Chapter

Performance-Based Screening Tools for Physical Frailty in Community Settings

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Abstract

Frailty is one of the leading causes of morbidity and premature mortality in older people. It is a multidimensional syndrome characterized by a reduced ability to deal with acute, physical, mental, socio-economic and spiritual stressors, and/or to perform daily living activities. Physical frailty is a complex condition deriving from multiple causes and contributors. It is characterized by the decline of physiological systems, leading to a loss of strength and endurance, and reduced physical ability. Frailty presents an increased risk of vulnerability to disease, dependency and/or death. Frail individuals are also prone to falls and are at greater risk of hospitalization and admission to long-term care. Consequently, there is a need for an effective tool or tools that can easily identify frail community-living individuals at an early stage of physical decline. Screening tools can be performance-based tests, questionnaires or a combination of both. The aim of the present narrative literature review is to describe the existing simple performance-based frailty screening tools.

Keywords: physical frailty, performance-based tests, community

1. Introduction

In recent years, specific importance has been placed on defining frailty in order to better understand the health, functional abilities of older adults, and to prevent or delay the onset of disability and its consequences [1]. It is widely recognized that frailty is associated with an increased risk of adverse health outcomes [2, 3], such as functional impairment and hospitalization [4, 5], loss of autonomy [6] and death [4, 7–9]. Globally, frailty can affect everyone at all stages of life, with a prevalence rate of 4.0% to 59.1%. This wide range of the established prevalence is probably due to various definitions of frailty used in scientific sources and professional literature [10].

Broader definitions of frailty, looking beyond physical functioning, have been put forward [11–13]. Frailty is a multidimensional syndrome characterized by a reduced ability to cope with acute, physical, psychological and socioeconomic stressors, and/or to perform activities of daily living [14, 15]. According to Gobbens and co-workers [16 , p. 342], frailty is a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (physical, psychological, social) caused by the influence of a range of variables and which increases the risk of adverse outcomes. However, frailty should rather be defined as a process and not as a state. A multidimensional approach to frailty is congruent with the interdisciplinary diagnostic process used in the Comprehensive Geriatric Assessment for frail older people, which also examines physical, mental [including both psychological and cognitive functioning], and social functioning [17, 18].

Human health is determined by the health in different biological (physical), psychological (mental), social, and spiritual domains. Performance and interaction of these four dimensions determine the behaviors and abilities of human beings [19]. Teo and colleagues [20] identified three dimensions of frailty in their research, namely, physical frailty [21], emotional [mental] frailty [22] and social frailty [23, 24], to which spiritual frailty can be added [25] (**Figure 1**). With aging, changes occur in physical, mental (psychological), social and spiritual functioning. Accumulation of problems in one or more of these domains of functioning is characteristic of frail people. Consequently, the age group most affected is the older adults. For example, the prevalence of frailty averages 10.7% of community dwelling adults aged 65 years or more and this percentage rises to 15.7% and 26.1% respectively in the 80–84 and >85 age groups [26]. The prevalence of frailty in community dwelling older adults is even higher in studies involving the use of multidimensional tools, which recorded a 13.9% of frail and 7.6% of very frail older adults living in the community [27].

Originally, frailty was primarily focused on the physical problems that older people encounter, as defined in the popular Fried's 'phenotype of frailty' [21]. Physical frailty is a medical syndrome with multiple causes and contributors that is characterized by diminished strength and endurance as well as reduced physiological function resulting in individuals' vulnerability, increased dependency and/or death [30]. Physical frailty is discrete from disease and disability and it may be reversible [1]. Physical frailty is the result of a sub-threshold reduction in the capacity of many physiological systems due to aging and disease. Consequent to the reduced ability to maintain homeostasis, this is a high-risk condition for adverse

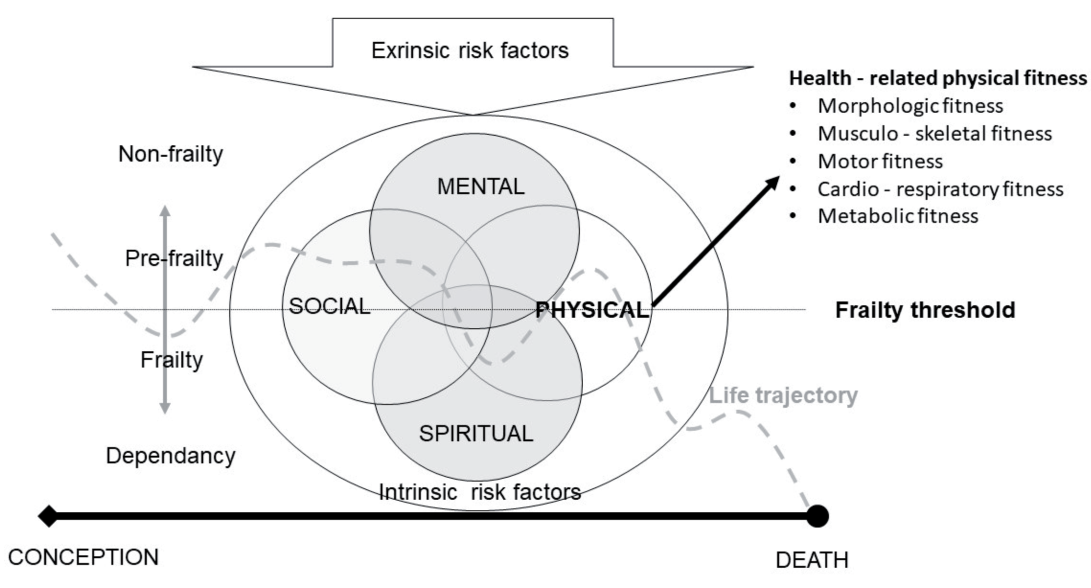

Figure 1.
Like life, frailty is dynamic, complex process, which is going on from the conception until the end of life, which oscillates between non-frailty [complete independency] and complete dependency. All components (of frailty) influence each other. The incidence of frailty is influenced by extrinsic and intrinsic (mental, physical, social, spiritual) factors. Physical frailty is closely connected with health-related physical fitness, since majority of frailty tests contain at least one of the components of health-related physical fitness. Physical fitness is a set of characteristics that individuals already have or achieve and relate to their ability to perform physical activity [28]. It is also is a state of well-being with a low risk of developing premature health problems and sufficient energy to participate in a variety of physical activities [29]. Health-related physical fitness is a more complex construct and includes the functional fitness needed to perform daily tasks.

health outcomes, including inability, dependence, falls, fractures, loneliness, poor quality of life, depression, cognitive decline, dementia, long-term care and death [31]. The risk of developing physical frailty increases with age and many older adults are frail, even though they do not have any life-threatening illness [32]. A systematic review of the literature on physical frailty in people aged 65 and over [26] shows that the prevalence of physical frailty ranges from 4.0–17% (average 9.9%). In women (9.6%), it is almost twice as high as in men (5.2%) and increases with advancing age, and very markedly after the age of 80 years. On the basis of the five Fried phenotype frailty criteria, the prevalence of prefrailty and frailty in community dwelling population (aged 65 and older) ranges from 4.9% to 27.3% and 34.6% to 50.9%, respectively [33]. It is important to note that the Survey of Health, Aging and Retirement in Europe evidences important differences among countries as regards the prevalence of frailty, varying from 5.8% in Switzerland to 27.3% in Spain. The prevalence is especially high in some southern European countries, including Spain, Italy, France, and Greece [34].

The prevalence of physical frailty increases with age, but 5.3% of the population is already fragile between the ages of 18 and 34 [35].

1.1 Screening

Physical frailty secondary prevention embodies the earliest possible detection of physical frailty or changes mostly leading to this syndrome. Screening is a strategy designed to diagnose frailty syndrome in elderly adults with subtle or no clinical manifestations of frailty by employing the most simple tests possible. This strategy is defined as the process of identifying individuals at higher risk for adverse outcomes, functional impairment and mortality. Management of frail seniors includes counseling, additional tests and appropriate treatment to mitigate the risks and possible subsequent complications of this condition [36]. The goal of screening is to reduce frailty incidence, which can be achieved by regularly examining selected groups of the population. In order to attain this goal, the participation of the target population should be adequately high. The selection of diseases which warrant screening is based on the revised criteria set by Andermann and co-workers [37 , p. 318], namely:

- The screening program should respond to the identified need.
- The objectives of the review should be defined at the outset.
- The target population must be defined.
- There should be scientific evidence on the effectiveness of the screening program.
- The program should integrate education, testing, clinical services, and program management.
- There must be a quality assurance system, with mechanisms to reduce potential screening risks.
- The program must ensure informed choice, confidentiality and respect for autonomy.
- The program should promote equal access to screening for the entire target population.

- Program evaluation should be planned from the outset.

- The overall benefits of screening should outweigh the harms.

Bowling and Dieppe [38] suggest that a forward-looking policy for older age would be a program to promote successful aging from middle age onwards, rather than simply aiming to support elderly people with chronic conditions.

1.2 Performance screening tests for community dwelling older adults

Prevention of frailty is therefore necessary as it may eventually lead to prevention or postponement of hospitalization and institutionalization of elderly people. It should be directed at both delaying the onset of frailty and slowing down the frailty process. Insight into the factors that are associated with the presence of frailty is the first step to assist the identification of potentially vulnerable groups.

Tools for the detection of frailty syndrome in older adults can be divided into self-report, performance-based screening instruments [39] and a combination of both. Performance-based instruments have several advantages, including the following:

- greater sensitivity to non-response, changes in time and differences in the execution of activities [40];

- greater precision and validity of answers [41, 42];

- reduced risk of bias associated with perceptions and mood [43–45];

- increased reliability across measurements by standardized administration and scoring [43–45];

- greater sensitivity to clinical changes as compared to self-report [43–45].

On the other hand, performance-based measures and tests also have several limitations. Some of these instruments are less user-friendly and may be time-consuming [41, 42, 46]. Sometimes they require sophisticated equipment, space, or trained personnel. They may sometimes be difficult to score or interpret rendering them impractical in most clinical settings. Experts warn of one major limitation of performance-based measures when used in a simulated environment. Due to the structure or context of the test, the results of these measures may mislead to overestimation or underestimation of the seniors' physical and functional capabilities.

2. Single performance-based tests

Although the phenotype elaborated by Fried and co-workers [21] is frequently used in research internationally, some researchers have proposed a more simplified index to detect physical frailty, with the objective of facilitating clinical practice and identifying individuals at risk [47, 48]. Measurements of physical performance, such as gait speed, five-time sit-to-stand test and grip strength can identify frailty [48] and may be suitable for frailty screening in primary care or population health survey [49].

2.1 Gait speed

Normal gait is defined as a highly controlled, coordinated and evenly repetitive movement of the lower limbs, the purpose of which is to reach a certain place at a certain time with the least possible energy consumption [50]. The combination of joint mobility, muscle capacity and nerve function, and energy expenditure affect stride length and relaxed walking speed. In the absence of impairment, walking is effective and easy, while disease processes or injuries can affect the accuracy, coordination, speed, and versatility that define normal walking [51]. Gait ability tests are clinically useful in screening older individuals at high risk of frailty [52]. To date, a large variety of methods [e.g. habitual and maximal gait speed] and distances [from 2.4 m to ten or more meters] have been used to measure gait speed [53]. Without regard to the exact measurement protocol, walking speed is a valid and reliable measure appropriate to assess the overall mobility function and health. This indicator is often associated with institutionalization and mortality [54].

Habitual gait speed (GS) has been recognized as a safe and simple measure with which adverse outcomes in community dwelling older people can be predicted [53]. It correlates with all indicators of health, functioning, and overall activity regardless of whether it was assessed at home over a 3-meter distance or in the research centre over a 10-m distance [55]. Differences in measuring devices [stopwatch vs. photocell] or distance should not affect the reliability of the measures [56].

The GS is valid [57, 58], reliable [56, 57], and sensitive [59, 60] measure. For gait speed of <0.8 m/s, the sensitivity is 0.99 and specificity 0.64 [60]. However, limited specificity implies many false-positive results indicating that these instruments cannot be used as accurate single tests to identify frailty [61]. Due to the measure's extensive predictive capabilities, as well as ease of administration, the GS is considered the "sixth vital sign" [62–66].

In future, it will certainly be necessary to unify the performance of the gait speed test for screening purposes with all the requirements for performing the test, with regard to the start of the test, the length of the track, the method of time measuring, client encouragement, the use of walking aids and the selection of appropriate footwear.

2.2 Handgrip isometric dynamometry

The unique composition of the hand provides the ability to perform important functions such as drinking, perceiving, or communicating [67]. Most daily activities involve human hand-object interaction. As one of the requirements for the handgrip is its strength, physical frailty phenotype criteria also include weakness based on the isometric handgrip strength (IHGS) measurement [21]. Of the five frailty indicators, the IHGS deserves attention as a simple and objective measure of the frailty syndrome [68, 69]. The test produces a measure of the isometric force of intrinsic and extrinsic hand muscles expressed in kilograms or Newtons and can be normalized allometrically [70, 71]. The IHGS has been recommended as a basic measure in the determination of musculoskeletal function as well as of weakness and disability [72–74]. It is a good general indicator of health and functioning regardless of whether it is assessed in the home setting or in more formal research centre settings [75, 76]. It is associated with a variety of aging outcomes [43, 77] and forms a key component of sarcopenia [78] and frailty [21, 79] phenotypes.

The IHGS is a simple, quick and inexpensive means of stratifying an individual's frailty. However, the methods used to characterize the IHGS vary considerably, both with regard to the choice of dynamometer and the measurement protocol used, which makes comparison between studies difficult [80]. The Jamar dynamometer is considered the "gold standard" in handgrip dynamometers [81, 82] at the handle position two [83]. When handgrip strength was assessed with similar devices at home and in the research centre the results correlated highly and were not affected by the participants' health, functioning and overall activity [55]. It seems that IHGS was least prone to measurement error related to different assessment tools and protocols [55, 75].

Weak handgrip strength in later life is a risk factor for disability, morbidity, and mortality and is central to the definitions of sarcopenia and frailty [75, 84]. Evidence indicates that low IHGS is significantly associated with physical frailty, also when the effects of body mass index and arm muscle circumference are ignored [85]. Several studies have suggested that hand dynamometry can be used to measure the manner in which muscles are used, which is a predictor of frailty and disability in the advanced age [85].

Grip strength thresholds for men ranged from 23.2 kg to 39.0 kg, and for women from 15.9 kg to 22.0 kg [86–89]. The British grip strength centiles [90] and their associated cut points accord with the definitions for sarcopenia and frailty across developed regions, but highlight the need for different cut points in developing regions [75].

The test–retest reliability of the IHGS in older adults is good to excellent [intraclass correlation coefficient ≥0.80] [91, 92] when using the mean value, the best value, or the first of the 2 measurements [92].

2.3 Sit-to-stand tests

The sit-to-stand (STS) movement is considered a fundamental prerequisite for mobility and functional independence since the movement is part of the various Activities of Daily Living [ADL] [93]. The STS maneuver is a common activity of daily living [94] and is partly dependent on lower limb muscle strength and performance [91, 95, 96], and balance [95, 97]. It seems, however, that the STS performance is also dependent, at least in part, on the factors other than muscular strength [e.g. motivation, pain] [97, 98].

Variations of the STS maneuver have been adapted as functional performance measures, including the time to perform a given number of the STS maneuvers [99] or the maximum number of the STS maneuvers in a given time period, usually 30 or 60 s [100, 101]. The STS tests correlate well with other objective physical performance measures such as Timed Up and Go test, gait speed [102] and the 6MWT [100] in healthy older community-living populations.

Regardless of all variations of the STS test, the same equipment is required; standard (folding) chair without arms, with seat height of 43.2 cm and a chronometer.

2.3.1 Five-time sit to stand test

The five-time STS test (FTSST) is the most frequently employed [99] and the best described STS test in older adults. The test measures the time taken to stand five times from a sitting position as rapidly as possible. It less likely reflects endurance than a ten repetition [103] or 30 second test [101]. Normative values [99] and data on reliability [104] and validity [96] have been well described in healthy older community dwelling individuals.

2.3.2 30-second sit to stand test

The 30-second sit to stand test (30STST) aimed to test leg strength and endurance in older adults. The 30STST involves recording the number of stands a person can complete in 30 seconds. It is part of the Fullerton Functional Fitness Test Battery. This test was developed to overcome the floor effect of the five or ten repetition sit to stand test in older adults [105]. It is possible to assess a wide variety of ability levels with scores ranging from 0 for those who cannot complete 1 stand to greater than 20 for more fit individuals [106]. The 30STST provides a reasonably reliable and valid indicator of lower body strength in generally active, community dwelling older adults [101]. Older adult persons were inferior in force production and quickness of movement, which decreased as elderly stood up from a chair of a lower height [107]. It is worth noting that chair seat height's relation to the lower leg length should be considered when interpreting the 30STST scores [108].

2.4 Transfer tests

Depending on the social and living environment, sitting down on and rising from the floor is essential for independent daily living. Irrespective of the culture, the ability to return to an upright position after the fall is of vital importance [109]. The inability to return to upright position is viewed as an indicator of frailty in older adults [110]. Tinetti et al. [110] report that 47% of their older adult study participants were unable to get up without assistance after falls without injury.

2.4.1 Timed floor transfer test

In order to assess the functional ability of seniors to sit down on and rise from the floor, Murphy and colleagues [111], designed the so-called timed floor transfer test (TFTT), which measures the time one needs to sit on the floor and return back to the standing position in any preferred manner. The test is also used to detect individuals with greater risk of falling [111].

The TFTT is a simple, cheap, easy and short performance-based assessment tool, which does not require additional training. It can be administered quickly and easily in both the clinical and home settings. Furthermore, it may reduce the need for extensive assessment via other instruments. For test execution, a chronometer, a matt and a chair for possible support is needed. In the cross-sectional study by Ardali and co-workers [112], one practice trial was performed for familiarization purposes, followed by three timed trials for each subject. The mean of the three timed trials was used for data analysis. Usually, a two-minute rest is allowed between trials in order to minimize fatigue. The TFTT is applied to identify older adults with physical disabilities and/or functional dependence and may be useful in assessing readiness for independent living [112].

The TFTT test has been shown to have good test–retest reliability ($ICC(3,1) = 0.79$, $p \leq 0.0001$) [111]. In the same study, the TFTT times showed also significant correlation with the completion times of the 5-Step Test ($r = -0.57$), functional reach distance ($r = -0.49$), 50-ft (15.24 m) walk test times ($r = -0.52$), and scores on the Performance-oriented Mobility Assessment for Balance ($r = 0.44$). In addition, the ability to complete the TFTT was shown to be a significant predictor of falls among community dwelling older adults. It could correctly classify 95% of fallers and non-fallers among 50 community dwelling older adults, with 81.8% correct prediction of falls and 100% correct prediction of no-falls [111]. Inclusion of the TFTT test at initial evaluation may reveal the presence of these conditions and address the safety of older adults in the community [112]. The study of FT ability by Tinetti and co-workers [110] reported that those who had a history of falls and were unable to get up without help were more likely to suffer functional decline than those without the history of falls, or those who had a history of falls and who were able to get up without assistance. Similarly, Alexander and co-workers [109] noted that 4 out of 9 congregate older adults [mean age = 80 years] who were unable to rise from the floor without support could complete the FT task with support, leaving 5 subjects who could not rise under any condition. In their work Bergland and Laake [113] concluded that the test "get up from lying on the floor" is a marker of failing health and function in older adults and a significant predictor of serious fall injuries. Murphy and co-workers [111] reported that the timed FT test predicted falls in independently functioning community dwelling adults older than 60 years, correctly classifying 95.5% of the participants.

2.4.2 Supine to stand test

The ability to rise from the floor to a standing position is a basic human motor skill [114], which is essential for maintaining independence and mobility through adulthood [114, 115]. For that reason, the assessment of supine to standing position has become an increasingly popular screening instrument to determine functional performance [115, 116]. The supine-to-stand (STS) test has been designed as a combined assessment of flexibility [117], strength [118], locomotion and balance [115], and overall motor competence [116].

Subsequent research by Ulbrich and co-workers [119] has demonstrated that older adults have more difficulty in rising from the floor than young adults. The congregate housing residents took more than three times as long as the healthy older adults to rise successfully from the floor, and the healthy older adults took twice as long as the young adults to rise. The most advanced movement pattern seems to be symmetrical (e.g., where both sides of the body move together in the same pattern), most often occurring in older adolescents and young adults [120–122].

Green and Williams [114] and Ng et al. [123] presented the sequence of procedures used in the assessment of supine-to-stand performance. The study participants were required to assume a supine position on a padded mat on the floor. They were instructed to stand up as fast as possible after a 'go' command. No prior demonstration was given so as to avoid influence on their moving patterns [114]. The participants were allowed a practice trial before conducting two trials for the purposes of data collection [123]. Two metrics of scoring supine-to-stand performance were used. Firstly, the time to complete the supine to stand movement was taken as a product measure of this motor performance. In the subsequent analysis the fastest time from the two trials was used. Timing started at the beginning of the movement after the 'go' command and stopped when the subjects were standing erect with both feet on the mat and with no compensatory movement or sway [114, 123].

2.5 Balance tests

The peripheral sensory systems that are responsible for maintaining posture control also deteriorate with aging [124, 125], while the ability to maintain control of posture is important for the successful performance of most daily activities [125]. Balance involves the reception and integration of sensory stimuli, and the planning and execution of movements to control the centre of gravity on the base support, carried out by the postural control system that integrates information from the vestibular and somatosensory system and visual receptors [126, 127]. Evidence shows that postural instability is related to frailty [128–131] and pre-frailty [132]. Accordingly, the presence of postural instability determines a greater chance of the elderly being frail or pre-frail [133].

2.5.1 Timed up and go test

Weaknesses of Up and Go Test (UGT) triggered the design and development of a modified version of the UGT, where the time in seconds required by the subject to perform the test is measured [134]. The authors named the test Timed Get Up and Go Test (TUGT). This test is an objective single continuous measure that is quick and easy to apply in all settings and requires no specialized equipment [e.g. chronometer, standard [folded] chair and masking tape or cone]. Individuals rise from a chair of standardized height, walk a fixed distance of 3 m, turn, return to the chair, and sit down again. The final test result expressed in seconds proved to be a more reliable criterion compared to the ranking scale of the original version [134].

The TUGT is a sensitive and specific measure of frailty that offers advantages in its measurement in cases when full application or interpretation of Fried's criteria is impracticable [135]. The TUGT can identify frail members of the population well but is less able to discriminate the non-frail from the prefrail or frail populations [135, 136]. For ordinal values, the TUGT times were categorized into fast ($\leq$ 10 seconds), intermediate (11–14 seconds), and slow ($\geq$15 seconds) groups, which correspond to non-frail, prefrail, and frail categories, respectively [135, 137]. The link between the impaired functional mobility and dynamic balance with frailty can be explained by the age-related physiological changes that occur in the body with frailty, such as sarcopenia resulting in loss of muscle mass and function [138].

The TUGT is an appropriate measure of functional mobility as well as dynamic balance among frail older adults [134]. The TUGT has good intra- and inter-rater reliability [139, 140]. It is correlated to regular physical activity [141], global health decline [142], disability in activities of daily living [142–144], and falls [143–145]. Less than optimal functional mobility and dynamic balance result in susceptibility to being frail [146].

2.5.2 Functional reach test

Functional Reach Test (FRT) is an assessment tool for ascertaining dynamic balance in one simple task. Duncan and co-workers [147] define functional reach as the maximal distance one can reach forward beyond arm's length, while maintaining a fixed base of support in the standing position. The only equipment required for the FRT is a yardstick or paper measuring tape fixed to the wall at shoulder height. Testing procedure is short and lasts less than five minutes. It was developed to predict fall in elderly people; being unable to reach more than 15 centimeters depicts a high fall risk and frailty [148]. The FRT is a practical instrument that correlates with physical frailty even more than with age [148].

There is evidence for excellent reliability for adults aged 20–87 years [147] and its concurrent [148], predictive [147, 149] and known groups validity [147, 150] among older adults. The FRT correlates with walking speed, tandem walk, and unipedal stance in community dwelling older adults [148].

2.5.3 Unipedal stance test

The Unipedal Stance Test (UPST) is a method of quantifying mostly static balance ability [151]. Individuals are tested with eyes open and they are asked to stand on either their left or right leg. They are instructed to keep their legs from touching and to maintain single-leg stance for as long as possible. A digital stopwatch is used for timing as this approach has previously been shown to exhibit near perfect inter-rater reliability [152 , p. 9]. The UPST and timing begin once the subjects have lifted their foot off the floor, and end when placing the lifted foot on the floor or with arm movement of placing the hand on a chair that is positioned beside them for support if needed. The test is terminated after a maximum of 60s. Each leg is tested three times unless subjects perform perfectly on the first two trials. Subjects typically alternate between legs and are allowed to rest between trials if needed. The best trial score is used for analysis which is typically used clinically [152].

Normative data for the eyes open and closed conditions have been established with which to compare the tested values [153–155]. Performance is age-specific and not related to gender [152]. The UPST is a valid measure [99] and is correlated with frailty and self-sufficiency in activities of daily living [156, 157], gait performance [158] and fall status [157]. The UPST with the eyes open, but not closed, is also reliable for testing health-related fitness [155].

2.6 Joint range of motion and flexibility tests

Along with strength, balance, and endurance, flexibility is considered an important physical dimension for active and healthy aging. Upper-extremity joint impairments, including pain, limitations in range of motion (ROM), and joint deformity are related to self-reported loss of independence in basic ADL tasks [159, 160]. Lower-extremity ROM is associated with self-reported difficulty in functional mobility, such as rising from a chair, stair climbing, and the need for assistive devices during ambulation [161]. Independent of demographics and non-musculoskeletal conditions, joint impairment is associated with diminished walking ability in older adults [162].

2.6.1 Back scratch test

The back-scratch test (BST) is a part of Senior Fitness Test Manual [163], which assesses upper limb and shoulder flexibility. The participants stand with one hand reaching over shoulder and reach for another palm behind the back as far as possible and the distance between the extended middle fingers is recorded. The test is performed twice, and the best trial is noted to one decimal point. The BST provides an indication of the general shoulder range of motion, and the upper body and shoulder flexibility. It is associated with lifestyle activities such as getting dressed, reaching for objects and putting on a car seat belt. The BS is reported to have a good intraclass test–retest reliability (ICC = 0.98) [164] and is regarded as a valid instrument for measuring the upper-body flexibility of older adults [165].

2.6.2 Chair sit and reach test

The chair sit-and-reach test (CSRT) of the Senior Fitness Test Manual [163] measures flexibility of the posterior muscle chain, more specifically in the lower back and hamstrings. It is a modification of the Sit and Reach test. The participants reach forward in an attempt to touch their toes from a sitting position on the edge of a chair. The distance between the extended middle finger and the big toe is recorded while in a static position for a couple of seconds at the point of greatest reach [166]. The test is performed twice. The best trial in centimeters to one decimal point is noted.

The CSRT provides good validity and intraclass test–retest reliability (ICC = 0.92 for men; ICC = 0.96 for women), and it better correlates to hamstring flexibility in elderly people than the floor sit-and-reach test [167]. Further studies indicate that the CSRT produces reasonably accurate and stable measures of hamstring flexibility [168].

2.7 Cardiorespiratory tests

Maximal aerobic capacity, as measured by maximal oxygen consumption ($\dot{V}O_{2max}$), declines progressively with adult aging [169]. Although $\dot{V}O_{2max}$ may not provide an optimal measure of functional capacity [170], the decline in $\dot{V}O_{2max}$ with age contributes importantly to the age-related reduction in physical functional capacity [171–173]. A $\dot{V}O_{2max}$ of 15–18 ml kg^{-1} min^{-1} must be maintained for independent function [172, 174], maintaining maximal aerobic capacity is therefore an important component of successful aging.

Direct (maximal exercise) and indirect (submaximal exercise) laboratory measurement of $\dot{V}O_{2max}$, which have been defined as indicators of cardiorespiratory fitness, result in considerable expense to the healthcare system [equipment, medical personnel]. In addition, such kind of testing may in older adults provoke dyspnoea, muscle pain and fatigue. All submaximal methods of predicting the $\dot{V}O_{2max}$ are based on linear relationship between HR and $\dot{V}O_{2max}$. Furthermore, the majority of the equations used to estimate $\dot{V}O_{2max}$ were developed on the basis of tests performed in young and middle age individuals. HR can be affected by many extrinsic (environmental temperature and humidity) and intrinsic (state of health, medication) factors [175]. In older adults and especially in frail older people, multimorbidity and polypharmacy are common, which adds to the difficulty to properly assess cardiopulmonary fitness. Because of all mentioned problems, submaximal field exercise tests are useful alternatives to measurement of the $\dot{V}O_{2max}$ [176, 177]. Submaximal field exercise tests provide a feasible, safe, easy-to-administer, and inexpensive technique for the prediction of $\dot{V}O_{2max}$ [177].

2.7.1 Six minute walk test

Among field walking tests, the 6-minute walk test (6MWT) is used by reason of its ease of administration [178]. The 6MWT was first introduced as a functional exercise test by Lipkin [179]. The 6MWT measures the maximal distance that a person can walk in 6 minutes [180]. The European Respiratory Society and the American Thoracic Society [181] published the detailed 6MWT procedure guidelines. The 6MWT may be conducted in different environments, indoors or outdoors, with different track length.

Determining factors of the 6MWD in healthy adults are age [106, 182, 183], gender [106, 183, 184], height and weight [183], body mass index, ankle-arm blood pressure index, 1-second forced expiratory volume [184], health status [182, 184] and smoking [184].

The reliability of the test in healthy elderly persons is high (ICC = 0.93) [185]. The test results are highly correlated with those of the 12-minute walk test [186] and with cycle ergometer or treadmill based exercise tests [187]. The 6MWT performance correlates with both aerobic capacity and muscle fitness [188]. Several authors propose either reference equations or normative data for the 6MWT outcome [106, 183, 184].

2.7.2 Two minute step test

If the 6MWT is not feasible [space limitation], it can be replaced by the Two Minute Step test (TMST) [106]. Protocol involves determining the number of times within a period of 2 minutes that a person can step in place, raising the knee to a height halfway between patella and iliac crest. Performance on the test is defined as the number of right-side steps of the criterion height completed in 2 minutes. A chronometer and adhesive tape of a clearly visible color are the necessities needed to perform the test.

Rikli and Jones [106] found the TMST to demonstrate good interday test–retest reliability (ICC = 0.90). They also reported convergent validity relative to 1-mile walk treadmill performance time (r = 0.73) and known group validity [106]. It detects performance differences across different age groups and levels of physical activity [106, 165, 189] and proposes exercise intervention in various community-residing population [190, 191]. Rikli and Jones [192] also published normative reference values for adults 60 to 94 years old.

2.8 Functional fitness test batteries

The concept of fitness encompasses beneficial health outcomes, including aerobic conditioning, muscle strength and feelings of vigor [193], as well as increased physiological and cognitive functioning [194, 195] leading to a reduced mortality rate [196] and fewer years of disability before death [197]. Functional fitness has been defined as having the physiological capacity to perform normal everyday activities safely and independently without undue fatigue. Therefore, the test batteries must assess the physiological attributes that support the behavioral functions necessary to perform activities of daily living [106]. The frail older adults tend to depend on others due to limitations of physical functions compared to the normal elderly, and the maintenance of function is more important to the elderly than healing from diseases [198, 199]. Unlike frailty, maintenance of functional fitness is associated with successful aging [200, 201]. Slow gait speed and low physical activity/exercise seem to be the most powerful predictors followed by weight loss, lower extremity function, balance, muscle strength, and other indicators of frailty [202]. Functional fitness is typically assessed using batteries that include a combination of health- and performance-related tests, including measurements of aerobic capacity, muscular strength and endurance, body weight and composition, flexibility, balance, and coordination [203]. Physical performance factors are strongly associated with decreased frailty, suggesting that physical performance improvements play an important role in preventing or reducing the frailty [204].

Physical fitness in community dwelling older adults declines early in frailty and manifests differentially in both genders [205]. However, a decline in physical fitness [represented by agility, endurance, flexibility and strength] may begin as early as in middle life. After the age of 50, the annual decline of 1–2% in muscle mass is matched by a progressive loss of 1.5–3% in muscle strength every year [206]. A significant drop in aerobic capacity is observed after the age of 40 and this loss may reach as much as 30% by the age of 65 [207].

By convention, weakness in frailty criteria has included only grip strength and it is the most salient feature [208, 209] even though loss of muscle strength in the lower limbs is typically greater than in upper limbs [201, 210]. It is also interesting to note that physical exhaustion is observed much later in the frailty cycle despite the loss of nearly 10% of aerobic ability after every decade [209, 211]. Since deterioration in physical fitness typically precedes functional dependence [212], a comprehensive physical fitness assessment can be included in conventional measures of frailty to facilitate early detection and prevention of frailty.

2.8.1 Short performance physical battery

The Short Physical Performance Battery (SPPB) test [213] is designed to measure functional status and physical performance. It has primarily been used to assess elderly patients in the hospital, clinical and community settings. The SPPB test might be also used as a screening tool to detect frailty syndrome in community dwelling older adults [214, 215].

The SPPB test consists of three assessments: repeated chair stands, balance tests (side-by-side, semi-tandem and tandem balance tests) and eight-foot walk (2.44 m) test [213]. In terms of equipment, it requires only the use of a standard chair with arms, chronometer, tape measure and two cones to mark the distance. Categories of performance is created for each set of performance measures to permit analyses that includes those unable to perform a task. Those completing the task are assigned scores of 1 to 4, corresponding to the quartiles of time needed to complete the task, with the fastest times scored as 4. The three tests of standing balance are considered as hierarchical in difficulty in assigning a single score of 0 to 4 for standing balance. A summary performance scale is created by summing the category scores for the walking, chair stand, and balance tests [213]. The time taken to perform the test is around 10 minutes and the test is reasonably quick. The data can also be analyzed using the lower extremity continuous summary performance score [0 to 3], where each subscale has a maximum score out of 1 [216].

Regarding the threshold score for frailty, community dwelling older adults who score ≤ 9 points on the SPPB test are most likely to be classified as frail [217] and are at risk of losing the ability to walk 400 m [218]. In order to classify participants as frail, pre-frail and non-frail, the following cut-offs are used [6]: 0–6 points (frail), 7–9 points (pre-frail), 10–12 points (non-frail) [6].

The SPPB has been shown to have a high level of validity, reliability and responsiveness in measuring physical function within an older community dwelling population [219]. Test–retest reliability for community dwelling older adults ranges from 0.81 to 0.91 [220–222]. The SPPB test has satisfactory short (1 week) and long-term (6 months) reliability [222, 223].

The SPPB test has good concurrent validity when compared to other measures of frailty [217, 224] and internal consistency [213]. In the study of Pritchard and co-workers [225], there was fair ($R = 0.488$, $p < 0.001$) to moderate ($R = 0.272$, $p = 0.002$) agreement between Fried's phenotype method and the SPPB determining which participants were frail and pre-frail. The SPPB test score of ≤9 has the most desirable sensitivity (92%), specificity (80%) and greatest area under the curve (AUC =0.81) for identifying frail adults [224]. The SPPB better discriminated frailty in elderly with higher socioeconomic conditions [224]. Standard error of measurement for community dwelling older adults is between 0.68 and 1.42 points [220, 226, 227] and minimal detectable change is from 0.54 to 2.9 points [225, 226].

2.8.2 Physical performance test

Originally described in 1990, the Physical Performance Test (PPT) was developed by Reuben and co-workers [228] as an assessment tool to monitor and describe the multiple domains of physical function in frail and non-frail community dwelling elderly people through several performance tasks. These tasks simulate activities of daily living using various degrees of difficulty. The two versions presented [228] encompass a nine-item scale that includes writing a sentence, simulated eating, turning 360°, putting on and removing a jacket, lifting a book and putting it on a shelf, picking up a penny from the floor, a 50 ft. (15.24 m) walk test, and climbing stairs (scored as two items), and a seven-item scale that does not include stairs. Both versions demonstrate concurrent validity where high correlation is shown in comparison with basic daily activities and Performance Oriented Mobility Assessment [228] and the 7-item version showed high correlation with lower extremity muscle force and lower extremity joint range of motion as well [229]. The majority of PPT items are scored based on the time taken to finish the task. Scores vary from 0 to 28 and from 0 to 36 for the 7-item and 9-item PPTs, respectively, with higher scores showing better performance. The PPT involves few instruments and minimal instructions and takes about 10 minutes to complete [228].

2.8.3 Senior fitness test

Rikli and Jones [106] developed the Senior Fitness Test (SFT) which may be used to assess six underlying functional fitness parameters for older adults. These parameters include lower and upper body strength, aerobic endurance, lower and upper body flexibility, and agility/dynamic balance. The test components of the SFT have been singled out for their high content validity, criterion validity, construct validity, and reliability [230, 231]. The SFT is usually performed in a fitness facility or large community facility. However, Rikli and Jones [232] intentionally selected testing procedures that require very little equipment, and therefore could theoretically be easily adapted to other locations (even at home).

3. Discussion

Frailty is difficult to diagnose, particularly within primary care settings, due to its coexistence with other age-related conditions and lack of a universally accepted clinical definition [233, 234]. There is also a debate about frailty screening, especially in relation to screening eligibility as well as the place and time of its administration [235].

All single screening performance based instruments are less time-consuming than the two reference standard, most frequently used frailty indicators. Self-assessment questionnaires seem to be even faster to implement, they are simple and inexpensive. However, their weakness resides in lower rates of completion compared to instruments administered by health workers [236].

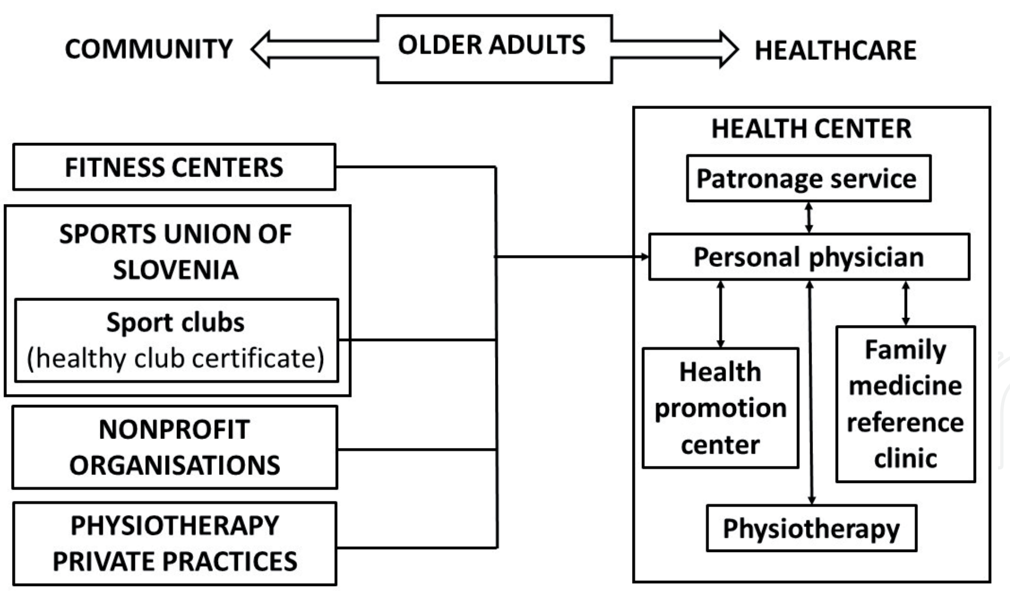

Figure 2.
The proposed screening scheme for frailty in the elderly in Slovenia. The two tests which proved to be most efficacious as regards the consumption of time for its performance, their good metric properties and costs are the handgrip isometric dynamometry and especially the five-time sit to stand test. The older adults can voluntarily commit to frailty testing or are referred for screening by their personal physician. Within the health centres, they can be advised to participate in frailty screening by their personal physician and can receive it within community nursing services, centres for health promotion, reference outpatient clinics or physiotherapy clinics. If participation in testing is voluntary, there are several possibilities. Numerous non-profit organizations (patients' associations, red cross, older people's associations, etc.) can organize the screening for frailty of the elderly once or several times a year either autonomously or in collaboration with sports associations, private physiotherapy outpatient clinics or fitness centres. It is of great importance to inform the participants' personal physician about the screening results on the basis of which they can perform a complete geriatric assessment. The elderly can be advised to undertake one of the available programmes within a health Centre or their community (e.g. ABC of physical activity for health monitored by certified sports clubs).

Individual performance tests can be conducted in all environments (**Figure 2**), including the subjects' home. Test batteries, however, require more organization, professional staff, and space. Such test batteries may be conducted in gyms or outdoors in collaboration with public health organizations, sports associations, fitness centres, and other interested non-profit organizations (**Figure 2**). Due to their simplicity, the tests can also be performed by non-medical professionals. The only requirement is strict observance of the test protocols and providing data to a personal physician.

For most performance tests, there are normative values for individual age groups and for each country or geographical area. Therefore, the evaluation of deviations from the expected results makes it difficult to classify the subjects into individual frailty stages. For that reason, the researchers frequently opt for the Z-score system which expresses the value as a number of standard deviations or Z-scores below or above the reference mean or median value. For population-based uses, a major advantage is that a group of Z-scores can be subjected to summary statistics, such as the mean and standard deviation [237]. For population-based assessment, the Z-score is widely recognized as the best system for analysis and presentation of health-related data because of its advantages compared to the other methods [237].

Physical fitness declines early in frailty and manifests differentially in both genders [205]. Prefrail/frail individuals have significantly poorer performance in upper limb dexterity, lower limb power, tandem and dynamic balance and endurance [205]. Except for balance and flexibility, all fitness measures usually differentiate prefrail/frail from robust women. In men, only lower body strength is significantly associated with frailty [205].

4. Conclusions

In screening for the condition of frailty, the latter should be first recognized as being a significant public health problem. The treatment should be successful, and the sufficient equipment and staff must be available for diagnosis and treatment. The examination must be reliable, inexpensive and simple to perform, and as mild as possible for the subjects. Given that physical frailty is correlated with other forms of frailty, any adverse outcome of an individual performance test or test batteries is a base for continuing a comprehensive geriatric assessment.

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