College of Public Health and Health Professions, Gainesville, Fla; the Division of Geriatric Medicine (S.P.), University of Pittsburgh, Pittsburgh, Pa; and the Rehabilitation Outcomes Research Center (S.S.W.), Division of Biostatistics, University of Florida College of Medicine, Gainesville, Fla.

Correspondence to Arlene Schmid, PhD, OTR, Department of Occupational Therapy, School of Health and Rehabilitation Sciences, Indiana University, 1140 W Michigan St, CF 311 Indianapolis, IN 46202-5119. E-mail araschmi@iupui.edu

Stroke is available at http://www.strokeaha.org DOI: 10.1161/STROKEAHA.106.475921

indicated mild impairment and a walking speed of >0.8 m/s; furthermore, increases in gait velocity were related to improved home and community ambulation. Similarly, Lord and colleagues[8] used 4 categories to define community ambulation. They found that gait velocity differed between the categories and ranged from an average of 0.52 m/s for those unable to leave home to an average of 1.14 m/s for those able to ambulate in a shopping center.

Gait velocity has been described as the "almost perfect" measure.[9] However, in a recent review of measurements of community ambulation after stroke, Lord and Rochester[10] concluded that there is "no guarantee that increases in gait velocity will denote a meaningful improvement in performance." It is therefore important to determine changes in poststroke gait velocity that are "clinically meaningful," in that they are associated with important improvements in function and quality of life. The objective of this study was to determine whether a change in gait velocity based on a classification scheme related to community ambulation was clinically meaningful in terms of changes in stroke-related function and quality of life as measured by the Stroke Impact Scale (SIS). In this classification scheme, gait velocity was stratified into 3 clinically meaningful functional ambulation classes: household ambulation (<0.4 m/s), limited community ambulation (0.4 to 0.8 m/s), and full community ambulation (>0.8 m/s). We wished to determine whether favorable transitions across the functional mobility classes were associated with differences in self-reported SIS scores of activities of daily living (ADLs), instrumental activities of daily living (IADLs), mobility, and social participation after stroke.

Methods

Design

Data in this study were derived from a parent study: a prospective, randomized, controlled, single-blind, clinical intervention trial.[11] The trial was designed to determine the effects of a therapist-supervised 12- to 14-week home-based, structured, and progressive exercise intervention in participants after stroke. This secondary analysis was approved by the University of Florida Health Science Center institutional review board.

This analysis did not examine differences between intervention and usual-care groups, which have been published elsewhere[11]; rather, we examined the differences in ADLs, IADLs, mobility, and social participation between those who did and did not successfully advance to the next ambulation classification as defined by Perry et al.[5] For example, the participants considered successful in walking recovery transitioned from an initial gait velocity of <0.4 m/s to 0.4 to 0.8 m/s or faster, or they advanced from an initial gait velocity of between 0.4 and 0.8 m/s to >0.8 m/s. We realize that there are other classifications available. However, agreed-on exact cutoffs are unavailable, as in classifications from Perry et al[5] and Lord et al.[8] However, it is likely that there are transition points when a change in function can be expected. Therefore, we chose to use the classifications described by Perry et al[5] to assess whether changes assessed in classifications are reflected in meaningful changes in function.

Participants

All participants in this study were enrolled in the Kansas City Stroke Registry. All those registered gave informed consent and permission to be screened for eligibility for future research studies. Those eligible for the registry had a confirmed diagnosis of stroke within 3 to 28 days, were >50 years old, and lived within a 50-mile radius. Registry exclusion criteria included the following: subarachnoid hemorrhage, being lethargic, obtunded, or comatose; having uncontrolled blood pressure, hepatic or renal failure, New York Heart Association class III/IV heart failure, a known limited life expectancy, or prestroke disability in self care; or having previously lived in a nursing home before the stroke.

Those in the registry were eligible to be screened for the randomized clinical trial. Inclusion for the parent clinical trial included the following: (1) stroke within 30 to 150 days; (2) ability to ambulate 25 feet independently; (3) mild to moderate stroke deficits defined by a Fugl-Meyer score of 29 to 90 for upper and lower extremities, an Orpington Prognostic Scale score of 2.0 to 5.2, and palpable wrist extension on the involved side; and (4) a Folstein Mini-Mental Status examination score >16. Exclusion criteria included the following: (1) serious cardiac conditions (hospitalization for heart disease within 3 months, active angina, serious cardiac arrhythmias, hypertrophic cardiomyopathy, severe aortic stenosis, pulmonary embolus, or infarction); (2) dependence on supplemental oxygen; (3) severe weight-bearing pain; (4) other serious organ system disease; and (5) a life expectancy of <1 year as reported in the medical chart and defined by the medical team at the time of stroke onset. All participants signed an informed consent form to participate in the trial, and all had approval from a primary care physician.[11] Ninety-two individuals completed the clinical trial. For this secondary analysis, individuals were excluded when they could walk >0.8 m/s at baseline. Sixty-four participants walked <0.8m/s at the baseline assessment. This analysis did not compare the intervention with the usual-care groups but combined all 64 participants walking <0.8 m/s at baseline to include those who changed and those who did not change gait velocity over time.

Gait Velocity and Walking Recovery

Gait velocity was assessed at baseline and was repeated at 3 months. It was measured as the average of 2 trials of the 10-m walk.[12] Participants were asked to walk at their normal comfortable pace and used a walking aid when needed. All participants were able to accelerate before the assessment began and started the assessment from a stopped position. Successful walking recovery was defined when participants shifted from <0.4 m/s to 0.4 to 0.8 m/s (household to limited community ambulation) or from 0.4 to 0.8 m/s to >0.8 m/s (limited to full community ambulation).[5] A dichotomous variable of "success" or "failure" was used for the analysis.

Function and Quality of Life

Function and quality of life were assessed according to the activity and participation constructs of the SIS, a comprehensive and psychometrically robust stroke-specific outcome measure.[13,14] The SIS was developed from the perspective of patients, caregivers, and health professionals with stroke expertise. The SIS is reliable, valid, and sensitive to changes in stroke-related recovery. There are 8 domains and 59 items in version 3.0. For this study, we use the ADL/IADL (all SIS scores were converted to a scoring scale of 0 to 100), mobility, and participation domains. The SIS-16 is a shorter version of the SIS composite physical function domain and is limited to assessment of physical functioning.[14–16] We also included the SIS-16 in this analysis.

Statistical Analysis

All analyses were completed with SAS statistical software, version 8.2.[17] Simple descriptive statistics were used for demographics and outcome scores. Independent-sample *t* tests were used to determine significant differences in SIS outcomes between those who succeeded and those who failed to transition to a higher level of walking. χ^2 tests were used as appropriate to compare results from categorical variables. Because age and baseline scores for the SIS-16 and the SIS ADL/IADL were at least marginally significantly different between groups, analyses were adjusted for all variables in an ANCOVA, with age and baseline score as the covariates.

TABLE 1. Baseline Characteristics for Participants With Initial Gait Velocity <0.8 m/s, Stratified by Success or Failure to Advance to a Higher Ambulation Class

Variable	All	Success	Failure	*P* Value
Demographics				
Sample size	64	29	35	
Age, y	71.0 (10.64)	66.72 (9.29)	74.6 (10.48)	0.0023†
Male, n (%)	35 (55%)	16 (46%)	19 (54%)	0.9434*
Race (white), n (%)	50 (78%)	22 (44%)	28 (56%)	0.6902*
Stroke characteristics				
Orpington Prognostic score	3.51 (0.84)	3.67 (0.89)	3.38 (0.78)	0.176
NIH Stroke Scale score	6.62 (3.33)	6.76 (3.46)	6.50 (3.27)	0.763
Right hemisphere, n (%)	34 (53%)	15 (44%)	19 (56%)	0.1530*
Left hemisphere, n (%)	24 (38%)	9 (38%)	15 (63%)	
Brain stem/other, n (%)	4 (9%)	3 (83%)	1 (17%)	
Stroke type, ischemic, n (%)	57 (89%)	25 (44%)	32 (56%)	0.6920*
Baseline measures				
Folstein MMSE	26.45 (4.23)	26.31 (3.72)	26.57 (4.67)	0.804
Geriatric Depression Scale	4.61 (3.29)	4.59 (3.61)	4.63 (3.06)	0.960
SIS ADL/IADL	65.6 (14.7)	69.40 (12.88)	62.5 (15.57)	0.0570†
SIS mobility	63.4 (14.8)	66.57 (11.84)	60.71 (16.63)	0.1059
SIS participation	49.4 (21.7)	51.08 (20.55)	48.04 (22.83)	0.5771
SIS-16	68.6 (13.1)	72.25 (9.91)	65.49 (14.65)	0.0323†

NIH indicates National Institutes of Health; MMSE, Mini-Mental State Examination. Other abbreviations are as defined in text. Values are mean (SD) where appropriate.

*P valued derived from χ^2 test.

†P value significantly different or marginally significantly different, making ANCOVA necessary for subsequent analyses.

Results

Baseline demographics for the 64 participants are presented in Table 1. These participants had an average age of 71 years, were diverse in sex and ethnicity, and had mild to moderate stroke deficits. Baseline characteristics of participants who succeeded or failed in transitioning to a higher ambulatory class are presented in Table 1. In the sample as a whole, those who succeeded were younger than those who failed ($P=0.0023$), but initial gait velocity did not differ: 0.51 m/s for those who succeeded and 0.49 m/s for those who failed ($P=0.689$; Table 2). In addition, those who successfully transitioned to a higher ambulation class had a significantly higher SIS-16 score than those who failed to transition ($P=0.0323$). The difference between SIS ADL/IADL scores verged on significance at the 0.05 level ($P=0.0570$). Those with an initial gait velocity of 0.4 to 0.8 m/s demonstrated increased baseline scores on all SIS measures when compared with those with an initial gait velocity of <0.4 m/s (Table 3). However, all those successful in reaching the next ambulation class demonstrated increased SIS scores compared with those who failed to transition.

The 3-month gait velocity for the entire group was 0.68 m/s (Table 2). As anticipated, 3-month gait velocity scores were higher among those who succeeded in transitioning to a higher ambulation class (0.82 m/s) than those who failed to do so (0.56 m/s) ($P<0.0001$; Table 2). In all, 45% of the sample was successful and 55% failed to increase to a higher ambulation class at 3 months. Of 19 initial household ambulators, 12 (63%) succeeded in transitioning to limited com-

TABLE 2. Baseline SIS Scores for Participants, Stratified by Initial Gait Velocity and by Success or Failure to Advance to a Higher Ambulation Class

Variable	Baseline	Success	Failure
<0.4 m/s at baseline			
Sample size	19	12	7
SIS ADL/IADL	60.4 (15.3)	75.5 (15.2)	51.4 (12.5)
SIS mobility	58.8 (14.1)	77.1 (11.4)	50.5 (10.9)
SIS participation	43.3 (20.3)	66.1 (15.2)	42.9 (19.6)
SIS-16	63.8 (12.2)	67.2 (12.5)	46.7 (9.8)
0.4–0.8 m/s at baseline			
Sample size	45	17	28
SIS ADL/IADL	67.8 (14.0)	79.6 (13.5)	74.2 (17.7)
SIS mobility	65.3 (14.8)	77.9 (13.1)	69.3 (14.9)
SIS participation	52 (22.0)	69.7 (21.0)	55.5 (20.5)
SIS-16	70 (13.0)	81.8 (12.7)	67.6 (13.7)

TABLE 3. Gait Speed Measures at Baseline and 3 Months With a *t* Test Comparison

Variable	All	Success	Failure	*P* Value
10-m walk, m/s, at baseline	0.50 (0.16)	0.51 (0.17)	0.49 (0.16)	0.689
10-m walk, m/s, at 3 months	0.68 (0.24)	0.82 (0.25)	0.56 (0.16)	<0.0001

Values are mean (SD).

TABLE 4. Proportions of Success/Failure for Transitioning to the Next Ambulation Class Between Baseline and 3 Months

Initial Gait Velocity in m/s	Success (%)	Failure (%)
<0.4 (household)	12 (63)	7 (37)
0.4–0.8 (limited community)	17 (38)	28 (62)
Total	29 (45)	35 (55)

munity ambulation or higher, whereas of 45 limited community ambulators, 17 (38%) transitioned to full community ambulators (Table 4).

For the group as a whole, success in transition was associated with improved stroke-related quality of life as assessed with the SIS, where such transition led to higher SIS participation scores (P=0.0009), and SIS mobility scores neared a significant difference (P=0.0576; Table 5). Among household ambulators, those who succeeded in transitioning to limited community ambulation or higher had significantly better SIS mobility and social participation scores than those who failed (Table 6). Among initially limited community ambulators, those who succeeded had significantly higher SIS participation scores (Table 6).

Discussion

Gait velocity is a valid and reliable measure of walking recovery after stroke[3] and has been shown to be a valuable indicator of future health and function.[7,18] Changes in gait velocity have been reported in observational studies and clinical trials,[7,11,19–21] but the amount of change that is considered clinically meaningful and reflective of the level of community ambulation has not been established. Lord and Rochester[10] recently reported that "continued reliance on the 10-meter walk as a proxy measure for community ambulation is misplaced." They suggested that self-report of community ambulation is the most useful outcome measure.

However, the results of the current study indicate that when 10-m gait velocity measures are stratified into clinically meaningful functional ambulation classes such as household ambulation (<.4 m/s), limited community ambulation (0.4 to 0.8 m/s), and full community ambulation (>0.8 m/s), changes in 10-m gait velocity are clinically meaningful. Transitioning to a higher class of ambulation is associated with substantially better function and quality of life, especially with regard to mobility and community participation, in initial household ambulators.

The results of this study also demonstrate that it is necessary to consider the severity of stroke deficits when examining relations between changes in gait velocity and changes in function and quality of life. The household ambulators who successfully transitioned to limited community ambulators demonstrated significant changes in SIS-scored mobility and participation. In contrast, those who transitioned from limited community ambulation to full community ambulation only exhibited significant changes in participation. Those classified as household ambulators at baseline possibly had the greatest deficits, making "ceiling" effects in mobility and participation measures less likely. Additionally, the SIS mobility assessment includes items regarding climbing stairs and walking long distances; if these items are not in the participants' environments, they do not know whether they are able to perform such activities, and therefore, they receive a lower score, decreasing their chance to demonstrate improvement. Although both groups were likely unable to complete all activities, it is more likely that those walking at an increased gait speed and who were demonstrating increased function and quality of life were more likely able to rely on these more difficult items to demonstrate an increased score. Because these individuals are more likely to leave the home environment and engage in the community, there are more items available to be answered, and thus, they are able to gain a higher score.

A limitation of the study is the small sample size. Future studies with larger samples are necessary to fully understand the effects of stroke severity on the probability of transition to different levels of mobility and the associated effects on quality of life. However, the study results have several important implications for clinical research design of post-stroke recovery trials. When gait velocity is used to stratify subjects into clinically meaningful functional ambulation classes such as those used herein, then gait velocity is a clinically meaningful outcome measure. Second, it is important to make sure that chosen outcomes are clinically meaningful for all levels of severity. This can be achieved by not assuming that similar changes in gait velocity are clinically meaningful for all levels of severity. In this study, successful walking recovery was defined by a sliding dichotomy.[22] The idea of a sliding dichotomy is based on a definition that is tailored for each participant's baseline function or prognosis, rather than a single definition of good outcome for all participants.

Using this sliding dichotomy, we observed (as expected) that those who walked the fastest at baseline were already functioning well with respect to ADL/IADL and that changes in gait velocity may not be associated with changes in ADL/IADL but rather that changes in gait velocity are associated with recovery of more complex community par-

TABLE 5. Three-Month Outcomes for Entire Sample

Variable	Success	Failure	P Value (t Test)	P Value* (ANCOVA)
SIS ADL/IADL	77.8 (14.1)	69.6 (19.0)	0.0524	0.6379
SIS mobility	77.6 (2.2)	65.5 (16.1)	0.0015	0.0576
SIS participation	68.2 (8.6)	52.9 (20.6)	0.0031	0.0009
SIS-16	81.3 (11.2)	71.6 (16.5)	0.0076	0.3262

**P* value after adjusting for significantly different baseline SIS scores and age when age is significantly different at the <0.100 level.

TABLE 6. Three-Month Outcomes Stratified by Gait Velocity

Variable	Success	Failure	*P* Value (*t* Test)	*P* Value* (ANCOVA)
<0.4 m/s at baseline				
Sample size	12	7		
SIS ADL/IADL	75.5 (15.2)	51.4 (12.5)	0.0026	0.6650
SIS mobility	77.1 (11.4)	50.5 (10.9)	<0.0001	0.0299
SIS participation	66.1 (15.2)	42.9 (19.6)	0.0100	0.0277
SIS-16	67.2 (12.5)	46.7 (9.8)	<0.0001	0.1351
0.4–0.8 m/s at baseline				
Sample size	17	28		
SIS ADL/IADL	79.6 (13.5)	74.2 (17.7)	0.2891	0.6429
SIS mobility	77.9 (13.1)	69.3 (14.9)	0.0565	0.2952
SIS participation	69.7 (21.0)	55.5 (20.5)	0.0308	0.0085
SIS-16	81.8 (12.7)	67.6 (13.7)	0.1756	0.7090

**P* value after adjusting for significantly different baseline SIS scores and age when age is significantly different at the <0.100 level.

ticipation. In contrast, in those with the slowest gait velocity, we observed changes in mobility and participation.

Duncan et al[23] reported wide variation and inconsistent use of outcome measures in stroke clinical trials and little agreement about what constitutes a favorable or unfavorable outcome. Our systematic assessment of gait velocity as an outcome measure needs to be replicated with other measures to ensure that the outcomes we observed are clinically meaningful for all levels of severity and that we appropriately selected measures that did not suffer from floor or ceiling effects.

In summary, outcome assessment based on transitions within a mobility classification scheme that is rooted in gait velocity yields potentially meaningful indicators of clinical benefit. However, it is necessary to ensure that chosen outcomes are clinically meaningful for all levels of stroke severity.

Sources of Funding

This project was funded by a predoctoral dissertation award through the Department of Veteran Affairs, Rehabilitation Outcomes Research Center of Excellence, North Florida/South Georgia Malcolm Randal VA Hospital. The original research study was funded by the National Institute on Aging, Claude D. Pepper Older Americans Center grant 5P60AG14635, and was completed at the University of Kansas Theo and Alfred M. Landon Center on Aging and the University of Kansas Medical Center, Kansas City.

Disclosures

None.

References

1. AHCPR. *Clinical Practice Guidelines: Post-Stroke Rehabilitation.* Washington, DC: US Department of Health and Human Services; 1995.
2. O'Sullivan SB. Stroke. In: O'Sullivan SB, Schmitz TJ, eds. *Physical Rehabilitation: Assessment and Treatment.* Philadelphia: FA Davis Co; 2001:519–582.
3. Richards C, Malouin F, Wood-Dauphinee S. Gait velocity as an outcome measure of locomotor recovery after stroke. In: Craik RA, Oatis C, eds. *Gait analysis: Theory and Applications.* St Louis, Mo: Mosby; 1995: 355–364.
4. Richards C, Olney SJ. Hemiparetic gait following stroke, part III: recovery and physical therapy. *Gait Posture*. 1996;4:149–162.
5. Perry J, Garrett M, Gronley JK, Mulroy SJ. Classification of walking handicap in the stroke population. *Stroke*. 1995;26:982–989.
6. Goldie PA, Matyas TA, Evans OM. Deficit and change in gait velocity during rehabilitation after stroke. *Arch Phys Med Rehabil*. 1996;77: 1074–1082.
7. Studenski S, Perera S, Wallace D, Chandler JM, Duncan PW, Rooney E, Fox M, Guralnik JM. Physical performance measures in the clinical setting. *J Am Geriatr Soc*. 2003;51:314–322.
8. Lord SE, McPherson K, McNaughton HK, Rochester L, Weatherall M. Community ambulation after stroke: how important and obtainable is it and what measures appear predictive? *Arch Phys Med Rehabil*. 2004;85: 234–239.
9. Wade D. *Measurement in Neurological Rehabilitation.* Oxford, UK: Oxford University Press; 1992.
10. Lord SE, Rochester L. Measurement of community ambulation after stroke: current status and future developments. *Stroke*. 2005;36: 1457–1461.
11. Duncan P, Studenski S, Richards L, Gollub S, Lai SM, Reker D, Perera S, Yates J, Koch V, Rigler S, Johnson D. Randomized clinical trial of therapeutic exercise in subacute stroke. *Stroke*. 2003;34:2173–2180.
12. Eng JJ, Chu KS, Dawson AS, Kim CM, Hepburn KE. Functional walk tests in individuals with stroke: relation to perceived exertion and myocardial exertion. *Stroke*. 2002;33:756–761.
13. Duncan PW, Wallace D, Lai SM, Johnson D, Embretson S, Laster LJ. The stroke impact scale version 2.0: evaluation of reliability, validity, and sensitivity to change. *Stroke*. 1999;30:2131–2140.
14. Duncan PW, Bode RK, Min Lai S, Perera S. Rasch analysis of a new stroke-specific outcome scale: the Stroke Impact Scale. *Arch Phys Med Rehabil*. 2003;84:950–963.
15. Lai SM, Studenski S, Duncan PW, Perera S. Persisting consequences of stroke measured by the Stroke Impact Scale. *Stroke*. 2002;33:1840–1844.
16. Duncan PW, Lai SM, Bode RK, Perera S, DeRosa J. Stroke Impact Scale-16: a brief assessment of physical function. *Neurology*. 2003;60:291–296.
17. Ohrui T, Kubo H, Sasaki H. Care for older people. *Intern Med*. 2003;42: 932–940.
18. Marquis S, Moore MM, Howieson DB, Sexton G, Payami H, Kaye JA, Camicioli R. Independent predictors of cognitive decline in healthy elderly persons. *Arch Neurol*. 2002;59:601–606.
19. da Cunha IT Jr, Lim PA, Qureshy H, Henson H, Monga T, Protas EJ. Gait outcomes after acute stroke rehabilitation with supported treadmill ambulation training: a randomized controlled pilot study. *Arch Phys Med Rehabil*. 2002;83:1258–1265.
20. Judge JO, Underwood M, Gennosa T. Exercise to improve gait velocity in older persons. *Arch Phys Med Rehabil*. 1993;74:400–406.
21. Green J, Forster A, Young J. Reliability of gait speed measured by a timed walking test in patients one year after stroke. *Clin Rehabil*. 2002; 16:306–314.
22. Berge E, Barer D. Could stroke trials be missing important treatment effects? *Cerebrovasc Dis*. 2002;13:73–75.
23. Duncan PW, Jorgensen HS, Wade DT. Outcome measures in acute stroke trials: a systematic review and some recommendations to improve practice. *Stroke*. 2000;31:1429–1438.