Designation: F3528 – 21

Standard Test Method for Exoskeleton Use: Gait[1]

This standard is issued under the fixed designation F3528; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 *Purpose:*

1.1.1 The purpose of this test method, as a part of a suite of exoskeleton use test methods, is to quantitatively evaluate an exoskeleton's (see Terminology F3323) safety (see 1.4) or performance, or both, for gait.

1.1.2 Exoskeletons shall possess a certain set of allowable exoskeleton user movement capabilities, including user-motion adaptability, to suit operations such as: industrial/occupational, military, response, medical or recreational. Environments in these typical sectors often pose constraints to exoskeleton user movement to various degrees. Being able to walk, as intended by the user or test requestor, while using an exoskeleton is essential for exoskeleton deployment for a variety of tasks. This test method specifies test setup, procedure, and recording to standardize this gait task for testing exoskeleton user movement.

1.1.3 Exoskeletons shall be able to handle many types of task and terrain complexities. The required movement capabilities include, for example: walking, running, crawling, climbing, traversing gaps, hurdles, stairs, slopes, various types of floor surfaces or terrains, and confined spaces. Standard test methods are required to evaluate whether or not exoskeletons meet these requirements.

1.1.4 ASTM Subcommittee F48.03 develops and maintains international standards for task performance and environmental considerations that include but are not limited to, standards for safety, quality, and efficiency. This subcommittee aims to develop standards for any exoskeleton application, as exemplified as in 1.1.2. The F48.03 test suite consists of a set of test methods for evaluating exoskeleton capability requirements. This gait test method is a part of the test suite. The setup, procedure, and apparatuses associated with the test methods challenge specific exoskeleton capabilities in repeatable ways to facilitate comparison of different exoskeleton models or exoskeleton capabilities to tasks. Not all exoskeletons may have the capabilities needed to use this test method.

1.1.5 This test method tests for generic gait exoskeleton capability, with straight paths and no test course curves, obstacles, or other complexities not described herein (see 4.6). This test method is considered the basis for exoskeleton gait capability testing.

1.1.6 The test methods quantify elemental exoskeleton use capabilities necessary for sector applications listed in 1.1.2, and perhaps others. As such, users of this standard should use either the entire suite or a subset based on their particular requirements. Users are also allowed to weight particular test methods or particular metrics within a test method differently based on their specific requirements. The testing results should collectively represent an exoskeleton's overall safety or performance, or both, as required for the task. These performance data can be used: to guide procurement specifications, for acceptance testing, and for training to use exoskeletons intended for specified applications.

NOTE 1—Additional test methods within the suite are anticipated to be developed to address additional exoskeleton capability requirements, including newly identified requirements and even for new application domains.

1.2 *Performing Location*—This test method shall be performed in a testing laboratory or at a site that represents the place where the exoskeleton will be used.

1.3 *Units*—The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversions to inch-pound units. They are close approximate equivalents for the purpose of specifying material dimensions or quantities that are readily available to avoid excessive fabrication costs of test apparatuses while maintaining repeatability and reproducibility of the test method results. These values given in parentheses are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

[1] This test method is under the jurisdiction of ASTM Committee F48 on Exoskeletons and Exosuits and is the direct responsibility of Subcommittee F48.03 on Task Performance and Environmental Considerations.

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Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3323 Terminology for Exoskeletons and Exosuits

F3427 Practice for Documenting Environmental Conditions for Utilization with Exoskeleton Test Methods

F3443 Practice for Load Handling When Using an Exoskeleton

F3474 Practice for Establishing Exoskeleton Functional Ergonomic Parameters and Test Metrics

F3517 Practice for Movement Tests When Using an Exoskeleton

F3527 Guide for Assessing Risks Related to Implementation of Exoskeletons in Task-Specific Environments

2.2 *Other Standards:*

ISO 13482 Robots and robotic devices — Safety requirements for personal care robots[3]

3. Terminology

3.1 General terminology for ASTM Committee F48 standards is listed in Terminology F3323. Terminology specific to this standard is shown in this section.

3.2 *Definitions:*

3.2.1 *apparatus, n*—a structure, object, test component, or artifact thereof, found or placed in an environment and used for a test.

3.2.2 *test suite, n*—designed collection of test methods that are used, collectively, to evaluate an exoskeleton's safety and/or performance.

4. Summary of Test Method

4.1 The task for this test method, exoskeleton-user walking, is defined as the exoskeleton-user performing all three of the following tests: *(1)* 6 minute walking test (6MWT) **(1)**[4]; *(2)* 10 meter walking test (10MWT) **(2)**; and *(3)* timed up and go (TUG) test **(3)**. The tests are described as follows:

4.1.1 *6MWT*—This test is used to assess aerobic capacity and endurance, where the distance covered over a time period of 6 min is used as the outcome. The user begins at a START point specified by the test supervisor and ends when the test supervisor has timed 6 min. Two points, START and TURN, are spaced (for example, 30 m apart) for the user to walk and turn about such that the user continuously walks for 6 min between the two points.

4.1.2 *10MWT*—This test is used to assess functional mobility, walking speed, and balance over a short distance. The user begins at a START point and ends at an END point spaced 10 m apart, both specified by the test supervisor. Two additional lines are placed at 2 m and 8 m from the start line to allow measurement of the user's steady state velocity between the two lines.

4.1.3 *TUG*—This test is used to assess fall risk and measure the progress of balance, sit-to-stand, and walking. A full TUG test (see 9.20) can be performed as a single test in its entirety where the user begins by sitting in a chair, stands when the test supervisor directs the user to begin the test, walks three (3) meters, turns around 180°, walks back to the chair, turns back around 180°, and sits in the chair. As some exoskeletons may not be able to perform a full TUG test, a phased TUG test (see 9.21) can instead be performed. The phased TUG test divides the full TUG test into six independent phases where selected TUG test phases (for example, phases 1 and 2; phases 1 through 5), which shall be selected prior to the test by the test requestor, are to be performed by an exoskeleton user. The phased TUG test divides the full TUG test as follows:

4.1.3.1 *Phase 1*—Stand up from a chair (or from an alternative position from sitting (for example, kneeling) as set by the test requestor prior to the test);

4.1.3.2 *Phase 2*—Walk 3 m;

4.1.3.3 *Phase 3*—Turn around 180°;

4.1.3.4 *Phase 4*—Walk 3 m in the opposite direction from Phase 2;

4.1.3.5 *Phase 5*—Turn around 180°;

4.1.3.6 *Phase 6*—Sit down in a chair (or configure to an alternative position from sitting (for example, kneeling) as set by the test requestor prior to the test).

4.2 For all tests, the specified path from the START point to the END point, TURN point, or chair, as needed, shall be defined by the test requestor prior to the test. The required apparatuses are described in Section 6.

4.3 The exoskeleton's capability is defined as the exoskeleton's ability to complete the gait task, where the exoskeleton or user, or both, is capable of performing the 6MWT, 10MWT, and full or phased TUG tests, as set by the test requestor and can perform the test at the associated effective speed and stability. The average effective speed shall be used as the exoskeleton-user's capability and sustained speed.

4.4 The exoskeleton user is allowed to practice before the test.

4.5 Once the test begins, there shall be no verbal communication between the exoskeleton user and the test supervisor regarding the performance of a test repetition other than instructions on when to start and notifications of faults, and any safety related conditions. The user shall have the full responsibility to determine whether and when they have completed a repetition, and notify the test supervisor accordingly. However, it is the test supervisor's authority to judge the completeness of the repetition.

NOTE 2—Practice could help establish the applicability of the exoskeleton for the given test method. It allows the operator to gain familiarity with the standard setup, procedure, apparatus, and environmental conditions. It also helps the test supervisor to establish the initial setup, procedure, including both the user and testing personnel, or apparatus setting for the test, when applicable, or combinations thereof.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

4.6 The test requestor has the authority to select the parameters that may affect the user for the gait task. The test requestor also has the authority to select test methods that constitute the test event, to select one or more test site(s) at which the test methods are implemented, to determine the corresponding statistical reliability and confidence levels of the results for each of the test methods, and to establish the participation rules including the testing schedules and the test environmental conditions.

4.7 Variations to this test method are also described in this standard and can include, for example:

4.7.1 6MWT, 10MWT, or TUG while carrying a load(s);

4.7.2 TUG from a squat position instead of a chair;

4.7.3 Environmental conditions including, for example, ground surfaces that are level or undulating, hard or soft, dry or wet; temperatures and humidity levels that are normal or extreme; precipitation that is no, low, or high.

5. Significance and Use

5.1 Exoskeletons are being used in the industrial/occupational, military, response, medical, and recreational sectors to enhance safety and effectiveness of the user to perform tasks. Gait is a component of many tasks that someone would do with an exoskeleton. For example, an exoskeleton may be used to help rehabilitate a patient who suffered a traumatic leg injury. In manufacturing, warehousing, military, and other similar environments, workers and soldiers in exoskeletons walk with and without carrying loads, many times over long distances, indoors or outdoors, as part of their daily activities. Fig. 1 shows examples of exoskeleton users walking, which, depending upon the task, may require people to traverse various ground surfaces while wearing an exoskeleton. The testing results of exoskeletons shall describe, in a statistically significant way, how reliably the exoskeleton is able to support tasks within the specified types of environments, confinements, and terrains, and thus provide sufficiently high levels of confidence to determine the applicability of the exoskeleton to a given task.

5.2 This test method addresses exoskeleton safety and performance requirements expressed by manufacturing, emergency responders, military, or other organizations requesting this test. The safety and performance data captured within this test method are indicative of the test exoskeleton's and the exoskeleton user's capabilities. Having available direct information from tested exoskeleton(s) with associated performance data to guide procurement and deployment decisions is essential for exoskeleton purchasers and users.

5.3 The standard test setup and apparatus (see Section 6) is specified to be easily fabricated to facilitate self-evaluation and replication of gait tests by exoskeleton designers, developers, manufacturers, and users. The standard test setup and apparatus can also be used to support training and establish proficiency of exoskeleton users, as well as provide manufacturers with information about the usefulness of their exoskeleton(s) for tasks.

5.4 Although the test method was developed for the sectors listed in 5.1, it may be applicable to other operational domains.

6. Test Course and Apparatus

6.1 The actual performance space where the exoskeleton is to be used or in-situ (that is, typically found in the environment, such as trees, loads, natural markings) apparatus of which will be used, as exemplified in Fig. 1, or both, may be used for this test. In the event that the actual performance space or the in-situ apparatus, or both, is not available or the test is to be exactly replicated by others, or both, test setups and the standard apparatus, as described in the following subsections, shall be used. Refer to Fig. 2 for test course layouts.

6.2 *Optional Equipment:*

6.2.1 *Safety equipment,* for example: heart rate monitor, pulse oximeter, oxygen administration kit, sphygmomanometer, telephone, automated electronic defibrillator, and Borg breathlessness scale that can be at the ready as needed.

6.2.2 *User measurement devices,* for example: walkway (that is, pressure mats) or force plates for human gait analysis; user tracking system; heart rate, pulse, and oxygen monitors.

6.2.3 *Loads,* for example: tools, crates, and bags (refer to Practice F3443).

6MWT

6.3 The walking course shall be 30 m (98 ft) in length with at least 2 m beyond the course on both ends for turnaround space. The length of the course should be marked every 3 m. (A shorter corridor requires users to take more time to reverse directions more often, reducing the 6MWT.) The turnaround points at 30 m should be marked with a highly visible marker, such as an orange traffic cone. A starting line, which marks the START and END of each 60 m lap, should be marked on the floor using brightly colored tape.

6.4 The use of a treadmill is not recommended for the 6MWT as users are unable to pace themselves on a treadmill. Treadmill test results, therefore, are not interchangeable with corridor tests.

6.5 *Required Apparatus:*

6.5.1 34 m or greater straight, unimpeded corridor or path,

6.5.2 Countdown timer (or stopwatch),

6.5.3 Lap counter,

6.5.4 Two small markers (for example, cones) to mark the turnaround points,

6.5.5 Tape (bright colored),

6.5.6 A chair that can be easily moved along the walking course, and

6.5.7 Test report (see Section 9).

10MWT

6.6 The walking course shall be 10 m (33 ft) in length with at least 2 m additional space beyond the end for deceleration. A starting line should be marked on the floor using brightly colored tape. Tape marks should be placed at 1 m and 9 m from the START line.

6.7 *Required Apparatus:*

6.7.1 Stopwatch,

6.7.2 12 m long or greater straight, unimpeded corridor or path,

NOTE 1—Examples include: (*a*) medical rehabilitation (courtesy Gogoa), (*b*) military material handling (courtesy Mawashi), (*c*) military soldiering (courtesy Mawashi), (*d*) recreational hiking through snow and (*e*) walking on pavement as part of daily work duties (courtesy Humotech), and (*f*) industrial worker standing up from a chair prior to walking (courtesy SuitX).

FIG. 1 Examples of Exoskeleton Users Walking in Various Sectors

6.7.3 Tape (bright colored), and
6.7.4 Test report (see Section 9).

TUG

6.8 The course shall be 3 m (10 ft) in length with 2 m additional space beyond for turnaround. A chair with armrests is placed at one end of the course. An END line should be marked on the floor using brightly colored tape at 3 m from the front of the chair.

6.9 *Required Apparatus:*
6.9.1 5 m long or greater straight, unimpeded corridor or path,
6.9.2 Chair with armrests,
6.9.3 Stopwatch,
6.9.4 Tape (bright colored), and
6.9.5 Test report (see Section 9).

7. Hazards

7.1 Hazards for gait tests when using exoskeletons can be as follows: slips, trips, falls, fatigue, and collisions dependent upon the exoskeleton, the test environment, and the apparatus (for example: chairs, surrounding walls). Refer to the References section (**4 and 5**) in order to characterize biomechanical stressors. Note that although these references address typical

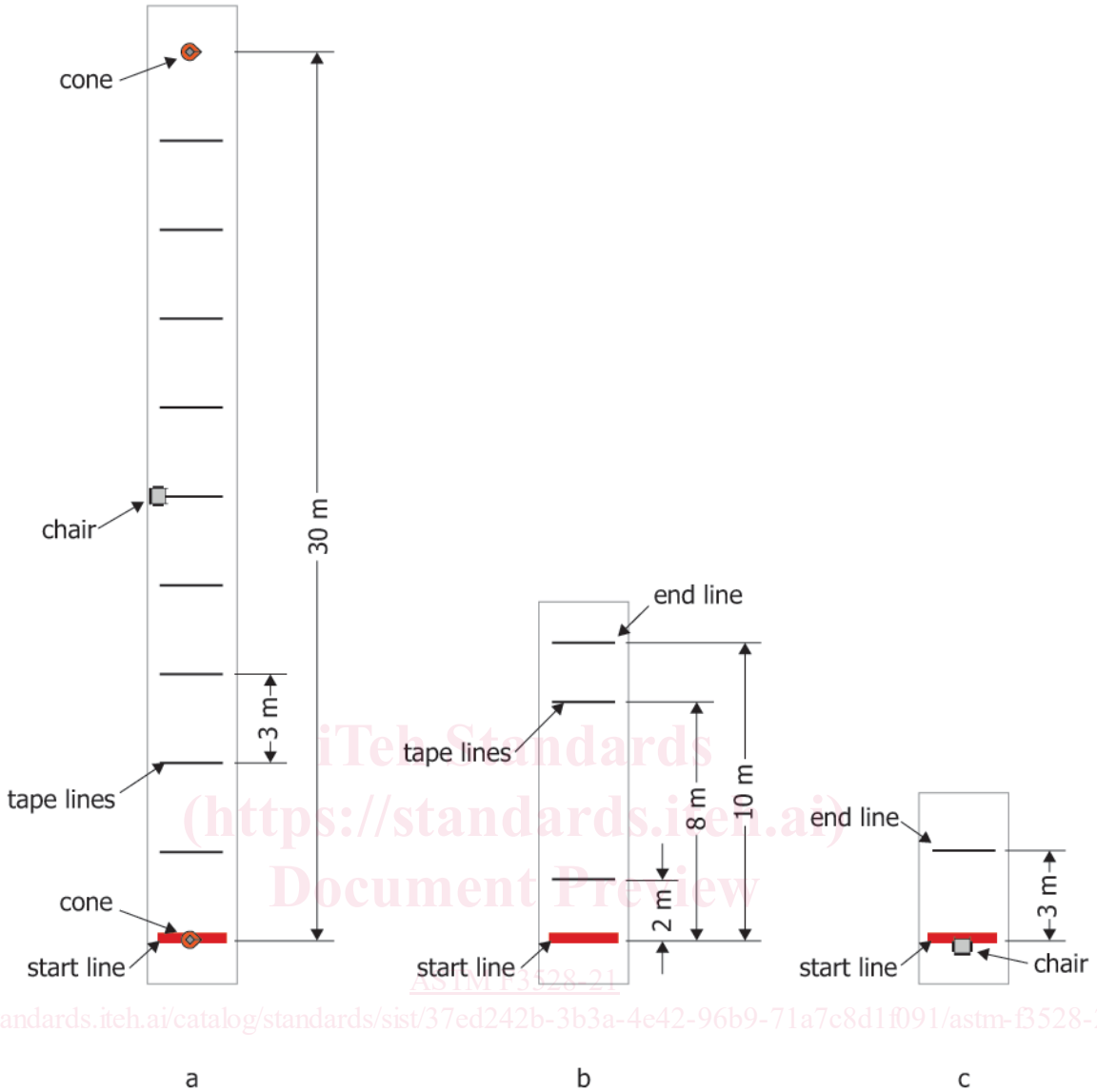

FIG. 2 Gait Test Course Layouts for (*a*) 6MWT, (*b*) 10MWT, and (*c*) TUG test

risks and mitigation procedures, they may not address safety issues for an exoskeleton user.

7.2 Safety standards providing risks and mitigation procedures for hazards when using an exoskeleton are developed or being developed, including:

7.2.1 ISO 13482 Robots and robotic devices — Safety requirements for personal care robots;

7.2.2 ASTM Guide for Safety Considerations in Designing and Selecting Exoskeletons for Industrial, Medical and Military Applications;[5]

7.2.3 ASTM Guide for System Usefulness and Usability;[5]

7.2.4 ASTM Guide for Hazards for Consideration when Designing Exoskeletons;[5]

7.2.5 ASTM Guide for General Guidelines to Risk Management of Exoskeletons;[5] and

7.2.6 ASTM Guide F3527 for Assessing Risks Related to Implementation of Exoskeletons in Task-Specific Environments.

8. Calibration and Standardization

8.1 The exoskeleton configuration as tested shall be described in detail on the test form, including all subsystems and components, and their respective features and functionalities including version or iteration details as applicable. The configuration shall be subjected to all the test suites, as defined in 3.2.2, as appropriate. Any variation in the configuration shall cause the resulting exoskeleton variant to be re-tested across all the test suites to provide a consistent and comprehensive representation of the performance.

[5] New standard under development.

8.2 Once an exoskeleton user begins a test, by starting to execute the task as specified in 4.1, the exoskeleton shall be used to perform the task for the specified number of repetitions through completion without changing the exoskeleton or apparatus.

8.3 A battery may be changed or charged between repetitions provided that other configurations remain unaltered, and if allowed by the test requestor. Battery changes/charging shall be noted on the test report. Unless otherwise stated by the requestor, during the test the exoskeleton shall not be allowed to have the energy/power source replenished nor shall the exoskeleton be allowed any human physical intervention, including adjustment, maintenance, or repair. Any such actions shall be considered a fault condition and the test should be restarted from the beginning.

8.4 The metric for this test method is the complete and successful gait tests for the specified number of continuous repetitions where a completed test is set by the test requestor (see Section 4). In addition, the elapsed time for the user to successfully complete all three gait tests (that is, 6MWT, 10MWT, and TUG) is a performance proficiency index reflecting the combination of the exoskeleton's capability and efficiency, and the user's skill level. Therefore, this temporal aspect is a part of the test and the results shall be recorded on the test form. The average speed is specified as the sustained speed. Metrics shall also include any test anomalies or occurrences, such as: stumbles, trips, falls, rests, variation in gait throughout the test, or from baseline (that is, no exoskeleton used) to exoskeleton test (exoskeleton is used).

8.5 The test requestor has the authority to specify the environmental variables, which may affect the test results. All environmental settings shall be documented using Practice F3427.

8.6 The test requestor has the authority to specify the number of repetitions required for each of the 6MWT, 10MWT, and TUG tests. Considerations for user fatigue, abilities, exoskeleton capabilities, and other characteristics that may impact the tests shall be considered. Extending the duration of the test (for example, perform the 6MWT four times over eight hours, separated by two hour rests, for several days and several weeks to achieve 30 repetitions) may also be included in the overall test confidence and shall be noted on the test report. Guidance on reliability of test data given the number of repetitions is provided in Appendix X1.

9. Procedure

9.1 A test requestor requests a gait test (that is, 6MWT, 10MWT, and TUG), including all test parameters (for example, test apparatus, environment, exoskeleton configuration, etc.) to be recorded and documented.

9.2 For all tests, the environmental conditions of the space where the test will be performed shall be documented using Practice F3427, allowing test repeatability.

9.3 The exoskeleton configuration is documented in full detail to ensure that repeatable tests can occur. Upon publication and to ensure standardized documentation, a future Practice for Documenting Exoskeleton Configuration[5] and Practice for Documenting Exoskeleton Fit to the User[5] shall be used to record the exoskeleton configuration.

9.4 If a load (for example, tool, equipment, artifact load) is to be handled during the test, document the artifact or real load using Practice F3443.

9.5 The test requestor shall set the number of times each test is to be repeated. Refer to Appendix X1 for test data reliability guidance.

9.6 The test administrator shall be consistent in their measurement technique. For example, measure all subjects in the same manner (for example, video cameras at the same locations) and measure that the subject has fully crossed a line by consistently measuring when the trailing foot crossed.

9.7 The test requestor shall establish the required measurement uncertainty. Examples are as follows:

9.7.1 *Less Certain*—The test administrator watches the exoskeleton user as they start, cross measurement markers, or stand up from/sit down in a chair. *More Certain*—Outfit the test setup locations/apparatus (that is, distance markers, chair) and exoskeleton user with markers and using an optical tracking system, measure and analyze user movements at marker and chair locations in reference to the test setup locations/apparatus.

9.7.2 *Less Certain*—Record the test using one or more video cameras and subjectively review the recorded test video to establish when the trailing foot crossed a line or when the exoskeleton user stood up from a chair. *More Certain*—Calibrate all video cameras to the scene detecting markers or exoskeleton users passing markers and using a computer program, review the recorded test video using a computer program to determine with set uncertainty, when the user crossed lines or stood up from/sat down in a chair.

9.7.3 *Less Certain*—Use handheld stopwatch to record when the exoskeleton user crosses a line or stands up from/sits down in a chair. *More Certain*—Using recorded video of the test that includes the user movements, markings, and clock showing at least $1/10^{th}$ of a second resolution, review the test video using slow motion to determine the time when the trailing foot crossed the line or when the exoskeleton user stood up from/sat down in a chair.

9.8 *User Preparation:*

9.8.1 The user should wear the appropriate, comfortable clothing and shoes for walking in the chosen test environment. Also, the exoskeleton user should use the appropriate walking aids normally needed by the user or needed for the test (cane, walker, etc.).

9.8.2 The user should not have exercised vigorously within 2 h of beginning the test. Prior to the test, the amount of typical weekly exercise, current pains, etc. shall be documented. Upon publication and to ensure standardized documentation, a future Practice for Documenting Exoskeleton User Information[5] shall be used to record the exoskeleton user information.

6MWT

9.9 *Test Set-Up* (see Fig. 2):

9.9.1 Place cones at either end of the 30 m stretch as turning points.

9.9.2 Mark, using tape or other easily detected marker, 3 m increments along the test course as shown in Fig. 1.

9.9.3 Place a chair halfway along the walkway.

9.10 *User Instructions:*

9.10.1 Walk as long as possible for 6 min, as timed by the test supervisor, back and forth in the test space, reaching each cone before turning briskly and walking to the opposite cone.

9.10.2 The user is permitted to slow down, to stop, and to rest as necessary. A chair is provided if needed, or they may lean against the wall, tree, etc. to rest and to resume walking as soon as they are able.

9.11 The test supervisor should track the approximate distance achieved at each minute mark (that is, at 5 min, 4 min, and so on).

9.12 When approximately 15 s remain, the test supervisor should inform the user as such.

9.13 The test supervisor instructs the user to "stop" when the 6 min time is reached.

9.14 The test supervisor should refrain from using words of encouragement (or body language) to influence the user's walking speed.

9.15 The test technician shall record the distance the user walked in 6 min and all other parameters measured during the test, for example, heart rate, electromyography, the distance at which the oxygen saturation drops <88 %, and other occurrences, such as trips, falls, stops, etc.

10MWT

9.16 *Test Set-Up* (see Fig. 2):

9.16.1 Measure and mark a 10 m walkway.

9.16.2 Add marks at 2 m and 8 m.

9.17 *User Instructions:*

9.17.1 The user walks without assistance for 10 m, with the time measured during the intermediate 6 m (that is, between the 2 m and 8 m marks) to allow for acceleration and deceleration.

9.17.2 Assistive devices may be used although they must be kept consistent and documented for each test.

9.17.3 The test supervisor instructs the user to begin the test and starts timing when the toes pass the 2 m mark.

9.17.4 The test supervisor stops timing when the toes pass the 8 m mark.

9.17.5 The test can be performed at either preferred walking speed or maximum walking speed, and shall be documented accordingly.

9.17.5.1 For normal comfortable speed, the test supervisor instructs the user: "I will say ready, set, go. When I say go, walk at your normal comfortable speed until I say stop."

9.17.5.2 For maximum speed, the test supervisor instructs the user: "I will say ready, set, go. When I say go, walk as fast as you safely can until I say stop."

9.17.6 The number of repetitions shall be provided by the test requestor where the test is performed with at least three repetitions and the average of the three or more repetitions are calculated and documented.

9.18 The test technician shall record all other parameters measured during the test, for example, heart rate, pulse oxidation, electromyography, noted fatigue, and other occurrences, such as trips, falls, stops, etc.

TUG Test

9.19 *Test Set-Up* (see Fig. 2):

9.19.1 A chair with armrests is placed in the test area. The chair shall not move (that is, chair includes non-skid feet) when the user sits on the chair or stands from the chair.

9.19.2 At 3 m from the front of the chair, a tape line or visible mark is placed on the floor.

9.20 *Full TUG Test User Instructions:*

9.20.1 A practice test should be completed before the timed test.

9.20.2 The user starts in a seated position.

9.20.3 The test supervisor instructs the user to stand up, walk 3 m, turn around, walk back to the chair, and sit down when the test supervisor says "start." At which time the test technician begins timing the test with a stopwatch.

9.20.4 The test technician stops the stopwatch when the user is seated.

9.20.5 The assistive device used, if any, shall be documented.

9.21 *Phased TUG Test User Instructions*—The phased TUG test divides the full TUG test as described in 4.1.3.

9.21.1 A practice test should be completed before the timed test.

9.21.2 The user is informed as to which phase(s) the user will perform and the number of repetitions that will be performed to complete the test.

9.21.3 *Phase 1*—The user starts in a seated position (or an alternative position from sitting (for example, kneeling)) and the test supervisor instructs the user to stand up.

9.21.4 *Phase 2*—The test supervisor instructs the user to walk 3 m.

9.21.5 *Phase 3*—The test supervisor instructs the user to turn around 180°.

9.21.6 *Phase 4*—The test supervisor instructs the user to walk back to the chair or start position (that is, opposite direction from 9.21.4 Phase 2).

9.21.7 *Phase 5*—The test supervisor instructs the user to turn around 180° (that is, opposite direction to 9.21.5 Phase 3).

9.21.8 *Phase 6*—The test supervisor instructs the user to sit down (or to an alternative position from sitting (for example, kneeling)).

9.21.9 When the test supervisor says "start." At which time the test technician begins timing the test with a stopwatch or other more certain time method can be used (see 9.7).

9.21.10 The test technician stops the stopwatch or other time method when the user completes the requested test.

9.21.11 The assistive device used, if any, shall be documented.

9.22 The test technician shall record all other parameters measured during the test, for example, pulse oxidation, heart