

# The Amputee Mobility Predictor: An Instrument to Assess Determinants of the Lower-Limb Amputee's Ability to Ambulate

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**ABSTRACT.** Gailey RS, Roach KE, Applegate EB, Cho B, Cunniffe B, Licht S, Maguire M, Nash MS. The Amputee Mobility Predictor: an instrument to assess determinants of the lower-limb amputee ability to ambulate. *Arch Phys Med Rehabil* 2002;83:613-27.

**Objectives:** To describe the development of the Amputee Mobility Predictor® (AMP) instrument designed to measure ambulatory potential of lower-limb amputees with (AMPPRO) and without (AMPnoPRO) the use of a prosthesis, and to test its reliability and validity.

**Design:** Measurement study using known groups method and concurrence with existing measures.

**Setting:** Academic medical center.

**Participants:** A convenience sample of 191 lower-limb amputee subjects who had completed prosthetic training, 24 in the reliability study (mean age  $\pm$  standard deviation,  $68.3 \pm 17.9$ y, range, 28–99y) and 167 in the validity study (mean age,  $54.8 \pm 18.6$ y; range, 18–100y).

**Interventions:** Not applicable.

**Main Outcome Measures:** Intra- and interrater reliability; construct validity by known groups method; concurrent validity by comparisons with 6-minute walk test, Comorbidity Index, age, and time since amputation; predictive validity by comparison with 6-minute walk test after controlling for other factors.

**Results:** Interrater reliability was .99 for subjects tested with and without their prosthesis; intrarater reliability was .96 and .97. Both the AMPnoPRO ( $P < .0001$ ) and the AMPPRO scores ( $P < .0001$ ) distinguished among the 4 Medicare functional classification levels. The AMP correlated strongly with 6-minute walk scores (AMPnoPRO  $r = .69$ ,  $P < .0001$ ; AMPPRO  $r = .82$ ,  $P < .0001$ ) and the amputee activity survey (AMPnoPRO  $r = .67$ ,  $P < .0001$ ; AMPPRO  $r = .77$ ,  $P < .0001$ ), and negatively correlated with age (AMPnoPRO  $r = -.69$ ,  $P < .0001$ ; AMPPRO  $r = .56$ ,  $P < .0001$ ) and comorbidity (AMPnoPRO  $r = -.43$ ,  $P < .0001$ ; AMPPRO  $r = .38$ ,  $P < .0001$ ).

**Conclusion:** The AMP with and without a prosthesis are reliable and valid measures for the assessment of functional ambulation in lower-limb amputee subjects.

**Key Words:** Amputees; Amputation; Outcome assessment (health care); Recovery of function; Rehabilitation.

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IN 1995, MEDICARE ADOPTED the US Health Care Financing Administration's (HCFA) Common Procedure Coding System,<sup>1</sup> using code modifiers (K0, K1, K2, K3, K4) as a 5-level functional classification system (MFCL) to describe the functional abilities of persons who had undergone lower-limb amputation. The MFCL also describes the medical necessity of certain prosthetic components and additions (table 1). By using this system, the physician and prosthetist determine the patient's ability to reach a "defined functional state within a reasonable period of time."<sup>1</sup> That decision is based on a subjective evaluation of the patient's past history (including prior prosthetic use, if applicable); the patient's current condition, including the status of the residual limb; concomitant medical problems; and the patient's desire to ambulate.<sup>2-5</sup> To standardize this process would require an instrument that could classify the amputee subject by functional level and quantify function. The instrument would need to be applicable across a wide range of functional abilities.

To be clinically feasible, such an instrument must be efficient in its use of time and resources, must yield consistent responses,<sup>6,7</sup> and must clearly differentiate among the different levels of prosthetic prescription. Ultimately, this instrument should enable the clinician to measure an amputee subject's functional capabilities without a prosthesis and to predict his/her ability to ambulate with a prosthesis.

Currently, a wide range of instruments are available to measure ability to perform activities of daily living (ADLs) and to assess functional skills, such as the FIM™ instrument,<sup>8,9</sup> Tinetti's Performance-Oriented Assessment of Mobility Problems<sup>10</sup> (POMA), and Duke Mobility Skills Profile<sup>11</sup> (DMSP). Although any of these instruments could be administered before prosthetic fitting, none is specific to amputees and, as a result, they do not cover the range of functional skills necessary to assess fully an amputee subject's prosthetic potential.

Muecke et al<sup>12</sup> were the first to look at the use of the FIM with 68 amputee subjects assessed at admission and discharge, producing mean admission scores of 52.7 (range, 25.2–70), with no significant relationship to age, gender, or level of amputation. Amputee subjects who scored lower on admission had highly variable improvement; some improved markedly, whereas others showed very little progress. Amputee subjects who scored high on admission had very little room for improvement and experienced a ceiling effect. The FIM score proved to be a poor predictor because amputee subjects in the lower levels showed more improvement in functional status. Whereas those who scored high on admission, received more funds, and had a longer length of stay achieved near perfect discharge scores.<sup>12</sup>

Leung et al<sup>13</sup> examined the value of the FIM score as a prognostic indicator for prosthetic use in 29 amputee subjects and found that admission FIM score is not useful in predicting successful prosthetic rehabilitation in lower-extremity amputee patients. Only the motor subscore at discharge correlated with the use of a prosthesis. Level of amputation, age, and comorbidity also had a significant correlation with use of a prosthesis.

Table 1: Definitions for the MFCL Classification

K-Level 0	Does not have the ability or potential to ambulate or transfer safely with or without assistance, and a prosthesis does not enhance quality of life or mobility.
K-Level 1	Has the ability or potential to use a prosthesis for transfers or ambulation in level surfaces at a fixed cadence. Typical of the limited and unlimited household ambulator.
K-Level 2	Has the ability or potential for ambulation with the ability to transverse low-level environmental barriers such as curbs, stairs, or uneven surfaces. Typical of the limited community ambulator.
K-Level 3	Has the ability or potential for ambulation with variable cadence. Typical of the community ambulator who has the ability to transverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic use beyond simple locomotion.
K-Level 4	Has the ability or potential for prosthetic ambulation that exceeds basic ambulation skills, exhibiting high impact, stress, or energy levels. Typical of the prosthetic demands of the child, active adult, or athlete.

NOTE. K is an arbitrary letter assigned by HCFA to this classification system.

However, amputee-specific instruments do exist, such as the Functional Ambulation Profile<sup>14</sup> and the Prosthetic Goal and Achievement<sup>15</sup> test. The Functional Ambulation Profile instrument was initially tested on 31 amputee subjects and was reported to have very good reliability.<sup>14</sup> In a subsequent study<sup>16</sup> of 59 amputees, investigators reported its clinical relevance with regard to ambulatory potential, but prosthetic use or testing validity was not reported. The 2 most valuable tests on face validity appear to be the single-limb stance and 1 form of the 12-m walk and the Prosthetic Goal and Achievement test.<sup>16</sup> These instruments have the disadvantage of assuming that the amputee subject already has a prosthesis. Existing questionnaires are designed to collect information on the amputee subject's preamputation level of function, medical history, number of comorbidities, age, and psychologic profile.<sup>17-19</sup> Although useful for standardizing the information that clinicians use to make prosthetic recommendations, such questionnaires do not provide guidelines for those recommendations.

One commonly used instrument, the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36), may provide insight into many areas of functioning and well-being but does not appear to be a good predictive tool nor is it designed specifically for the amputee patient. If, as Smith et al<sup>20</sup> suggest, that the SF-36 was too "high end," that is, applicable to young persons with traumatic amputations, then presumably, it would be inappropriate for the much older general population of amputee patients.

Several different classification scales for amputee patients have been proposed.<sup>15,19,21-27</sup> However, absent a reliable and valid measure of functional status, classifying patients relative to prosthetic prescription is largely subjective. All amputee patients receiving prosthetic intervention from Medicare are currently being classified under the MFCL, as mandated by HCFA.<sup>1</sup>

Our intention was to develop an instrument that would enable physicians, prosthetists, and physical therapists to assess objectively an amputee patient's ability to ambulate with a prosthesis. The resulting instrument, the Amputee Mobility Predictor© (AMP), was designed to meet the following criteria: (1) to be administered before prosthetic fitting; (2) to be clinically feasible in terms of time, resources, and ease of use, and; (3) to assist in assigning an MFCL for prosthetic prescription of Medicare-eligible patients.

The AMP was designed to measure an amputee patient's functional capabilities without a prosthesis and to predict his/her ability to ambulate with a prosthesis. It can therefore be used before prosthetic fitting to predict functional mobility after prosthetic fitting. Although the AMP can be administered both with (AMPPRO) and without (AMPnoPRO) a prosthesis,

the AMPnoPRO has the greatest potential to assist in prosthetic prescription. The AMP scoring form is in appendix 1.

In order for the AMP to be used in this capacity, its reliability and validity as a measure of ambulation ability had to be established. Studenski and Duncan<sup>28</sup> state: "In rehabilitation, there are no gold standards of function, so validation is a roundabout process. We can compare one measure with others that seem to reflect the same phenomena." Therefore, to validate the AMP required that we compare it with other instruments that measure the same or closely related phenomena. The first test selected was the 6-minute walk test. This test has been used extensively in a wide variety of populations. The literature<sup>29-32</sup> suggests that it is a reliable and valid measure of functional mobility.

Van Bennekom et al<sup>33</sup> suggested that rehabilitation assessment should not only focus on objective measures to determine degree of disability but also on the patient's perceived problems. Several investigators<sup>34,35</sup> showed that amputee patients can provide reliable self-assessment of their present functional level. Independence in self-care or ADLs was the strongest indicator for returning home after amputation.<sup>36-38</sup> For this reason, we also selected the Amputee Activity Survey (AAS) to validate the AMP.

Several other factors, such as age, time since amputation, and number and severity of comorbidities, have been repeatedly shown to have a significant impact on the amputee patient's course of rehabilitation and ability to ambulate with a prosthesis.<sup>13,39-44</sup> Because of the differences found in the literature with respect to patients' medical, prosthetic, and rehabilitation history, we took each subject's medical history during the reliability study and later refined our queries for the validity study. For the reliability study, we used an open-ended questionnaire to document medical history; for the validity study, we used the Melchiorre Comorbidity Scale, a version of the Charlson Comorbidity Scale, for amputee patients<sup>45</sup> because it provided data more conducive to statistical analysis.

The purposes of the present study were (1) to determine the intra- and interrater reliability of the AMP; (2) to examine the construct validity of the AMP by examining (by known groups method) its ability to distinguish among MFCL levels in terms of ability to ambulate; (3) to test the AMP's concurrent validity by examining the correlation between AMP scores and 6-minute walk test, AAS, Comorbidity Index, age, and time since amputation; and (4) to examine the predictive validity of the AMP by determining the relationship between the AMPnoPRO score and the 6-minute walk score after controlling for the influence of other related factors such as age, comorbidity, and time since amputation.

**Table 2: Description of Subjects: Amputation Level, Gender, Age, and Cause of Amputation**

Amputation Level	Men	Women	Total	Age (y)	Disease	Trauma	Time since Amputation (mo)
Unilateral TTA	5	5	10	59.7±15.63	6	4	103.9±163.98
Unilateral TFA	2	6	8	73.9±16.69	7	1	32.13±23.23
Bilateral amputee subjects	3	3	6	75.17±20.1	6	0	56.33±53.63
Total	10	14	24	68.3±17.98	19	5	68.1±111.15

NOTE. Values for age and time since amputation are mean ± SD. Abbreviations: TTA, transtibial amputee; TFA, transfemoral amputee.

**METHODS**

We studied a convenience sample of 191 lower-limb amputee patients, 24 of whom participated in the reliability study and 167 in the validity study, with an age range of 18 to 100 years. Subjects were recruited from hospitals, rehabilitation centers, extended-care facilities, and amputee patient support groups from Miami, FL, Oklahoma City, OK, and Chicago, IL. Subjects were medically stable and considered appropriate for testing with the ability to follow basic verbal commands and perform testing activities without risk. Ambulatory amputee patients had to have appropriately fitted prostheses and be pain free at the time of testing. Subjects had reached the peak of their prosthetic independence and were not participating in a rehabilitation program at the time that they were studied. Exclusion criteria included (1) obvious mental deterioration based on interview; (2) an advanced neurologic disorder; (3) severe congestive heart failure, angina pectoris, or obstructive pulmonary disease; (4) significant ulcers or infections associated with a compromised circulation of the other lower limb; and (5) irreducible, pronounced knee or hip flexion contractures. Bilateral amputee patients were included for the reliability study; however, they were excluded from the validity study. Therefore, all subjects for the validity study had to be unilateral amputee patients, with the exception of partial foot amputation on the contralateral side. Ankle disarticulation (Syme’s amputation) and higher were considered bilateral amputee patients and therefore excluded from the study. Essentially, all unilateral amputee patients were included who were medically stable enough to perform the test.

All subjects meeting the inclusion criteria were given a written copy of the University of Miami Institutional Review Board consent form to read and sign. The examiner gave a verbal explanation of the testing procedures to each subject and all his/her questions were answered.

**Reliability Study**

Twenty-four lower-extremity amputee subjects (10 men, 14 women; age range, 28–99y; mean age ± standard deviation [SD], 68.3±17.8y) participated in this study. Disease was the cause of amputation for 19 subjects, including all 6 bilateral amputee subjects. Trauma accounted for the remaining 5 amputee subjects. There were 10 unilateral transtibial amputee subjects, 8 unilateral transfemoral amputee subjects, and 6 bilateral amputee subjects with a variety of amputation combinations (3 bilateral transtibial, 2 transtibial transtarsal, 1 transtibial transfemoral) (table 2).

The average time since amputation was 68.1±111.15 months for the primary amputation and 35 months for the amputation of the contralateral limb in the bilateral amputee subjects. The health status of participants ranged from healthy, with no known comorbidity, to debilitated with 11 known ailments (table 3). Of the 20 subjects who were nonsmokers at

the time of testing, 11 had previously smoked and had quit; only 4 subjects had never smoked. All prostheses were in good condition, and their sockets were well fitted and comfortable to wear at the time of testing.

**Validity Study**

Subjects were classified into 1 of the 5 MFCLs (table 4) at the time of testing. Those in level K0 (n=7) and level K1 (n=11) were the 2 smallest groups, with the majority of subjects coming from extended-care living facilities. Following the Medicare guidelines, the level 0 group had no prosthesis or if they had one could not use it to any degree, whereas the level 1 group had a prosthesis that could be used for transfers. The remaining subjects, those in level 2 (n=43), level 3 (n=67), and level 4 (n=39), were seen either on an outpatient basis at clinical facilities or in a specially designed isolated room at amputee support group meetings.

**Instrument Design**

Careful examination of the existing assessment instruments produced 2 that offered a basis for the construction of the AMP test, the Tinetti’s POMA<sup>15</sup> and DMSP.<sup>46-49</sup>

The POMA identifies components of balance and mobility in persons susceptible to falling. The 16-item test was primarily designed for the frail elderly population with impaired functional capabilities and, as a result, low physical expectations. The DMSP is a 13-item test designed to assess balance and mobility in community-dwelling elderly persons without significant disease, and the test appears to impose more rigorous tasks, and higher functional expectation is implied. Because the AMP was intended for use across a wide range of functional abilities, we selected items from both indices for the AMP. The

**Table 3: Reliability Study Comorbidity Description and Frequency**

Comorbidities	TTA	TFA	Bilateral Amputee Subjects
Arteriosclerosis	3	2	5
Venous insufficiency	1	0	0
Hypertension	4	2	5
Cardiorespiratory	2	0	2
Diabetes	5	3	4
Urinary tract	0	1	1
Kidney	2	0	1
Skin lesion	1	1	1
Ulceration	1	0	1
Contractures	0	3	1
Arthritis	5	2	2
Osteomyelitis	1	1	0
Cerebrovascular accident	1	1	2

Table 4: Gender, Cause and Level of Amputation, and Smoking History and Percentages According to MFCL Level

	MFCL 0	MFCL 1	MFCL 2	MFCL 3	MFCL 4	Total
Gender (%)						
Men	2 (29)	1 (9)	24 (56)	32 (48)	27 (69)	86 (51.5)
Women	5 (71)	10 (91)	19 (44)	35 (52)	12 (31)	81 (48.5)
Total	7 (4.2)	11 (6.6)	43 (25.8)	67 (40.1)	39 (23.4)	167 (100)
Amputation cause (%)						
Disease	7 (100)	10 (91)	31 (72)	24 (36)	4 (10)	76 (45.5)
Trauma	0 (0.0)	0 (0.0)	8 (19)	31 (46)	22 (57)	61 (36.5)
Tumor	0 (0.0)	0 (0.0)	3 (7)	10 (15)	11 (28)	24 (14.4)
Congenital	0 (0.0)	1 (9)	1 (2)	2 (3)	2 (5)	6 (3.6)
Total	7 (4.2)	11 (6.6)	43 (25.8)	67 (40.1)	39 (23.4)	167 (100)
Amputation level (%)						
Ankle disarticulation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5)	2 (1.2)
Transtibial	3 (43)	6 (55)	22 (51)	33 (48)	18 (46)	82 (49.1)
Knee disarticulation	0 (0.0)	0 (0.0)	1 (2)	5 (8)	1 (3)	7 (4.2)
Transfemoral	3 (43)	5 (45)	16 (38)	26 (39)	17 (43)	67 (40.2)
Hip disarticulation	1 (14)	0 (0.0)	3 (7)	3 (5)	0 (0.0)	7 (4.2)
Transpelvic	0 (0.0)	0 (0.0)	1 (2)	0 (0.0)	1 (3)	2 (1.2)
Total	7 (4.2)	11 (6.6)	43 (25.8)	67 (40.2)	39 (23.4)	167 (100)
Smoking (%)						
No, never	4 (67)	5 (45)	19 (44)	32 (48)	24 (62)	84 (50.6)
No, quit	2 (33)	5 (45)	15 (35)	22 (33)	7 (18)	51 (30.7)
Yes	0 (0.0)	1 (10)	9 (21)	13 (19)	8 (20)	31 (18.7)
Total	6 (3.6)*	11 (6.6)	43 (25.9)	67 (40.4)	39 (23.5)	166 (100)

NOTE. Values are n (%).

\* Smoking data unavailable on 1 subject.

AMP also includes an item measuring single-leg stance because amputee subjects perform this activity frequently.

Because the MFCL is used extensively in prosthetic prescription and is defined by the amputee subject's ability to perform transfers, to traverse low-level environmental barriers such as curbs and stairs, and to vary a cadence, the AMP was also designed to assess the specific tasks identified in the MFCL scale.

To improve the AMP's clinical suitability, we made every effort to limit the amount of equipment required and to create an instrument with a short administration time and a simple scoring system. We also considered that the AMP's administration must be easily understood by clinicians with diverse educational qualifications, including physicians, prosthetists, physical therapists, and nurses.

The AMP is designed as a clinical tool for assessing an amputee subject's mobility and for assessing existing or potential functional ambulation of the lower-limb amputee. Each item included in the AMP was selected for its contribution to the overall assessment of amputee function with and without a prosthesis. It evaluates transfers, sitting and standing balance, and various gait skills.

The AMP is also designed to assess unilateral amputee subjects with (AMPPRO) and without (AMPnoPRO) a prosthesis; however, bilateral amputee subjects with amputation levels higher than transtibial foot amputations may be tested only with the AMPPRO because it is not physically possible for them to perform the AMPnoPRO. The total score range for the AMP is 0 to 42 points. In its AMPnoPRO configuration, the highest possible score is 38 points because item 8, single-limb standing, is eliminated (standing on the prosthetic side is impossible). By using an assistive device, the subjects' potential total score possibilities increase by 5 points (to 43 and 47 points for the AMPnoPRO and AMPRO, respectively), depending on the type of assistive device used during testing.

Appendix 2 provides a detailed description of instructions and scoring for each test item.

The item selection of the AMP is organized with an increasing level of difficulty to permit progressive assessment of the amputee subject. Items 1 and 2 test the person's ability to maintain sitting balance. The sitting reach test assesses the ability to displace one's center of mass (COM) and to return to balanced sitting without falling. If the amputee subject does not have the ability to sit and reach in sitting independently, then the possibility for even limited prosthetic use is remote and the amputee subject therefore would be classed as a level K0 (see appendix 2).

Items 3 through 7 are specifically designed to examine the amputee subject's ability to maintain balance while performing the relatively simple task of transferring from chair to chair and standing unchallenged. These skills are necessary for a level 1 amputee subject who would receive a prosthesis for transfers and simple standing activities. The ability to perform these test items safely would probably suggest that the patient could manage a prosthesis in limited situations, especially in a supervised environment (see appendix 2).

Items 8 through 13 are more challenging activities related to standing balance. To show capability in these tasks, the amputee subject must maintain some single-limb balance and perform a modified standing reach test that requires reaching 30.5cm without losing balance. Other balance tests, such as the nudge test, check reactive balance or the ability to maintain upright posture when perturbed or to change postural position as required for picking up a pencil from the floor. To maintain standing balance with eyes closed requires adequate somatosensory and vestibular systems for balance. These qualities imply that the amputee subject has the potential to be a safe household ambulator; that is, he/she can function at level K2 (see appendix 2).

AMP items 14 through 20 evaluate quality of gait and the ability to negotiate specific obstacles. The capacity to initiate gait without hesitation shows automatic movement strategies and the ability to organize simple planned movement. Step continuity and equality of step length shows that the person is able to maintain single-limb balance in a dynamic situation and can use momentum as required for an efficient gait. Moreover, the competency to perform repetitive motor skills using an assistive device and/or a prosthesis during walking also shows the amputee subject's capabilities with complex tasks. Turning provides additional information concerning maintaining a stable base and controlling COM for dynamic balance and movement planning. Variable cadence, stepping over a curb or obstacle, and negotiating stairs are specific activities defined for a Medicare level K3 ambulator. Level 4 requires no additional skills and provides no additional prosthetic components and would only suggest that, in theory, this level amputee subject can perform all skills with greater ease. Item 21 accounts for the use of particular assistive devices.

The scoring system is intentionally kept very simple. Most AMP items offer 3 scoring choices: 0 indicates inability to perform the task, 1 implies minimal level of achievement or that some assistance was required in completing the task, and 2 denotes complete independence or mastery of the task. Appendix 2 describes in detail the scoring for each assessment item and the corresponding point values.

### Other Instruments

**Amputee Activity Survey.** The AAS is a 20-item questionnaire that allows amputee subjects to describe their average daily activity level.<sup>34</sup> A linear relationship was found between step rate and AAS scores.<sup>34</sup> On face validity, descriptive analysis appeared to support Day's<sup>34</sup> contention that amputees have a fairly accurate assessment of their activity level and supported his conclusions that amputees with higher AAS scores walked more. Hubbard and McElroy<sup>50</sup> found that the preferred walking speed of persons with vascular transtibial amputation correlated highly with the AAS. For the purposes of the present study, we modified the AAS's original text, which used terms familiar to residents of the United Kingdom, to terms more typically used in the United States.

**Six-Minute Walk.** McGavin et al<sup>30</sup> suggested the use of the 12-minute walk test to measure exercise tolerance; this was later found to be a useful and measurable indication of exercise tolerance.<sup>2,30,32</sup> Butland<sup>51</sup> had a series of elderly patients perform the 2-, 6-, and 12-minute walk tests and concluded that the time chosen to assess exercise is not critical, that shorter times are easier for both patients and investigators, and that the 6-minute walk test is the sensible compromise. The 6-minute walk was very reliable for patients with peripheral arterial occlusive disease with intermittent claudication and also had a strong relationship to physical activity.<sup>51</sup> Used with older adults, the 6-minute walk also showed excellent test-retest reliability and was found to correlate moderately with balance and gait speed.<sup>52</sup>

Although we found no reports of the 6-minute walk being used with amputee subjects, the test appears to be a practical method to measure exercise tolerance and functional capabilities. Published reports describing test groups with diagnoses similar to those that many amputees present with, such as pulmonary disease, congestive heart failure, and peripheral arterial occlusive disease also confirm that the 6-minute walk is

a clinically appropriate and safe instrument for this population.<sup>53,54</sup>

### Validity Testing Procedure

A group of 5 trained examiners were involved in data collection. They were taught in a 1-hour session, practiced during 2 subsequent 1-hour sessions, and were experienced in the administration of the AMP and the supplemental data collection procedures. Examiners first interviewed potential subjects to determine if they were cognitively, neurologically, and physically able to safely perform the required physical test items of the study. All subjects who did not meet these criteria were excluded from participation. Subjects who reported that they were not comfortable in their socket or were experiencing prosthetic problems that would preclude normal prosthetic function were also excluded from testing.

### Procedures

Demographic data, medical history, the Melchiorre Comorbidity Index, and prosthetic information were obtained through an interview of subjects by the assigned examiner. If the subject could not provide critical information, a medical chart search was performed for residential patients or the appropriate health professional was contacted to complete the forms. The AAS was also administered orally and recorded by the examiner.

The MFCL was assigned by an independent prosthetist or physician examiner (table 1). The subject's MFCL classification was not disclosed at the time of assessment and the results were not made available until the conclusion of the study. Only prosthetists and physicians familiar with the MFCL scoring system and its guidelines as published by HCFA and who used the system in their clinical practice were permitted to participate as examiners.<sup>1</sup>

Subjects were asked to perform each of the 20 items in the AMP twice, once without their prosthesis (AMPnoPRO) and again with the prosthesis (AMPPRO). Subjects had the option to refuse any task at any time without coercion by the examiner. Examiners had the option, by professional judgment, to exclude any item that they perceived to be contraindicated. Exclusion of items typically occurred with subjects who were at a lower MFCL and who were clearly incapable of performing test items, and only if the examiner felt the task unsafe or impossible to attempt because of the subject's physical abilities. A score of 0 was assigned to any "refusals" or "contraindicated" test items. The subjects performed the test at a self-selected pace to avoid the effects of fatigue.

An alternating assignment of test order was maintained when possible. Often the practical convenience for the subject had to be considered, for example, the inconvenience or fatigue of having to undress and dress to don their prosthesis, if first tested without the prosthesis. All subjects were allowed ample rest time between test trials.

The 6-minute walk test was administered after the completion of the AMP testing. All subjects were offered sufficient time to rest before beginning the test. Each subject was instructed to walk at a comfortable walking speed and permitted to rest as often and as long as needed during the test. No 2 subjects walked together, and the examiner always walked behind the patient to avoid inadvertent pacing.

The subjects participating in the reliability study followed the same protocol with the exception of the 6-minute walk. Each subject was tested by 2 raters on the initial contact (trial 1) and tested again by the same 2 raters at the follow-up contact

**Table 5: Description of Subjects Within Collapsed MFCL System**

Group	MFCL	n	% of sample	Age (y)	Time Since Amputation	Amputation Level
A	0	4	16.7	85.75±15.95	34.75±41.75	TTA 0 TFA 2
B	1&2	7	29.2	69.85±21.46	44.57±49.88	Bilateral 2 TTA 2 TFA 3
C	3&4	13	54.2	62.00±13.41	91.00±144.01	Bilateral 2 TTA 8 TFA 3

NOTE. Values for age and time since amputation are mean ± SD.

(trial 2). Trial 2 occurred within 21 days of trial 1. The 14-to-21-day follow-up period was chosen to reduce the chance of testing familiarity by the subjects and to reduce the chance of memory bias by the raters. Because all subjects were functionally stable and had long since completed their rehabilitation, no appreciable between-test change was anticipated or observed. At the time of the initial testing session, subjects were assigned to 2 examiners, each of whom was blinded to the other and to their own previous findings. After trial 1 was completed, the forms were stored until trial 2 was completed. Examiners were not permitted to review their previous findings or to discuss results with any other tester. All subjects were asked to reschedule for retest within 21 days from initial testing.

### Statistical Analyses

**Intraclass correlation coefficients.** Intraclass correlation coefficients (ICCs) were used to determine test-retest and interrater reliabilities with regard to the AMP. ICCs were calculated for interrater reliability at both trial 1 and trial 2. Test-retest reliability was calculated separately for each rater based on data from trial 1 and trial 2. Intrarater reliability was a component of test-retest reliability and was not assessed directly.

**Known groups analyses.** Our assumption was that if the AMP really measures an amputee subject's ability to ambulate, it should be able to discriminate among MFCL levels. This assumption was examined by using the known groups method with a single-factor between-subjects design. The MFCL groups formed 1 independent variable with 4 levels. None of the subjects at level K0 performed the 6-minute walk, AMPPRO, or the AAS because use of a prosthesis was required for those tests. Therefore, we compressed level K0 and level K1 into a single level K1 group (table 5).

One-way analyses of variance (ANOVAs) were used to determine differences among subjects in each of the MFCLs in AMPnoPRO score and AMPPRO score. To protect against inflated type I error, the Tukey honesty significant difference post hoc procedure was used in the overall analysis was statistically significant. To determine the validity of measures used to examine concurrent validity, a similar analysis was performed for 6-minute walk scores and for the AAS score.

**Concurrent validity.** The concurrent validity of the AMP was tested against 2 known tests, the 6-minute walk, which is a rehabilitation standard, and the AAS, which has been shown to be a valid subjective instrument for amputee subjects. The Pearson product-moment correlation coefficient was used to examine the association between the 2 AMP scores and the 6-minute walk, AAS, and other possible confounding vari-

ables: age, time since amputation, pack years smoked, and comorbidity.

**Predictive validity.** If the AMP really measures ability to ambulate, then the AMPnoPRO should be a significant predictor of 6-minute walk score with a prosthesis even in the presence of other variables (eg, age, time since amputation, comorbidity) that are known to predict 6-minute walk score. This hypothesis was examined by using multiple regression analysis.

## RESULTS

### Reliability

Before testing, subjects were assigned to a classification level as described by the MFCL definitions (see table 1). However, because of the small number of subjects in the reliability study, the 5-class system was collapsed into a 3-level classification system (see table 5). The nonprosthetic candidate class (level K0) remained and was termed group A. A combination of classes 1 and 2 formed group B, and classes 3 and 4 formed group C. The number of subjects for each functional level was 4, 7, and 13, respectively.

The AMP's intra- and interrater reliability was excellent for tests taken with and without a prosthesis. The interrater score for both trials 1 and 2 demonstrated excellent reliability (.99) for the AMPPRO and the AMPnoPRO. Test-retest intrarater reliability also had excellent reliability, with rater 1 and rater 2 ICC scores of .96 and .98, respectively, for the AMPPRO. ICC scores for the AMPnoPRO were .97 and .86, respectively, for rater 1 and rater 2. The average interval between the test and retest dates was 2.86 weeks (table 6).

### Validity

Tables 7 and 8 present descriptive and background data on the 167 subjects, organized by MFCL. The proportion of men to women was generally similar, however, there were more women in the lower functional levels and more men in the higher functional levels. This latter sample contained a larger percentage of amputee subjects who lost limbs because of trauma or tumor and a lower percentage who lost limbs because of vascular problems than is typically reported in the United States.<sup>26</sup> Level of amputation in the study population appears to be congruous with figures previously published.<sup>27</sup> Half the subjects had never smoked, whereas 30% had smoked previously but quit before testing and only 20% continued to smoke. For subjects who did smoke, the number of packs of cigarettes smoked daily was multiplied by the number of years smoked to determine the pack years smoked. With the exception of subjects classified in level 0, the number of pack years declined as the level of function increased. The mean time after amputation for functional levels 0 and 1 was 26 months or less, level 2 was 90 months, whereas levels 3 and 4 were 143 and 148 months after amputation, respectively. As expected, chronologic age was greater in the lower levels. Also as expected, because amputation is often performed as a life-saving procedure and half of elder amputee patients die within 3 to 5 years, the time after amputation or the time that they have been an amputee

**Table 6: Inter- and Intrarater Reliability ICC Scores**

	Interrater Trial 1	Interrater Trial 2	Test-Retest Rater 1	Test-Retest Rater 2
AMPPRO	.99	.99	.96	.98
AMPnoPRO	.99	.99	.97	.86

**Table 7: Age, Time Since Amputation, Smoking History, and Comorbidity Mean, SD, and Range**

MFCL	Level 0	Level 1	Level 2	Level 3	Level 4	Total	Range
<b>Age</b>							
Mean $y \pm SD$	77.1±12.0	74.5±12.2	65.4±15.8	53.1±14.7	36.7±11.3	54.84±18.6	18–100
n (%)	7 (4.2)	11 (6.6)	43 (25.8)	67 (40.1)	39 (23.4)	167 (100)	
<b>Time since amputation</b>							
Mean mo $\pm SD$	26.1±34.9	18±16.7	89.7±101.9	148.1±159.5	143.0±141.8	119.4±138.7	1–636
n (%)	7 (4.2)	11 (6.6)	43 (25.8)	67 (40.1)	39 (23.4)	167 (100)	
<b>Packs smoked <math>\pm SD</math></b>							
Mean pack years $\pm SD$	1.0±2.23	21.27±26.32	18.9±29.55	16.92±22.30	5.09±7.68	14.43±22.69	0–150
n (%)	6 (3.6)*	11 (6.6)	43 (25.9)	67 (40.4)	39 (23.5)	166 (100)	
<b>Comorbidity</b>							
Mean no. from index $\pm SD$	3.86±1.21	3.41±3.07	2.79±2.31	1.69±1.94	0.97±1.87	2.01±2.24	0–10
n (%)	7 (4.2)	11 (6.6)	43 (25.8)	67 (40.2)	39 (23.4)	167 (100)	

\* Smoking data unavailable on 1 subject.

patient was noticeably less for persons in levels 0 and 1. This finding is consistent with poor life expectancy after amputation, in most cases less than 5 years.<sup>28-30</sup>

As expected, the Comorbidity Index score increased as functional level decreased. Even though comorbidity was treated as a continuous variable statistically, the frequency of comorbidities reflected in the Melchiorre Comorbidity Index scores are partitioned in table 4 for ease of review. Just a little less than 50% had a score of 1.0 or lower, whereas 33% of subjects were reported to have a score of 3.5 or higher. The range of scores was 0 to 10 (mean, 2.01±2.24).

The side of amputation was fairly equally divided right (n=79) to left (n=88) with 47% and 53%, respectively. When examining the contralateral limb, 80% were without lesion or deformity that would pose an acute or chronic problem. Most problems observed were foot deformities with 12% reporting as such. Skin lesions or partial foot amputations (ray or transmetatarsal) were noted in 3.6% of the subjects (table 9). No subjects who reported lesion or deformity had conditions that would impede performance or put them at risk.

**Known groups analysis.** A table of mean AMPPRO and AMPnoPRO scores for the 4 MFCL groups, is presented following the ANOVA results in table 10. There was a statistically significant difference among all 4 groups for both AMPPRO and AMPnoPRO scores.

Table 11 shows mean AAS and 6-minute walk scores for the 4 MFCL groups following the ANOVA results. There was a statistically significant difference among all 4 groups for both of these tests as well.

**Concurrent validity.** The 6-minute walk distance showed a moderate to high positive relationship with both the AMPnoPRO and AMPPRO ( $r=.69, P<.0001; r=.82, P<.0001$ , respectively). The AAS had a high to moderate positive correlation to the AMPnoPRO and AMPPRO ( $r=.67, P<.0001; r=.77,$

$P<.0001$ , respectively). As expected, a negative correlation was observed with age and comorbidity and smoking. Age was also found to have a moderate to high negative relationship with the AMPnoPRO and AMPPRO ( $r=-.69, P<.0001; r=-.56, P<.0001$ , respectively), whereas comorbidity had a moderate negative correlation with the AMPnoPRO and AMPPRO ( $r=-.43, P<.0001; r=-.38, P<.0001$  respectively), providing evidence that walking ability, age, and comorbidity are related to prosthetic function (table 12).

**Predictive validity.** Predictive validity of the AMP was examined by first determining the relationship between the 6-minute walk distance and the AMPnoPRO test, age, time after amputation, and comorbidity. The overall model was statistically significant ( $F_{4,160}=66.389, P<.0001, R^2=.62$ ), indicating that together these variables do a fairly good job of explaining the variance in the 6-minute walk distance. Table 13 presents the individual parameter estimates. Interestingly, comorbidity was not significant ( $P>.05$ ) in this model. The squared partial correlations present the unique contribution of each independent variable explaining the variance in the 6-minute walk distance. Note that the AMPnoPRO is the strongest predictor, accounting for 26% of the variance, with a 7.5% correlation with age, 3.9% with time since amputation, and less than 1% with comorbidity.

**Prediction formula.** The prediction formula is:

$$\hat{Y}_{(6\text{-min distance})} = -12.239 - 1.226_{(age)} + .129_{(amp\ mo)} + 7.956_{(AMPnoPRO)} - 6.235_{(comorbidity\ score)} \quad (1)$$

**Table 8: Comorbidity Index Scores, Frequency, and Percentages**

Index Score	Frequency	Percentage
0	35	21
0.5–1.0	46	27.6
1.5–2.0	28	16.8
2.5–3.0	19	11.4
3.5–5.0	21	12.6
5.5–10.5	18	10.6
Total	167	100

**Table 9: Side of Amputation and Condition of Contralateral Limb**

Variable	Frequency	Percentage
<b>Side of Amputation</b>		
Right	79	47.3
Left	88	52.7
Total	167	100
<b>Nonamputated side condition</b>		
No lesion	135	80.8
Skin lesion	6	3.6
Deformity	20	12
Ray amputation	2	1.2
Transmetatarsal amputation	4	2.4
Total	167	100

Table 10: Comparison of MFCL Groups' AMPPRO, AMPnoPRO, 6-Minute Walk, and AAS Scores

Mean Measure	MFCL 0-1 (n=18)	MFCL 2 (n=43)	MFCL 3 (n=67)	MFCL 4 (n=39)	P (1-way ANOVA)
AMPnoPRO	9.67*	25.28*	31.36*	38.49*	.0001
SD	9.51	7.32	7.38	3.03	
Range	0-28	9-39	14-43	27-43	
AMPPRO	25.0**	34.65*	40.50*	44.67*	.0001
SD	7.37	6.49	3.90	1.75	
Range	14-33	19-46	26-46	38-47	
6-minute walk (m)	49.86*†	189.9*	298.64*	419.46*	.0001
SD	29.82	111.30	102.37	86.15	
Range	4-96	16-480	48-475	264-624	
AAS	-36.5**	-7.51*	11.28	27.77	.0001
SD	25.19	27.47	20.29	14.06	
Range	-68 to -6	-80 to 51	-51 to 56	-8 to 51	

\* Significantly different from other groups at .0001 level.

† n=7.

‡ n=8.

## DISCUSSION

The AMP is designed as a quick, easily administered assessment tool to assess an amputee's current functional status as it relates to ambulating with a prosthesis. The major advantage of this instrument is its ability to be performed with or without the use of a prosthesis. Additionally, because of time constraints facing clinicians today, the test was also designed to be clinically feasible in that it takes less than 10 to 15 minutes to administer and requires very little equipment.

The test-retest reliability of the AMPnoPRO and AMPPRO show good instrument stability with little variation from the initial testing period to follow-up testing 3 weeks later. Because of the high intrarater reliability, the rater can be assured that not only will the test results be consistent regardless of who tests the amputee subject, but also that, absent clinical change, the test outcomes will remain constant across repeated tests.

The sample used in this study was generally representative of the amputee patient population. The most outstanding difference from the general amputee patient population was the lower percentage of vascular amputee patients and higher number of tumor and traumatic amputee patients. This is probably related to the greater ease in recruiting active, community-dwelling amputee patients compared with more sedentary amputee patients residing in institutions.

The mean time after amputation was 26 months or less for functional levels 0 and 1. This is consistent with this group's higher mean age of 75 years and the fact that 95% of the amputations in this group resulted from disease. The literature suggests most elderly vascular amputee patients die within 3 to 5 years after amputation with the surgery often considered a life-saving procedure.<sup>2,36,37,55,56</sup> Therefore, a mean of a little more than 2 years after amputation would not be considered

unusual. Subjects in levels 3 and 4 were 143 and 148 months after amputation, respectively. As expected, the mean age of the subjects in the MFCL groups also decreased as the classification level increased with average ages of 65, 53, and 37 years for MFCL categories 2, 3, and 4, respectively. Likewise, the percentage of amputations that resulted from disease decreased as functional levels increased. Again, these are expected results and reflect the characteristics of the amputee patient population as described throughout the literature.<sup>43,55,57</sup>

As anticipated, the Comorbidity Index score increased as the functional level decreased. If the number of comorbidities is rounded off, there are means of 4, 3.5, 3, and 1 diagnoses for the 5 MFCL classes 0 and 1, 2, 3, and 4, respectively. As suggested in the literature, patients not fitted with a prosthesis have a greater number of comorbidities, with an average of 3 or more additional diagnoses, and are confined to a wheelchair.<sup>58</sup> This was true with many of the level 0 and 1 amputee subjects. Likewise, as age increased within the general elderly population, an average of 3.7 medical diagnoses were found for each patient<sup>59</sup> as was also true with this study.

Examination of the contralateral limb revealed that 80% were without lesion or deformity that would pose an acute or chronic problem. The majority of problems (12%) observed were foot deformities followed by skin lesions or partial foot amputations, which were observed in 3.6% of the subjects. These findings were again consistent with the literature in that the opposite limb was preserved in 70% of diabetics and 90% of nondiabetic vascular amputee subjects at 5 years after amputation.<sup>1</sup> As dictated by the exclusion criteria, none of the problems observed posed a threat to the subject or altered gait or the ability to perform testing.

Table 11: Pearson Product-Moment Correlation for AMPnoPRO, AMPPRO, Age, Time Since Amputation, 6-Minute Walk Distance, 6-Minute Walk Velocity, and AAS

Variable Correlation	n	AMPnoPRO r	P	n	AMPPRO r	P
Age	167	-.686	.0001	156	-.564	.0001
Time since amputation	165	.292	.0001	156	.263	.0009
Comorbidities	167	-.433	.0001	156	-.378	.0001
6-min distance	155	.694	.0001	155	.818	.0001
AAS	156	.667	.0001	156	.768	.0001
Pack years smoked	164	-.146	.061	155	-.210	.009



**Table 12: Linear Regression Model for 6-Minute Walk Distance When the AMPnoPRO Is Applied**

Variables	b	$\beta$	t	P	Squared Partial Correlation Type II
Intercept	142.334	0.0	2.584	.0106	—
Age	-1.990	-.243	-3.611	.0004	.0754
Amputation method	.144	.131	2.534	.0122	.0386
Comorbidity	-3.997	-.592	-1.061	.2901	.0070
AMPnoPRO	7.726	.529	7.432	.0001	.2566

NOTE.  $F_{4,160}=66.389, P<.0001$ .

**Known groups method.** The MFCLs are widely used as a basis for prosthetic prescription in the United States. Currently, with the MFCL system, a physician or prosthetist classifies the amputee subject according to functional level. Functional level, as defined by Medicare, is a measurement of the capacity and potential of the patient to accomplish their expected, postrehabilitation, daily function.<sup>1</sup> Functional level is determined by 3 considerations: (1) the patient’s medical history; (2) the patient’s current condition, including the status of the residual limb and nature of other medical problems; and (3) the patient’s desire to ambulate. The MFCL describes 5 levels of function, ranging from nonambulatory to athletic. Because the AMP was designed to measure functional level in much the same way as is defined by Medicare, the scores it produces must differ across the levels of the MFCL system if the test is to be valid. The results of the present study show that both the AMPPRO and the AMPnoPRO are able to do this. Several other tests also meet these criteria. Both the AAS and the 6-minute walk test differentiate levels of the MFCL. However, the only one of these tests that can be administered before prosthetic prescription is the AMPnoPRO.

**Concurrent validity.** If the AMP actually measures the ability to ambulate, then scores on the AMP should have a strong, positive correlation to scores on the AAS and 6-minute walk. This relationship was shown. Both the AMPnoPRO and AMPPRO correlated strongly with the 6-minute walk, a physical performance measure of functional ambulation, and with the AAS, a self-report measure of function in amputee subjects. The AMP scores behaved as expected in that lower AMP scores were associated with older ages and more comorbidities. Time since amputation had a low to moderate correlation.

**Predictive validity.** Because AMP scores correlated to age and age correlated to 6-minute walk time and comorbidities, it could be argued that the AMP is not necessarily measuring function but is instead measuring some correlate of age unrelated to physical function. The regression analysis showed this to be untrue. Both AMPPRO and AMPnoPRO scores were significant predictors of 6-minute walk score in regression models that included age, comorbidity, and time since amputation. The AMP scores accounted for far more of the explained variance than did any of the other measures. This implies that AMP scores

generated before prosthetic prescription, along with age and comorbidity, could be used to predict an individual’s level of functional ambulation with a prosthesis.

**Limitations.** Although the mean AMPnoPRO scores differed among the MFCL classifications, considerable overlap existed in scores, and cut scores have not yet been established. For optimal use of the AMPnoPRO to guide prosthetic prescription, it will be important to conduct additional research on this instrument, using a large, representative sample to establish these cut points.

This does not mean that the AMPnoPRO cannot be used clinically today to help clinicians determine the ambulatory ability of lower-limb amputee subjects. The AMPnoPRO can provide a fairly clear picture of the amputee subject’s ambulation potential. Unlike the 6-minute walk and AAS, each AMP item can provide clinicians with considerable information concerning rehabilitation needs pertaining to balance, strength, mobility, agility, functional limitation, and much more. After prosthetic fitting, the AMPPRO may be used to document improvements in function and to identify areas in which further rehabilitation is needed.

Standardized indexes of functional status are increasingly used in both clinical research and clinical practice.<sup>60</sup> Health care industry demands for mechanisms to classify patients for purposes of reimbursement increase the need for reliable and valid measures of functional status. Both Medicare and managed care providers use the MFCL system to classify the amputee subject’s functional abilities and to determine the appropriate level of prosthetic prescription. Currently, the MFCL’s use is largely subjective and unstandardized. Function is a major consideration in assigning MFCL level, but no standard method exists for measuring function in the amputee. The lack of a standardized and objective system for assigning MFCL levels makes possible both over- and underprescription of prosthetic components.

**CONCLUSION**

The AMP instrument is relatively easy to administer in 15 minutes or less, with a simple scoring system, requiring very little equipment or space. It has a high inter- and intrarater reliability and appears to be a very practical clinical tool. Its high reliability suggests that, with proper training, multiple disciplines could administer the test with results that are consistent over time.

**Table 13: Linear Regression Model for 6-Minute Walk Distance When the AMPPRO Is Applied**

Variable	b	$\beta$	t	P	Squared Partial Correlation Type II
Intercept	99.567	0.0	2.172	.031	—
Age	-2.163	-.264	-4.763	.0001	.1242
Time since amputation	.123	.112	2.406	.0173	.0349
Comorbidity	-6.745	-.100	-2.028	.0443	.0251
AMPPRO	7.774	.568	10.195	.0001	.3938

NOTE.  $F_{4,160}=90.458, P<.0001$ .

The findings of the present study suggest that the AMP instrument is a valid measure of function as it pertains to an amputee subject's ability to ambulate. Not only can the AMP differentiate among MFCL categories, but it is also strongly related to other measures of function. Administered without a prosthesis, the AMPnoPRO, even after controlling for age and time since amputation, is a significant predictor of the distance an amputee can walk with a prosthesis.

The AMP is the first clinically feasible, reliable, and valid instrument available for objectively measuring function in amputee subjects both before and after prosthetic fitting. Because it provides objective information on the amputee subject's

ability to ambulate, it can help the clinician prescribe the most appropriate prosthetic components to achieve an optimal gait.

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**APPENDIX 1: AMPUTEE MOBILITY PREDICTOR SCORING FORM**

**Amputee Mobility Predictor Questionnaire**

Initial instructions:

Testee is seated in a hard chair with arms. The following maneuvers are tested with or without the use of the prosthesis. Advise the person of each task or group of tasks prior to performance. Please avoid unnecessary chatter throughout the test. Safety first, no task should be performed if either the tester or testee is uncertain of a safe outcome.

The Right Limb is:  PF  TT  KD  TF  HD  intact. The Left Limb is:  PF  TT  KD  TF  HD  intact.

1. Sitting balance: sit forward in a chair with arms folded across chest for 60s.	Cannot sit upright independently for 60s Can sit upright independently for 60s	=0 =1	_____
2. Sitting reach: reach forward and grasp the ruler. (Tester holds ruler 12in beyond extended arms midline to the sternum.)	Does not attempt Cannot grasp or requires arm support Reaches forward and successfully grasps item	=0 =1 =2	_____
3. Chair to chair transfer: 2 chairs at 90°. Pt may choose direction and use their upper extremities.	Cannot do or requires physical assistance Performs independently, but appears unsteady Performs independently, appears to be steady and safe	=0 =1 =2	_____
4. Arises from a chair: ask pt to fold arms across chest and stand. If unable, use arms or assistive device.	Unable without help (physical assistance) Able, uses arms/assist device to help Able, without using arms	=0 =1 =2	_____
5. Attempts to arise from a chair (stopwatch ready): if attempt in no. 4 was without arms then ignore and allow another attempts without penalty.	Unable without help (physical assistance) Able requires >1 attempt Able to rise 1 attempt	=0 =1 =2	_____
6. Immediate standing balance (first 5s): begin timing immediately.	Unsteady (staggers, moves foot, sways) Steady using walking aid or other support Steady without walker or other support	=0 =1 =2	_____
7. Standing balance (30s) (stopwatch ready): For items nos. 7 & 8, first attempt is without assistive device. If support is required, allow after first attempt.	Unsteady Steady but uses walking aid or other support Standing without support	=0 =1 =2	_____
8. Single-limb standing balance (stopwatch ready): time the duration of single limb standing on both the sound and prosthetic limb up to 30s. Grade the quality, not the time.	Nonprosthetic side Unsteady Steady but uses walking aid or other support for 30s Single-limb standing without support for 30s	=0 =1 =2	_____
Sound side ____ seconds	Prosthetic Side Unsteady Steady but uses walking aid or other support for 30s Single-limb standing without support for 30s	=0 =1 =2	_____
Prosthetic side ____ seconds			
9. Standing reach: reach forward and grasp the ruler. (Tester holds ruler 12in beyond extended arm(s) midline to the sternum.)	Does not attempt Cannot grasp or requires arm support on assistive device Reaches forward and successfully grasps item no support	=0 =1 =2	_____
10. Nudge test (subject at maximum position #7): with feet as close together as possible, examiner pushes firmly on subject's sternum with palm of hand 3 times (toes should rise).	Begins to fall Staggers, grabs, catches self, or uses assistive device Steady	=0 =1 =2	_____

11. Eyes closed (at maximum position #7): if support is required grade as unsteady.	Unsteady or grips assistive device	=0		
	Steady without any use of assistive device	=1	_____	
12. Picking up objects off the floor (pick up a pencil off the floor placed midline 12in in front of foot).	Unable to pick up object and return to standing	=0		
	Performs with some help (table, chair, walking aid, etc)	=1		
	Performs independently (without help from object or person)	=2	_____	
13. Sitting down: ask pt to fold arms across chest and sit. If unable, use arm or assistive device.	Unsafe (misjudged distance, falls into chair)	=0		
	Uses arms, assistive device, or not a smooth motion	=1		
	Safe, smooth motion	=2	_____	
14. Initiation of gait (immediately after told to "go").	Any hesitancy or multiple attempts to start	=0		
	No hesitancy	=1	_____	
15. Step length and height: walk a measured distance of 12ft twice (up and back). Four scores are required or 2 scores (a & b) for each leg. "Marked deviation" is defined as extreme substitute movements to permit clearing the floor.	a. Swing foot			
	Does not advance a minimum of 12in	= 0		
	Advances a minimum of 12in	= 1	_____	_____
			Prosthesis	Sound
b. Foot clearance				
	Foot does not completely clear floor without deviation	= 0		
	Foot completely clears floor without marked deviation	= 1	_____	_____
			Prosthesis	Sound
16. Step continuity.	Stopping or discontinuity between steps (stop & go gait)	= 0		
	Steps appear continuous	= 1	_____	
17. Turning: 180° turn when returning to chair.	Unable to turn, requires intervention to prevent falling	= 0		
	Greater than 3 steps but completes task without intervention	= 1		
	No more than 3 continuous steps with or without assistive aid	= 2	_____	
18. Variable cadence: walk a distance of 12ft fast as safely as possible 4 times. (Speeds may vary from slow to fast and fast to slow, varying cadence.)	Unable to vary cadence in a controlled manner	= 0		
	Asymmetrical increase in cadence controlled manner	= 1		
	Symmetrical increase in speed in a controlled manner	= 2	_____	
19. Stepping over obstacle: place a movable box of 4in in height in the walking path.	Cannot step over the box	= 0		
	Catches foot, interrupts stride	= 1		
	Steps over without interrupting stride	= 2	_____	
20. Stairs (must have at least 2 steps): try to go up and down these stairs without holding on to the railing. Don't hesitate to permit pt to hold on to rail. Safety first, if examiner feels that any risk in involved omit and score as 0.	Ascending			
	Unsteady, cannot do	= 0		
	One step at a time, or must hold on to railing or device	= 1		
	Steps over step, does not hold onto the railing or device	= 2	_____	
	Descending			
	Unsteady, cannot do	= 0		
	One step at a time, or must hold on to railing or device	= 1		
	Steps over step, does not hold onto the railing or device	= 2	_____	
21. Assistive device selection: add points for the use of an assistive device if used for 2 or more items. If testing without prosthesis use of appropriate assistive device is mandatory.	Bed bound	= 0		
	Wheelchair	= 1		
	Walker	= 2		
	Crutches (axillary or forearm)	= 3		
	Cane (straight or quad)	= 4		
	None	= 5	_____	
	Total Score _____/47			

Trial  no prosthesis  with prosthesis    Observer \_\_\_\_\_    Date \_\_\_\_\_

Abbreviation: PF, partial foot; TT, transtibial; KD, knee disarticulation; TF, transfemoral; HD, hip disarticulation; Pt, patient. Amputee Mobility Predictor. © 1999 Advanced Rehabilitation Therapy, Inc. Reprinted with permission.

## APPENDIX 2: AMP INSTRUMENT INSTRUCTIONS

### Amputee Mobility Predictor (AMP) Testing Methodology

The AMP testing protocol can be administered by a clinician, without an assistant. The average time required to administer the

AMP or AMPnoPRO is less than 15 minutes and often less than 10 minutes for an experienced examiner. The necessary equipment for testing consists of the following: a stopwatch, 2 chairs, a 12-in ruler, a pencil, a 4-in high obstacle (preferably 18–24in long), and a set of stairs with 3 steps. A safety or gait belt is also

suggested, along with the assistive device of the amputee's choosing. The AMPnoPRO eliminates question 8 because the task of standing on the prosthetic side is not possible. The use of an assistive device during testing is accounted for in the scoring system. The prosthesis wearer may use whatever assistive device he/she is most comfortable with whenever he/she requests it.

The following is an item-by-item description of the AMP testing and scoring procedure.

**Item 1: Sitting balance**

**Task:** The amputee subject sits upright in a chair; the patient's buttocks are slightly forward so that there is no support from the back of the chair and his/her arms are folded comfortably in the lap.

**Score 0:** The amputee subject cannot sit independently for 60 seconds or requires the observer's support or guarding.

**Score 1:** The amputee subject sits independently for 60 seconds and does not require support or guarding from the observer.

**Item 2: Sitting reach**

**Task:** Seated as in item 1, the amputee reaches forward and grasps a ruler held by the observer midline to the patient's sternum and 12in beyond the patient's dominant hand or sound limb side (the patient's choice).

**Score 0:** Does not attempt the task or verbally refuses it because of fear or lack of confidence that he/she may complete the task.

**Score 1:** Cannot grasp the ruler or requires arm support of either the chair or assistive device.

**Score 2:** Reaches forward and successfully grasps the ruler.

**Item 3: Chair to chair transfer**

**Task:** The amputee subject sits upright in an armless chair and is asked to transfer from 1 chair to another set at a 90° angle to the first. The amputee subject may choose direction to his/her amputated side or nonamputated side. Use of hands is permitted.

**Score 0:** Cannot transfer independently or requires physical assistance to complete the task.

**Score 1:** Performs independently, but appears unsteady or requires contact guarding.

**Score 2:** Performs independently, appears to be steady and safe.

**Item 4: Arises from a chair**

**Task:** The amputee subject sits upright and forward in a chair, arms folded comfortably across the chest. The observer asks the amputee subject to stand without using the arms for assistance unless it is necessary and then he/she may use the chair or assistive device.

**Score 0:** Unable to rise without physical assistance, this includes contact guarding.

**Score 1:** Able to rise but must use his/her arms, the chair, or an assistive device.

**Score 2:** Able to rise without using arms; in other words, they stand hands free.

**Item 5: Attempts to arise from a chair**

**Task:** If the amputee subject attempted in item 4 to rise without using his/her arms but failed in that attempt to arise from the chair, then ignore item 4 and allow another attempt (item 5) without penalty. However, if the amputee subject has difficulty and requires additional attempts or physical assistance or guarding, he/she must be graded accordingly in item 5, with the following scores:

**Score 0:** Unable to arise without the help of physical assistance or contact guarding.

**Score 1:** Able to stand independently but requires more than 1 attempt to reach the standing position.

**Score 2:** Able to rise to standing in a single attempt.

**Item 6: Immediate standing balance**

**Task:** Have stopwatch ready and begin timing the first 5 seconds that transpire immediately after the amputee achieves upright standing posture in front of the chair, with or without support of an assistive device. Be sure to check that the amputee is not leaning against the chair with his/her legs.

**Score 0:** Unsteady posture causes amputee to stagger, move foot quickly in an attempt to maintain balance, or sway excessively. A steady posture with normal foot movement to adjust for comfortable standing is permitted without penalty.

**Score 1:** Able to attain a steady standing posture using a walking aid or other support such as a chair back that has been provided to assist with the testing task.

**Score 2:** Able to attain a steady standing posture without walker or other support.

**Item 7: Standing balance**

**Task:** Standing balance is timed for 30 seconds by stopwatch. The first attempt is made without an assistive device. If during the task, the observer believes that an assistive device will help the amputee to stand safely, then repeat items 6 and 7 with an assistive device.

**Score 0:** The amputee subject is unsteady or unable to hold for 30 seconds a satisfactory upright posture that does not require contact guarding or support.

**Score 1:** Stands steady for 30 seconds but uses a walking aid or other support.

**Score 2:** Stands for 30 seconds without assistive device or physical support.

**Item 8: Single-limb standing balance**

**Task:** By using the stopwatch, the observer asks the amputee subject to stand first on the sound limb and then on the prosthesis for 30 seconds each. The observer grades the amputee's performance on both sides unless the amputee subject is being tested without the prosthesis, in which case scoring of the prosthetic side is ignored.

**Score 0:** If the amputee subject cannot show single-limb standing for 30 seconds even with an assistive device, the stance is considered unsteady.

**Score 1:** If the amputee subject grasps, even for a moment, a walking aid or requires other support, he/she is considered steady but requiring support.

**Score 2:** The amputee subject can maintain single-limb standing without support for 30 seconds.

**Item 9: Standing reach**

**Task:** The amputee subject stands with his/her feet 2 to 4in apart and reaches forward to grasp a ruler that is held by the observer midline to the amputee subject's sternum and 12in beyond his/her dominant hand or sound limb side (the amputee subject's choice). The amputee subject may not take a step forward, but may place the prosthetic limb in a position of comfort if the socket brim interferes with performance.

**Score 0:** Does not attempt the task or verbally refuses it because of fear or lack of confidence that he/she may complete the task.

**Score 1:** Cannot grasp the ruler or requires arm support from an assistive device.

**Score 2:** Reaches forward and successfully grasps the ruler.

**Item 10: Nudge test**

**Task:** The amputee subject stands as comfortably possible with feet together; the examiner pushes firmly on subject's sternum with palm of hand 3 times, quickly, with a consistent pressure that would cause body weight to move toward the heels but not typically cause a person to lose balance in a normal situation.

**Score 0:** The amputee subject begins to fall and requires the observer's assistance.

**Score 1:** The amputee subject cannot or will not stand without the use of the assistive device or he/she stands independently and when nudged staggers, grabs at support, or catches self.

**Score 2:** The amputee subject remains steady with independent standing free of assistive device.

**Item 11: Eyes closed**

**Task:** The amputee subject stands with his/her feet 2 to 4in apart. Stopwatch ready, the observer asks the amputee to close his/her eyes and maintain standing posture for 30 seconds.

**Score 0:** The amputee subject is unable to stand in a steady positions for 30 seconds without using an assistive device.

**Score 1:** The amputee subject remains steady accomplishing independent standing without the use of an assistive device.

**Item 12: Picking up objects off the floor**

**Task:** The amputee subject stands with his/her feet 2 to 4in apart. The observer places a pencil (or similar object of same height) on the floor midline from the amputee subject and 12in from the toe of the amputee subject's shoe. The observer asks the amputee to pick up the object off the floor without moving his/her feet, knee straight, and (if safely possible) without using any support.

**Score 0:** The amputee subject cannot pick up the object and return to standing safely.

**Score 1:** The amputee subject performs the task with some support from an assistive device, chair, or person.

**Score 2:** The amputee subject performs the task without any help from object or person.

**Item 13: Sitting down**

**Task:** The examiner asks the amputee subject to fold his/her arms across the chest and sit down in a controlled manner. If the amputee is unable to perform the task or is unsure, the examiner suggests the amputee subject use his/her arms or an assistive device.

**Score 0:** The amputee subject misjudges distance to the chair, falls into the chair, or requires contact guarding and is scored as unsafe.

**Score 1:** The amputee subject chooses for security or necessity to use his/her arms or cannot sit in a smooth and controlled motion.

**Score 2:** The amputee subject sits in a safe, smooth, and controlled motion.

To ensure safe ambulation in items 14–20, walking aids are permitted and encouraged whether or not the amputee wears a prosthesis. Item 21 compensates for the decision to use an assistive device on the ambulation tasks.

**Item 14: Initiation of gait**

**Task:** From a standing posture with or without an assistive device, as the amputee prefers and the clinician determines to be safe, the amputee is asked to begin walking.

**Score 0:** The amputee subject shows hesitancy, makes multiple attempts to start, or appears to be consciously organizing in their minds the process of initiating walking beyond the cognition required for normal ambulation.

**Score 1:** The amputee starts walking with no hesitancy, with a smooth transition from standing to walking.

**Item 15: Step length and height**

**Task:** The amputee subject walks a measured distance of 12ft (3.66m) twice (up and back) for a total of 24ft (7.32m). Four scores are required, ie, 2 scores (a,b) for the left leg and 2 for the right. "Marked deviation" is defined as extreme substitute movements made to permit the foot to clear the floor.

a. Swing foot

**Score 0:** The leg does not advance a minimum of 12in. If ambulating without the prosthesis and with an assistive device,

the same applies: the swing limb must advance a minimum of 12in.

**Score 1:** The swing advances a minimum of 12in, whether the prosthetic limb or the sound limb is being tested.

b. Floor clearance

**Score 0:** The foot does not completely clear floor with step or deviation. This description includes foot shuffling, sliding, and marked deviations such as circumduction that require significant substitution for clearing the floor.

**Score 1:** The foot completely clears floor without marked deviation

**Item 16: Step continuity**

**Task:** As the amputee subject performs the task described in item 15, the examiner observes the quality of gait. Step continuity is defined as continuous steps that are devoid of hesitation (ie, marked differences in step length that require adjustment for loss of balance between steps), and without difficulty maneuvering the assistive device sufficient to interrupt step continuity.

**Score 0:** The amputee exhibits stopping or discontinuity between steps that interrupts a smooth continuous gait.

**Score 1:** The amputee subject's steps appear to be continuous.

**Item 17: Turning**

**Task:** As the amputee subject completes the first 12ft of ambulation and turns to return to the chair, the examiner notes the quality of the movement.

**Score 0:** The amputee subject is unable to turn and therefore requires intervention such as contact guarding and verbal instructions in order not to fall.

**Score 1:** The amputee subject requires more than 3 steps to complete the task but requires no contact or verbal intervention.

**Score 2:** The amputee subject completes the task in 3 or fewer continuous steps, with or without an assistive aid.

**Item 18: Variable cadence**

**Task:** The examiner instructs the patient to walk a distance of 12ft fast as safely possible 4 times for a total of 48ft (14.63m). Speeds may vary from slow to fast and fast to slow, varying cadence. This task may also be completed with an assistive device although care must be taken that the patient is not extended beyond his/her capabilities.

**Score 0:** The patient is unable to vary cadence in a controlled manner.

**Score 1:** The patient asymmetrically increase his/her cadence in a controlled manner so that step length markedly differs between legs, and/or balance must be re-established with each step.

**Score 2:** The patient symmetrically increases his/her cadence in a controlled manner so that step lengths are equal and balance is maintained.

**Item 19: Stepping over obstacle**

**Task:** Place a movable, 4-in high box or hurdle (length, 18–24in) in the walking path. The object must be of a design that will not cause the amputee to stumble or fall should he/she be unable to complete the task. The amputee is asked to step over the obstacle without interrupting step continuity. This task may be performed en route to or from the stair climbing task. The amputee subject is penalized if he/she attempts to circumduct the obstacle by swinging the prosthetic limb to side of the obstacle.

**Score 0:** The amputee subject cannot step over the box.

**Score 1:** The amputee subject catches his/her foot on the obstacle, circumducts it, or interrupts stride by stopping in front of the obstacle to prepare physically or mentally to clear it.

**Score 2:** The amputee steps over the obstacle without interrupting stride.

**Item 20: Stairs**

**Task:** The examiner instructs the amputee to try to go up and down stairs without holding on to the railing. However, to ensure safety, do not hesitate to permit the amputee to grasp the rail. The stairs must have a minimum of 2 steps; 3 to 4 steps are preferred.

a. Ascending

**Score 0:** Unsteady, cannot ascend stairs or expresses fear of or inability to attempt the task.

**Score 1:** Ascends stairs 1 step at a time, or must hold on to railing or assistive device.

**Score 2:** Ascends stairs step-over-step and does not hold onto the railing or assistive device.

b. Descending

**Score 0:** Unsteady, cannot descend stairs or expresses fear of or inability to attempt the task.

**Score 1:** Descends stairs 1 step at a time, or must hold on to railing or assistive device.

**Score 2:** Descends stairs step-over-step and does not hold onto the railing or assistive device.

**Item 21: Assistive device selection**

**Task:** Points are awarded based on the use of an assistive device for items 14 to 20. If the amputee subject required an assistive device because the stairs lacked a railing, but he/she did not use an assistive device for ambulation, then award points based on the performance on items 14 to 19.

**Score 0:** Bed bound **Score 3:** Crutches (axillary or forearm)

**Score 1:** Wheelchair **Score 4:** Cane (straight or quad)

**Score 2:** Walker **Score 5:** None

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