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The Assessment of the Bone Quality with Low Back Pain

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Abstract

The aim of this study was to measure osteoporosis in the right heel bone. A total of 123 Iraqi men and women with low back pain (LBP) participated in the study (18 males and 105 females). Quantitative Ultrasound (QUS) was used to assess osteoporosis, speed of sound (SOS), broadband ultrasound attenuation (BUA), and calcaneus bone quality index (BQI). A dual x-ray absorptiometry (DXA) was used to determine tissue thickness, fracture risk factor, and abdominal fat percentage. The results indicate that SOS was 1495.43±18.780 m/sec. Participants had a Z-score of -1.10±1.56. The fracture risk factor for participants was 1.622± 1.90 when DXA measurements were taken. Low back pain measurements revealed that the age group between 51-60 years had the highest prevalence. The correlation between the T-score and the calcaneal SOS is a linear relationship with a P-value of 0.0001. When we examine the relationship between the Z-score and the calcaneal BUA, we see that it is linear and statistically significant (P-value less than 0.0001). The correlations between calcaneal BQI and BMI, as well as between calcaneal BUA and tissue thickness, were found to be statistically insignificant (P-value = 0.8 and 0.8, respectively). The correlation between calcaneal SOS and abdominal fat percent appears to be statistically significant (P-value=0.05) (linear correlation is weak).

Keyword: Quantitative ultrasound (QUS), Dual X-ray absorptiometry (DXA), Speed of Sound (SOS), Bone Quality Index (BQI), Broadband Ultrasound Attenuation (BUA).

تقييم جودة العظام مع آلم أسفل الظهر

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الخلاصة:

كأن الهدف من الدراسة هو قياس هشاشة العظام في عظام الكعب ا ليمنى. شارك في الدراسة مجموعة 123 رجلاً وامرأة عراقيين يعانون من آلم أسفل الظهر(LBP) (18 ذكور و 105 إناث). تم ا ستخدم الموجات فوق الصوتية الكمية (QUS) لتقييم هشاشة العظام، وسرعة الصوت (SOS)، وتوهين بالموجات فوق الصوتية ذات النطاق العريض (BUA)، ومؤشر جودة عظام العقدة (BQI). تم استخدام مقياس امتصاص الأشعة السينية المزدوج (DXA) لتحديد سمك الأنسجة وعامل خطورة الكسر ونسبة الدهون في البطن. تشير النتائج الى أن SOS كأن 1495.43±18.780m/se . حصل المشاركون على Z-score 1.56±1.10.- كأن عامل خطر الكسر للمشاركين 1.90 ±1.622 عندما تم أخذ قياسات DXA. اظهرت قياسات آلم أسفل الظهر أن الفئة العمرية بين 51−60 سنة كانت أعلى انتشاراً. العلاقة بين T-score و calcaneal SOS هي علاقة خطية P-value تبلغ قيمتها 0.0001 . عندما نفحص العلاقة بين Z-score و calcaneal BUA، نرى انها خطية وذات دلالة إحصائية (P-value أقل من 0.0001). تم العثور على الارتباطات بين calcaneal BQI و BMI، وكذلك بين calcaneal BQI وسمك الأنسجة، ليس لها دلالة احصائية (على التوالى، P-value=0.8,0.8). ظهر أن العلاقة بين calcaneal SOS ونسبة الدهون في البطن ذات دلالة احصائية (P-value=0.05) (الارتباط الخطي ضعيف).

الكلمات المفتاحية : الموجات فوق الصوتية الكمية (QUS)، سرعة الصوت (SOS)، التوهين بالموجات فوق الصوتية ذات النطاق العريض (BUA)، مؤشر جودة العظام (BQI)، قياس امتصاص الأشعة السينية المزدوج (DXA).

1. Introduction

Osteoporosis is correlated with a decrease in bone mineral density (BMD), tissue microarchitecture degradation, and a slow or stop in bone repair and growth [1]. The difference can be observed between the osteoporosis and bone normal as in Fig 1. Fragility fractures are known to cause severe pain, disability, emotional distress, and financial hardship, putting a strain on the healthcare system [2]. In clinical practice, DXA is used to diagnose osteoporosis. Where scans the entire body or a specific region of interest with x-rays at two distinct energy levels to produce a two-dimensional picture of BMD. The amount of mineral deposit per square in the bone is defined as the BMD [3]. The use of DXA to screen for bone health is limited due to the machine's cost, size, and technical requirements, despite the fact that it is successful in identifying people with low BMD. Ionizing radiation is used during, but only in small amounts [4]. QUS has been found as a new method for evaluating bones QUS. This method is widely used to screen for osteoporosis because of its low cost and low dose [5]. Broadband ultrasound attenuation (BUA) and speed of sound (SOS) are two QUS parameters that have been used to predict BMD and mechanical properties of bone like elasticity and strength [6]. It has been found that ultrasonic waves applied to the skin through a gel using a specific transducer will travel along with the bones, and it has been shown that the SOS is related to the quality of the bones. Where measurement the heel, radius, and tibia [3]. The technique QUS measurements at the heels were found to be higher than measurements taken at other anatomical sites. As it bears body weight and has a high concentration of trabecular bones, the calcaneus is the only anatomical site that has been validated for examining bone mass using QUS [6]. Low back pain (LBP) is characterized by discomfort, muscle tension, or stiffness in the region

of the vertebrae in the lower back, which may or may not be accompanied by leg pain (sciatica). [7]. LBP is a common complaint among the elderly, and it is caused by a degenerative process known as spinal degeneration, which manifests itself most prominently in the low back. Some psychological and social factors can cause LBP, such as the presence of psychological conditions, the use of maladaptive coping strategies, low job satisfaction, increased physical demands, poor general health or functional level, smoking, obesity, and other chronic pain risk factors [8]. LBP is more common in women than in men. In comparison to males, females are disproportionately affected by a variety of chronic pain issues and painful musculoskeletal conditions. According to the bio psychosocial model of chronic pain, sex differences in chronic pain are attributed to interactions. The biological response to pregnancy and childbearing, the physical stress of childrearing, and the increase in menopausal abdominal weight are all factors that contribute to LBP [7]. It caused by osteoarthritis in both men and women over 50. Considered osteoarthritis is a type of spine degeneration marked by narrowing of the intervertebral disc, the formation of osteophytes, and facet joint degeneration. [8]. Studies have shown that establishing a definitive relationship between bone density and back pain in the context of aging is difficult due to potentially vexing variables such as increased prevalence of degenerative and structural changes in the spine, accelerated bone loss due to low estrogen levels, and difficulty diagnosing spinal fractures [9]. Bones are made up of living tissue that is both strong enough to support our bodies and flexible enough to avoid breaking when we are injured. The two basic types of bones are the cortical bone, which forms the outer shell, and the trabecular bone, which forms the honeycomb-like mesh inside the cortex, as shown in Fig. 2. When loads are applied to the trabecular bone, it provides structural support while also allowing the bone to be flexible [10]. The aim of study, measure osteoporosis of the right foot bone at the heel (calcaneus) using the technique QUS with low back pain.

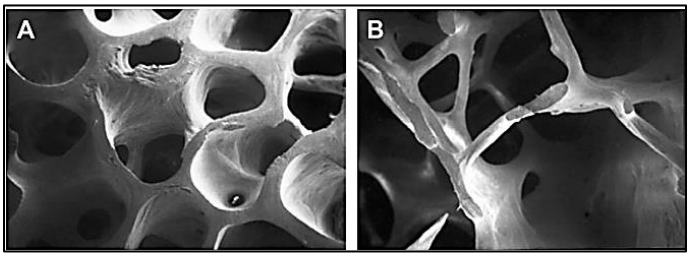

Figure 1. Normal and osteoporotic bone micrographs.(A) Ordinary bone(B) Osteoporosis of the bone

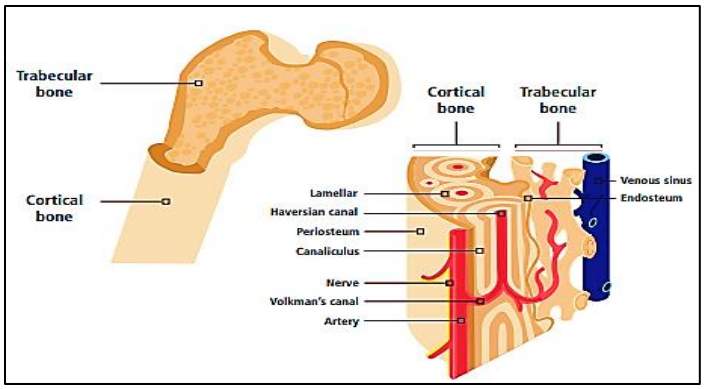

Figure 2. Bone structure [10].

2. Quantitative Ultrasound

Ultrasound is a safe technique for assessing osteoporosis because it is free of ionizing radiation. The SOS and BUA are the two most important parameters of QUS. Other metrics, such as the stiffness index (SI) and quantitative ultrasonic index (QUI), as well as the amplitude-dependent speed of sound (AD-SOS), have been introduced by integrating BUA and SOS to improve the precision and estimation of BMD [12]. This study used BQI, which combines SOS and BUA. The signal transit time ($\Delta t, \sec$), and sample thickness (x, m) are used to calculate ultrasound velocity (VOS) or SOS, which is expressed as ($SOS = x/t$) at unit m/sec. The Speed of ultrasound waves passing through the medium can be defined as follows: $V = \sqrt{E/\rho}$. Where (E) Young's coefficient of the medium (N/m^2) and (ρ) is the medium density (kg/m^3). BUA is the second QUS parameter, and it found the relationship between attenuation of ultrasound and frequency is linear as shown in Fig. 3. The slope of the line represents the BUA (dB/MHZ), it can be used to assess fracture risk. Fig. 3 shows procedures for measuring and calculating BUA. The attenuation at a frequency (f) is given as follows as in Eq. 1: [12].

$$Attenuation\ (f) = 20log_{10}[A_{ref}(f)/A_s\ (f)] \quad (1)$$

Where $A_{ref} and\ A_s$ represent the reference ultrasound signal amplitude through water and the ultrasound output signal amplitude through the heel.

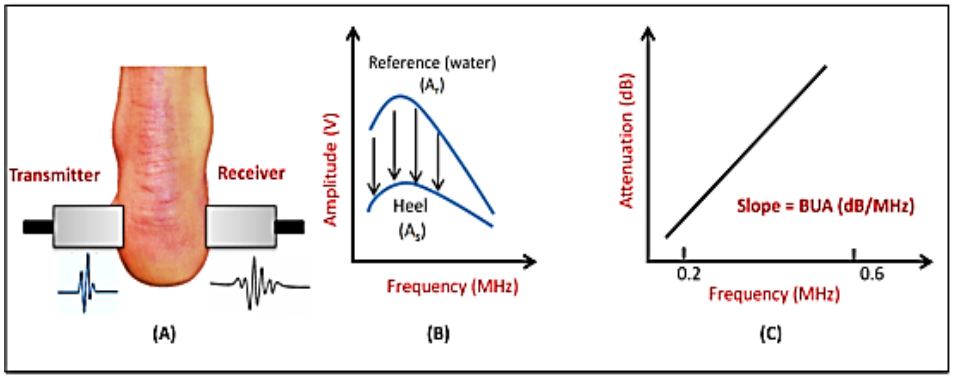

Figure 3. Schematic images showing the BUA measurement and calculation, (A) placement of ultrasound transducers in the heel. (B) Amplitude spectra of the reference signal through water (A_{ref}) and the output signal through the heel (A_s). (C) Attenuation-frequency [12].

Calcaneal (heel) has a high metabolic rate and a lot of trabecular bone; it is the best place to measure QUS parameters in the ratio of 90%. The calcaneus is also easy to get to because has two surfaces that are almost parallel and flat, the heel (calcaneus) region measured by QUS can be observed as in Fig. 4. This makes it easier for the transducers to make good contact with the heel and reduces the risk of repositioning errors. Unlike the spine and femur, the calcaneus has only a small amount of soft tissues that cover it. These include mostly skin and subcutaneous tissues. There are other parts of the body where QUS parameters can be measured. For example, one can measure the phalanges, the tibia, and the radius [12].

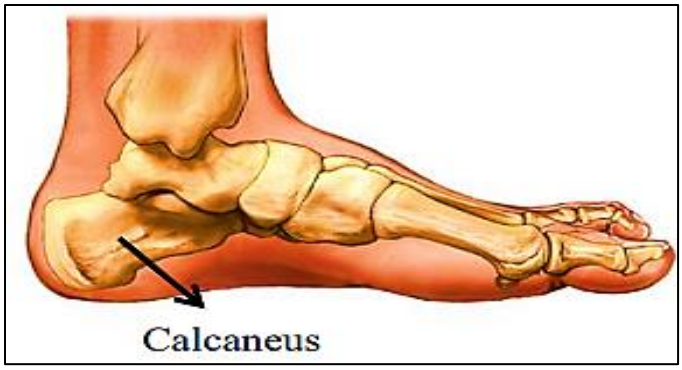

Figure 4. A image of the human foot bone (calcaneal bone) [12].

3. Research Method

The study was conducted in an osteoporosis screening clinic at a medical complex (Adam complex2) in Mosul City, Nineveh Governorate, Iraq. The study spanned studying between October 2021 and February 2022. The study enrolled 123 individuals, with 18 males and 105 females. Osteoporosis was diagnosed by assessing bone quality at the calcaneus (heel) of the right foot bone using QUS (SONOST 3000 OsteoSys). We collected anthropometric data, including weight, height, and body mass index (BMI). The body weight (Kg) was determined with the aid of a highly sensitive digital scale. A stadiometer was used to determine the individual's height (m). BMI is calculated as the ratio of (weight/height2) to (kg/m2). The World Health Organization classifies people with a BMI of less than 18.5 as underweight, 18.5–25 as normal, 25–30 as overweight, and 30.0 and above as obese.

Patients were asked about their history of LBP prior to the examination. When the QUS device stopped, it was calibrated using a calibration device, as shown in Fig. 5; the purpose of the calibration work is to activate the QUS . When the exam started, a gel was applied to the heel and the foot was put into the QUS device as shown in Fig. 6. SOS, BUA, BQI, T-score, and Z-score were measured using the QUS technique. The examination lasted between 5 and 10 minutes. In addition, DXA was used to measure tissue thickness, abdominal fat percentage and the patient's fracture risk factor. The examination results are presented in the form of two scores: the T-score and the Z-score. The T-score, which is inversely related to fracture risk, has been used to diagnose osteoporosis in the elderly, postmenopausal women, and men over the age of 50. The Z-score is used to detect low bone mass in children and young adults [13]. The T-score represents the difference between the patient's BMD and the mean BMD of a young adult of the same gender as in Eq. 2. The Z-score represents the difference in BMD between patients and the mean BMD of other people of the same age and gender as in Eq. 3. The T-score was classified using World Health Organization (WHO) criteria: Ordinary (-1.0 and above), osteopenia between (-1.0 to -2.5), and osteoporosis (below-2.5) [14,15]. The T-score and Z-score formulas are given as:

$$T - score = \frac{measured\ BMD - mean BMD_{of\ young\ healthy\ reference\ group}}{Standard\ Devitation} \quad (2)$$

$$Z - score = \frac{measured\ BMD - mean\ BMD_{of\ age-matched\ reference\ group}}{Standard\ Devitation} \quad (3)$$

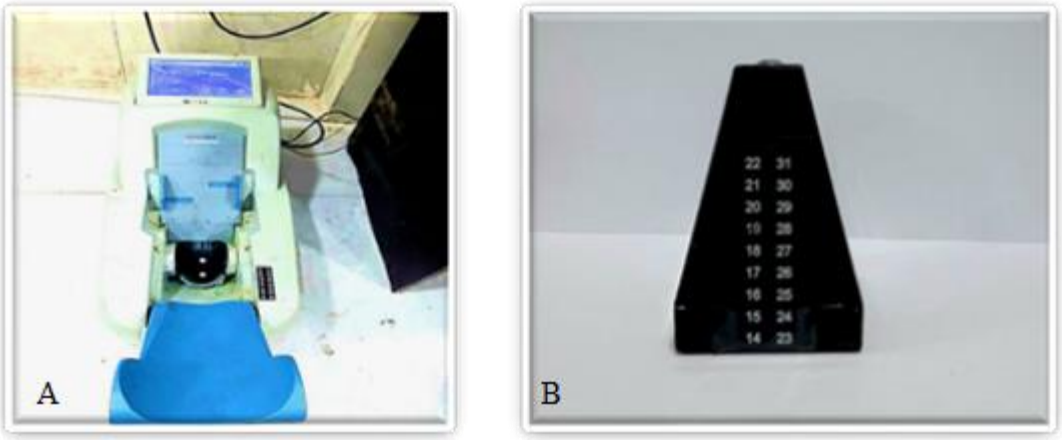

Figure 5. (A) Quantitative ultrasound device calibration, (B) Calibration device.

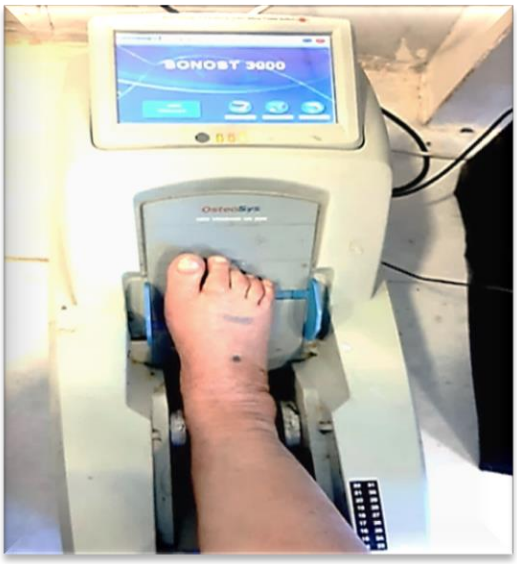

Figure 6. QUS was used to assess bone quality at the heel of the right foot.

3. Results

The SOS of the participants was 1495.43±18.780 m/sec (95% confidence interval (CI) = 1492.07-1498.78), as shown in Table 1 display the SOS measurements. Females seemed to have the highest SOS measurements of 1506.97 ± 11.31 in the age range of 31–40 years, while males had the highest SOS measurements of 1523.40 ± 58.54 in the same age range. The lowest SOS measurements for females were 1479.00±15.74 for the age period 71-80 years, while the lowest SOS measurements for males were 1480.15±8.41 in the age period 41-50 years. It turns out that the results of the SOS tests had a P-value greater than 0.05, which means that these results aren't important, the result can be shown in Fig. 7.

Table 1. SOS measurements.

Age range	SOS (m/sec)			P-value
	Female	Male	Total	
21-30	1503.30±11.03	1489.95±5.02	1496.63±10.41	0.2
31-40	1506.97±11.31	1523.40±58.54	1511.08±25.27	0.4
41-50	1500.29±17.02	1480.15±8.41	1498.37±17.35	0.1
51-60	1498.71±20.20	1502.20±19.73	1499.23±19.95	0.6
61-70	1488.81±13.35	1491.67±9.95	1489.07±12.98	0.7
71-80	1479.00±15.74	1480.60±1.69	1479.32±13.91	0.8

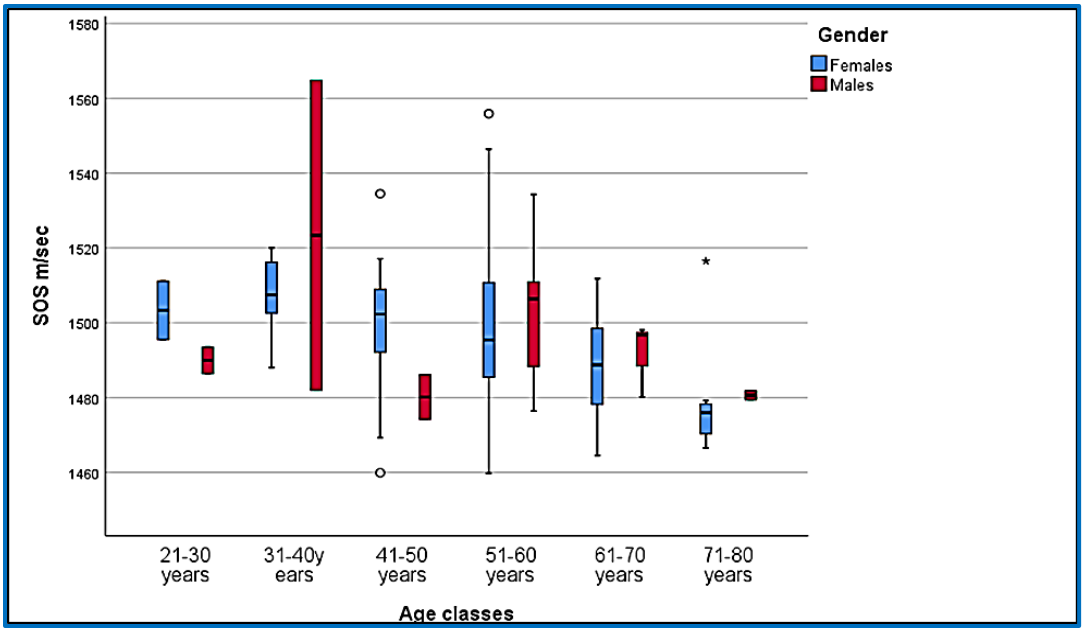

Figure 7. A graphic showing SOS for both genders according to age groups.

The participants' Z-score was -1.10±1.56 (95% CI = -1.39 ± 0.81. The Z-score measurements for both genders and age groups are shown in Table 2. Whereas females had the highest value of Z-score measurements at -0.73±1.789 for the age group 51-60 years, males had the highest value of Z-score measurements at 0.45±4.59 for the age group 31-40 years. Females had the lowest Z-score measurements of -2.06±1.299 for the age range 71-80 years, while males had the lowest Z-score measurements of -2.25±0.495 for the same age range. The results were obtained for all groups with a P-

value greater than 0.05, indicating that the results were not statistically significant, the result can be show in Fig. 8.

Table 2: Z-score measurements for both genders according to age.

Age classes years	Z-score			P-value
	Female	Male	Total	
21-30	-1.20±0.424	-2.05±0.212	-1.62±0.56	0.1
31-40	-1.18±0.608	0.45±4.59	-0.77±1.96	0.3
41-50	-0.99±1.196	-2.70±0.849	-1.16±1.25	0.6
51-60	-0.73±1.789	-0.04±1.936	-0.63±1.80	0.3
61-70	-1.32±1.238	-1.43±1.973	-1.33±1.27	0.8
71-80	-2.06±1.299	-2.25±0.495	-2.10±1.16	0.8

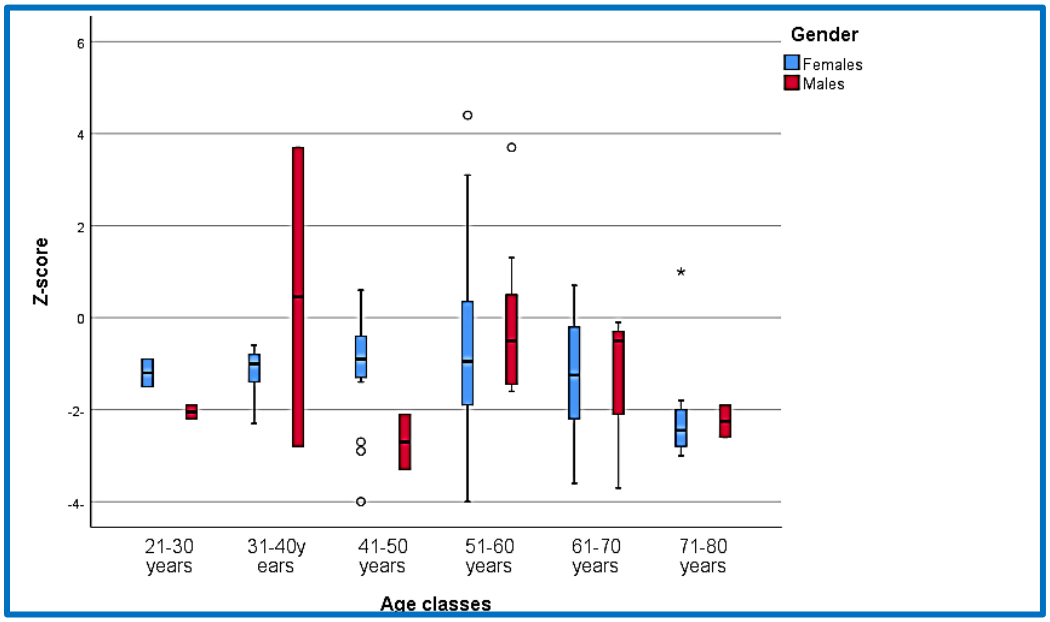

Figure 8. Z-score with age according to the gender.

The fracture risk factor of the participants was 1.622± 1.90. The fracture risk factor measurements for male and female participants can be distributed as shown in Fig. 9. Through the figure, we deduced that as age increases for males and females, the fracture risk factor also increases, indicating a line relationship between age and fracture risk factor. This means that there is no statistical significance in measuring fracture risk factors. The P-value for all groups of people is greater than 0.05, which means there is no statistical significance, the result can be shown in Table. 3.

Table 3. Fracture risk factor of both genders male and female.

Age classes years	Fracture risk factor			P-value
	Female	Male	Total	
21-30	-	-	-	-
31-40	0.01	0.11	.04.08	0.1
41-50	0.22	0.24	0.22	0.8
51-60	0.89	0.45	0.82	0.09
61-70	3.27	3.54	3.29	0.8
71-80	4.58	2.12	4.08	0.1

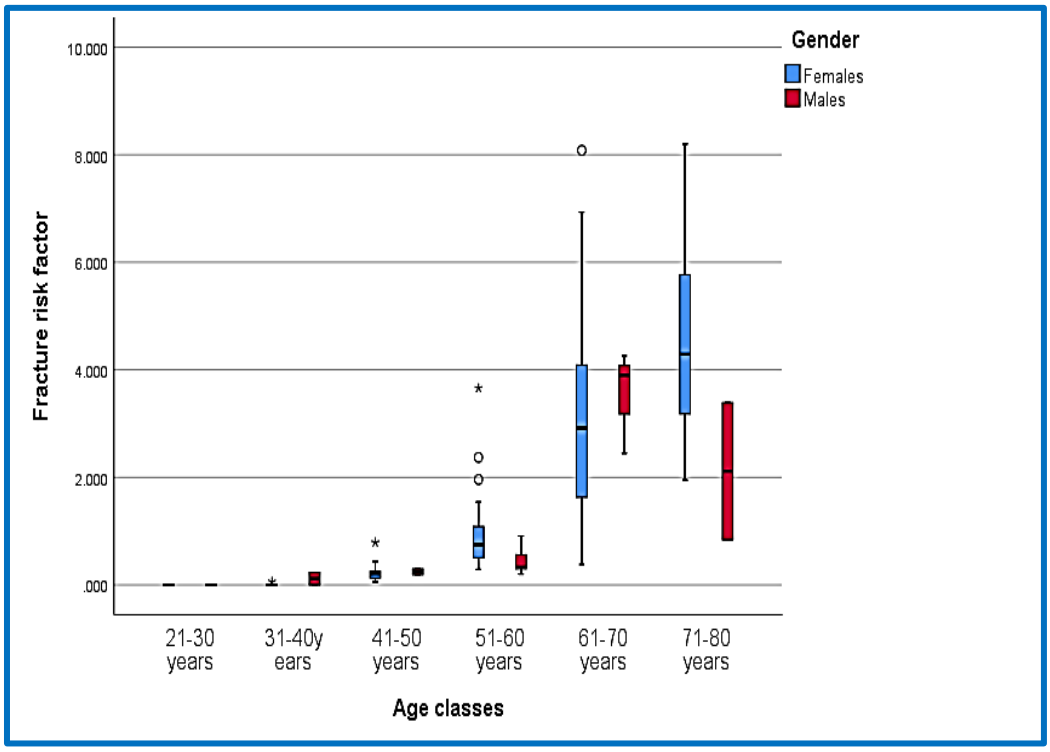

Figure 9. The graph illustrates the fracture risk factor in relation to the age of a group.

Table 4 shows the distributions of LBP among participants based on age groups ranging from 21 to 80 years old for the three cases. ((healthy) Absent No. (%), (pain) Present No. (%), (lumbar disc herniation) Prolapse No. (%)). The results that were obtained for all study groups, in the age group of 21–30 years, were healthy and had a ratio of 3 (5.6%), while the same age group had a lumbar disc herniation and a ratio of 1 (2.4%). In the age group of 31–40 years, the participants were healthy and had a ratio of 5 (9.3%), and some of them had lumbar disc herniation and a ratio of 3 (7.1%). Some were in pain, with a

ratio of 7 (25.9%), while others had lumbar disc herniation, with a ratio of 8 (19.0%), and some of them are healthy with a ratio of 6(11.1%) at the age period 41-50 years.

It was found that some participants who were in the age group 51–60 years, are healthy and in ratio 21 (38.9%), some others suffer from pain and in ratio 10 (37.0%), and others were found to have a lumbar disc herniation and in ratio 16 (38.1%). Some participants in the age group of 61–70 years old were healthy within a ratio of 14 (25.9%), some of them had pain within a ratio of 9 (33.3%), and some of them had lumbar disc herniation within a ratio of 10 (23.8%). The age group from 71-80 years old was as follows: some of them were healthy with a ratio of 5 (9.3%), others suffered from pain with a ratio of 1 (3.7%), and some had lumbar disc herniation with a ratio of 4 (9.5%). The findings in a table show that the age group 51–60 years had the highest number of LBP measurements, indicating that the people in this age group were healthier and had more than just pain and that many of them had lumbar disc herniation.

Table 4. Low back pain with age.

Age classes years	Low back pain			P-value
	Absent No. (%)	Present No. (%)	Prolapse No. (%)	
21-30	3 (5.6%)	-	1 (2.4%)	0.6
31-40	5 (9.3%)	-	3 (7.1%)	Nan
41-50	6 (11.1%)	7 (25.9%)	8 (19.0%)	Nan
51-60	21 (38.9%)	10 (37.0%)	16 (38.1%)	Nan
61-70	14 (25.9%)	9 (33.3%)	10 (23.8%)	Nan
71-80	5 (9.3%)	1 (3.7%)	4 (9.5%)	Nan

Results obtained show that there is a good relationship between T-score and parameters of QUS, including SOS calcaneal (heel) for the current study. Fig. 10 shows the correlation between T-score and calcaneus SOS, and it has statistical significance (P-value <0.0001), the value of the correlation coefficient (R = 0.953), and the value of the square of the correlation coefficient (Rsq = 0.909).

Fig. 11 shows the correlation between Z-score and calcaneal BUA. This relationship shows that it has a correlation coefficient (R = 0.840), the square of the correlation coefficient (Rsq = 0.706), and statistical significance (P< 0.0001).

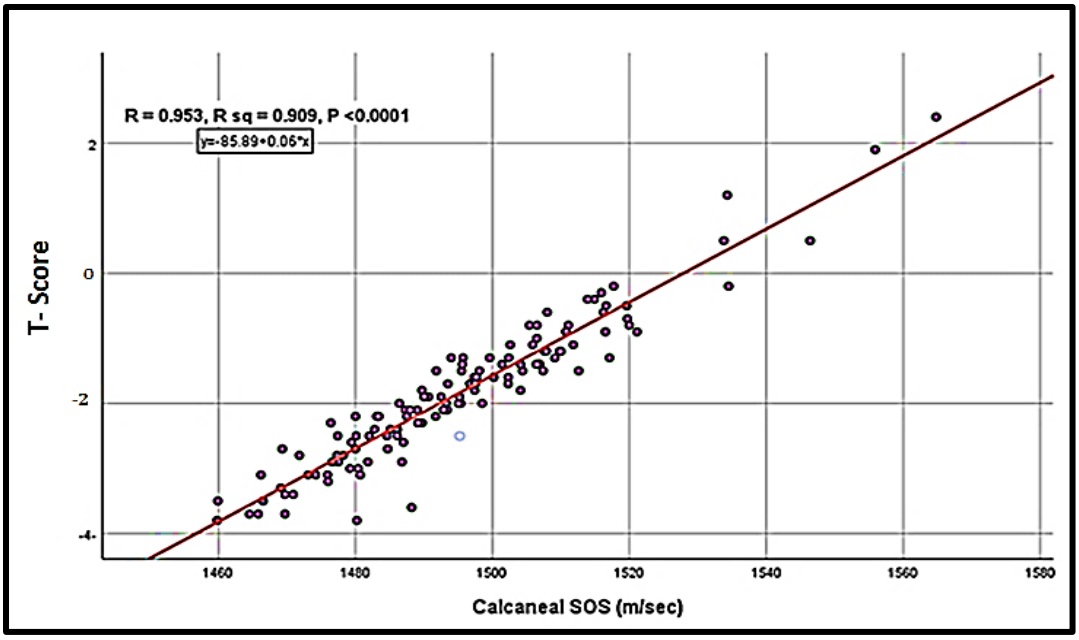

Figure 10. Correlation between T-score and calcaneal SOS.

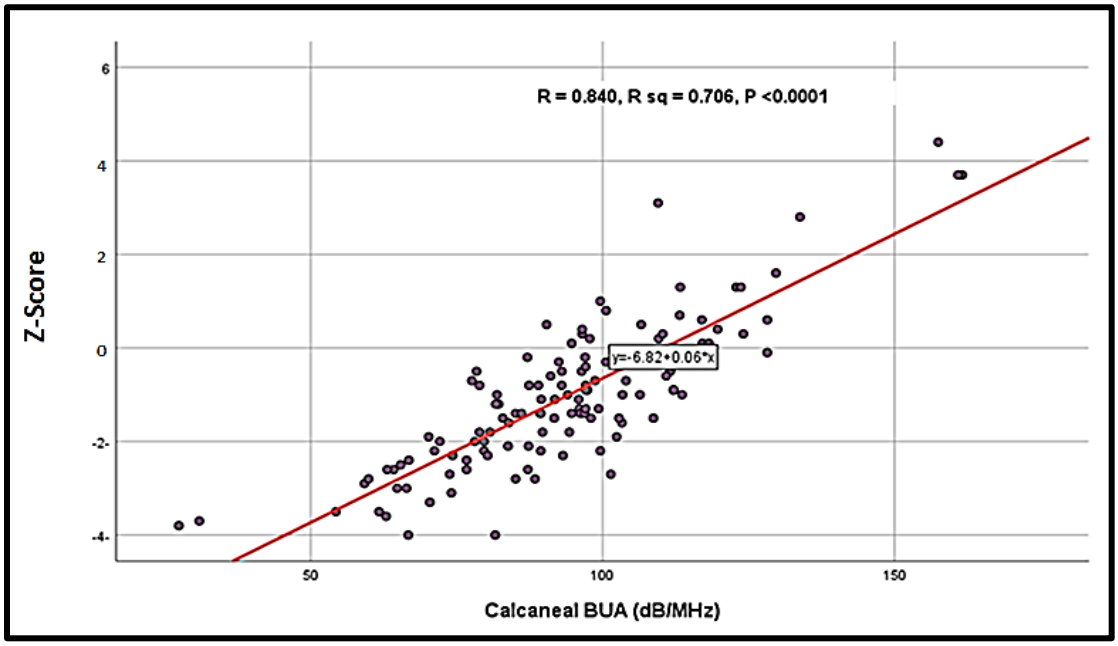

Figure 11. Correlation between Z-score and calcaneal BUA.

As previously stated, BMI = weight (kg) / height (m^2). Fig. 12 shows this relationship as the correlation between calcaneal BQI and BMI. The P value shows that it has no statistical significance (P = 0.8), the value of the correlation coefficient (R = -0.016), and the correlation coefficient square (Rsq = 0.0004).

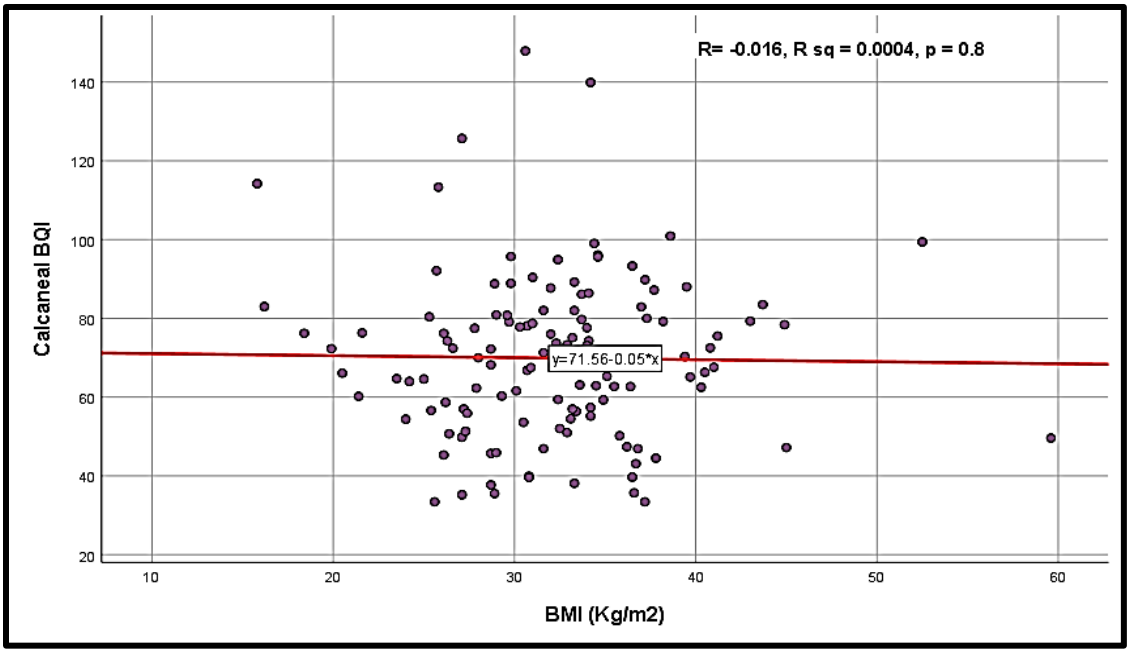

Figure12. Correlation between calcaneal BQI and BMI.

With the DXA device, it is possible to obtain measurements of tissue thickness. Fig. 13 shows that this relationship is the correlation between calcaneal BUA and tissue thickness, and it shows that it has no statistical significance (P = 0.8) and that the value of the correlation coefficient is R = 0.019 and the square of the correlation coefficient (Rsq = 0.0004). Fig. 14 shows a correlation between calcaneal SOS and abdominal fat percentage. This shows a relationship that has statistical significance (P = 0.05), the correlation coefficient (R = 0.197), and the square of the correlation coefficient (Rsq = 0.032).

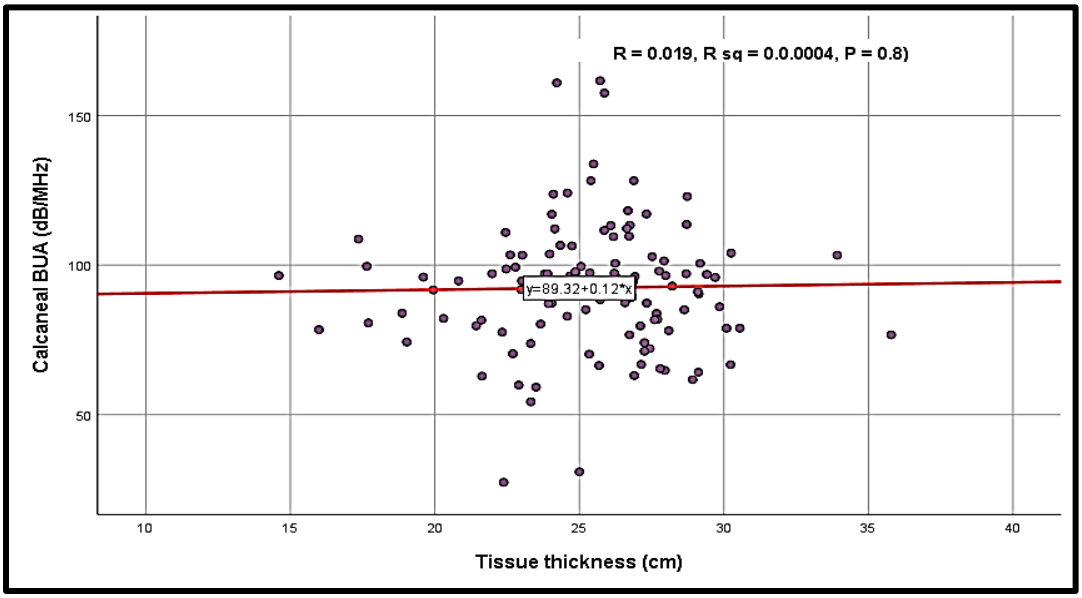

Figure 13. Correlation between calcaneal BUA and tissue thickness.

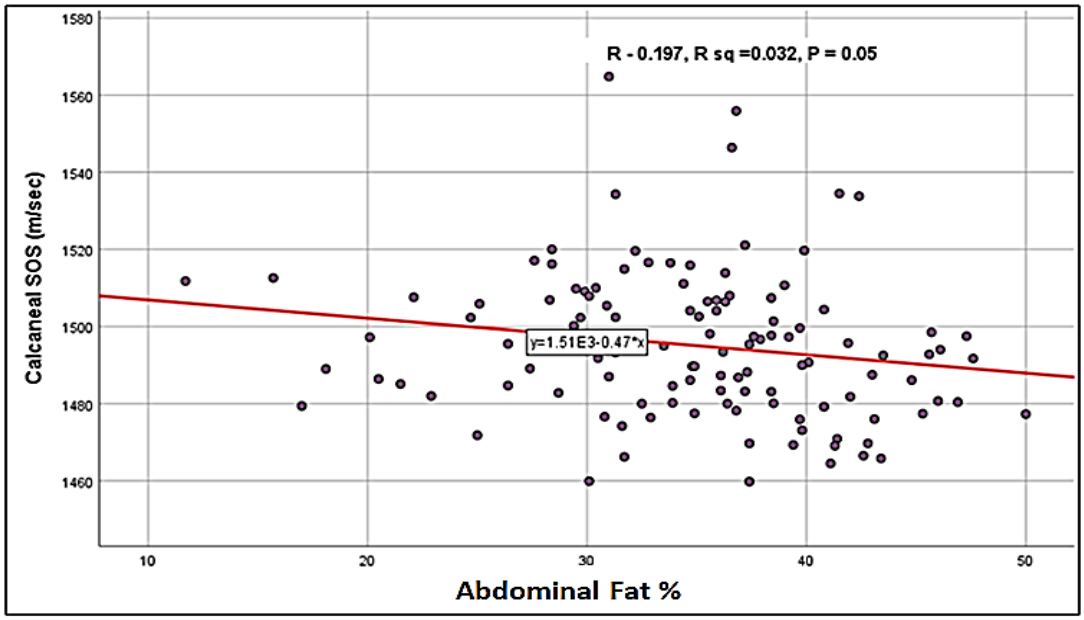

Figure 14. Correlation between calcaneal SOS and abdominal fat %.

4. Discussion

This study provides new information about how to tell if someone has osteoporosis in their right foot heel (calcaneus) when they have low back pain (LBP) in the male and female Iraqi population. Measurement of the SOS, BUA, and bone quality measurement of the calcaneus bone, T-score, and Z-score were obtained. In this study, a DXA device was used to measure the fracture risk factor, tissue thickness, and abdominal fat percentage. QUS can detect characteristics of bone quality that DXA cannot, such as bone microarchitecture or material qualities. So, QUS has the potential to be used in bone health or integrity testing [16]. The density, structure, and elasticity of bone tissue affect the speed at which ultrasound wave's move through the bone. So, the SOS and BUA are linked to the biomechanical properties of bone. SOS is a variable that is usually measured by QUS methods when they are used to measure the heel, radius, tibia, and patella. BUA is the most common way to measure how much ultrasound is attenuated through bone. It is a measure of how much the attenuation changes with frequency [17]. It is considered the best approach to find out if you have osteoporosis and how well your treatment is working using DXA. It can also be used to calculate abdominal fat percentage, tissue thickness, and fracture risk factor measurement. It may be used to determine the BMD of the bones in your lumbar spine and hip, as well as the amount of bone mineral in your body [18].

In Table 1 and Fig. 7, it was found that the SOS measurements decreased with age for females, where the decrease appeared from the age of 41–80 years, and for males, the measurements were different. The decrease appeared for males over the age of 60–80 years old. So, women enter menopause at or before the age of 50, while men reach the age of 60 or 65, during which time bone loss occurs faster for both sexes. Since men gain more bone mass than women, and as they age, women lose bone mass faster than men, so, the loss of BMD in women is greater after menopause due to a decrease in the level of estrogen during this period. Other secondary factors that contribute to bone loss in both sexes include a lack of physical activity, hypogonadism in males, malnutrition,

a decrease in growth hormone, hyperthyroidism, and some medications such as steroids; all of these factors contribute to a decrease in bone density, making the bones more vulnerable to fragility. The SOS can tell the difference between cortical bone and trabecular bone, and it shows how strong and dense the bone is. These results are in line with the results of (Rivas-Ruiz et al., 2015) in which the SOS of bone and age, of the studied sample were evaluated by measuring the SOS of the radius and tibia with QUS. It was found that women postmenopausal (45-50 years) appeared to have a significant decrease in SOS in both sites when compared to men. It was also discovered that women began to accumulate bone at an earlier age than men in both sites when they were 28 years old [16].

The fracture risk factor was measured using a DXA device. Table 3 and Fig. 9 show the measurements of the fracture risk factor. It appeared that with an increase in age, the risk factor for fractures increases for both sexes for females more than for males because the bone density of females is less than males as a result of a decrease in estrogen at menopause during the age of 50 or early menopause. Other factors that lead to a decrease in bone density are a lack of vitamin D, calcium, and other diseases like diabetes, arthritis, cancer, and some medications such as cortisone, which is used for chest allergies and other medications. Fracture risk factors are related to BMD, and one of the factors that lead to a decrease in BMD includes age. BMD loss occurs, and the bones are more susceptible to fracture from trauma, low calcium and vitamin D, low body mass index, excessive alcohol consumption, smoking, and family history fractures It shows that women are more likely to suffer fractures than men, as estrogen levels decrease when women reach primary or secondary menopause, and this leads to a loss of calcium and other minerals and a decrease in BMD. With regards to previous trauma fracture: when both men and women have been exposed to a previous fracture, the risk of fracture increases when compared to people who have not been exposed to a fracture, and the degree of fracture risk depends on age, gender, and location of the fracture) [19].

LBP is one of the most common causes. As shown in Table 4, the pain began at the age of 41 and increased with age, with the highest percentage recorded at the age of 51–60 years. So, men and women suffer from LBP, but women are more vulnerable to LBP due to the physical stress of raising children, pregnancy, and childbearing. One of the causes of pain is excess weight, which puts more pressure on the back, and some diseases, such as spinal column arthritis and cancer. The most common cause of LBP is lumbar disc herniation, which leads to pressure on the nerve roots and the pain travels to the lower leg and feet. Osteoporosis that occurs in the spine leads to LBP when fractures occur and a decrease in BMD occurs.

Fig. 10 shows correlations between T-score and calcaneal SOS. It was found that there is a strong linear correlation between T-score and calcaneal SOS because the value of the correlation coefficient R that lies between [1 to -1] is close to one. The increased calcaneal SOS value correlates with the T-score, and the lower the calcaneal SOS value, the lower the T-score. The T-score is considered predominant in diagnosing osteoporosis. Fig. 11 shows the correlation between Z-score and calcaneal BUA. There is a strong linear correlation between Z-score and calcaneal BUA because the value of the correlation coefficient R is close to one. Fig. 12 illustrates the correlation between calcaneal BQI and BMI. It shows a weak reverse correlation, i.e., almost non-existent, because the correlation coefficient R is close to zero. Fig. 13 shows the correlation between calcaneal BUA and tissue thickness. It appears to be a weak linear correlation, i.e., almost

non-existent, because the correlation coefficient R is close to zero. From Fig. 14 correlations between calcaneal SOS and abdominal fat percentage, show there is a weak linear correlation.

5. Conclusion

The QUS parameters of SOS and BUA reflect the mechanical properties of the bone. Women lose bone faster than men because men have stronger bone mass than women. When women begin to lose bone at the age of 50 or before, due to menopause, a decrease in the level of estrogen leads to a decrease in bone density. Other secondary factors affect bone density. The relationship between T-score and calcaneal SOS is a linear relationship. The relationship between Z-score and calcaneal BUA is also a linear relationship. There is a linear relationship between the risk factor for fracture and age. At the age of 41, LBP begins to appear; it increases with age; the most common type of pain is a herniated disc. In the event of pressure on the nerve roots, LBP leads to weakness in the leg muscles and extends to the foot. With age, a loss of BMD occurs and thus leads to osteoporosis. It can occur because of other factors.

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7. References

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