


# Bone Mineral Density Reference Values in 18- to 95-Year-Old Population in Lombardy Region, Italy

American Journal of Men's Health  
September-October 1–9  
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DOI: 10.1177/15579883221119363  
journals.sagepub.com/home/jmh  


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## Abstract

The aim of this study is to assess the bone mineral density (BMD) and *T*-score reference values in a population from 18 to 95 years old in Lombardy region, Italy. This study also investigates the association between BMD values and body mass index (BMI) divided by gender and age. The evaluation of BMD was analyzed by *T*-score and BMD in each site, femur, and column. A total of 10,503 patients (9,627 females and 876 males,  $65.04 \pm 12.18$  years) have been enrolled in this study. The women hip femur reference values associated with a situation of osteopenia highlighted in-line with the class of age of 45 to 55 years were: mean values:  $-1.3132$  *T*-score; 95% confidence interval (CI):  $-1.3600$  to  $-1.2664$  and of osteoporosis from the class of age 85 to 95 years, mean values:  $-2.6591$  *T*-score, 95% CI:  $-2.7703$  to  $-2.5479$ . The men hip femur reference values associated with a situation of osteopenia highlighted in-line with the class of age of 45 to 55 years were: mean values:  $1.2986$  *T*-score; 95% CI:  $-1.5454$  to  $-1.0518$ . A positive association between BMI and the two sites of BMD was recorded ( $p > .05$ ). This study provides an Italian overview of national and regional reference values about the BMD and *T*-score values divided by age and gender as reference values for clinicians for a correct assessment and monitoring.

## Keywords

osteoporosis, BMI, *T*-score, bone mineral density, obesity

Received December 23, 2021; revised July 4, 2022; accepted July 21, 2022

## Introduction

Osteoporosis is a progressive systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase of bone fragility and risk of fracture (Nutri et al., 2019). The most frequent osteoporotic fractures are those of the wrist, humerus, ribs, pelvis, spine column, and femur (Società Italiana dell'Osteoporosi, del Metabolismo Minerale e delle Malattie dello Scheletro, 2013).

These fractures can cause complex impairments, reduced quality of life, and functional limitation. Moreover, spine and hip fractures increase the relative risk of mortality in elderly people (Società Italiana dell'Osteoporosi, del Metabolismo Minerale e delle Malattie dello Scheletro, 2013).

In Italy, due to the increase in life expectancy and the consequently greater proportion of elderly people in the general population, osteoporosis and osteopenia represent a

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serious public health problem with high economic burden and health care costs (Marcellusi et al., 2020).

In Italy, 23% of women over 40 years old and 14% of men over 60 years old suffer from osteoporosis and these numbers are constantly growing, especially in relation to the increase in life expectancy. It is estimated that osteoporosis affects more than 5,000,000 people in Italy (*Osteoporosis*, n.d.).

The bone mineral density (BMD) reduction is due to menopause, nutritional deficiencies, some chronic diseases, and lack of exercise (Bian et al., 2015).

Many factors, such as the higher body mass index (BMI) could be considered a protection against osteoporosis because weight may increase mechanical loading on the skeleton, a mechanism known to stimulate bone formation (Reid, 2010; Zhao et al., 2008) and the lower incidence of hip fractures in obese subjects (Tang et al., 2013).

The aim of this study is to evaluate the reference values of BMD, and *T*-score on femur and column divided by age and gender in a population aged from 18 to 95 years screened in Lombardy, an Italian region in the North of Italy as secondary objective, this study investigates the association between BMD values and BMI by gender and age.

## Method

### Participants

The population was recruited from the dual-energy X-ray absorptiometry (DXA) unit of a Clinical Institute, in Lombardy region, Italy. Inclusion criteria are both sexes, age from 18 to 95 years old, and absence of diseases like cancer, endocrine diseases, and kidney diseases. This was a cross-sectional study approved by the ethics committee (approval number: 6723/22052019), and an individual written informed consent was obtained from each participant.

### Assessment of Anthropometric Parameters and Body Composition

Body weight was measured to the nearest 0.1 kg on an electronic scale, with subjects wearing light clothing and no shoes using a standardized method (Frisancho, 1984). BMD was measured by DXA with the use of a Lunar Prodigy DXA (GE Medical Systems).

### Statistical Analysis

Baseline data have been reported calculating the mean and 95% confidence interval (CI). Normal distribution of the data has been assessed by Kolmogorov–Smirnov test. The analysis of variance (ANOVA) was used to test the differ-

ences between subgroups for each class of BMI. Differences in BMD between all examined subjects, “for different classes of ages,” and the subgroups defined above were analyzed using unpaired ANOVA. The distribution of BMD has been characterized by its main parameters (*T*-score and BMD in each site, femur, and column). The *p*-values below .05 were considered significant. All statistical analyses were performed using the JASP package. Sample size was calculated. A total of 9,603 or more measurements are needed to have a confidence level of 95% that the real value is within  $\pm 1\%$  of the measured/surveyed value.

## Results

This study enrolled 10,503 patients, 9,627 females (91.66%) and 876 males (8.34%).

Table 1 includes the mean and the 95% CI for hip femur and entire femur (*T*-score and BMD) stratified by gender and class of age.

The mean reference values of L1 to L4 BMD, and of hip and entire femur stratified by gender and age subgroups are given in Figure 1. Figure 2 showed the mean reference values on hip and entire femur divided by gender and age subgroups. Between-group effect was  $p < .05$  for hip and total femur.

In women, the mean levels of the *T*-score (*T*s) of the entire femur ranged from  $-0.57$  *T*s by age  $\leq 45$  years to  $-2.510$  *T*s in women aged between 85 and 95 years.

In women, the *T*-score of the entire femur becomes indicator of osteopenia between the ages of 55 to 65 years, while it becomes indicative of osteoporosis from the age of 85 to 95 years.

As for the *T*-score values relating to the hip femur mean, the results show an average value of  $-0.90$  *t*s for age  $\leq 45$  years, up to a mean value of  $-2.65$  *t*s in women over 85 years of age. In this case, the *T*-score becomes indicator of osteopenia in a lower age group, on the class of age 45 to 55 years, and it became indicator of osteoporosis starting from 85 years. In men, the mean *T*-score value for the entire femur became indicator of osteopenia from age of 75 ( $-1.39$  *t*s), while it does not become an indicator of osteoporosis; in fact, the mean value in the older age group considered, 85 to 95 years, is  $-1.88$  *t*s.

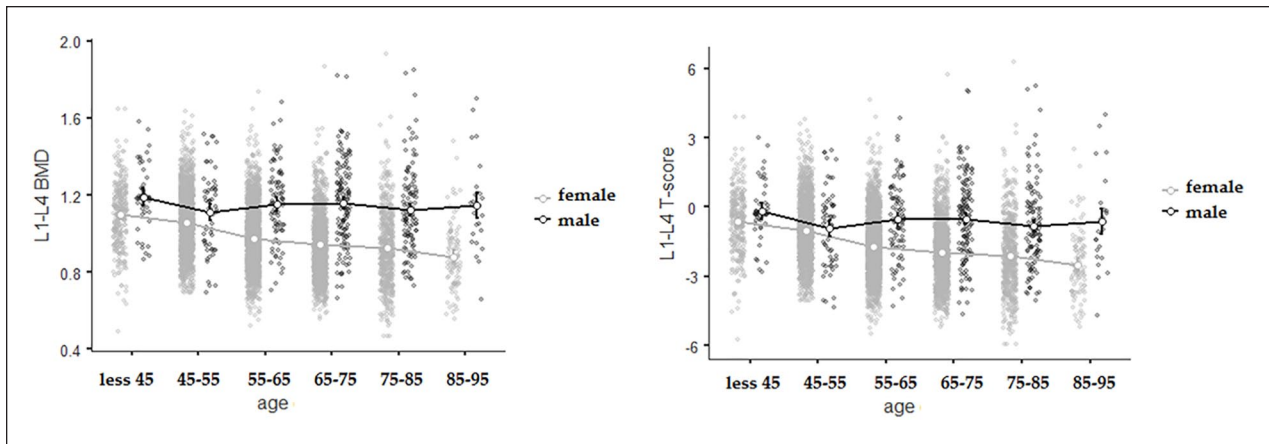
As for the *T*-score values relating to the hip femur mean in men, they became indicators of osteopenia in the age group from 45 to 55 years.

As shown in Table 2, concerning the vertebral column (L1–L4), in women, the average *T*-score value became indicative of osteopenia ( $-1.69$  *t*s) by class of age from 55 to 65 years, with an average value of BMD of 0.9761; while the *T*-score value became indicative of osteoporosis at the mean level of  $-2.13$  *t*s in the age group from 75 to 85 years with a mean value of BMD of 0.92 *t*s.

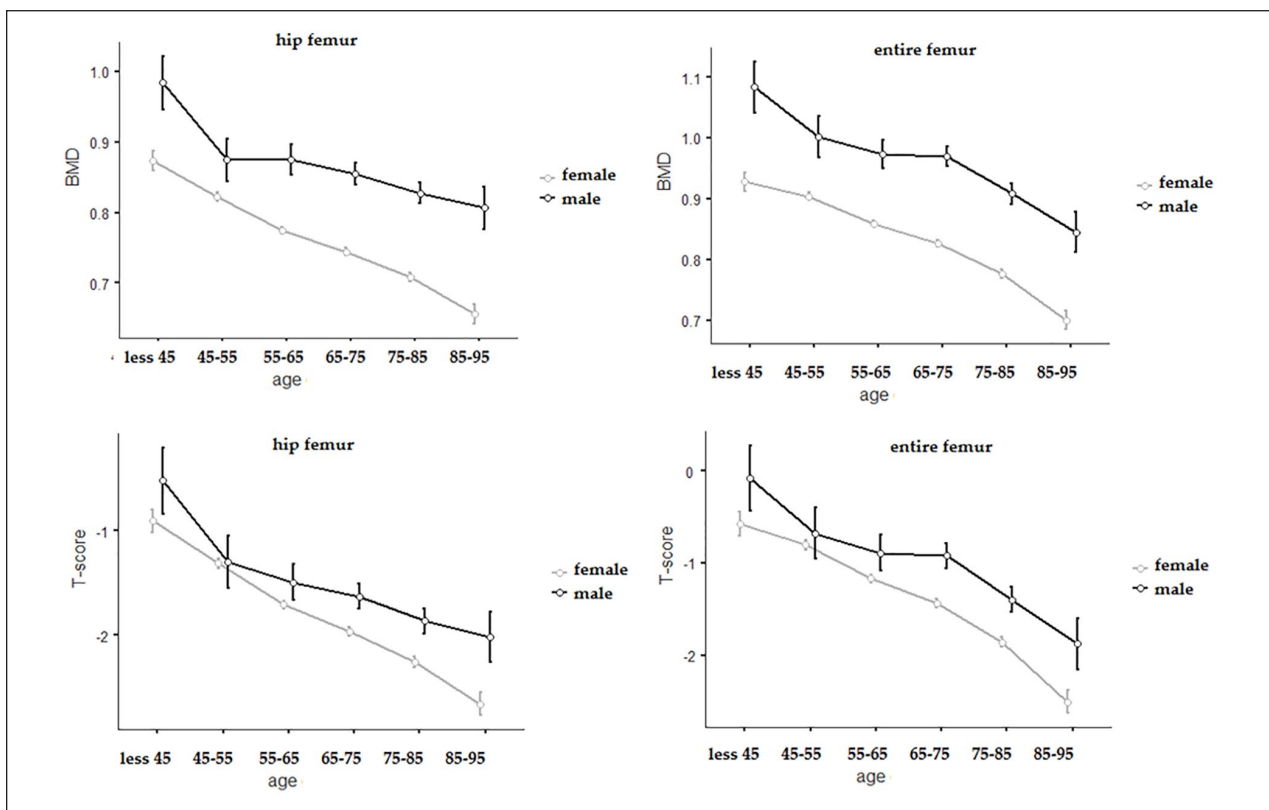
**Table 1.** Mean and 95% Confidence Interval for Hip Femur and Entire Femur (T-Score and Bone Mineral Density) Stratified by Gender and Class of Age.

Gender	Age	Mean: hip femur BMD M (95% CI)	Mean: entire femur BMD M (95% CI)	Mean: hip femur T-score M (95% CI)	Mean: entire femur T-score M (95% CI)
Female	45 years and less	0.8732 (0.8598–0.8867)	0.9276 (0.9127–0.9424)	-0.9055 (-1.0173 to -0.7938)	-0.57718 (-0.7029 to -0.4514)
	45 to 55 years	0.8225 (0.8167–0.8284)	0.9038 (0.8974–0.9102)	-1.3132 (-1.3600 to -1.2664)	-0.80264 (-0.8554 to -0.7499)
	55 to 65 years	0.7749 (0.77004–0.7794)	0.8593 (0.8543–0.8643)	-1.7071 (-1.7434 to -1.6707)	-1.17269 (-1.2136 to -1.1318)
	65 to 75 years	0.7444 (0.7394–0.7494)	0.8267 (0.8212–0.8321)	-1.9612 (-2.0012 to -1.9213)	-1.44201 (-1.487 to -1.397)
	75 to 85 years	0.7083 (0.7019–0.7146)	0.7766 (0.7696–0.7836)	-2.2541 (-2.3051 to -2.2031)	-1.8586 (-1.916 to -1.8012)
Male	85 to 95 years	0.6555 (0.6417–0.6693)	0.6995 (0.6842–0.7147)	-2.6591 (-2.7703 to -2.5479)	-2.51004 (-2.6352 to -2.3849)
	45 years and less	0.9837 (0.9457–1.0217)	1.0835 (1.0413–1.1257)	-0.5178 (-0.8348 to -0.2008)	-0.07956 (-0.4352 to 0.2761)
	45 to 55 years	0.8747 (0.8445–0.9409)	1.0017 (0.968–1.0354)	-1.2986 (-1.5454 to -1.0518)	-0.67959 (-0.9564 to -0.4027)
	55 to 65 years	0.8753 (0.8541–0.8965)	0.9736 (0.9503–0.9969)	-1.4938 (-1.6645 to -1.3232)	-0.89155 (-1.083 to -0.7001)
	65 to 75 years	0.8549 (0.8397–0.8700)	0.9694 (0.9528–0.9861)	-1.6262 (-1.7485 to -1.504)	-0.92283 (-1.0597 to -0.786)
	75 to 85 years	0.8276 (0.813–0.8423)	0.9078 (0.8916–0.9239)	-1.8626 (-1.9808 to -1.7445)	-1.39999 (-1.5328 to -1.2672)
	85 to 95 years	0.8066 (0.7766–0.8366)	0.8446 (0.8114–0.8778)	-2.0191 (-2.2604 to -1.7777)	-1.881 (-2.1537 to -1.6082)

Note. BMD = bone mineral density.



**Figure 1.** Mean Reference Values of L1 to L4 BMD Divided by Gender and Age Subgroups. Between-Group Effects ( $p < .05$ ).



**Figure 2.** Mean Reference Values on Hip and Entire Femur Divided by Gender and for Age Subgroups. Between-Group Effects ( $p < .05$ ).

In men, the spine  $T$ -score (L1–L4) did not become indicative of osteoporosis at any of the ages considered and the mean BMD values remain above 1 in all age groups, including subjects older than 85 to 95 years. As shown in Figure 3, there is a positive association between BMI with column, entire femur, and hip femur BMD.

Table 3 shows the prevalence of osteoporosis in men and women aged from 18 to 95 years.

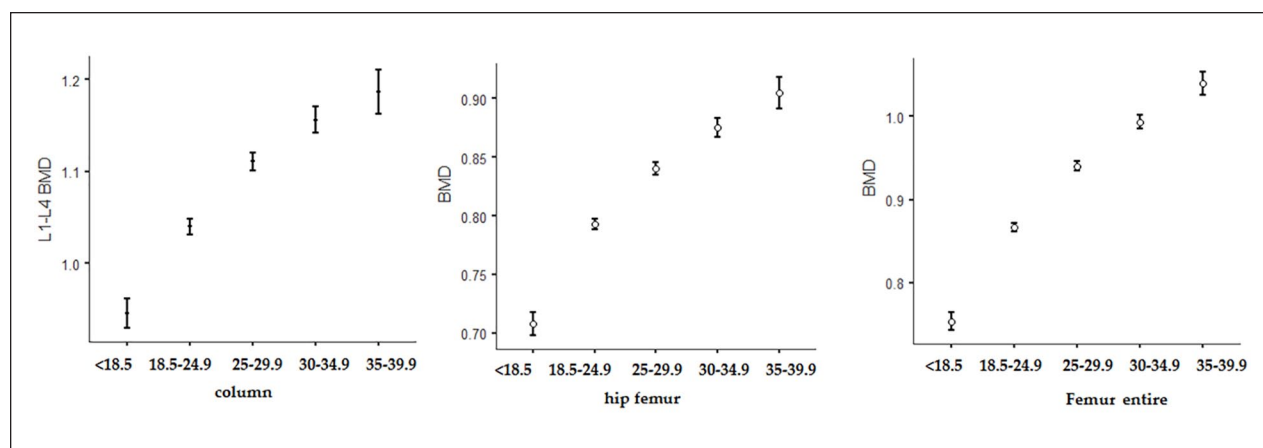
### Discussion

For the first time in literature, this study assessed the reference values of BMD and  $T$ -score for an Italian

**Table 2.** Mean and 95% Confidence Interval for Columns L1–L4 (T-Score and Bone Mineral Density) Stratified by Gender and Class of Age.

Gender	Age	Mean: L1 to L4 BMD M (95% CI)	Mean: L1 to L4 T-score M (95% CI)
Female	45 years and less	1.0969 (1.078–1.157)	–0.634 (–0.797 to –0.47103)
	45 to 55 years	1.0605 (1.0522–1.0688)	–0.9962 (–1.0655 to –0.92684)
	55 to 65 years	0.9761 (0.9691–0.9831)	–1.6985 (–1.757 to –1.64004)
	65 to 75 years	0.9432 (0.9344–0.9521)	–1.9731 (–2.0469 to –1.89935)
	75 to 85 years	0.9243 (0.9103–0.9382)	–2.1331 (–2.2489 to –2.01733)
	85 to 95	0.8812 (0.8492–0.9132)	–2.50 (–2.7565 to –2.22357)
Male	45 years and less	1.1908 (1.1478–1.2338)	–0.1774 (–0.5452 to 0.19042)
	45 to 55 years	1.1103 (1.068–1.1525)	–0.9144 (–1.266 to –0.5628)
	55 to 65 years	1.1539 (1.1196–1.1882)	–0.5468 (–0.8322 to –0.26135)
	65 to 75 years	1.1587 (1.1305–1.1869)	–0.5112 (–0.746 to 0.27633)
	75 to 85 years	1.1222 (1.0915–1.1529)	–0.8121 (–1.0674 to –0.55676)
	85 to 95	1.1465 (1.0809–1.2122)	–0.6121 (–1.1587 to –0.0655)

Note. BMD = bone mineral density.

**Figure 3.** Mean Reference Values on L1 to L4 and Femur by Gender and Stratified for BMI Subgroups. Between-Group Effects ( $p < .05$ ).**Table 3.** Prevalence of Osteoporosis in Men and Women From 18 to 95 Years.

Class of age	L1 to L4 % prevalence osteoporosis in men	L1 to L4 % prevalence osteoporosis in women	Hip femur % prevalence osteoporosis in men	Hip femur % prevalence osteoporosis in women
45 years and less	No data, $n < 5$	8.5	No data, $n < 5$	6.2
45–55 years	No data, $n < 5$	12.3	16.7	9.8
55–65 years	13.6	27.0	22.5	18.8
65–75 years	13.1	35.5	22	28.1
75–85 years	18.2	42.8	33.3	41.3
85–95	No data, $n < 5$	53.5	43.5	62.5
Total sample	14.4	26.2	26.4	24.2

population from 18 to 95 years located in Lombardy region, Italy.

This study found that women were associated with a situation of osteopenia starting from 45 to 55 years and osteoporosis from the class of age of 85 to 95 years.

In addition, the cohort of men was associated with a situation of osteopenia from age of 45 to 55 years, but none of the class of age was associated with osteoporosis.

Osteoporosis is often considered a female disease, typical of postmenopausal women; in women, there are factors associated with an increased risk of fracture related to osteoporosis. These include general factors that refer to aging, such as lack of sexual steroids, lifestyle, smoking habit, lack of nutritional factors, and specific risk factors, such as the use of glucocorticoids that cause reduced bone formation, reduced bone quality, and disruption of microarchitecture integrity (Riggs et al., 1982).

Men are screened less and more frequently undertreated than female patients (Diab & Watts, 2021; Mendoza et al., 2019). On average, men have hip fractures about 10 years later in life than women, and due to old age, they may have more comorbidity at the time of fracture. In the study of Bliuc et al., it is noted that 25% to 35% of older men die within a year of a hip fracture, about twice the percentage of women, and among those who survive, there is a lower probability of regaining independence, compared to women (Bliuc & Center, 2016). Thus, while fracture incidence is lower in men than in women, the fracture consequences are greater. This means that an appropriate diagnosis must be made in all patients (women and men) to better identify fracture risk and possible treatment resulting in fewer fractures, lower mortality, and very likely less money spent on health care (Adler, 2018).

A positive association between BMI, and with femur and column BMD levels was recorded in men showing a possible protective effect of higher BMI on osteopenia and osteoporosis.

An adequate nutritional status is essential to achieve and maintain optimal bone mass, and dietary approaches can be an important strategy for the prevention of osteoporosis, so that, a specific dietary approach can represent an important modifiable environmental factor for the prevention of osteoporosis (Sahni et al., 2015). Indeed, calcium and vitamin D are considered the primary nutrients for the prevention of osteoporosis in the elderly. However, vitamins (A, B, C, E, and K), minerals (potassium, magnesium, and silicon), and macronutrients (proteins and fats) can also contribute to skeletal health by supporting both bone matrix production and mineralization (Sahni et al., 2015).

Differences in the severity of osteoporosis across Europe, suggesting a lower incidence of the disease in the Mediterranean area, have been reported (Prentice, 2004).

One of the most accredited hypotheses for this association suggests that the protective effects of mediterranean diet (MD) are mediated by the anti-inflammatory properties of beneficial compounds, such as polyphenols, which are largely present in Mediterranean foods, such as vegetables, fruit, and extra virgin olive oil, the main source of MD fats (Tresserra-Rimbau et al., 2014).

The importance to have reference values could lead to an early identification of frail people (especially postmenopausal women) at increased risk of developing osteoporosis and fragility fractures could reduce the economic and social cost of osteoporosis in terms of mortality and morbidity due to fractures (Cauley et al., 2000; D'Amelio et al., 2013).

The current study describes the reference values of BMD in the range of the female and male population aged between 18 and 95 years in the Lombardy (an Italian region) in relation to BMD, BMI, and age. A greater amount of lean mass and subcutaneous fat improves bone biomechanics, stimulating osteoblasts, and bone cells, and may indicate less BMD change during the process of aging (Coin et al., 2000).

The results show that in women, the value of *T*-score relative to the entire femur becomes indicative of osteopenia between the ages of 55 to 65 years, while it becomes an indicator of osteoporosis from the age of 85 to 95 years. As for men *T*-score values relating to the hip femur mean, it becomes an indicator of osteopenia in a lower age group between 45 and 55 years, and becomes an indicator of osteoporosis starting from 75 years.

These results are consistent with the observations of D'Amelio et al. (2013), who highlighted that osteoporotic women were generally older, with a lower BMI than normal subjects and with underwent a shorter period of estrogen exposure. The Epidemiologic Study on the Prevalence of Osteoporosis (ESOPO) on which the notebooks of the Ministry of Health for Osteoporosis are based, investigated the prevalence of osteoporosis and osteopenia in Italy; it was reported that the prevalence of osteopenia and osteoporosis among women was 44.7% and 18.5%, respectively, while in men, it was 36% and 10%, respectively.

The prevalence of both conditions was therefore higher in women and significantly increased with age; these results are consistent with the results obtained in the current study, in which the hip femoral *T*-score values mean in men become indicators of osteopenia in the age group of 45 to 55 years and never indicative of osteoporosis in the older age group of 85 to 95 years. In men, the average *T*-score value for the entire femur becomes indicative of osteopenia starting from the age of 75 years, while it does not become an indicator of osteoporosis.

Considering the average values of BMD, our results show that in women, there is a reduction with age and in relation to osteoporosis. The reduction in BMD is also observed in men in relation to age, and the *T*-score of the hip and whole femur, but the reduction observed is lower than in women.

These results are in line with what is reported by Cipriani et al. (2018), where the prevalence of osteoporosis is highlighted in postmenopausal Italian women aged 50 years and over, focusing both on measuring BMD and evaluating other factors, which define the risk of fracture and which have been included in the definition of osteoporosis.

The current results are consistent with the data reported by Gjesdal et al. (2004), who identified a significant reduction in BMD of the entire femur and trochanter in elderly men and women. The prevalence of osteoporosis among middle-aged women was 0.8%, while it was 20.7% in elderly women; in addition, in subjects over 50 years of age, osteoporosis was generally more frequent in women than in men, as reported by Looker et al. (1997) and Tenenhouse et al. (2000).

The results of the current analysis are also in agreement with the study conducted by Ho-Pham et al. (2010) where 58.5% of men and 51% of women were over the age of 50 years and, as expected, BMD in men was 12% higher than in women at the femoral neck and 7% at the level of the lumbar spine. Whereas, the prevalence of osteoporosis in postmenopausal Asian and Caucasian women is approximately 29% and 20 to 25%, respectively (Limpaphayom et al., 2001; Nguyen et al., 2000). Vietnamese women peak BMD at the age of 27 to 29 years, while Caucasian women first at the age of 20 to 25 years. The factors underlying this apparent difference cannot be determined, but it is known that Asian girls tend to have a late menarche compared to Caucasian girls (13 vs. 12 years).

Individuals with greater lean mass generally have a more active lifestyle, with more adequate nutritional habits that may have a direct impact on bone health (Pluijm et al., 2001).

**Body composition.** Particularly, the lean and fat mass tissue in older men is positively associated with BMD at all body sites (arms, legs, and trunk) (Alonso et al., 2018). Body composition changes significantly in older individuals, including increase and redistribution of adipose tissue; this distribution progressively increases in the abdominal cavity and is less in the limbs. Although fat mass also had positive relationships in all sites, this is not the most appropriate way of improving bone quality. Higher levels of visceral fat reduce muscle mass and increase fragility and risk of fracture through intramuscular fat infiltration (Song et al., 2014; Zhang et al., 2015).

This study provides Italian national and regional reference values about the BMD and *T* score values divided for age and gender divided as reference for clinicians for a correct assessment and monitoring overtime.

The main limitation of this study is that it is a photograph of a specific region of Italy and therefore cannot necessarily be extended to other realities. Furthermore, it would have been interesting to consider the fracture risk of the subjects considered in the study. Another important limitation of this study is that other skeletal sites, a part of hip femur and column, were not available. The study was part of a larger study on body composition and, so that, only a whole-body DXA scan using standard protocol was performed (without considering other surrogate measures detected by other instruments). Only site-specific scans of the femoral neck and the hip region were performed.

### Author Contributions

Conceptualization, M.R. and S.P.; methodology, S.P.; software, S.P. and Ga.P.; formal analysis, S.P.; investigation, Ga.P. and C.G.; writing—original draft preparation, C.G. and F.P.; writing—review and editing, M.A.F. and M.N.; visualization, A.R. and Gi.P.; supervision, M.R. All authors have read and agreed to the published version of the manuscript.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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