

## CHAPTER 1

# Epidemiology of Muscle Mass Loss with Age

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## INTRODUCTION

The development of new body composition methods in the early 1970s and 1980s led to more research on this topic, including the study of differences in body composition between young and older persons. These initial studies were followed by much larger studies covering a wide age range investigating how body composition varied across the life span. Variations in lean body mass and fat-free mass were described between age groups. These studies served as the important scientific basis for developing the concept Sarcopenia. Sarcopenia was defined as the age-related loss of muscle mass [1]. The term is derived from the Greek words *sarx* (flesh) and *penia* (loss). The development of this concept further stimulated research in this specific body composition area. More recently, large-scale studies among older persons have included accurate and precise measurements of skeletal muscle mass. Moreover, these measurements have been repeated over time, enabling the sarcopenia process to be studied.

This chapter will discuss the results of epidemiological studies investigating the age-related loss of skeletal muscle mass. First, several cross-sectional studies will be presented comparing the body composition between younger and older persons. Then prospective studies will be discussed investigating the change in body composition with aging. The chapter will conclude with the results of more recent, prospective studies that precisely measured change in skeletal muscle mass in large samples of older persons.

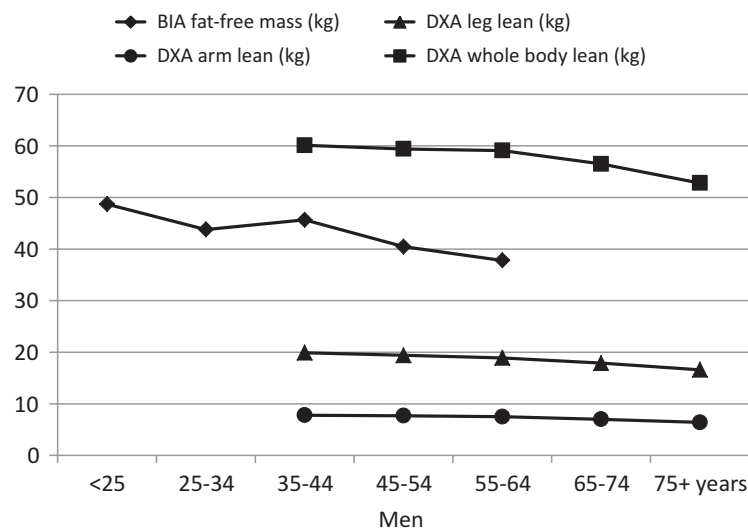
## MUSCLE MASS DIFFERENCES BETWEEN AGE GROUPS

Comparisons between young and older men and women with regard to muscle size have been made in several small studies. The results showed that healthy women in their 70s had a

33% smaller quadriceps cross-sectional area as obtained by compound ultrasound imaging compared to women in their 20s [2]. Using the same methodology and age groups, healthy older men had a 25% smaller quadriceps cross-sectional area [3]. In a study investigating thigh composition using five computed tomography scans of the total thigh, smaller muscle cross-sectional areas were observed in older men compared to younger men even though their total thigh cross-sectional area was similar. The older men had a 13% smaller total muscle cross-sectional area, 25.4% smaller quadriceps and 17.9% smaller hamstring cross-sectional area [4]. Using magnetic resonance imaging of the leg anterior compartment, muscle area was measured in young and older men and women [5]. The older persons had a smaller area of contractile tissue; 11.5% less in women and 19.2% less in men; compared to the young persons. These data, obtained by different body composition technologies, clearly showed a smaller muscle size in older persons compared to young persons. The observed differences in muscle size between age 20 and age 70 suggested a loss of skeletal muscle mass of about 0.26% to 0.56% per year.

The amount of non-muscle tissue within the muscle was also assessed using five computed tomography scans of the thigh in 11 elderly men and 13 young men [4]. Older men had 59.4% more non-muscle tissue within the quadriceps and 127.3% within the hamstring muscle. In a similar study, the amount of non-muscle tissue in older men was 81% higher in the plantar flexors as compared to young men [6]. Thus, apart from the smaller muscle size in old age, these studies suggested that the composition of the muscle also changed with aging, leading to less 'lean' muscle tissue in old age.

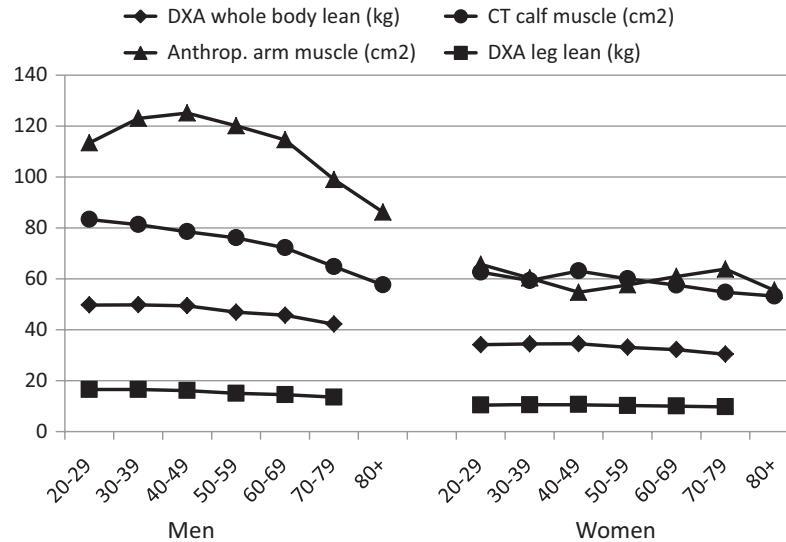
With the greater availability of body composition methods such as bioelectrical impedance and dual-energy x-ray absorptiometry over time, cross-sectional data on muscle size in large study samples including a broad age range have been collected. Examples of these studies using lean mass from DXA (the non-bone, non-fat soft tissue mass) and fat-free mass from bioelectrical impedance, presented by 10-year age groups of men, are presented in Figure 1.1 [7,8]. Older age groups had a lower total body fat-free mass, lower



**Figure 1.1** Differences in fat-free mass and lean mass using different body composition methodologies between men of different age groups. BIA = bioelectrical impedance. DXA = dual-energy x-ray absorptiometry. Based on references 7 and 8.

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**Figure 1.2** Differences in muscle cross-sectional area and lean mass using different body composition methodologies between men and women of different age groups. DXA = dual-energy x-ray absorptiometry. CT = computed tomography. Anthrop. = anthropometry, using arm circumference and triceps skinfold. Based on references 9–11.

total body lean mass, and lower arm and leg lean mass. Figure 1.2 presents the differences in muscle size between 10-year age groups in men and women. With increasing age group, the data suggested a lower whole body lean mass and leg lean mass as assessed by DXA [9], a smaller arm muscle cross-sectional area (from anthropometric measures [10]) and a smaller calf muscle cross-sectional area (from peripheral qualitative computed tomography [11]). These cross-sectional data derived from samples from Italy, Australia, India, Japan, and the USA consistently suggested a decline in muscle size with aging. These data also suggested a steeper decline in muscle size with aging in men compared to women.

Cross-sectional data from a sample of 72 women aged 18 years to 69 years suggested a strong correlation between age and the amount of low density lean tissue as assessed by a computed tomography scan of the mid-thigh. The density of muscle tissue as assessed by computed tomography is indicative of the amount of fat infiltration into the muscle [12]. Higher age was associated with greater amounts of low density lean tissue (correlation coefficient = 0.52 [13]). This result again suggested a greater fat infiltration into the muscle with increasing age.

These cross-sectional data, however, should be interpreted carefully as cohort and period effects, and not aging per se, may have caused the observed differences in muscle size and muscle composition between the age groups. For example, well-known cohort differences in body height, a strong determinant of muscle size, may partly explain the lower muscle mass in older persons compared to younger persons. In addition, period differences in lifestyle (e.g. sports participation and diet) and job demands may have differentially affected muscle size and muscle composition between age groups. Therefore, prospective data are preferred to investigate the change in muscle mass with aging.

## CHANGE IN MUSCLE MASS WITH AGING

Forbes was among the first researchers to report prospective data on the age-related decrease in lean body mass in a small group of adults using potassium<sup>40</sup> counting data [14]. The reported decline was  $-0.41\%$  per year as obtained in 13 men and women aged 22–48 years.

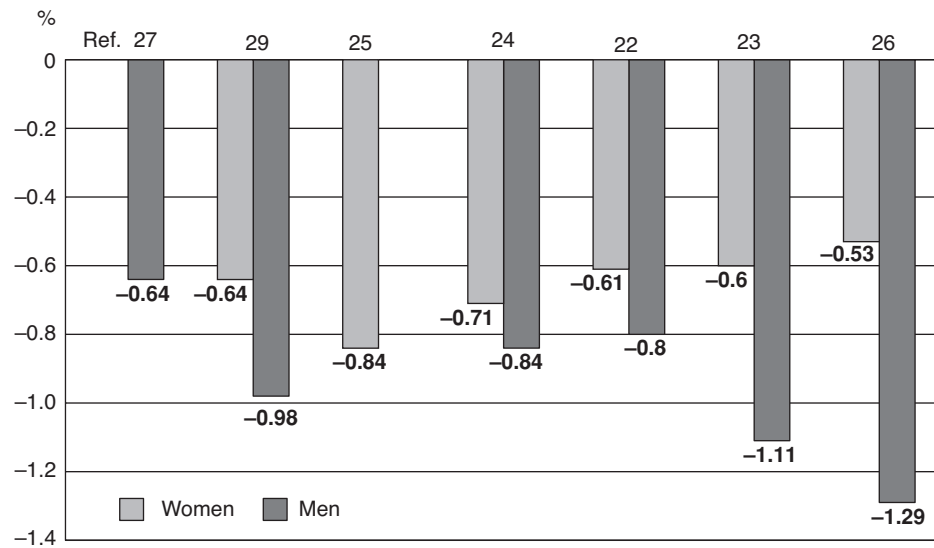
Many prospective studies followed using body composition techniques such as bioelectrical impedance, isotope dilution, skinfolds and underwater weighing to study change in fat-free body mass and total body water with aging [15–21]. However, due to the body composition methodologies used in these studies, no precise measurement of skeletal muscle mass could be obtained because fat-free mass and total body water also include lean, non-muscle tissue such as the visceral organs and bone. Therefore, these studies only provide a crude estimate of the sarcopenia process with aging.

More recent prospective studies have measured the decline in appendicular skeletal muscle mass using DXA [22–25], the decline in total body skeletal muscle mass using 24-h urinary creatinine excretion [26], and the decline in muscle cross-sectional area by CT in older persons [27,28]. The characteristics of these studies are presented in Table 1.1. From these studies a precise and accurate estimation of the sarcopenia process can be obtained. The relative annual decline in skeletal muscle mass was estimated to be between  $-0.64$  and  $-1.29\%$  per year for older men and between  $-0.53$  and  $-0.84\%$  per year for older women (Figure 1.3). In older persons the absolute as well as the relative decline of skeletal muscle mass with aging was larger in men compared to women.

**Table 1.1** Characteristics of prospective studies investigating the age-related change in skeletal muscle mass in older men and women

Reference	N and sex	Age (mean (SD)) or range (y)	Mean follow-up time (y)	Body composition method	Muscle measurement
27	12 men	71.1 (5.4)	8.9	CT	Mid-thigh total anterior muscle cross-sectional area
28	813 men 865 women	70–79	5	CT	Mid-thigh muscle cross-sectional area
25	26 women	75.5 (5.1)	2.0	DXA	Leg skeletal muscle mass
24	1129 men 1178 women	70–90	5	DXA	Leg skeletal muscle mass
22	24 men 54 women	60–90	4.7	DXA	Appendicular skeletal muscle mass
23	62 men 97 women	71.6 (2.2) 71.4 (2.2)	5.5	DXA	Appendicular skeletal muscle mass
26	52 men 68 women	60.4 (7.9) 60.4 (7.4)	9.7	24-h urinary creatinine excretion	Total body skeletal muscle mass

SD = standard deviation, CT = computed tomography, DXA = dual-energy x-ray absorptiometry



**Figure 1.3** Annual decline (%) in skeletal muscle mass in older men and women from prospective studies with follow-up times from 2 to 9.7 years.

Limited data are available on the prospective change in muscle fat with aging. Data from the Health, Aging and Body Composition Study showed an increase in intermuscular fat at the mid-thigh of 3.1 cm<sup>2</sup> in older men and 1.7 cm<sup>2</sup> in older women during the 5-year follow-up [28]. This translated to an annual increase of 9.7% in men and 5.8% in women. This increase was paralleled by a decline in subcutaneous fat at the mid-thigh and shows specifically the increasing fat infiltration into muscle tissue with increasing age.

From these body composition studies it can be concluded that the amount of skeletal muscle mass declines substantially with aging. At the same time, the composition of the muscle changes and a greater fat infiltration into the muscle occurs. It is important to understand the potential impact of these changes on healthy aging.

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