

# Prevalence, incidence, and clinical impact of sarcopenia: facts, numbers, and epidemiology—update 2014

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Received: 27 August 2014 / Accepted: 1 September 2014 / Published online: 22 October 2014  
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**Abstract** Sarcopenia is now defined as a decline in walking speed or grip strength associated with low muscle mass. Sarcopenia leads to loss of mobility and function, falls, and mortality. Sarcopenia is a major cause of frailty, but either condition can occur without the other being present. Sarcopenia is present in about 5 to 10 % of persons over 65 years of age. It has multiple causes including disease, decreased caloric intake, poor blood flow to muscle, mitochondrial dysfunction, a decline in anabolic hormones, and an increase in proinflammatory cytokines. Basic therapy includes resistance exercise and protein and vitamin D supplementation. There is now a simple screening test available for sarcopenia—SARC-F. All persons 60 years and older should be screened for sarcopenia and treated when appropriate.

Sarcopenia was originally defined as an excessive loss of muscle mass that is associated with aging [1]. Subsequently, it was recognized that the key element was a loss of muscle strength (dynapenia) rather than a loss of muscle mass [2]. This has led to a change in the definition of sarcopenia to include strength (grip strength) or function (walking speed or distance). Based on this concept, a number of societies around the world have provided revised definitions of sarcopenia (Table 1) [3–8]. These definitions have to some extent de-emphasized the importance of aging, recognizing that

sarcopenia has a variety of causes in addition to the physiological effects of aging. Sarcopenia, cachexia, and anorexic disorders (protein-energy malnutrition) represent the major causes of muscle-wasting disorders [9]. The increased interest in sarcopenia is clearly seen by the number of publications published in the last few years compared to previously (Fig. 1). This article represents the third update on sarcopenia published in the journal [10, 11].

## 1 Prevalence of sarcopenia

Since Baumgartner et al. [12, 13] originally defined sarcopenia as being two standard deviations below the normal appendicular muscle mass divided by height squared, numerous groups have examined the prevalence of low muscle mass. Multiple techniques have been used to measure muscle mass, e.g., dual-energy X-ray absorptiometry (DEXA), computed tomography, MRI, ultrasound, bioelectrical impedance, and anthropometry. On the average, 5–13 % of older persons over 60 years of age have low muscle mass, with the prevalence increasing to as high as 50 % in persons over the age of 80 years [11, 14]. Normal aging is associated with approximately a 1 % loss of muscle from 30 years of age, and this loss tends to accelerate after the age of 70 years [15]. In a recent study, 25 % of patients in a geriatric ward were deemed to be sarcopenic [16]. Coin et al. [17] found that about 20 % of community-dwelling persons in Italy had low muscle mass [18]. In Korea, the prevalence of sarcopenia using the Baumgartner criteria was 0.8 % in women and 1.3 % in men over 60 years of age [19]. In Barcelona, low lean mass was present in 33 % of elderly women and 10 % of males [20]. In Taiwan, low muscle mass was present in 2.5 % of community-dwelling women and 5.4 % of males [21]. Two medical conditions, stroke and hip fracture, rapidly lead to an increase in muscle loss [22, 23]. This appears to be due to disuse and

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**Table 1** Comparison of sarcopenia definitions

Definition	Function	Muscle mass
SIG: cachexia-anorexia in chronic wasting disease [3]	Gait speed <0.8 m/s, OR other physical performance test	Low muscle mass (2SD)
EWGSOP [4]	Gait speed <0.8 m/s; grip strength 40 kg males, 30 kg females	Low muscle mass (not defined)
IWGS Sarcopenia Task Force [5]	Gait speed <1.0 m/s, grip strength	Low appendicular lean mass (<7.23 kg/m <sup>2</sup> in men, 5.67 in women)
Sarcopenia with limited mobility (SCWD) [6]	6 min walk <400 m, OR gait speed <1.0 m/s	Low appendicular lean mass/height <sup>2</sup>
Asian Working Group for Sarcopenia [7]	Gait speed <0.8 m/s; grip strength 26 kg males, 18 kg females	Low appendicular lean mass/height <sup>2</sup>
Foundation for the National Institutes of Health [8]	Gait speed <0.8 m/s; grip strength 26 kg males, 16 kg females	Appendicular lean mass/BMI

EWGSOP European Working Group of Sarcopenia in Older Persons, SCWD Sarcopenia, Cachexia and Wasting Disorders, IANA International Association of Nutrition and Aging)

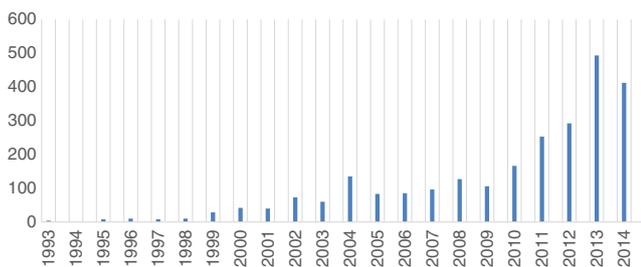
inflammation, and in the case of stroke, denervation. In addition, persons with diabetes mellitus have accelerated muscle loss [24, 25].

Persons with muscle loss in combination with excess fat are considered to have obese sarcopenia [26–28]. These persons are at a much higher risk of functional decline and mortality.

## 2 Validation of the new sarcopenic definitions

Using the European Working Group on Sarcopenia in Older People (EWGSOP) definition, 4.6 % of males and 7.9 % of women in Hertfordshire had sarcopenia [29]. In Japan, 21.8 % of men and 22.9 % of women aged 65 to 89 years had sarcopenia [30]. In a population of persons 80 years and older, 12.5 % had sarcopenia by the EWGSOP definition [31]. In nursing home residents, 32.8 % had sarcopenia [32]. Sarcopenia was highly predictive of earlier mortality [33–36]. Sarcopenic individuals had a greater than threefold increase in falls [21, 37]. Sarcopenia has also been shown to prospectively predict mobility and instrumental activities of daily living (IADL) disability [38].

The prevalence of sarcopenia was slightly less common using the International Working Group on Sarcopenia (IWGS) criteria compared to the EWGSOP [39]. The Sarcopenia, Cachexia and Wasting Disorders (SCWD) definition was



**Fig. 1** Publications on sarcopenia as shown in PubMed (1993 to August 2014)

found to predict ADL and IADL difficulties, frailty, and mortality in a longitudinal study [40].

The Foundation for the National Institutes of Health (FNIH) criteria were based on developing cutoffs using a variety of large epidemiological studies [8]. These criteria are more restrictive with only 1.3 % of men and 2.3 % of women being defined as having sarcopenia. While there was a strong negative percent agreement with the other definition, the positive percent agreements were low ranging from 5 to 32 %. There is a need to compare the FNIH criteria to other definitions to determine which has the best predictive ability.

## 3 Can sarcopenia be predicted by a questionnaire without measurements?

Recently, it has been determined that fracture risk can be determined almost as accurately by the FRAX questions as by measuring bone mineral density [41]. This raises the question of whether or not a simple questionnaire can be used to identify persons with sarcopenia. Two such questionnaires have been developed [42, 43]. The SARC-F questionnaire has been validated in two published studies (Table 3) [44, 45]. Woo et al. [44] found that SARC-F had comparable predictive activity to EWGSOP, IWGS, and the Asian Working Group for Sarcopenia. Like the others in this Asian population, it had modest predictive value for 4-year physical limitation. Cao et al. [45] have also provided evidence for validity of the SARC-F.

## 4 Differentiating between frailty and sarcopenia

The physical frailty phenotype as originally defined by Fried et al. [46] has been demonstrated to be highly predictive of poor outcomes [47, 48]. A simple questionnaire—the FRAIL (Table 2)—has been developed and shown to be equally

**Table 2** Comparison of the brief screens for sarcopenia and frailty

(a) SARC-F			(b) FRAIL
Component	Question	Scoring	
Strength	How much difficulty do you have in lifting and carrying 10 lb?	None=0 Some=1 A lot or unable=2	Fatigue Resistance (Can you climb a flight of stairs?) Aerobic (Can you walk a block?)
Assistance in walking	How much difficulty do you have walking across a room?	None=0 Some=1 A lot, use aids, or unable=2	Illness (>5) Loss of weight (5% in 6 months) (three or more positive answers = frail; one or two positive answers = prefrail)
Rise from a chair	How much difficulty do you have transferring from a chair or bed?	None=0 Some=1 A lot or unable without help=2	
Climb stairs	How much difficulty do you have climbing a flight of 10 stairs?	None=0 Some=1 A lot or unable=2	
Falls	How many times have you fallen in the past year?	None=0 1–3 falls=1 ≥4 falls=2	

predictive of poor outcomes [49–53]. While sarcopenia is clearly a major component of frailty, they are not identical conditions. Overlap between sarcopenia and frailty ranges from 50 to 70 %.

can be used to assess the number and the size of the motor units [56]. This is important as loss of motor unit input to muscle is an important cause of sarcopenia in at least half of older persons.

**5 Sarcopenia and biomarkers**

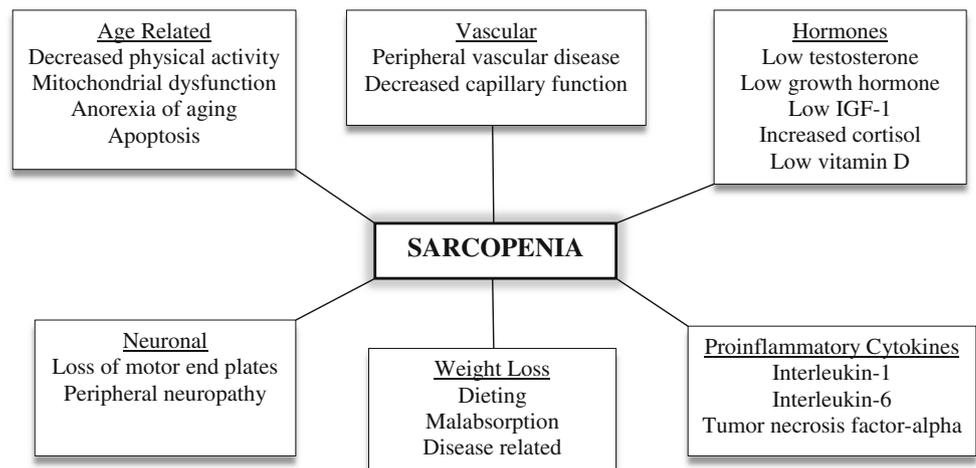
Diagnostic imaging and functional tests are the basic biomarkers for the diagnosis of sarcopenia [54]. A consensus statement has provided a long list of possible serum biomarkers [55]. These are listed in Table 3. To these needs to be added the measurement of motor unit number index, which

**6 Pathophysiology of sarcopenia**

The factors leading to sarcopenia are multifactorial (Fig. 2) [57, 58]. Disuse coupled with aging is the major underlying cause: Poor blood flow to muscle, especially the muscle capillaries due to a decline in nitric oxide production, is another important age-related cause of sarcopenia. Aging is

**Table 3** Biomarkers for sarcopenia

Biomarker	Aging	Exercise	Comments
Creatine kinase	↓	↑	
Aldolase (A)	↓		Correlates with walking speed in old
Coenzyme Q	↓		More strongly correlated with FFM
MLC1	↓		
Troponin T	?	↑	
Creatine (U)			Correlates with muscle mass
Myoglobin	↓	↑	
Creatinine (U) (?/cystatin C)	↓		Correlates with muscle J-shaped curve with function
N-terminal propeptide III collagen	↓		Increased with testosterone
C-terminal agrin fragment	↓		Correlates with degeneration of the neuromuscular junction

**Fig. 2** The causes of sarcopenia

associated with an increase in mitochondrial abnormalities leading to damage to the mitochondrial membrane permeability pore and apoptosis.

Aging is associated with a physiological anorexia of aging that leads to weight loss [59, 60]. Weight loss results in a 75 % loss of fat and a 25 % loss of muscle and bone. Only a very small amount of muscle is regained when a person gains weight. The increase of fat during weight regain is one of the major causes of sarcopenic obesity.

The age-related loss of motor neuron end plates is a major component of sarcopenia [56]. It leads not only to muscle wasting but also to a decrease in muscle function. Loss of anabolic hormones, such as testosterone, DHEA, growth hormone, and insulin-growth factor 1, occurs with aging. Of these, testosterone has been shown to be the hormone that most closely determines the decline in muscle mass and strength [61]. Testosterone is important not only for protein synthesis but also for the maintenance of satellite cells [62, 63]. Insulin resistance, which occurs with aging and obesity, plays an important role in decreasing available glucose and protein for muscle anabolism [64]. Obesity and disease lead to an increase in proinflammatory cytokines (e.g., interleukin-6, interleukin-1, and tumor necrosis factor alpha). These lead to protein catabolism through the activation of NFκB [65].

## 7 Therapeutic approaches

It is now clear that resistance exercise is the primary therapeutic strategy to prevent and reverse sarcopenia [66–70]. The LIFE study has also shown a therapeutic role for aerobic exercise [71]. There is evidence that leucine-enriched essential amino acid supplementation will increase muscle mass and probably function [72–75]. Vitamin D has been shown to

enhance muscle function in persons with low muscle function (<50 nmol) [76, 77].

There is a small amount of data suggesting that testosterone will increase muscle mass and strength and may improve function in older frail persons with hypogonadism [78–81]. However, its safety is not clearly established. Selective androgen receptor modulators (SARMs) have shown some promise in increasing muscle mass and stair climb [82]. A number of antibodies that modulate myostatin and the activin II receptor are in clinical trials [83]. Ghrelin agonists, which increase food intake and release growth hormone, are also under evaluation [84].

## 8 Conclusion

Sarcopenia represents a major cause of falls and functional deterioration in older persons. Loss of muscle mass is commonly associated with loss of bone, making these individuals at high risk for hip fractures [85]. Persons with muscle loss develop accelerated loss of muscle mass and strength when they develop a variety of diseases such as heart failure, chronic obstructive pulmonary disease, and renal failure [86–89]. Like osteoporosis, sarcopenia is becoming recognized as a definable condition [90]. It is time for physicians to screen for sarcopenia and provide treatment for it—at a minimum resistance exercise and protein and vitamin D supplementation.

**Acknowledgments** The authors certify that they comply with the ethical guidelines for authorship and publishing of the *Journal of Cachexia, Sarcopenia and Muscle* 2010; 1:7–8 (vonHaehling S, Morley JE, Coats AJ, and Anker SD).

**Conflict of interest** No outside funding was received for the writing of this article. All authors (JEM, SDA, SH) declare that they have no conflicts of interest involving this work.

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