ISSN 1669-9106 MEDICINA (Buenos Aires) 0000: 00: 00-00

Original article

AGE-RELATED CHANGES IN BODY COMPOSITION: A CROSS-SECTIONAL STUDY FROM A SINGLE CENTER IN BUENOS AIRES, ARGENTINA

RUBÉN ABDALA[1,2], LORENA CONEJOS[1], DIANA G. GARATE CORREA[3], GISELLE MUMBACH[1], MAILEN GONZALEZ[4], MARIELA SESTA[1], FERNANDO JERKOVICH[1], MARÍA B. ZANCHETTA[1,2]

[1]Instituto de Diagnóstico e Investigaciones Metabólicas, Buenos Aires, Argentina, [2]Cátedra de Osteología, Universidad del Salvador, Buenos Aires, Argentina, [3]Hospital Monte Sinaí, Cuenca, Ecuador, [4]Instituto de Investigación en Tecnología Informática Avanzada, Universidad Nacional del Centro de la Provincia de Buenos Aires, Argentina, Tandil, Buenos Aires, Argentina

Postal address Rubén Abdala, Instituto de Diagnóstico e Investigaciones Metabólicas, Libertad 836, 1012 Buenos Aires, Argentina
E-mail: dr.rubenabdala@gmail.com
Received: 22-I-2025
Accepted: 27-X-2025

Abstract

Introduction: Several physiological changes occur during the aging process, with perhaps the most apparent being modifications in body composition.

The objective was to evaluate ongoing changes in body composition, throughout the aging process.

Materials and methods: A cross-sectional study was conducted in 975 participants (612 women, 363 men) aged 18–89 years, whose body composition was assessed using dual-energy X-ray absorptiometry (DXA).

Results: The mean age was 48 ± 17 years for women and 43 ±15 years for men ($p < 0.01$). Men exhibited a greater amount of lean mass compared to women (54.5 ± 9.4 vs. 37.7 ± 5.5 kg; $p<0.0001$). Women showed a higher percentage of lower limb lean mass than men (78 vs. 74%; $p < 0.05$). Age was independently associated with decreased appendicular muscle mass, with a reduction of 0.38 kg per decade. On the other hand, women exhibited higher relative fat mass and a greater proportion of lean tissue in the lower limbs. Fat tissue increased with age in both sexes, remaining consistently higher in women. Lean mass and bone mineral content peaked in the second and third decades of life and declined thereafter.

Conclusion: This study highlights the changes in body composition at various life stages, revealing a peak gain of lean tissue between the second and third decades, followed by a decline in subsequent years. To our knowledge, this is the first study that evaluates the changes in body composition in our country.

Key words: body composition, DXA, lean mass, fat mass

Resumen

Cambios en la composición corporal relacionados con la edad: estudio transversal en un centro de la ciudad de Buenos Aires

Introducción: Durante el proceso de envejecimiento ocurren diversos cambios fisiológicos, siendo quizás los más evidentes las modificaciones en la composición corporal. El objetivo fue evaluar los cambios que se producen en la composición corporal a lo largo del envejecimiento.

Materiales y métodos: Se realizó un estudio transversal en 975 participantes (612 mujeres, 363 hombres) de entre 18 y 89 años, cuya composición corporal fue evaluada mediante absorciometría de rayos X de doble energía (DXA).

Resultados: La edad promedio fue de 48 ± 17 años en mujeres y 43 ± 15 años en hombres ($p < 0.01$). Los hombres presentaron una mayor cantidad de masa magra en comparación con las mujeres (54.5 ± 9.4 vs. 37.7 ± 5.5 kg; $p < 0.001$). Además, las mujeres mostraron un mayor porcentaje de masa magra en los miembros inferiores respecto de los hombres (78 vs. 74 %; $p < 0.05$). La edad se asoció de forma independiente con una disminución de la masa muscular apendicular, con una reducción de 0.38 kg por década. Por otro lado, las mujeres presentaron mayor masa grasa relativa y una mayor proporción de tejido magro en los miembros inferiores. El tejido graso aumentó con la edad en ambos sexos, manteniéndose siempre superior en mujeres. La masa magra y el contenido mineral óseo alcanzaron su máximo en la segunda y tercera décadas de la vida y posteriormente declinaron.

Conclusión: Este estudio describe los cambios en la composición corporal en distintas etapas de la vida, evidenciando un pico de ganancia de tejido magro entre la segunda y tercera décadas, seguido de una disminución en los años posteriores. Hasta donde sabemos, es el primer trabajo que evalúa los cambios en la composición corporal en nuestro país.

Palabras clave: composición corporal, DXA, masa magra, masa grasa

KEY POINTS
Current knowledge

- Aging is associated with numerous physiological changes, among which modifications in body composition are particularly remarkable.
- In recent years, the concept of sarcopenia, referring to the loss of lean mass associated with aging and alterations in muscle function, has gained prominence due to its correlation with adverse health outcomes, including greater morbidity and mortality

Contribution of the article to current knowledge

- This study provides valuable insights into age-related changes in body composition parameters among men and women in our population. Our findings highlight the importance of considering sex-specific differences in body composition and their implications for overall health and well-being

Aging is associated with numerous physiological changes, among which modifications in body composition (BC) are particularly remarkables[1,2]. Factors such as gender, race or ethnicity, genetics[3], as well as physiological processes like growth, puberty, pregnancy, menopause, and aging itself, can influence these changes[4,5].

During the aging process, there is a decline in fat-free mass (FFM), encompassing body water, skeletal muscle, smooth muscle, and bone tissue[6]. Lean mass, constituting approximately 40% of FFM, experiences its peak gain around the age of 30, followed by an annual decline of 1 to 3% after the fifth decade of life[7-9]. Sex plays a pivotal role in the acquisition and distribution of lean mass, especially between the lower and upper limbs, crucial for locomotion and physical fitness[10].

In recent years, the concept of sarcopenia, referring to the loss of lean mass associated with aging and alterations in muscle function, has gained prominence due to its correlation with adverse health outcomes, including greater morbidity and mortality[11,12]. Common complications associated with sarcopenia include fractures, falls, hospitalization, and increased mortality rates[13].

Adipose tissue, another essential component of BC, gradually increases during the second and third decades of life, with distribution patterns influenced by sex, age, ethnicity, and health status[14-16]. Sexual maturity directly affects adipose tissue distribution, with girls showing greater total fat mass accumulation and subcutaneous distribution during and after puberty, while boys exhibit abdominal fat deposition, known as the android pattern, during puberty and prepubescence[17,18].

In adulthood, fat tissue typically accumulates in the abdominal (visceral) region, often independently of body weight[14]. Various methods can measure BC, with magnetic resonance imaging (MRI) and computer tomography (CT) scans considered gold standards due to their high accuracy[19,20]. However, their high cost and radiation exposure limit routine use. Dual-energy X-ray absorptiometry (DXA), commonly utilized in epidemiologic studies, offers a cost-effective and low-radiation alternative, enabling comprehensive assessment of fat, lean, and bone compartments and their regional distribution[21,22].

Despite advances in BC research, normative reference data often derive from international sources, and literature on BC changes remains limited, particularly in our country[23]. Therefore, the primary objective of this single-center study was to evaluate changes in BC (lean, fat, and bone mineral content) and their associations with age, height, and weight in both sexes within a cohort of patients aged 18 years and older.

Materials and methods

Study design and participants

A cross-sectional study was conducted, involving 975 ambulatory individuals from the community (612 women and 363 men) aged 18 years and older (range 18-89) who underwent routine body composition (BC) measurements using dual-energy X-ray absorptiometry (DXA). The measurements were conducted at a bone clinic in Buenos Aires, Argentina, between November 2015 and December 2018. All tests were prescribed by evaluating physicians as part of regular health checks. Individuals with neuromuscular diseases, physical disabilities, recent use of a wheelchair and/or cane, rest periods exceeding 30 days in the previous 6 months, and end-stage chronic renal insufficiency were excluded. Data were retrieved from participants' clinical records, and a questionnaire was administered prior to the DXA test. All participants provided written consent for data use. The study protocol was reviewed and approved by the corresponding academic committee (registry IDIM-003-2020).

Anthropometric measurements

All tests were performed by the same trained technician. Body weight was measured using a mechanical scale with a precision of 0.1 kg, and height was measured using a wall-mounted stadiometer with a precision of 0.5 cm. Participants were instructed to remove metallic items, clothing, and shoes.

Body composition evaluation

All evaluations were conducted using the same DXA equipment, Lunar Prodigy Advance (GE Lunar, Madison, WI, USA), following manufacturer standards. The following data were obtained:

• *Lean Compartment:* Expressed as lean mass (LM, in kg). From these data and their distribution in regions, the following parameters were derived:

o Appendicular skeletal muscle mass (ASMM, in kg): sum of lean mass of the 4 limbs (both arms and legs).

o Percentage of lean mass (%): calculated as 100 × LM / total mass ratio.

• *Fat Compartment:* Expressed as total fat mass or tissue (TFM, in kg). The following data were obtained:

o Percentage of regional fat: calculated as 100 × TFM / total mass.

o Percentage of tissue fat: calculated as 100 × TFM / (TLM + TFM).

• *Bone Compartment:* Expressed as bone mineral content (BMC, in g) and bone mineral density (BMD, in g/cm2).

Statistics

Baseline characteristics were expressed as mean ± standard deviation (SD). For statistical analysis, Student's t-test or the Wilcoxon rank sum test was applied according to data distribution. Comparisons between age groups were performed using one-way ANOVA. Following a significant global F-test, Tukey's post hoc multiple comparison test was applied to control for type I error and to identify pairwise differences among group means. Results in the tables are indicated with superscript letters: means sharing a common letter are not significantly different ($p \geq 0.05$). The relationship between quantitative variables was assessed using Pearson's correlation test. To evaluate the impact of age on changes in body composition, multivariable linear regression analyses were performed adjusted for sex, weight, height, and BMI. Regression coefficients (β) with 95% confidence intervals (CI) and p-values were reported. Sex was entered into the regression models as a binary dummy variable (0 = women, 1 = men). A p-value < 0.05 was considered statistically significant for all tests. Statistical analyses were performed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA).

Results

Total participant's characteristics

A total of 975 participants were included, comprising 363 men and 612 women. The clinical characteristics of the total cohort are summarized in Table 1. The mean age higher in women than men. Compared to women, men exhibited greater BMD, BMC, and lean tissue. However, fat tissue was significantly greater in women.

Lean mass changes

When evaluating total lean tissue as a relative measurement in men expressed as a percentage, a decrease with age was observed, which became more pronounced in the sixth decade ($p < 0.05$). However, this trend was not observed in absolute (kg) measurements (Table 2). Total lean mass showed a positive correlation with height ($r = 0.72$; $p < 0.05$). Conversely, appendicular skeletal muscle mass (ASMM) exhibited an

Table 1 | Baseline characteristics in men n=363 and women n=612

Variable	Men (Mean ± SD)	Women (Mean ± SD)	p-value
Age (years)	43 ± 15	48 ± 17	*0.008
Weight (kg)	79.9 ± 15.8	63.8 ± 12.9	*<0.001
Height (cm)	173 ± 8	160.80 ± 6.81	*<0.001
BMI (kg/m2)	26.55 ± 4.41	24.53 ± 4.69	*<0.001
BMC (g)	3062 ± 610	2281 ± 401	*<0.001
TBBMD (g/cm2)	1.23 ± 0.14	1.10 ± 0.13	*<0.001
Lean mass (%)	69 ± 8	60 ± 8	*<0.001
Lean mass (kg)	54.5 ± 9.4	37.7 ± 5.5	*<0.001
Arms lean mass (kg)	6.5 ± 1.6	3.6 ± 0.8	*<0.001
Legs lean mass (kg)	18.4 ± 3.6	12.6 ± 2.3	*<0.001
ASMM (kg)	24.9 ± 5.0	16.2 ± 2. 9	*<0.001
FAT (%)	28 ± 9	37 ± 8	*<0.001
FAT (kg)	22.3 ± 9.9	23.5 ± 9.4	*<0.001

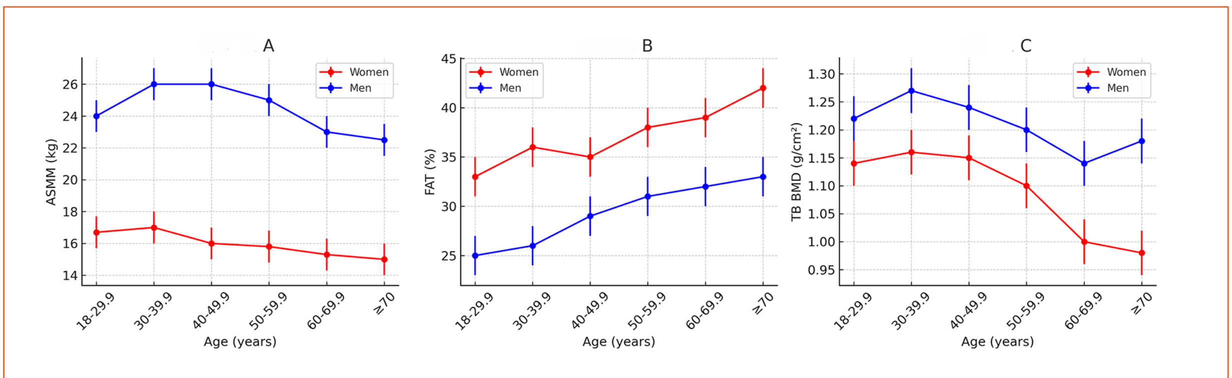
BMI: body mass index; BMC: bone mineral content; TBBMD: total body bone mass density; ASMM: appendicular skeletal muscle mass
*Student's T-test for independent samples

Table 2 (men) | Changes in body composition with age (n=363)

Age categories	18-29.9 (n=80)	30-39.9 (n=97)	40-49.9 (n=73)	50-59.9 (n=65)	60-69.9 (n=28)	≥70 (n=20)
Weight (kg)	73 ± 17 A	80 ± 16 AB	84 ± 15 B	82 ± 15 AB	80 ± 12 AB	80 ± 13 AB
Height (cm)	172 ± 9	174 ± 9	174 ± 8	174 ± 8	171 ± 5	171 ± 10
BMI (kg/m²)	24.57 ± 4.20 A	26.45 ± 4.37 AB	27.76 ± 4.56 B	27.11 ± 4.18 AB	27.31 ± 3.95 B	27.67 ± 4.01 B
BMC (g)	2967 ± 688 A	3183 ± 628 A	3146 ± 605 A	3031 ± 556 A	2819 ± 381 A	2981 ± 490 A
Lean mass (%)	72 ± 10 AB	71 ± 8 AB	68 ± 7 ABC	67 ± 7 C	65 ± 6 C	65 ± 6 C
Lean mass (kg)	52.5 ± 12.2 A	56.1 ± 9.3 A	56.8 ± 8.7 A	54.1 ± 7.6 A	51.9 ± 5.4 A	51.8 ± 6.8 A
FAT (Kg)	18.2 ± 9.5 A	21.1 ± 10.7 AB	23.8 ± 9.0 AB	25.1 ± 9.6 B	25.5 ± 8.1 B	25.9 ± 8.0 B

BMI: body mass index; BMC: bone mineral content; TBBMD: total body bone mass density
Values are presented as mean ± SD. One-way ANOVA followed by Tukey's *post hoc* test
Means with a common superscript letter are not significantly different ($p < 0.05$)

Figure 1 | Changes in body composition according to age categories in men and women
A: Appendicular skeletal muscle mass (ASMM, kg). B: Fat tissue (%). C: Total bone mineral density (TBMD g/cm²)



Values are means with 95% confidence intervals (CI) by age increasing trend between the second and third decades and later declined (Fig. 1A). This decline was particularly notable after the fifth decade of life, with a loss of 13.9% of its maximum reach being evident ($p < 0.05$) (Fig. 1A). Analyzing the distribution of ASMM in the upper and lower limbs, greater absolute muscle mass (kg) was observed in men in both regions. However, men had a smaller relative lean mass (%) in the lower region compared to women (74 vs. 78 %, $p < 0.05$).

Women showed a decrease absolute (kg) and relative (%) lean mass with age ($p < 0.05$). Absolute lean mass peaked in the second and third decades of life and then declined by approximately 10% over the years (Table 3). In addition to age, height and weight also influenced muscle mass. Total lean mass exhibited a positive correlation with height ($r = 0.60$; $p < 0.05$). Paradoxically, weight was positively correlated with absolute lean mass ($r = 0.73$; $p < 0.05$) but inversely related to relative muscle mass or the percentage of weight occupied by lean mass ($r = -0.65$; $p < 0.05$).

Fat mass changes

In men, both relative (kg) and absolute fat tissue (%) increased over the years (Table 2 and Fig. 1B). This increase reached approximately 30% in those over 70 years of age (from 18.19 ± 9.53 to 25.85± 7.98 kg; $p< 0.05$). Age correlated positively with fat mass ($r = 0.29$; $p < 0.05$).

Regarding women, aging was associated with an increase in the percentage of fat tissue, reaching its peak between the sixth and seventh decade of life (Table 3 and Fig. 1B). Age correlated positively with fat mass ($r = 0.32$; $p < 0.05$).

Changes in bone compartment

In men, BMC and BMD peaked between the second and third decades of life and then declined by about 12% (Table 2). BMD appeared to follow a similar curve of lean mass accumulation and loss, as depicted in Figure 1A and C.

In women, BMC and BMD reached a peak in the second decade of life, followed by a decrease of around 12% observed after the age of 70 (Table 3 and Fig. 1C).

Multivariable regression analyses

Age emerged as an independent predictor of body composition changes. After adjustment for sex, BMI, height, and weight, each additional decade of life was associated with a reduction of 0.38 kg in ASMM (95% CI –0.46 to –0.30; $p < 0.001$); an increase of 0.46 kg in fat mass (95% CI +0.31 to +0.61; $p < 0.001$); a decline of 66 g in BMC (95% CI –78 to –54; $p < 0.001$), and a decrease of 0.019 g/cm² in BMD (95% CI –0.024 to –0.014; $p < 0.001$).

Sex-related differences also remained significant after multivariable adjustment: compared with women, men exhibited higher ASMM (+3.56 kg; $p < 0.001$) and BMC (+170 g; $p < 0.001$), but lower fat mass (–6.75 kg; $p < 0.001$), independently of age and anthropometric variables.

Table 3 (women) | Changes in body composition with age n=612

Age categories	18-29.9 (n 122)	30-39.9 (n 114)	40-49.9 (n 104)	50-59.9 (n 105)	60-69.9 (n 103)	≥70 (n 64)
Weight (kg)	61 ± 13 A	66 ± 13 A	63 ± 14 A	64 ± 11 A	64 ± 13 A	65 ± 12 A
Height (cm)	162 ± 7	163 ± 6	1614 ± 7	161 ± 6	159 ± 6	157 ± 7
BMI (Kg/m²)	23.05 ± 4.53 A	24.81 ± 4.54 ABC	24.07 ± 4.78 AB	24.66 ± 4.27 ABC	25.15 ± 4.92 BC	26.35 ± 4.59 BC
BMC (kg)	2380 ± 362 A	2487 ± 326 A	2416 ± 375 A	2226 ± 400 B	2032 ± 359 C	1996 ± 312 C
Lean mass (%)	64 ± 7 A	61 ± 8 BC	62 ± 8 AC	59 ± 7 BC	58 ± 6 BD	56 ± 7 D
Lean mass (kg)	38.3 ± 6.2 AB	39.3 ± 5.2 A	37.9 ± 5.9 AB	37.5 ± 4.8 ABC	36.3 ± 5.4 BC	35.6 ± 4.3 C
FAT (kg)	20.1 ± 8.9 A	24.0 ± 10.0 BC	22.2 ± 9.9 AB	24.4 ± 8.5 BC	25.0 ± 8.7 BC	27.3 ± 8.9 C

BMI: body mass index, BMC: bone mineral content, TBBMD: total body bone mass density
Values are presented as mean ± SD. One-way ANOVA followed by Tukey's *post hoc* test
Means with a common superscript letter are not significantly different ($p < 0.05$)

Discussion

In clinical practice, the evaluation of body composition with DXA is considered the reference technique, offering reliable and reproducible measurements[21-24]. Consequently, DXA was utilized in this study for evaluating the sample, enabling unique observations regarding the quality and distribution of body tissue at different stages of life and contributing to local data collection[25]. To date, no population studies have been published in our country, and evidence regarding changes in body composition in selected cohorts remains controversial[12, 26-29].

On average, total lean mass represented more than 70% of body weight in men and 60% in women. In the present investigation, this percentage, or relative lean mass, tended to decrease mainly from the sixth decade of life. Additionally, this study reports that men exhibited greater absolute lean mass in the arms and legs than women. However, the relative distribution (%) of lean mass differed according to sex, being greater in the upper limbs but lower in the lower limbs in men compared to women. These differences in the percentage of distribution align with findings by Janssen et al.[30]. Additionally, our participants showed a maximum gain in ASMM around the third decade of life, followed by a gradual decrease until the seventh decade of life to approximately 13% and 12% loss in men and women, respectively. Similar observations were reported by other authors, who noted a maximum acquisition of muscle mass around the second and third decades with a subsequent decrease[30-33]. The age-related decline in muscle mass observed in our cohort, independent of body size, is consistent with the progressive loss of appendicular lean tissue described as a hallmark of sarcopenia, which begins as early as the fourth decade of life and accelerates thereafter.

When analyzing the influence of height on ASMM, a significant positive correlation was found in both sexes, consistent with previous studies, indicating that individuals with greater height generally exhibit higher lean mass[30]. Sarcopenia, referring to the loss of muscle mass and function accompanying aging, has adverse consequences for health. Therefore, the evaluation of muscle mass becomes crucial in diagnosing sarcopenia[34]. Measuring ASMM (arms + legs) is highly recommended, as this region has minimal interposition of structures and is responsible for locomotion[34, 35].

Various causes contribute to the pathogenesis of muscle mass loss, including age-related motor neuron losses, leading to denervation of muscle fibers and decreased contraction.[36]. On the other hand, as a consequence of this denervation, a decrease in the size and number of type II muscle fibers is observed[36,37]. Recognizing muscle loss thresholds associated with limitations in muscle function is important in clinical practice[34].

Regarding fat tissue, sex was observed to play a fundamental role in its distribution and quantity. As in previous studies, a higher proportion in women was found regardless of the fat measurement technique used[14-16]. This difference is already identified at an early age when greater fatty deposits are evident in the extremities. In this study, a significant increase in the percentage of adipose tissue with age was observed, reaching a maximum around the sixth decade of life. However, despite the quantity, redistribution of adipose tissue is a prominent feature among changes in body composition. This phenomenon is characterized by an increase in the deposition of visceral adipose tissue and a decrease in subcutaneous fat[38-40]. It was observed that fat (% and kg) was positively correlated with age in both sexes.

Finally, bone mineral content peaked between the second and third decades in both men and women, followed by a decrease similar to muscle mass. This likely supports the close relationship between both structures. The increase in muscle mass imposes higher mechanical loads on bone tissue, activating osteogenic pathways that enhance bone formation and mineral accrual.

Although this study is cross-sectional and has limitations such as the absence of biochemical data the importance of establishing local reference values for body composition parameters should be emphasize. Furthermore, the usefulness of DXA for measurements needs to be distinguished for each compartment separately.

In conclusion, this study provides valuable insights into age-related changes in body composition parameters among men and women in our population. Our findings highlight the importance of considering sex-specific differences in body composition and their implications for overall health and well-being. We hope our data could contribute to a better understanding of age-related changes in body composition. Moving forward, further longitudinal studies incorporating biochemical markers are warranted to elucidate the underlying mechanisms and potential interventions to mitigate age-related changes in body composition and associated health outcomes.

Acknowledgment: The authors thank Ariel Sanchez (Rosario, Argentina) for his time spent reviewing our manuscript, careful reading, and insightful comments and suggestions that lead to improving the quality of this manuscript.

Conflict of interest: None to declare

References

1. St-Onge MP. Relationship between body composition changes and changes in physical function and metabolic risk factors in ageing. *Curr Opin Clin Nutr Metab Care* 2005; 8: 523–8.
2. Baumgartner RN. Body composition in healthy ageing. *Ann N Y Acad Sci* 2000; 904: 437-48.
3. Lee S, Kuk JL, Hannon TS, Arslanian SA. Race and gender differences in the relationships between anthropometrics and abdominal fat in youth. *Obesity (Silver Spring)* 2008; 16: 1066-71.
4. Ambikairajah A, Walsh E, Tabatabaei-Jafari H, Cherbuin N. Fat mass changes during menopause: a metaanalysis *Am J Obstet Gynecol* 2019; 221: 393-409.e50.
5. Westerterp KR. Changes in physical activity over the lifespan: impact on body composition and sarcopenic obesity. *Obes Rev* 2018;19: 8-13.
6. Kehayias JJ. Aging and body composition. *Nestle Nutr Workshop Ser Clin Perform Programme* 2002; 6: 63-74.
7. Midorikawa T, Kondo M, Beekley MD, Koizumi K, Abe T. High REE in Sumo wrestlers attributed to large organ-tissue mass. *Med Sci Sports Exerc* 2007; 39: 688-93.
8. Rush EC, Freitas I, Plank LD. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. *Br J Nutr* 2009; 102: 632-41.
9. Tian S, Morio B, Denis JB, Mioche L. Age-related changes in segmental body composition by ethnicity and history of weight change across the adult lifespan. *Int J Environ Res Public Health* 2016; 13: 821.
10. Gallagher D, Visser M, De Meersman RE, et al. Appendicular skeletal muscle mass: effects of age, gender, and ethnicity. *J Appl Physiol* (1985) 1997; 83: 229-39.
11. Anker SD, Morley JE, von Haehling S. Welcome to the ICD-10 code for sarcopenia. *J Cachexia Sarcopenia Muscle* 2016; 7: 512-4.
12. Zanchetta MB, Abdala R, Massari F, et al. Postmenopausal women with sarcopenia have higher prevalence of falls and vertebral fractures. *Medicina (B Aires)* 2021; 81: 47-53.
13. Bachettini NP, Bielemann RM, Barbosa-Silva TG, Menezes AMB, Tomasi E, Gonzalez MC. Sarcopenia as a mortality predictor in community-dwelling older adults: a comparison of the diagnostic criteria of the European Working Group on Sarcopenia in Older People. *Eur J Clin Nutr* 2020; 74: 573-80.
14. Kuk JL, Saunders TJ, Davidson LE, Ross R. Age-related changes in total and regional fat distribution. *Ageing Res Rev* 2009; 8: 339-48.
15. Guo SS, Zeller C, Chumlea WC, Siervogel RM. Aging, body composition, and lifestyle: The Fels Longitudinal Study. Am J Clin Nutr 1999; 70: 405-11.
16. JafariNasabian P, Inglis JE, Reilly W, Kelly OJ, Ilich JZ. Aging human body: changes in bone, muscle and body fat with consequent changes in nutrient intake. *J Endocrinol* 2017; 234: 37-51.
17. Komiya S, Eto C, Otoki K, Teramoto K, Shimizu F, Shimamoto H. Gender differences in body fat of low- and high-body-mass children: relationship with body mass index. *Eur J Appl Physiol* 2000; 82: 16-23.
18. Yip C, Dinkel C, Mahajan A, Siddique M, Cook GJ, Goh V. Imaging body composition in cancer patients: visceral obesity, sarcopenia and sarcopenic obesity may impact on clinical outcome. *Insights Imaging* 2015; 6: 489-97.
19. Fuller NJ, Hardingham CR, Graves M, et al. Assessment of limb muscle and adipose tissue by dualenergy X-ray absorptiometry using magnetic resonance imaging for comparison. *Int J Obes Relat Metab Disord* 1999; 23: 1295–302.
20. Visser M, Fuerst T, Lang T, Salamone L, Harris TB. Validity of fan-beam dual-energy X-ray absorpti-

ometry for measuring fat-free mass and leg muscle mass. Health, Aging, and Body Composition Study-Dual-Energy X-ray Absorptiometry and Body Composition Working Group. *J Appl Physiol.* 1999; 87:1513–20.

21. Shepherd JA, Ng BK, Sommer MJ, Heymsfield SB. Body composition by DXA. *Bone* 2017; 104:101-5.
22. Petak S, Barbu CG, Yu EW, et al. The Official Positions of the International Society for Clinical Densitometry: body composition analysis reporting. *J Clin Densitometer* 2013; 16: 508-19.
23. Fan B, Shepherd JA, Levine MA, et al. National Health and Nutrition Examination Survey whole-body dual-energy X-ray absorptiometry reference data for GE Lunar systems. *J Clin Densitom* 2014; 17: 344-77.
24. Schousboe JT, Shepherd JA, Bilezikian JP, Baim S. Executive summary of the 2013 International Society for Clinical Densitometry Position Development Conference on bone densitometry. *J Clin Densitom* 2013; 16: 455-66.
25. Kelly TL, Wilson KE, Heymsfield SB. Dual energy X-Ray absorptiometry body composition, reference values from NHANES. *Plos One.* 2009; 4:e7038
26. Mautalen C, Bagur A, Vega E, Gonzalez D. Body composition in normal and osteoporotic women. *Medicina (B Aires)* 1996; 56: 29-34.
27. Seijo M, Deferrari JM, Bagur A, et al. A pilot study of body composition and bone mineral density in healthy men from Argentina. *J Clin Densitom* 2007; 10:381-5.
28. Mastaglia SR, Solis F, Bagur A, Mautalen C, Oliveri B. Increase in android fat mass with age in healthy women with normal body mass index. *J Clin Densitom* 2012; 15: 159-64.
29. Kyle UG, Genton L, Hans D, Karsegard L, Slosman DO, Pichard C. Age-related differences in fat-free mass, skeletal muscle, body cell mass and fat mass between 18 and 94 years. Eur J Clin Nutr 2001; 55: 663-72.
30. Janssen I, Heymsfield SB, Wang ZM, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. *J Appl Physiol* 2000; 89: 81-8.
31. Francis P, Lyons M, Piasecki M, Mc Phee J, Hind K, Jakeman P. Measurement of muscle health in aging. *Biogerontology* 2017; 18: 901-11.
32. Narici MV, Maffulli N. Sarcopenia: characteristics, mechanisms and functional significance. *Br Med Bull* 2010; 95: 139–59.
33. Cao L, Morley JE. Sarcopenia is recognized as an independent condition by an International Classification of Disease, Tenth Revision, Clinical Modification (ICD-10-CM) code. *J Am Med Dir Assoc* 2016; 17:675- 7.
34. Jentoft AJ, Bahat G, Bauer J, et al. Writing Group for the European Working Group on Sarcopenia in Older People 2 (EWGSOP2), and the Extended Group for EWGSOP2. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing* 2019; 48: 16-31.
35. Zanker J, Sim M, Anderson K, et al. Consensus guidelines for sarcopenia prevention, diagnosis and management in Australia and New Zealand. *J Cachexia Sarcopenia Muscle* 2023; 14: 142-56.
36. Gonzalez-Freire M, de Cabo R, Studenski SA, Ferrucci L. The neuromuscular junction: aging at the crossroad between nerves and muscle. *Front Aging Neuroscience* 2014; 6: 208.
37. Luff AR. Age-associated changes in the innervation of muscle fibers and changes in the mechanical properties of motor units. *Ann N Y Acad Sci* 1998; 854: 92–101.
38. Henche SA, Torres RR, Pellico LG. An evaluation of patterns of change in total and regional body fat mass in healthy Spanish subjects using dual-energy X-ray absorptiometry (DXA). *Eur J Clin Nutr* 2008; 62: 1440-8.
39. Raguso CA, Kyle U, Kossovsky MP, et al. A3-year longitudinal study on body composition changes in the elderly: role of physical exercise. *Clin Nutr* 2006; 25: 573–80.
40. Kuk JL, Saunders TJ, Davidson LE, Ross R. Age-related changes in total and regional fat distribution. *Ageing Res Rev* 2009; 8: 339–48.