Measurement of Community Ambulation After Stroke
Current Status and Future Developments

Susan E. Lord, MSc; Lynn Rochester, PhD

Background and Purpose—This report considers the measurement of community ambulation for people with stroke. The conceptual issues underlying measurement of community ambulation are reviewed, and tests that measure either the task itself or at least some of its components are identified and discussed.

Conclusions—the findings from this review suggest that although some progress has been made toward identifying community ambulation as a stand-alone entity, reliable and valid measures have not yet been developed. Gait speed, which is used often as a proxy measure for community ambulation, does not consistently reflect the level of community ambulation attained, and continued reliance on its use, particularly the 10-m timed walk, is misplaced. The limitations of the measures reviewed here point toward self-report as being the most useful outcome for current clinical use. However, this report highlights the need for research to first inform a theoretical framework for the measurement of community ambulation, from which a measurement tool or a battery of measurements can be developed and tested. (Stroke. 2005;36:1457-1461.)

Key Words: ambulation ■ community ■ gait ■ mobility ■ stroke, acute

Much of the impetus for stroke rehabilitation rests in the desire to regain normal walking, a goal still identified as relevant months or years after the acute event. For many people, the reintegration into community life marks the end point of their rehabilitation. The definition and meaning of community ambulation varies in the literature, and little is known about the dimensions of the task and the specific attributes required for its safe and independent execution. Lord et al1 asked 130 home-dwelling, post–acute stroke survivors to identify relevant community destinations, and from that a definition of community ambulation was developed: independent mobility outside the home, which includes the ability to confidently negotiate uneven terrain, private venues, shopping centers and other public venues. Patla and Shumway-Cook2 developed an operational definition of community mobility that considered 8 environmental dimensions: ambient conditions, terrain characteristics, external physical load, attentional demands, postural transition, traffic level, time constraints, and walking distance. A subsequent study,3 whereby people with disability (including stroke) were observed walking in the community and then compared with people without disability, identified 4 of these dimensions as being important: temporal factors, postural transitions, physical load, and terrain. Interestingly, endurance did not feature as an important dimension of community ambulation, although earlier research has identified it as so.4 Although these studies provide a starting point for the development of a theoretical framework to describe the focus and components of community ambulation, further clarification is required. For example, attention is an attribute of all actions associated with community ambulation,5 and reduced gait performance has been observed with additional attentional demands.6,7 The relationship between the attentional cost to maintain motor performance and the actual performance is complex and may be influenced by a variety of factors, and assessments need to take account of this.8 It may, therefore, be prudent to consider measuring attentional cost, implied through reduced gait performance, as one attribute of community ambulation.

Mobility outcomes for people with stroke have been evaluated with measures that cover impairment,9 activity,10 participation,11 and health-related quality of life.12 The endorsement of the International Classification of Functioning (ICF) by the World Health Assembly in May 200113 turned the spotlight toward understanding functioning and disability as multidimensional concepts that relate not only to physical and psychological features but also to each person’s life situation and social role, which is influenced by external factors, most importantly the physical environment, physical aids and appliances, societal attitudes and beliefs, and social policies. Of particular importance to community ambulation is the acknowledgement in the ICF of the role of environmental factors to functioning, and the relationship between environment and participation. Although the ICF is first and foremost a framework and a classification system rather than a tool for measurement, clinicians and researchers are encouraged to consider their relationship to each other and to link or map items from rehabilitation measures to ICF domains.14 Any new measure of community ambulation...
should, therefore, be considered within the ICF framework, instead of being separate from it.

Although the ICF does not present a single code for community ambulation, it is possible to use the framework to classify aspects of the task. The codes (eg, 4602, 4501, 4502, 4503) are only complete with the presence of at least 1 “qualifier” that personalizes the assessment to the individual. In the case of community ambulation, which is viewed as a task from the activity and participation domain, the relevant qualifier is the performance qualifier, which describes what an individual does in his or her own environment. Further environmental factor qualifiers can be used to denote either the extent of positive effects of the environment (facilitators) or the extent of negative effects (barriers). The Figure gives an example of the measurement of a person’s ability to carry out tasks related to community ambulation using these components of the ICF framework.

Current Measures of Community Ambulation
Current measures are composed of items that researchers consider best represent the task, such as gait velocity or endurance, functional mobility scales, the locomotion domain of global functional measures; or self-reported levels of activity. The Table lists the measures that have been used in research that focuses on the attainment of community ambulation. Gait velocity, measured using the 10-meter timed walk, is used in both research and clinical situations because of its simple clinical application, its robust psychometric properties, and the ratio data it yields. It has been shown to be more responsive than functional scales to changes in mobility following stroke, and it has been described as the “almost-perfect” measure. However, there is no guarantee that an increase in gait velocity, which must first exceed the bounds of measurement error, will denote a meaningful improvement in performance. Because it is measured inside, in a predictable, uncluttered, controlled environment, the skills required for it cannot be assumed to transfer to outside mobility. Although gait velocity has been used as a key parameter to measure levels of community ambulation with thresholds that vary from 48 m/min to 79 m/min, it is not sufficiently discrete to be able to classify different levels of community ambulation without error. In our study, which investigated mobility outcomes on discharge from physical therapy services for people following stroke, although the relationship between gait speed and attained levels of community ambulation was moderate \((r=0.60; P<0.01)\), the confidence intervals for gait velocity, which presented as the most robust of the variables measured, still overlapped for 3 of 4 self-reported levels of community ambulation. Perry et al likewise defined three groups of community walkers based on self-report and gait velocity.

Endurance (another proxy measure for community ambulation) was measured using the 6-minute walk test, a test originally developed to measure the stamina of people with respiratory and cardiac conditions. Pohl et al reported that although motor impairments impact greatly on the 6-minute walk test scores, the test does provide insight into endurance for people with stroke, the pulse rate and systolic blood pressure of which increased significantly with the test.

Lernier-Frankiel et al identified the mobility requirements for safe community ambulation in the Los Angeles area, and recommended a normal gait speed of 79 m/min, a walking distance greater...
than 332 meters, and the ability to step up and down a curb up to 22 centimeters in height. Cohen et al.\textsuperscript{22} who examined community ambulation in older adults with and without physical disabilities, suggested parameters that were very similar. Robinett and Vondran\textsuperscript{23} documented a wide range of distances and gait speeds required for safe ambulation in communities of different sizes. Hill et al.\textsuperscript{24} suggested 4 criteria for community ambulation that included minimum thresholds for gait velocity (48 m/min), endurance (500 meters), the locomotion domain of the Functional Independence Measure\textsuperscript{25} (FIM; score of 5) and the Functional Ambulation Classification\textsuperscript{26} (score of 6). The Dynamic Gait Index\textsuperscript{27} assesses the effects of speed and direction change, head turns and obstacle negotiation on gait, although again it is tested in a clinical environment. The Activities-specific Balance Scale\textsuperscript{28} which has just been shown to be valid and reliable for people with stroke,\textsuperscript{29} is a self-efficacy scale that evaluates confidence in 16 mobility tasks, 9 of them outside. The Community Balance and Mobility Scale\textsuperscript{30} is an example of a test that measures multiple components. It consists of 13 physical tasks, such as tandem pivot and lateral foot scooting, and it includes some dual and multiple task items such as walking, looking, and carrying. Although the scale was developed for people with traumatic brain injury and may not be suitable for people with stroke, it may provide a starting point for a tool that captures the complexity of the task.

**Global Scores of Function**

Global measures of functional activity usually include several items that might be considered prerequisite actions required for community mobility. For example, the Rivermead Mobility Index\textsuperscript{10} tests the ability of a person to mobilize independently in

### Measures Used to Evaluate Community Ambulation

<table>
<thead>
<tr>
<th>Items Measured</th>
<th>Reference(s)</th>
<th>Items Detailed</th>
<th>Domain(s) of CA Represented (ICF)</th>
<th>Dimensions of CA Framework Represented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait speed, self-reported attainment of community ambulation</td>
<td>Lord et al\textsuperscript{1}</td>
<td>m/min derived from 10-meter timed walk categorized into 3 levels of self-reported community ambulation</td>
<td>Activity and participation</td>
<td>Time constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walking as far as the mailbox: 39.6 m/min</td>
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<tr>
<td></td>
<td></td>
<td>Walking in immediate outside environment: 49.2 m/min</td>
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<tr>
<td></td>
<td></td>
<td>Walking to shopping venues and/or other places of interest: 68.6 m/min</td>
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<tr>
<td></td>
<td>Perry et al\textsuperscript{19}</td>
<td>m/min derived from footswitch stride analyzer categorized into 3 levels of self-reported community ambulation</td>
<td>Activity and Participation</td>
<td>Time constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most-limited community walker: 24 m/min</td>
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<tr>
<td></td>
<td></td>
<td>Least-limited community walker 35 m/min</td>
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<tr>
<td></td>
<td></td>
<td>Community walker: 48 m/min</td>
<td></td>
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</tr>
<tr>
<td>Speed, distance, FIM and FAC</td>
<td>Hill et al\textsuperscript{24}</td>
<td>48 m/min</td>
<td>Activity</td>
<td>Time constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 meters</td>
<td>Minimum walking distance</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>FIM 5</td>
<td>Terrain characteristics</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>FAC 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed, distance</td>
<td>Robinett and Vondran\textsuperscript{23}</td>
<td>Curb height</td>
<td>Activity</td>
<td>Time constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance of street and pedestrian crossing, banks, supermarkets, malls, stores, etc from closest car park</td>
<td>Activity</td>
<td>Minimum walking distance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Velocity (ranged from 30 m/min to 82.5 m/min for safe street crossing)</td>
<td>Terrain characteristics</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Assessed for 3 communities of different populations: &lt;10 000; 10 000–40 000; &gt;95 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed, distance, stepping</td>
<td>Lernier-Frankiel\textsuperscript{4}</td>
<td>73 m/min</td>
<td>Activity</td>
<td>Time constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>332 meters</td>
<td>Minimum walking distance</td>
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<tr>
<td></td>
<td></td>
<td>Stairs and curbs</td>
<td>Terrain characteristics</td>
<td></td>
</tr>
<tr>
<td>Speed, distance, stepping</td>
<td>Cohen et al\textsuperscript{22}</td>
<td>73 m/min</td>
<td>Activity</td>
<td>Time constraints</td>
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<td></td>
<td></td>
<td>360 meters</td>
<td>Minimum walking distance</td>
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<td></td>
<td>Stairs and curbs</td>
<td>Terrain characteristics</td>
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</table>

FIM indicates Functional Independence Measure; FAC, Functional Ambulation Category.
a nonclinical environment, including negotiating uneven terrain and walking up and down 4 steps without help if necessary and their ability to run or walk quickly 10 meters without limping in 4 seconds. The highest scoring item on the FIM measures the ability of an individual to walk 50 meters safely without assistive devices in a reasonable time frame, but the environment is not specified. The Barthel Index asks about independent mobility and stairs. However, none of these measures by themselves gives a complete picture of a person’s ability to walk in the community.

Self-Reported Measures
The 2 self-reported measures that accompanied the studies outlined above provide for different levels of community mobility. Perry et al identified 6 functional categories that included the ability to get to appointments, visit friends, go shopping, go to church, and undertake recreational activities, with 4 levels of attainment from “unable” to “independent.” In the study of Lord, people were asked whether they walked independently either as far as the mailbox, around their immediate environment, or to places of interest and/or shopping malls.

Measures of Participation and Quality of Life
Measures of participation, quality of life, life satisfaction, and social integration often contain several items specific to either community ambulation or community mobility; the distinction between these two is not always clear. The Subjective Index of Physical and Social Outcome, a 14 item scale that includes 4 items that cover movement within the local neighborhood, shopping, leisure activities, and visiting friends. Likewise, the Reintegration to Normal Living Index includes 3 items of similar content. Several items on The Sickness Impact Profile inquire about the ability of a person to walk distances, to negotiate hills, stairs, and public transportation, and to gain access to the wider community. The Frenchay Activities Index records the frequency of activities undertaken over a 6-month period and includes items such as local shopping, walking outside >15 minutes, driving a car or getting on a bus, travel outings, and car rides. The Nottingham Extended Activities of Daily Living Index contains items that measure, on a 4-point Likert scale, tasks that denote advanced mobility status, including the ability to shop. The Stroke Impact Scale was developed from the perspective of the patient and caregiver to provide a multidimensional, broad-stroke outcome measure. The 64-item scale covers 8 domains with items that measure impairment, activity, and participation on a 5-point Likert scale. Eight of these items reflect aspects of community ambulation or mobility, such as shopping, climbing flights of stairs, getting in and out of a car, and carrying a heavy object.

What Might a Relevant Measure for Community Ambulation Look Like?
In a systematic review of outcome measures used in drug trials for acute strokes, Duncan et al reported a wide variation and inconsistent use of outcome measures, with little agreement about what constitutes a favorable or unfavorable outcome. Part of the problem is that functional outcome measures in rehabilitation have suffered for the lack of a theoretical or conceptual framework to guide their development. A widely accepted conceptual foundation for the definition and measurement of community ambulation, and its relationship to community mobility, must be agreed on between both users and researchers before considering options for measurement.

However, 2 approaches to its measurement have emerged. The first is to measure the level of task attainment and the second is to break the task itself down into the impairments and activities that predict community ambulation. The first is measured through self-report and aligns itself to measuring what counts, that is, at what ICF level of activity does this person attain community ambulation and with what assistance? Although there is empirical evidence to support the advantages of self-reported measures mostly because of their superior content validity (eg, the Patient Generated Index, the Patient-Specific Measure), this approach may be limited because of the difficulties in determining criteria for clinically important change in a heterogeneous group of patients, the judgments of whom regarding change are neither necessarily congruent nor consistent over time. Comparisons of outcomes across studies, therefore, can become problematic. Perhaps more importantly, outcome comparisons do not help the tester identify which aspects of the task the person finds difficult to master and identify those people who may attain community ambulation; the comparisons, therefore, are less able to inform the rehabilitation process.

The second option requires an operational definition of community ambulation and the reliable and valid measurement of impairments that constitute the activity as well as measurement, in a separate domain or test, of the activity itself, both of which are best tested through observation of performance. These predictors may include gait speed, postural transitions, dual and/or multiple attention tasks (such as motor plus walking, cognitive plus walking), attentional cost, fatigue, motivation, and endurance. Given the likelihood that performance will vary under different environmental conditions, testing will also need to be carried out in a range of ecologically valid environments rather than in the clinic. Development of a measure using this approach will be time consuming and protracted; because of the complexity of the task, a substantial body of basic research will first need to be undertaken before a definitive list of predictors for community ambulation can be identified. An example of a method of evaluation that examines these issues has been conducted in people with Parkinson disease both to identify difficulties compared with a control population and to measure changes in response to intervention. We are also currently investigating the effect of a secondary task on gait performance in people with stroke in ecologically valid environments, which may also contribute to our understanding of the complexity of the task. With either approach, it is important to consider the effect of task limitations on broader domains such as participation and quality of life. Ultimately, it may be necessary to produce a battery of tests that encompasses all domains.

In the interim, it may be expedient for clinicians and researchers to use an instrument of self-report depicting different levels of task attainment that extend from accessing the external home environment to accessing more challenging environments that include shopping centers and suburban streets, rural roads, and public transport and that also includes the ability to do 2 things at once, eg, walking and talking.
Summary
Community ambulation is the ability to integrate walking with other tasks in a complex environment. The presence of impaired physical performance and possible cognitive and behavioral factors will further interact with the performance of gait and the resultant effect will be impaired community ambulation. The development of clinical tests that incorporate dual-task paradigms as part of assessment methods and take into account the context in which assessment takes place (eg, clinic, home, community) may prove helpful in identifying those who may have difficulty generalizing the performance of gait in a simple environment to a complex environment. In addition, they may identify those for whom safety in terms of risk of falls under these more complex situations is an issue. Patla and Shumway-Cook\(^2\) have noted that mobility in a complex environment is the norm, not the exception, and we require tools that reflect this. Community ambulation is an ecologically valid outcome to measure, and although the 10-meter timed walk remains central to mobility measurement, it needs to be considered alongside measures that reflect the broader dimensions of this complex task.

Acknowledgments
We thank Dr William Taylor for his comments on an earlier draft of this manuscript.

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Stroke. 2005;36:1457-1461; originally published online June 9, 2005;
doi: 10.1161/01.STR.0000170698.20376.2e

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