The Journal of Frailty & Aging

SPECIAL ARTICLE

PHYSICAL FUNCTIONAL ASSESSMENT IN OLDER ADULTS

E. PATRIZIO[1], R. CALVANI[2], E. MARZETTI[2,3], M. CESARI[4]

1. Azienda di Servizi alla Persona Istituti Milanesi Martinitt e Stelline e Pio Albergo Trivulzio, Milan, Italy; 2. Fondazione Policlinico Universitario «Agostino Gemelli» IRCCS, Rome, Italy; 3. Università Cattolica del Sacro Cuore, Institute of Internal Medicine and Geriatrics, Rome, Italy; 4. Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy.

Corresponding author: Enrica Patrizio, Azienda di Servizi alla Persona Istituti Milanesi Martinitt e Stelline e Pio Albergo Trivulzio, Milan, Italy, Email: patrizio.enrica@gmail.com,

Abstract: The evaluation of the physical domain represents a critical part of the assessment of the older person, both in the clinical as well as the research setting. To measure physical function, clinicians and researchers have traditionally relied on instruments focusing on the capacity of the individual to accomplish specific functional tasks (e.g., the Activities of Daily Living [ADL] or the Instrumental ADL scales). However, a growing number of physical performance and muscle strength tests has been developed in parallel over the past three decades. These measures are specifically designed to: 1) provide objective results (not surprisingly, they are frequently timed tests) taken in standardized conditions, whereas the traditional physical function scales are generally self- or proxy-reported measures; 2) be more sensitive to changes; 3) capture the real biology of the function through the assessment of standardized tasks mirroring specific functional subdomains; and 4) mirror the quality of specific mechanisms underlying more complex and multidomain functions. Among the most commonly used instruments, the usual gait speed test, the Short Physical Performance Battery, the handgrip strength, the Timed Up-and-Go test, the 6-minute walk test, and the 400-meter walk test are widely adopted by clinicians and researchers. The clinical and research importance of all these instruments has been demonstrated by their predictive capacity for negative health-related outcomes (i.e., hospitalization, falls, institutionalization, disability, mortality). Moreover, they have shown to be associated with subclinical and clinical conditions that are also not directly related to the physical domain (e.g., inflammation, oxidative stress, overall mortality). For this reason, they have been repeatedly indicated as markers of wellbeing linked to the burden of multiple chronic conditions rather than mere parameters of mobility or strength. In this work protocols of the main tests for the objective assessment of physical function in older adults are presented.

Key words: Physical function, physical performance, gait speed, muscular strength, comprehensive geriatric assessment, older adults.

J Frailty Aging 2020;in press
Published online November 24, 2020, http://dx.doi.org/10.14283/jfa.2020.61

Introduction

The aging of the global population is accompanied by an epidemiological transition from infectious and communicable diseases to a growing burden of chronic diseases. Health status in older persons is determined by the complex interaction of multiple factors (multiple chronic diseases, psychological, social, and environmental factors), that is not captured by traditional paradigms based on the concept of standalone diseases. The most common manifestation of poor health status in this population is represented by the loss of functioning, decrease in the autonomy of mobility and activities of daily living (ADLs), till the onset of disability and dependence (1, 2).

The Comprehensive Geriatric Assessment (CGA), evaluating not only the presence of diseases, but also the individual's functions (intended both as physical and cognitive abilities), psychological factors, and social aspects, is a diagnostic and therapeutic process able to objectively define the health status of the frail older individual and support the design of tailored plans of intervention (3).

Loss of muscle strength and decline of physical performance are critical elements to consider in the detection of important age-related conditions. The definition of physical frailty usually includes measurements of handgrip strength and gait speed. Consistently, physical performance measures, as gait speed, Timed Up-and-Go (TUG) test, and the Short Physical Performance Battery (SPPB) are useful instruments for the screening of frailty in the general population (4). The European Working Group On Sarcopenia In Older People (EWGSOP2) recently published the updated diagnostic criteria for sarcopenia, that include poor muscle strength, and reduced physical performance to define the presence of sarcopenia and quantify its severity, respectively (5–7).

A recent position paper of the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO) working group on frailty and sarcopenia proposed a standardization of the clinical assessment of muscle function and physical performance in order to promote the diagnosis of these conditions and facilitate the design of care programs (8). Muscle strength was defined as "the amount of force a muscle can produce with a single maximal effort". Physical performance, on the other side, is considered a rather

Received July 27, 2020
Accepted for publication August 25, 2020

multidimensional concept, a function of the whole body, resulting from the functioning of multiple organs and systems (e.g., musculoskeletal, cardiovascular, respiratory, central and peripheral nervous systems). Hence, poor physical performance can be considered an early marker of frailty and subclinical diseases. Muscular strength and physical performance measures are related to pathophysiological conditions (i.e., atherosclerosis, inflammation, reduction of aerobic capacities), and are proved to predict the risk of healthcare use (i.e., hospitalizations, institutionalization) and adverse events (i.e., falls, cognitive decline, disability, death) (9–12). At the same time, these measures may represent a target and marker of efficacy for preventive interventions, such as rehabilitative and physical activity programs, being sensitive to changes of the health status. Such predictive capacity is confirmed across large and different populations. Furthermore, being these tests very clinical-friendly, they have been gradually embraced in the daily routine by different disciplines and settings, from the primary care to oncology, from cardiology to surgery, in order to support the diagnostic and therapeutic process (13–16).

In the last years, a number of measures and tools have been developed for the assessment of physical function. The aim of this paper is to describe standard procedures guiding the administration of the most important measures of strength and physical performance. In particular, we here present how to administer the handgrip strength test, the gait speed test, and the 400-meters walking test (17–19). Other important and well-established instruments, as the SPPB and the TUG test are not object of the present work as detailed instructions and video tutorials are already available (https://sppbguide.com/, and https://youtu.be/BA7Y_oLElGY respectively) (20, 21).

Protocols

The protocols here presented are routinely part of a standard geriatric evaluation and do not require any authorization by institutional human research ethics committees. All patients can undergo the following tests. Exclusion criteria are specified within each protocol.

Handgrip strength test

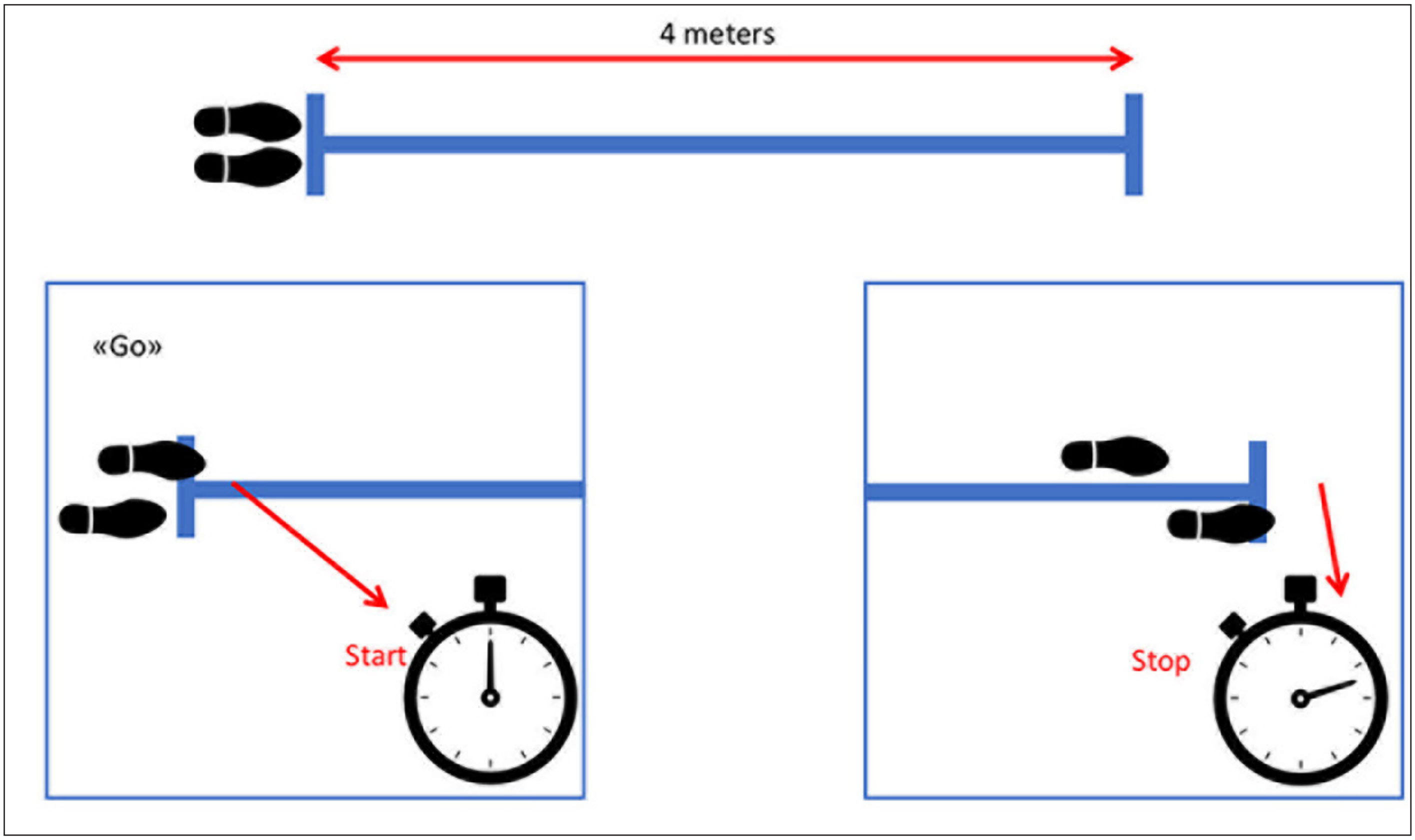
To perform the test, a regularly calibrated, handheld hydraulic dynamometer is recommended (the JAMAR dynamometer is considered the gold standard). Use the same chair for every measurement. Subjects reporting current flare-up of pain in the wrist or hand or has recently undergone to surgery of the hand or wrist should not be tested on the affected side.

1 Seat the participant in a standard chair. Instruct to place forearms resting on the arms of the chair, with wrist just above the end of the arm of the chair. Tell to keep the hand in a neutral position, with the thumb pointing upwards.
2 Show the subject how to use the dynamometer. Place your hand around the handle, putting the base with the thumb on one side, and the other four fingers on the other. Tell the participant that he/she will not feel the grips moving when squeezing but the device is working and measuring his/her strength. Demonstrate the subject that the tighter the grip, the better score is registered by the instrument. Caution the participant that the dynamometer is quite heavy.
3 Place the adjustable handle of the dynamometer in the second position from the inside, unlocking the clip located on the lower post and fitting the adjustable handle on the second space between the teeth of the post.
4 Give the dynamometer to the participant and make sure that the grip bars are at the correct distance (with the fixed handle resting in the middle of the palm and the movable part in the center of the four fingers). If the handle seems to be too large or narrow to allow the patient to squeeze comfortably, remove the dynamometer and adjust, widening or tightening the handle.
5 Support the base with the palm of the hand while the subject holds the dynamometer, being careful not to limit its movement. Allow the participant to try to squeeze to familiarize with the instrument.
6 Check that the peak needle is set to zero. If it is not, rotate counter-clockwise the small caster in the middle of the gauge to move it to zero.
7 Start the test with the right hand. Invite the participant to squeeze the handle as strongly as possible. Use standard encouragement to highly motivate the participant during the test (e.g. «Squeeze, squeeze, harder!»). Ensure the participant maintains the maximum isometric effort for at least 3-5 seconds. When the needle stops rising, invite the participant to stop squeezing.
8 Read grip strength in kilograms from the outside dial and record the result to the nearest 1 kg. After each reading, reset the peak needle to zero. Repeat the measurement at the left hand. Obtain three readings in total for each hand, alternating the sides. Allow 10 seconds rest between each measurement. Note: the peak-hold needle automatically records the maximum result. The gauge presents two dials, the inner one registers the value in lb, the outside in kg.
9 The highest reading of the 6 measurements is reported as the final result. Ask for and report about the hand dominance (i.e. right, left or ambidextrous).
10 If the participant complains about pain, discontinue the test and repeat the assessment only on the other side. If pain appears at both hands, stop the test.

Gait speed

To perform the test, the subject should wear comfortable clothes and shoes (with low heels for women). Only a single straight cane may be used during the walk. If the person can walk a short distance without it, should be encouraged to do so. If a person is unable or uses a walker, he/she should be considered as presenting mobility disability. As such, although

Figure 1
4-meter walking test. The walking course should be unobstructed. Timing begins when the first foot starts to move across the starting line, and should be stopped when the first foot crosses the 4-meter mark



the test can still be conducted with the use of the device, the meaning of the results for this specific geriatric outcome might be of limited value.

1 To perform the test, get a stopwatch and mark a 4-meter track along a flat floor. Ensure that the walking course is devoid of obstacles and include at least an extra meter at each end (Figure 1).
2 Encourage the person to walk without using any assisting devices. During the test watch particularly closely participants who normally use them, to prevent falls.
3 Instruct the participant to stand with both feet touching the starting line, and to start walking at usual pace over the 4-meter course, after a verbal command ("Go"). The assessor will then show how to perform the test to the participant, again stressing the request of walking at usual pace without running.
Note: The individual should not be aware where the goal line is placed in order to avoid a possible reduction of the pace when approaching to it. However, the tape on the floor might provide an implicit goal to the participant. For this reason, the participant might be instructed at walking well past the line on the floor.
4 During the walk stay to the side and slightly behind the subject, outside of the participant's visual field, in order not to set the pace, but remaining in a good position for the safety of the person.
5 Begin timing when the first foot starts to move across the starting line, and stop when the first foot crosses the 4-meter mark. Do not start the watch when saying the verbal command, but when the participant actually begins to move. Do not stop timing if the foot lands on the line but does not completely cross it.
6 Report the time of execution of the test and calculate the gait speed. Repeat the test a second time and use the fastest time as result.
Note: If there is a problem with the stopwatch or the examiner is not sure of the timing, the test should be repeated.

400-meter walking test

To perform the test, the subject should wear comfortable clothes and shoes (with low heels for women). During testing, the use of walk assistive devices, other than a single straight cane, is not allowed. If the subject does not feel safe attempting the walking course without aids (i.e. walker, quad cane, crutch), do not administer the test.

The assessor must be completely familiar with the test procedures and practice before attempting to administer the

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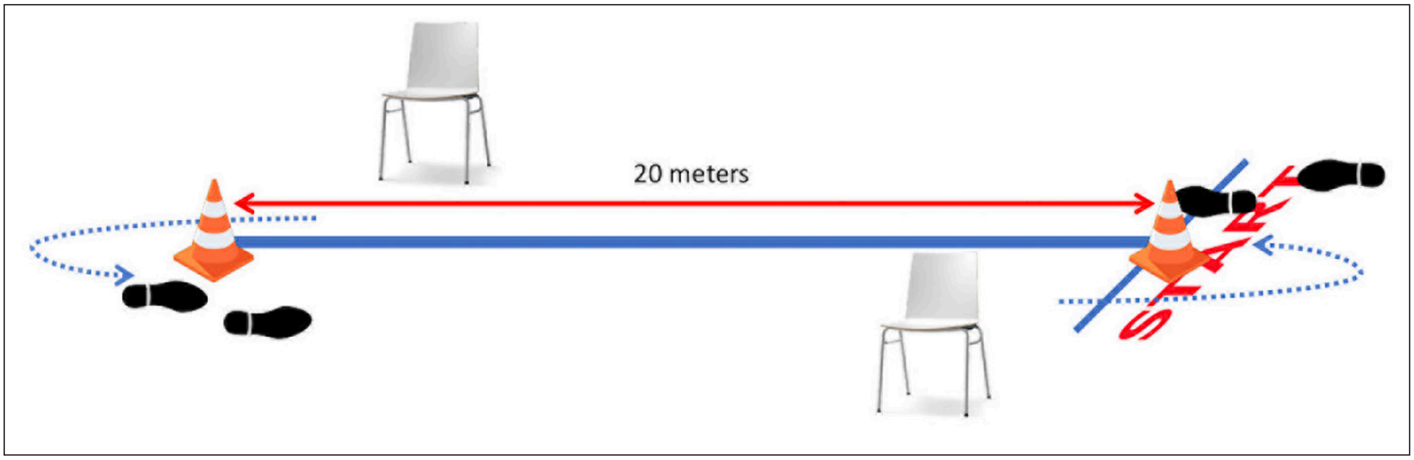
Figure 2

400-meter walking test. A 20-meter long track should be identified by marking it with small traffic cones. The participant has to walk at usual pace back-and-forth the 20-meter track for ten times, turning around the traffic cones in a continuous loop. The two chairs should be positioned by the side of the walking course, in order to not obstruct the track, but close enough to be rapidly reached if the subject needs to rest and sit during the test



test to a participant. Procedures should be clearly demonstrated to the participants before performing the test and they should be queried to ensure that they understand the instructions. To ensure reproducibility, it is imperative that all participants are given the same instructions and that quantitative measurements associated with the tests are made in a uniform manner.

1 Identify a 20-meter long track by marking it with small traffic cones. Make sure that the walking path is not obstructed and include at least an extra meter at each end. Get a stopwatch and position two standard chairs along the walking course in order to allow the subject to rest during the test, if necessary (Figure 2).
2 Conduct the subject to the starting line and instruct to stand in a still position behind the line. It is important to clarify the goal of the test to the participant, i.e. to complete the 400-meter course.
3 Before starting the test measure the radial pulse for 30 seconds and blood pressure.
4 Instruct the subject to walk at usual pace, without overexerting, back-and-forth the 20-meter track for ten times, in order to allow the participant to plan the activity and consequently organize the walking pace according to his/her own reserves.
5 When participant indicates to feel ready to begin, proceed with the test. Instruct the individual to start to walk down the corridor at the command "Go", and turn around the traffic cones, generating a continuous loop. Start timing when the participant takes the first step.
6 Stay by the side and just behind the participant, outside the subject's visual field, during the walk. Be close enough to be able to support the participant if manifests difficulty or risks to fall, but not so close to dictate the pace.
7 When the 4rth lap is completed, ask the participant to report the perceived exert, and record the corresponding score of the Borg index for dyspnea.
Note: The test should be conducted at usual pace and the final goal is to complete the 400-meter course and not to reach the maximal effort. The participant should not overexert, therefore, if the participant reports "hard" or "very hard" should be invited to reduce the effort. The measurement of vital signs (radial pulse and blood pressure) before starting and at the end of the test, as well as the administration of the Borg scale after 4 laps and at the end of the test provide additional information useful to guarantee the participant's safety and provide insights about the undergoing aerobic stress.
8 At the end of each lap (20-meter back and forth), encourage the subject with standardized phrases and count the number of completed and remaining laps.
9 Provide the participant the cane if he/she asks for it during the test, or has the evident necessity to use it to complete the walk.
10 Allow the participant to stop the walk to rest at any time, but not to lean against the wall, other surface (desk, counter, etc.), or sit. After 30 seconds, ask the participant if he/she can continue walking. If it is possible, continue the test, otherwise another 30 seconds of rest, in standing position, are allowed. If the subject is unable to continue after a 60-second rest or needs to sit down, stop the test.
Note: There is no limit to the number of rest stops as long as they can complete the walk without sitting.
11 Stop the stop-watch when the participant completes 400 meters (10 laps, first foot touching the floor beyond the finish line) or after 15 minutes, even if the participant has not covered all the distance. Record the time or, in the second case, measure the accomplished distance.
12 Immediately stop the test if participant reports chest pain or tightness, dyspnea, feeling faint, dizzy, or lower limbs pain.

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Table 1
Relationship between the handgrip strength with incident mobility and functional limitations. Adapted from Rantanen et al. JAMA 1999

	Odds ratio (95% confidence interval)	
	Lowest tertile of handgrip strength	**Middle tertile of handgrip strength**
Slow gait speed	2.77 (1.70-4.54)	1.76 (1.11-2.77)
Inability to rise from a chair	2.73 (1.19-6.27)	2.80 (1.32-5.94)
Self-reported difficulty in walking 0.8 km	1.25 (0.93-1.67)	1.07 (0.83-1.38)
Self-reported difficulty in lifting 4.5 kg	1.94 (1.25-3.02)	1.57 (1.05-2.34)
Self-reported difficulty in doing heavy household work	1.69 (1.69-2.27)	1.31 (1.02-1.70)
Self-reported difficulty in dressing	2.43 (1.42-4.15)	1.65 (1.01-2.71)
Self-reported difficulty in bathing	2.06 (1.18-3.59)	1.76 (1.07-2.92)
Self-reported difficulty in toileting	1.96 (0.98-3.46)	1.84 (0.98-3.46)

Results from multiple logistic regressions testing the predictive capacity of midlife grip strength for functional limitation and disability at advanced age (n=3,218); highest tertile used as reference group. Adjusted for age, weight, height, education, occupation, smoking, physical activity, and chronic conditions (i.e., arthritis, chronic obstructive pulmonary disease, coronary heart disease, stroke, diabetes, and angina).

13 At the end of the test, record the Borg index score, the sitting radial pulse for 30 seconds and blood pressure. Record the number, timing, and reasons for the rest stops (fatigue, chest pain, feeling faint or dizzy, shortness of breath, or other).

Importance and predictive value of the presented tests

Low grip strength was found to be associated with slow gait speed, incident dismobility, disability, functional dependence, cognitive impairment, depression, cardiovascular diseases, hospital admission, and mortality (all-cause mortality, cardiovascular and non-cardiovascular mortality), in both sexes and independently of age and comorbidities (22–25). This relationship is confirmed across different populations and times of follow-up. Rantanen and colleagues studied the relationship between the handgrip strength with incident mobility and functional limitations in a large population (8,006 men from the Honolulu Heart Program and the Honolulu Asia Aging Study) aged at baseline 45-68 years old, with a 25 years follow-up (26). They found a strong association between the muscle strength in midlife and the risk of becoming disabled over the long-term follow-up. The strongest participants (i.e., >42.0 kg) had a significantly better risk profile when compared with those with poorest results at the handgrip, even after adjustment for a number of confounding conditions (Table 1). These results may be explained by greater physiological reserves in these subjects. Dodds and colleagues recently pooled data of grip strength from 8 different studies conducted in Great Britain on the general population. A total of 49,964 persons were considered to produce life-course nomograms of handgrip strength. The generated curves described a three period-evolution, with an increase to peak in early adulthood (i.e., 51 kg between 29-39 years old for men, and 31 kg between 26-42 years old for women), broad maintenance through to midlife, and a declining phase at older age (27). Different cut points were identified in the literature for poor handgrip strength, ranging from 16 to 21 kg for women and 26 to 30 kg for men, defining the risk of adverse events. Values adjusted for BMI or height also exists (23). The EWGSOP proposed values for poor grip strength <27 kg for men and <16 kg for women (7). Data on sensitivity to change in grip strength are still limited and inconsistent, a change of 6 kg was proposed to be significant. Some studies considered also the effect size (difference between the mean/median values of grip strength at baseline and after an intervention, divided by the standard deviation/inter-quartile range of the baseline measurement), and a value of 0.2–0.5 has been considered as indicative of low responsiveness, 0.51–0.8 of moderate responsiveness, and >0.8 of high responsiveness (17).

Gait speed is a strong predictor of negative health outcomes, independently of the presence of common medical conditions and disease risk factors. Many studies demonstrated a strong association with incident disability (intended both as loss of ADL independency and dismobility), cognitive decline and dementia, falls and related fractures, mortality, and healthcare utilization (e.g., hospitalization and institutionalization) (11, 18, 28). Although tested in very different populations (e.g., inpatients and outpatients, independent, frail, and disabled subjects), different walking distances, and studied outcomes, the prognostic value is very consistent (Table 2). Studenski and colleagues studied the relationship between gait speed and mortality in a pooled population of 34,485 community-dwelling older people derived from 9 studies (Cardiovascular Health Study, Health, Established Populations for the Epidemiological Study of the Elderly, Aging and Body Composition study, Hispanic Established Populations for Epidemiological Study of the Elderly, InCHIANTI Study, Osteoporotic Fractures in Men, Third National Health and Nutrition Examination

Table 2
Gait speed and ADL or mobility disability. Adapted from G. Abellan Van Kan et al. The Journal of Nutrition, Health & Aging, 2009

Study	N. of participants	Characteristics	Years of follow-up	Walk distance	Gait Speed cutpoints	Outcomes
Health ABC study (Cesari, J Am Geriatr Soc. 2005; 53:1675-1680)	N=3047	Mean age 74.2 Well-functioning older persons	4.9	6-m	<1.0 m/s	Persistent lower extremity limitation, RR 2.20 (1.76-2.74)
Health ABC study (Cesari, J Am Geriatr Soc. 2009; 57:251-259)	N=3024	Well-functioning older persons	6.9	6-m	<1.0 m/s	Persistent lower extremity limitation, RR 1.53 (1.35-1.74)
CHS (Rosano, J Am Geriatr Soc. 2008; 56:1618- 1625)	N=3156	Free from disability Cognitively intact	8.4	15-ft	<1.0 m/s VS ≥1.0 m/s	Incident ADL disability, HR 0.88 (0.80-0.96)
WHAS-I (Onder, J Gerontol Med Sci. 2005; 60(1):74-79)	N= 1002	No ADL disability	3	4-m	*	Incident ADL disability per 0.31 m/s increase: RR 0.72 (0.53-0.99)
Hispanic EPESE (Ostir, J Gerontol Med Sci. 1998; 53(6):491-495)	N=1946	Community-dwelling Well functioning	2	8-ft	Highest VS lowest gait speed group	ADL disability, OR 5.4 (1.2-23.6) Mobility disability, OR 3.4 (1.8-6.5)
Medicare Health maintenance organisation, HMO, and Veterans Affairs, VA (Studenski, J Am Geriatr Soc. 2003; 51:314-322)	N= 487	>65 years Cognitively intact No mobility disability	1	4-m	Fast walkers >1 m/s	Difficulty in personal care, OR 0.62 for every 0.2 m/s increase
Health ABC study (Simonsick, J Gerontol Med Sci. 2008; 63(8): 841-847)	N=3056	Free from disability Cognitively intact	2	400-m	<1.0 m/s	New mobility limitations: Men, OR 2.15 (1.44-3.20); Women, OR 1.33 (0.99-179)
Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Aging (Shinkai, Age Ageing. 2000; 29:441-446)	N=736	Aged 65 and older Well-functioning Community-dwelling	6	11-m	Highest vs lowest gait	Onset of functional ADL dependence age 65-74: HR 2.43 (1.42-4.17)
Hong Kong Chinese cohort (Woo, J Am Geriatr Soc. 1999; 47:1257-1260)	N=2032	Aged 70 and older Community-dwelling Well-functioning	3	16-ft	Highest vs lowest gait speed group	Age >74: HR 6.18 (3.16-12.1)
Hong-Kong Old Study (Ho, J Gerontol Med Sci. 1997; 52(6):356-362)	N=1483	Community-dwelling Well-functioning	1.5	8-ft	*	ADL dependency per second of increase: Men, OR 1.19 (1.13-1.26); Women, OR 1.16 (1.12-1.21)

* These studies analyzed the risk of disability considering gait speed variation rather than a specific cutpoint, as mentioned in the last column of the table; Health ABC study: Health Aging and Body Composition study, CHS: Cardiovascular Health Study, WHAS-I: Women's Health and Aging Study, Hispanic EPESE: Hispanic Established Population for the Epidemiological Study of the Elderly, RR: relative risk, HR: hazard ratio, OR: odds ratio, ADL: activity of daily living.

Table 3
Risk of death according to 400-meter walk test characteristics. Adapted from Vestergaard et al. Rejuvenation research, 2009

Walk test characteristics	Adjusted model Mortality HR (95% CI)
Ability to perform the 400-meter walk (n = 948)	1.10 (0.62–1.95)
Slow 400-meter walking time (n = 801)	2.84 (1.21–6.63)
Stopped to rest during walk (n = 801)	1.43 (0.62–3.30)

The model is adjusted for age, sex, Mini Mental State Examination score, symptoms of depression, education, smoking, body mass index, being sedentary, number of comorbid conditions (max 10, hypertension, coronary heart disease, congestive heart failure, stroke, peripheral artery disease, diabetes, pulmonary disease, hip fracture, cancer, arthritis), and SPPB score; HR: Hazard Ratio, CI: Confidence interval

Survey, Predicting Elderly Performance, Study of Osteoporotic Fractures). The Authors found an overall HR for survival per each 0.1 m/s faster gait speed of 0.88 (95% CI, 0.87-0.90; P <0.001) confirmed after further adjustment for sex, BMI, smoking status, systolic blood pressure, diseases, prior hospitalization, and self-reported health (overall HR 0.90; 95% CI, 0.89-0.91; P <0.001). They also estimated the median life expectancy based on sex, age, and gait speed, providing a sort of nomograms (29). The value of 0.8 m/s for a 4-meter distance was found to identify frail patients with a high sensitivity (0.99), moderate specificity (0.64), and a high negative predictive value (0.99), and has been chosen by the EWGSOP2 as cut-off to diagnose severe sarcopenia (7, 30). At the same time, in their systematic review of the literature, Abellan van Kan and colleagues identified multiple cut-points of gait speed related to adverse outcomes, categorizing older people as slow (<0.6 m/s), intermediate (0.6-1.0 m/s), and fast (>1.0 m/s) walkers, demonstrating a continuum gradient of risk ranging from very fit to mobility impaired subjects (11). Furthermore, gait speed at usual pace in a 4-meter walk demonstrated also to be sensible to changes, with 0.05 m/s defining a minimally significant change and 0.1 m/s indicating a substantial change, with a corresponding reduction of 17.7% in absolute risk of death when increases of this value (31).

The ability to perform the 400-meter walking test in less than 15 minutes defines the presence of mobility disability. This distance, corresponding to the length of about two blocks in the United States, is considered the minimum walking distance needed to have an independent life. The limit of 15 minutes, corresponds to a gait speed of 0.4 m/s, proven to be incompatible with functional autonomy. This instrument has a strong predictive capacity for development of negative health events (disability, mortality). Although this test is mostly used as a dichotomous indicator (presence/absence of mobility disability), its predictive capacity has been established also in relation to some of the parameters characterizing specific aspects of the performance (e.g., mean gait speed, number of stops to rest). Vestergaard and colleagues studied the differences in mortality and functional impairment rates during a 3- and 6-year follow-up period in the InCHIANTI Study population, analyzing the walking time and the variability in lap time. They found these factors to be both a short- and long-term predictors of mortality, and rest stopping mostly a long-term predictor of mortality (Table 3) (32). In a second study, based on the LIFE-P study, they found that the risk of mobility disability at follow-up was higher in those taking longer to complete the baseline 400-MWT and among those who needed to rest during the test (risk adjusted for age, sex, and clinic site: OR 5.4; CI 2.7–10.9) (33).

Discussion

The protocols presented in this paper are an attempt to standardize the methods of administration of these measures, in order to provide comparable results. Although there is not a unique way to conduct the here described assessments, given the different clinical settings and research protocols in which they can be applied, some steps are recognized as critical and able to affect results.

The absolute values and precision of grip strength measurements can be influenced by aspects of the protocol, such as hand size and dominance, posture (of the whole body and position of joints of the upper limb), provided encouragement, and the use of the maximum or the mean grip strength values (17). The observance of definite instructions in these steps, as already highlighted in the review of Roberts and colleagues, is crucial to ensure homogeneous measures and the training of the examiner assume a special importance to guarantee the reliability of the test (17). Taken with a handheld hydraulic dynamometer, the handgrip strength test demonstrated to have a good test–retest reliability (Intraclass Correlation Coefficient, ICC ≥ 0.85) and an excellent inter-rater reliability (ICC 0.95–0.98) (8, 17). The use of a handheld hydraulic dynamometer (units in Kg) is, therefore, considered the gold standard, but, for patients with upper extremity impairment or musculoskeletal deformations or diseases (as rheumatoid arthritis, osteoarthritis, or carpal tunnel syndrome), may not guarantee an accurate measure of muscle strength and may lead to underestimations, because it can cause stress on weak joints. Other available instruments are pneumatic, which measure grip pressure, mechanical, and strain dynamometer.

The dynamometer should be calibrated at least once per year.

Elements of variability in the execution of gait speed test are walk distances (4, 6, or 10 meters, 8 or 15 foots), a static or dynamic start for walking, the usual or maximal gait speed, and the use of walking aids. A distance of 4 meters has been demonstrated to be feasible in different clinical settings, with a better accuracy compared to shorter walks. Moreover, the same distance is one of the components of the SPPB, allowing to deduce comparable measures from the whole battery (11). However, the test is characterized by a ceiling effect in high functioning persons with a high baseline walking speed (8). For these reasons, longer versions of the gait speed test (e.g., using 6- or 10-meter tracks) have been developed and validated in the literature for allowing a better discrimination of results in very fit individuals. Given the growing use of photocell-based systems of measurement, the method here proposed give the chance to have comparable results. Timing can also be measured differently from how we presented in the protocol, as starting and stopping the watch when the foot lands beyond the starting and finish lines. Moreover, some studies report measures of gait speed in full movement, starting the time measurement after the first two meters of walking. However, including the phase of acceleration provides information regarding subject's abilities of coordination and movement planning, that are influenced by conditions frequently affecting older persons (i.e. Parkinson disease and other movement disorders). In the systematic review of the literature conducted by Peels and colleagues, the use of a moving start showed no significant difference in gait speed compared to a static start. They also found in a single study that subjects using a walking aid (cane) have a slower gait speed compared to those without (34).

To ensure the reproducibility of the 400-meter walking test, the training of the examiner is critical, in order to provide the same instructions and encouragement to participants, and to avoid to affect the results of the test dictating the pace during the walk. To ensure the correct execution the assessment, is also important to respect the provided timing for the stop rest and for the whole test. Moreover, the possibility to use walking aids and to warm up can influence the performance. The 400-meter walking test also demonstrated a high test-retest reliability, but it is mostly applied in research setting, requiring a higher administration time and a bigger space to be performed. On the other hand, being a dichotomous measure able to identify mobility disability, it provides an important and easy-to-understand indication of fitness of the subject, useful to address treatments or other tailored interventions (35).

The hand-grip strength test has been found to correlate with strength of other muscle groups, thus a good indicator of overall strength. The sensitivity to changes of the gait speed, together with an excellent test-retest and inter-rater reliability (ICC, 0.96-0.98) make gait speed a good marker for efficacy of intervention programs and treatments. Test-retest reliability of gait speed has been confirmed across different populations, from healthy older adults, people with comorbidities, to patients affected by stroke, cardiovascular disease, COPD. Compared to other tests (SPPB, chair stand test), gait speed has a stronger or similar predictive capacity for adverse events (ADL and mobility disability, hospitalization, health decline). Composite measures, as the SPPB, may have a better prognostic value, especially for high performance subjects (10, 11). Moreover, a walking speed less than 0.5 m/s is highly predictive of inability to perform the 400-meter walking test. Being very easy to perform, even in restricted places, and with minimal risk, it may be used as an alternative indicator of mobility disability when the performance of the 400-meters walking test is not possible (35).

In conclusion, the strong predictive capacity for adverse outcomes of muscle strength and physical performance measures as well as the reliability and the high feasibility of these tools make them suitable for supporting clinical and research decisions. In particular, the assessment of these measures may support the development of person-tailored interventions aimed at preventing/managing age-related conditions, as frailty and sarcopenia. These measures can both identify subjects at risk (who may benefit from tailored interventions), especially in primary care, but also serve as markers for monitoring the efficacy of the decisions. The dissemination of their use in clinical and research setting with a standard procedure may permit an early application and monitoring of critical aspects of the wellbeing of older persons.

Funding: None.

Conflcit of interest: The authors have no conflicts of interest to disclose.

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