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DETERMINATION OF SERUM MACRONUTRIENT ELEMENTS (SODIUM, POTASSIUM, CHLORIDE AND SULFATE) AND MICRONUTRIENT ELEMENTS (COPPER, AND SILICON) FOR WOMEN OSTEOPOROSIS

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ABSTRACT--*In this study clarification to evaluate serum macronutrient elements including potassium, sodium, chloride, and sulfate, also some micronutrient elements including copper, and silicon in patients and; they were compared with the control group. The disease was diagnosed by Dual-energy X-ray absorptiometry for women aged 50-75 years, the incidence of the disease was determined by an indicator by T-scores.The value of potassium and other elements was measured for the (65) patients and (35) healthy patients diagnosed by radiation. Results were compared between patients and healthy women and the correlation coefficient was calculated for some parameters.The results demonstrated significantly higher values of chloride, sulfate, and copper in the serum of osteoporosis women when compared to women (healthy). T-scores were significantly decreased in osteoporosis group women, compared to control groups.Serum copper, chloride and sulfate are high for women with osteoporosis and there is a significant relationship when compared to the control group. There was no significant difference for serum sodium, silicon, and potassium measured for both groups; And was used to diagnose fragility according to the data of the scale T-scores from the scan.*

Keywords-- *Osteoporosis, Sodium, Potassium, Chloride, Sulfate, Copper, Silicon.*

I. INTRODUCTION

Osteoporosis “osteon mean bone and poros mean hole”,[1] is a common and morbid disease, characterized by decreased bone mass and microarchitectural deterioration of bone tissue, leading to bone fragility, and increased susceptibility to fracture.[2]-[5] According to the World Health Organization,[6] the disease has been defined as a decrease in bone density because bone density is associated with a risk of fracture [7] although the composition of the bone remains normal.[8] The crippling effect of this disease is recognized as a major medical problem.[7],[9],[10] Osteoporosis has been labeled a “silent disease” and a more amenable to prevention than treatment. It is silent, because one is unaware of bone loss process until it becomes clinically evident as a fracture, and it is more amenable to prevention than treatment because its consequences of cumulative bone loss over time may ultimately be irreversible.[11],[12] Osteoporosis is the most widespread of metabolic bone diseases,[10] and it is almost “ physiologic ” accompaniment of old age in both sexes, and occurs with great frequency even in

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comparatively young women after menopause.[9] Osteoporosis is described by reducing BMD and enhanced the likelihood of bone fracture.[13] The fracture sequela incorporates torment mental trouble, stature changes, raise horridness and mortality, and expanded hospitalization.[14],[15] The diagnosis of osteoporosis can be done by measuring BMD.[16] Depending on the probability of a hidden issue, examinations for the tumor with metastasis deep down, various myeloma, Cushing's infection and other previously mentioned causes might be performed. Estimation of BMD, radiography, and biochemical markers are critical in diagnosing osteoporosis.[17] Bone density testing is utilized to analyze quiet experience the ill effects of osteoporosis, and X-beam films are discounted other bone or ligament conditions. Thin bones might be analyzed on an X-ray film, yet bone thickness testing is more exact. It is conceivable to recognize osteoporosis noninvasively and early. Osteoporosis might be determined after cracks that happen to have an insignificant injury, by estimation of BMD with bone densitometry which is otherwise called DEXA check, or by a coincidental finding on an X-ray film.[18],[19] Many studies have shown that bone density at any anatomical site is the same as that of cracking.[15]-[18] DXEA is viewed as the highest quality level for the conclusion of osteoporosis. Osteoporosis is analyzed when BMD is not exactly or equivalent to,[13],[16] standard deviations underneath that of a youthful 30–40-year-old healthy adult women reference population.[20]-[22] This is translated as a T-score. A T-score of −2.5 or below indicates osteoporosis.[23] Minerals are essential elements for normal growth and development of the skeleton in humans and animals, but they have an active role in bone metabolism and turnover. These elements are not clarified on osteoporosis.[24],[25]

II. MACRONUTRIENT MINERALS

The abundance and the percentages of the macronutrients in the body weight are as follows:[26]

Calcium	1.5 - 2.2 %	Sodium	0.15 %
Phosphorus	0.8 – 1.2 %	Chloride	0.15 %
Potassium	0.35 %	Magnesium	0.05 %
Sulfur	0.25 %		

III. SODIUM

Sodium is the most abundant cation in the ECF. About half of the sodium in the body is found in the extracellular fluids. Under normal conditions, such as little as 10 % of total body, sodium is found within cells. The rest of the sodium in the body is found in the skeleton, where it is bound to the surface of the bones.[27] In general, sodium has two main physiologic functions water pull and neuromuscular excitability. Sodium is essential for the absorption of glucose and transport of many other nutrients across membrane, particularly in intestinal cells. Symptoms of low level of sodium include weakness, lethargy, confusion, convulsions and possibly death.[28],[29] Renal tubular resorption of calcium and sodium are linked, and the reduction in renal tubular resorption of sodium will lead to increase calcium excretion.[30] Another study showed that increased Na intake increases the loss of Ca in the urine.[31] In experimental animals, high salt intake was associated with reduced bone mineral content. Since when rats were given 1.8 % sodium chloride to drink instead of tap water, sodium excretion increased from

1.96 mmol/day to 27 mmol/day and the calcium excretion increased tenfold.[32] However there is a proposed mechanism for the effect of dietary sodium on bone mineral content Fig.(1).

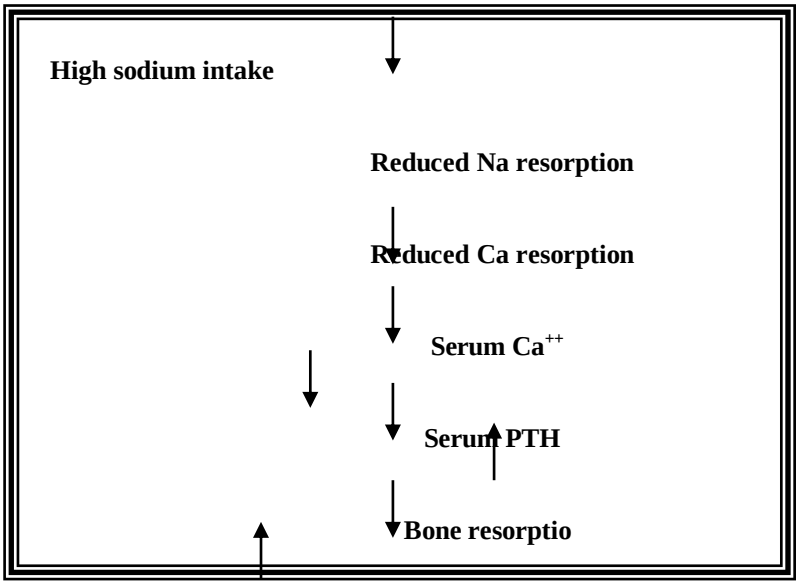

Figure 1: Proposed mechanism of increased bone resorption induced by high sodium intake

IV. POTASSIUM

Potassium is the major intracellular cation, with a concentration 20 times greater inside the cell than outside. This low ECF concentration is important in the physiology of K+ and its function in neuromuscular excitability, and controlling the rate and force of contraction of the heart.[31] Potassium ions are an integral and essential part of every cell, and it is required for cell growth, as well as it is necessary for normal protein metabolism.[33] Potassium has been shown to influence urinary calcium excretion. Since administering 60 mmol potassium bicarbonate per day to healthy subjects reduced calcium excretion, improved calcium balance, and skeleton metabolism.[30] Also in a study of 18 postmenopausal women showed improved calcium balance, increased serum osteocalcin concentrations, and decreased urinary hydroxyproline excretion when the women were given enough potassium bicarbonate.[34] On the other hand, potassium depletion causes an increase in calcium excretion.[35] However greater potassium intake is significantly associated with great BMD at some sites for men and women, probably through neutralizing endogenous acid loads from normal diets and this buffering protects the skeleton, in the other wards potassium promotes renal calcium retention.[36] The main symptoms of potassium deficiency are, general weakness, specific weakness of respiratory muscle, poor intestinal function.[29]

V. CHLORIDE

Chloride is the major extracellular anion.[37] It accounts for 1.5 g/k of the body weight.[38] Chloride participates in acid production in stomach and nerve transmission. It is taken as NaCl in various forms of diets. Dietary deficiency of chloride does not occur under normal circumstances. As with sodium, normal intakes far exceed the estimated requirements. The clinical symptoms of the chloride deficiency include failure to thrive (poor growth), anorexia, lethargy, and weakness.[39]

Sulfur: Sulfur represents about 0.25 % of the body weight, it is found as "organic" sulfur within organic compounds, and as "inorganic" sulfur within ions such as the sulfate ion (SO_4^{2-}), and the sulfite ion (SO_3^{2-}). Sulfur is found in many important compounds in the body, such as some amino acids (like methionine). And it is an essential component of biotin, thiamin, and pantothenic acid. It is found in all skin and connective tissues and is vital for the growth of hair and nails. In addition, it plays an important role in energy metabolism, Insulin production, and hormone synthesis.[29] Because proteins supply the sulfur we need, sulfur has become a natural component of a healthful diet.[33]

VI. MICRONUTRIENT MINERALS

Trace elements are essential for normal growth and development of the skeleton in humans and animals. Although they are micro building components in bone, they play important functional roles in bone metabolism, and bone turnover. However, the exact involvement of trace elements in osteoporosis and other bone diseases has not been clarified.[40],[41]

VII. COPPER

Copper is a trace element known as a co-factor for enzymes involved in the synthesis of bone matrix.[30] The total copper content of the body is estimated at 75–150 mg, 4 % of which is found in muscles, while the liver with 15 % of body copper is the major copper storage site, the rest is found in the heart, brain, kidney, and other tissues.[37] It is required for lysyloxidase, one of the principal enzymes involved in collagen cross-linking.[41] Since copper is recognized as a dietary essential; bone mineral content and bone strength are reduced in animals fed a copper-deficient diet. Symptoms of copper deficiency include anemia, growth retardation, hypopigmentation, various bone, and joint abnormalities.[42]

Silicon: Silicon is, next to oxygen, the most abundant element in the earth's crust.[43],[44] It is found only in small amounts in the serum of healthy subjects, and it has also been identified in mitochondrial granules of the liver, kidney and spleen.[45] Notwithstanding, its abundance in nature, little is known about the metabolism of silicon, and its essentiality for human,[46] but research groups for Carlisle and Schwarz have proved, that silicon is an essential element for chicks and rats.[43],[47] In addition, animals are given silicon supplementation show growth stimulation and maintain normal bone structure.[48] However, the distribution of silicon in vertebral tissue, and physiological changes in bone caused by dietary silicon deficiency indicate that silicon influences bone formation by affecting cartilage composition and ultimately cartilage calcification.[41],[49]

VIII. MATERIAL AND METHODS

According to cross-sectional dual center study conducted at DEXA unit in the radiology department in Al-Sader Teaching Hospital in AL-Najaf Province/Iraq from August 2018 to April 2019, the prevalence of osteoporosis in Iraqi women a total of 100 females from age of 50–75 years were randomly selected from the patients attending the outpatients clinic. Osteoporosis was diagnosed according to WHO criteria. Women were excluded from the study if they had endocrine diseases, environmental factors, diseases with altered activity (like

rheumatoid arthritis, cerebrovascular mischances, incessant obstructive aspiratory sicknesses) or got any hostile to osteoporosis treatment, as well as hormone substitution treatment at the season of BMD estimation. Blood samples were taken from (65) osteoporosis women and (35) women apparently healthy as a controls group.

IX. METHODS ASSAYS

Estimation of potassium, sodium, chloride, sulfate, copper, and silicon quantitatively were performed using a calorimetric method by auto biochemistry analyzer (AU240, China), units provided by (JTC, Germany Pishtaz Teb-Iran). DEXA estimation and restorative history members with DEXA estimations were characterized into various classes of osteoporosis in view of their T-scores. The most critical data to check is the right recognizable proof of the patient, his date of birth, and furthermore the sex and ethnicity. T-scores recorded at the lumbar spine (L1–L4) by using the (Dexxum). Osteoporosis was diagnosed according to the (WHO) guidelines criteria for a diagnosis of Osteoporosis.

X. STATISTICAL ANALYSIS

Statistical analysis was performed in the data of this study and was explained as (Mean ± standard deviation), the statistical analysis (descriptive statistics, correlation coefficients, P-value). The comparison between the two groups was analyzed by the t-test and the comparison between the two groups was analyzed by SPSS 24.0. when P-value < 0.05 was statistically significant.

XI. RESULTS AND DISCUSSION

Serum Sodium In Osteoporosis Women:

The results of serum sodium in osteoporosis are shown in Tables. (1), and Fig. (2). The statistical analysis of data shows that there is no significant ($p>0.05$) difference between the group as compared with the control group. Also, there is no significant difference between women with osteoporosis and controls. It is suggested that these results agree with those of Christopher (1996).[50] These results may be due to the normal renal function of these patients and the normal level of aldosterone hormone, which controls sodium reabsorption by the kidneys. Since when blood sodium levels are high the secretion of aldosterone is diminished causing less sodium to be reabsorbed by the kidneys, and more to be excreted in the urine.[29],[37]

Table 1: Comparison of serum some minerals between women with osteoporosis and controls

Minerals	Patients (*n* = 122) (Mean ± S.D.)	Control (*n* = 32) (Mean ± S.D.)	*P* value
K (mg/dl)	4.77 ± 0.52	4.81 ± 0.48	>0.05
Na (mg/dl)	145.8 ± 7.2	145.7 ± 7.9	>0.05
Cl* (mg/dl)	111.3 ± 8.1*	106.2 ± 4.9	<0.01

SO4* (mg/dl)	**2.37 ± 0.95***	**1.33 ± 0.45**	**<0.0001**
Si (mg/dl)	**4.92 ± 0.49**	**4.89 ± 0.36**	**>0.05**
Cu* (mg/dl)	**24.2 ± 4.9***	**18.6 ± 4.7**	**<0.0001**
T-scores	**−3.82 ± 0.29***	**1.90 ± 0.19**	**<0.0001**
(*): Statistically significant differences (*P* < 0.05).			

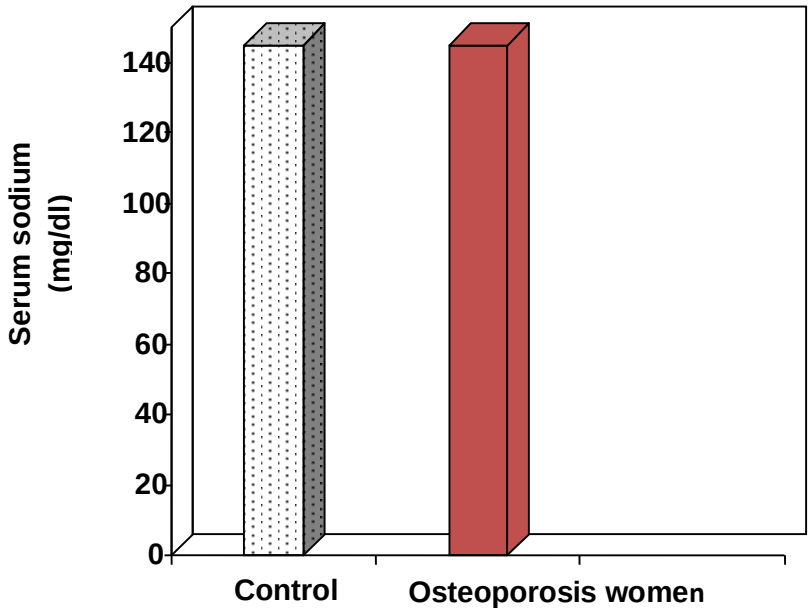

Figure 2: Serum sodium in osteoporosis women.

XII. SERUM POTASSIUM IN OSTEOPOROSIS WOMEN:

The Table. (1) and Fig. (3) show that there is no significant difference (p>0.05) in S.potassium between women with osteoporosis & the control group. A similar finding has been reported by Christopher, (1996).[50] Though some studies reported a correlation between potassium intake and BMD. Dietary potassium may affect bone resorption by affecting calcium balance.[36]

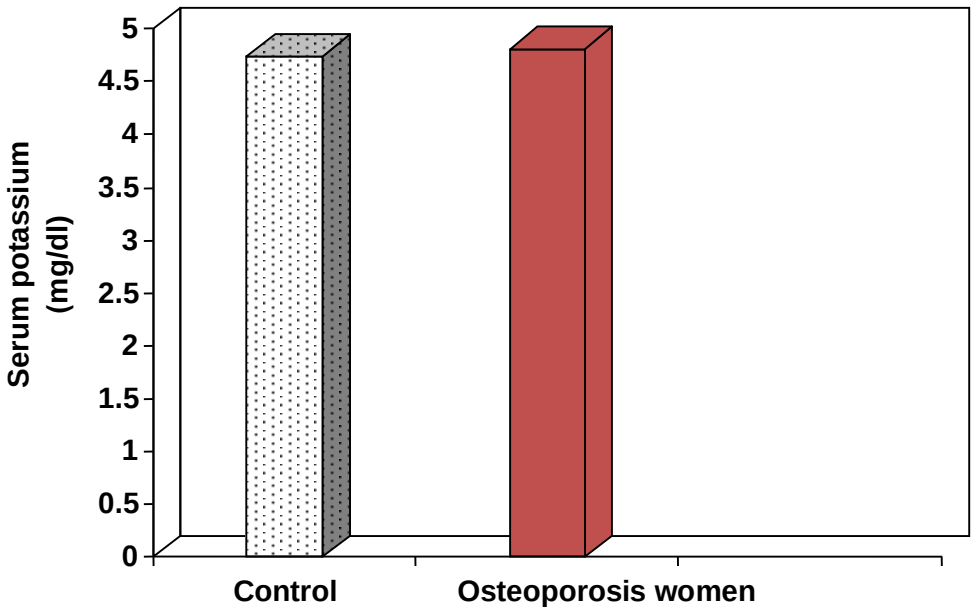

Figure 3: Serum potassium in osteoporosis women.

XIII. SERUM CHLORIDE IN OSTEOPOROSIS WOMEN:

The statistical analysis of data shows that there is a significant ($p<0.01$) increase in S.chloride in women with osteoporosis from the control group as shown in Table.(1) and Fig.(4). These results are found to be compatible with the result obtained by Christopher, (1996).[50] This author found that serum chloride is more than the normal range in osteoporosis women. Also sometimes serum chloride increase to abnormal levels when the body resorbed bone. In the present study, this result may be due to the dietary salt sodium chloride, which is considered one of the causes of osteoporosis. In this case, it is the chloride rather than the usual suspect the sodium, because chloride contributes to dietary acidity. Since some foods produce a net acid load on the kidneys, which leak calcium from the bones. This leaking rests in excreting more calcium from the body than absorbing it. Since the skeleton is not a mere framework of the body but the bones are also calcium stores, which is drawn upon to neutralization acidity in the digestive process.[51],[52]

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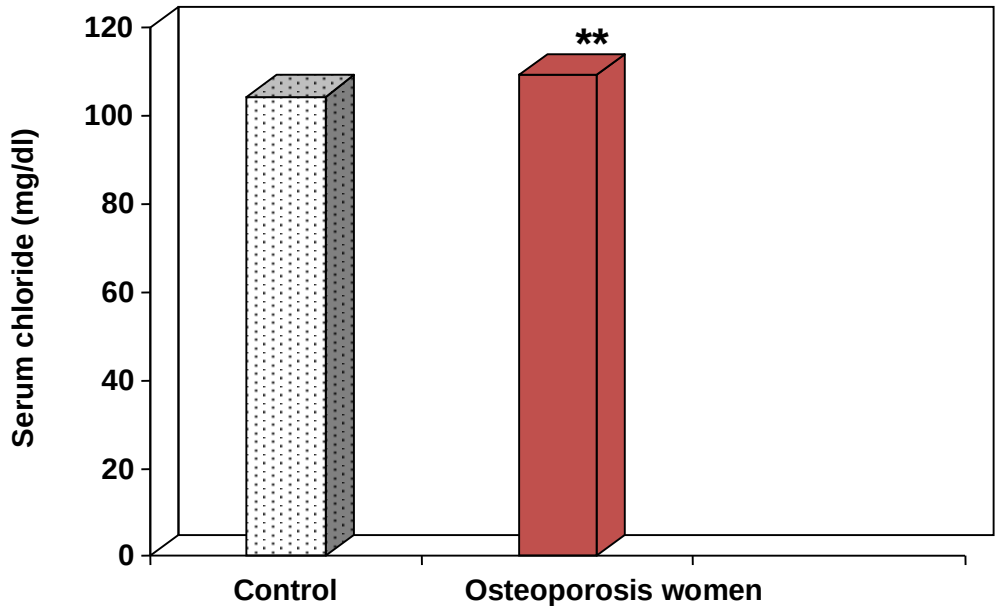


Figure 4: Serum chloride in osteoporosis women.

** Significant difference from control ($p<0.01$),

XIV. SERUM SULFATE IN OSTEOPOROSIS WOMEN:

A significant ($p<0.0001$) increase is found in S.sulfate in women with osteoporosis from the control group (Table.(1) and Fig.(5)). This result may be due to changes in the mineral metabolism in this group because among elderly persons the influence of some dietary rules may differ metabolically from that in younger adults. However, Fernandes, et al. (1997).[52] observed that there is an abnormal sulfate metabolism when vitamin D and some nutrients are deficient in rats. Moreover it has been observed in this study, that there is a positive correlation between serum sulfate and the degree of the disease so this study suggested that bone resorption lead to an increase serum sulfate through breakdown the bone and release the sulfate from the matrix, there is a significant difference ($p<0.0001$) in S.sulfate between osteoporosis women and controls.

Figure 5: Serum sulfate in osteoporosis women**.**

*** Significant difference from control ($p<0.0001$),

XV. SERUM SILICON IN OSTEOPOROSIS WOMEN

The present laboratory finding indicates that serum silicon in the control group is (4.89 ± 0.36 mg/dl). This result coincides with those of VanDyck, et al. (2000).[43] It has been reported that serum silicon in healthy subjects is (5.3 mg/dl). The results in Table. (1) and Fig. (6) show that there is no significant ($p>0.05$) difference in serum silicon between osteoporosis and the control group. Although some studies have reported that silicon may play a role in BMD since it performs a beneficial and normal role in the body because it is apparently required for the formation of cartilage, collagen, and bone. This can be attributed to the unique localization of silicon and its relationship with calcium in active calcification sites, but most of the evidence on silicon's role in metabolism has come from animal studies (Valkovic, 1975; Guthrie and Picciano, 1995).[37],[43] In this study, it has been suggested that it is probable to find a deficiency in bone silicon, but not in serum silicon. However, a specific study carried out on osteoporosis women has demonstrated changes in BMD after supplementing them with silicon.[53] Among these changes is the significant increase in the femoral BMD.[55],[56] Moreover, in a study conducted at center Hospital de Toulon in France, 50 mg of absorbable silicone was injected to eight women with osteoarthritis, aged 64 years, twice a week for four months with. According to the pictures taken before and after the supplements used, this consumption increased the density of the femur significantly, but did not affect the density of the spine bones.[56] If a small portion of ultrafiltration silicon can also circulate as aluminic silicate, being associated with bone development, it is possible that serum silicone is present in the form of silic acid, in the aqueous medium both silica and silicate compounds are known to degrade in silicate acid, this study, no significant difference between osteoporosis women in serum silicon has been observed.[49]

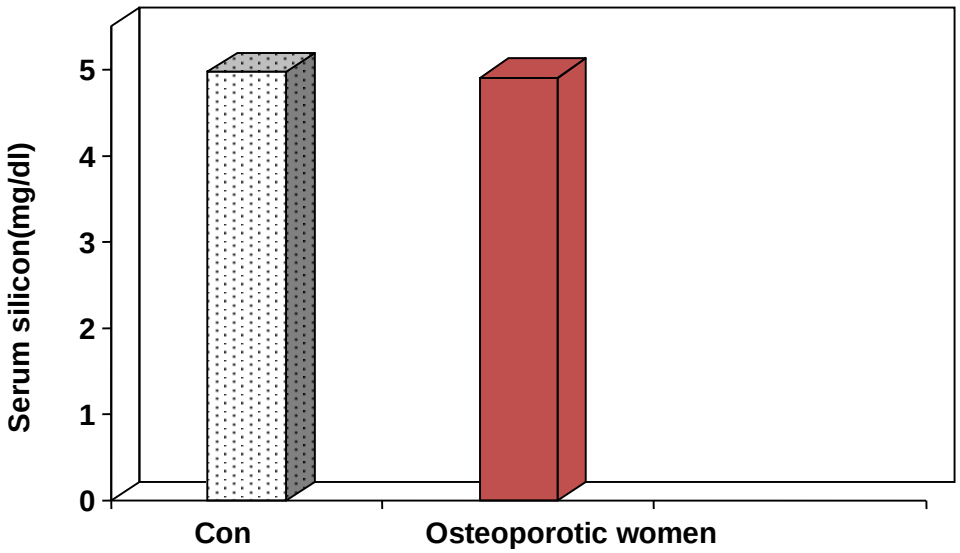
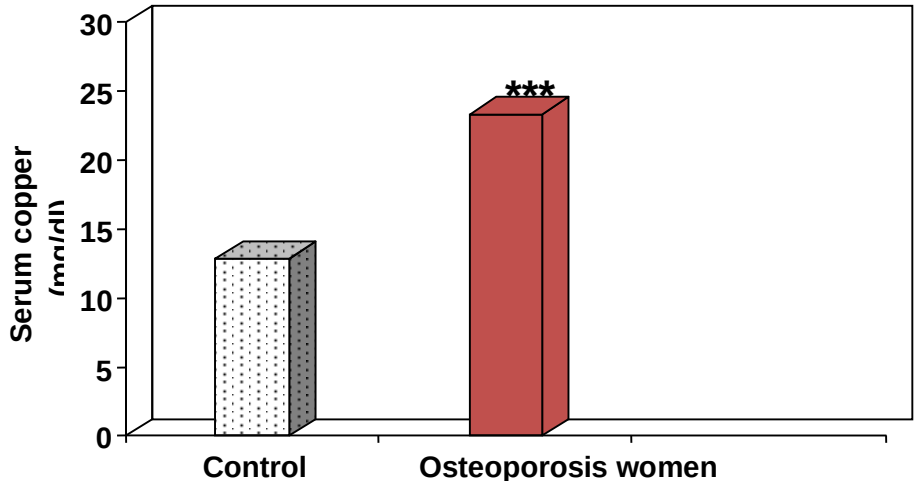


Figure 6: Serum silicon in osteoporosis women.

XVI. SERUM COPPER IN OSTEOPOROSIS WOMEN

As shown in Table. (1) and Fig. (7), there is a significant ($p<0.0001$) increase in serum Cu in women osteoporosis from the control. This result may be due to the collagen disorder,[57] or it is probably ascribed to the Zn deficiency, since Zn tends to become deficient due to Increase copper-bearing protein, ceruloplasmin, by relying on Zn and thus depleting Cu stores.[58] In fact, zinc competes with copper for sulfhydryl binding sites. Therefore, the antagonism of zinc towards copper absorption manifests an increase in one of them leading to a deficiency in the other.[59] In another study of children with zinc deficiency, low levels of zinc were accompanied by elevated levels of copper and other toxic metals.[60],[61] The deficiency in serum zinc may lead to an increase in serum copper because zinc and copper compete with each other for absorption.[62] This result is probably due to the collagen disorder in osteoporosis women.



*** Significant difference from control ($p <0.0001$),

Figure 7: Serum copper in osteoporosis women.

XVII. THE CORRELATION BETWEEN THE PARAMETERS IN SERUM OSTEOPOROSIS WOMEN

In this study, there is a significant correlation ($r = 0.288$, $p<0.0001$) between sodium and potassium in serum osteoporosis women as shown in Fig.(8). Also serum sodium exhibits a significant correlation

($r = 0.222$, $p<0.05$) with chloride in osteoporosis women as shown in Fig.(9). These results are probably due to the majority of these ions (K^+, Na^+ , Cl^-) in the body. Such ions are often considered together.[63] However, with respect to serum sulfate, the results in Fig. (10) show that there is a significant correlation ($r = -0.277$, $p<0.05$) between sulfate and silicon. These results may be caused by the state of silicon in the body because it is present in the form of a low molecular weight compound not bound to protein, which is converted with water to silica and silicate and then to silicic acid.[64]

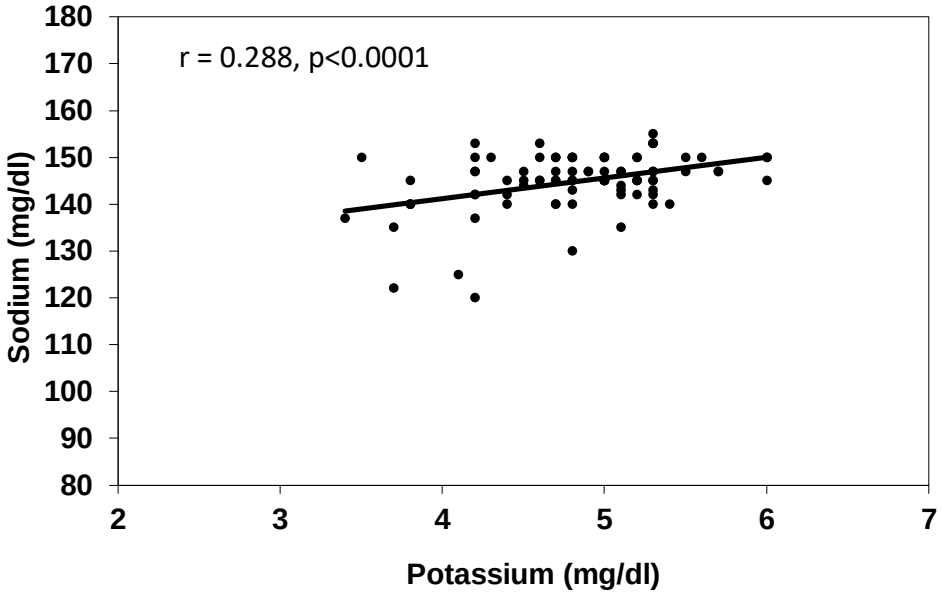


Figure 8: The correlation between serum sodium and potassium in osteoporosis women

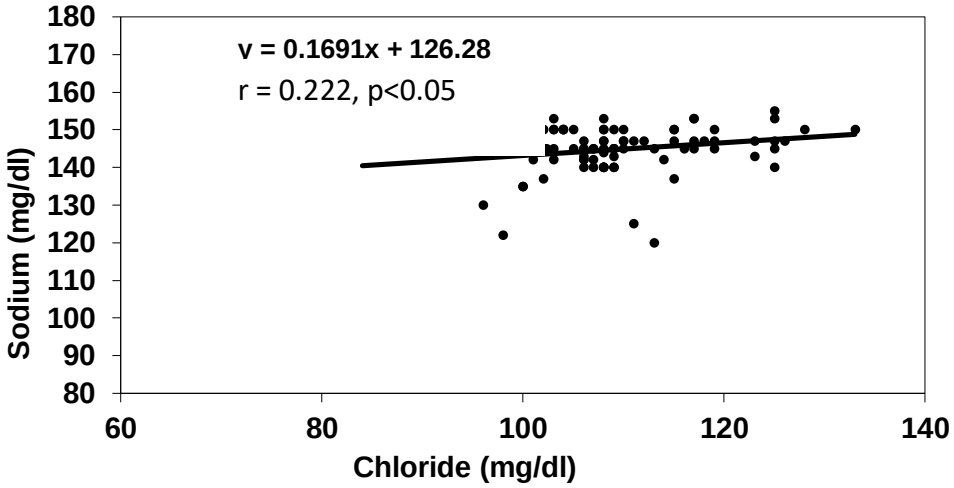


Figure 9: The correlation between serum sodium and chloride in osteoporosis women.

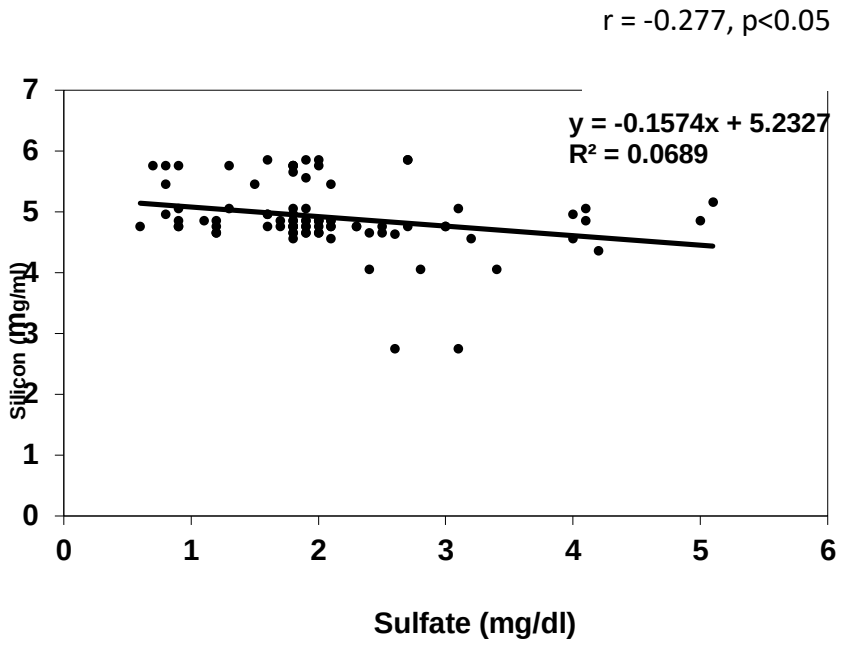


Figure 10: The correlation between serum sulfate and silicon in osteoporosis women

In addition there is a significant correlation (r=-0.331, p<0.05) between serum sulfate and copper in osteoporosis women see Fig. (11).

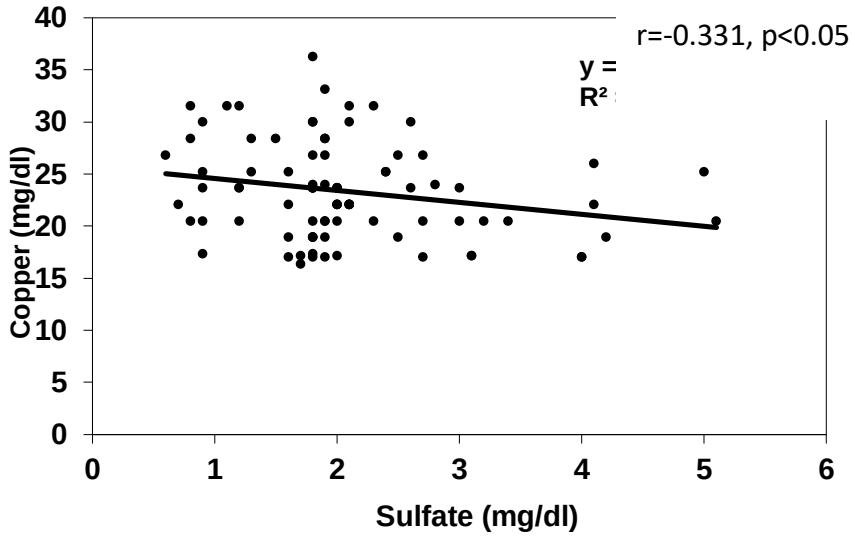


Figure 11: The correlation between serum sulfate and copper in osteoporosis women**.**

XVIII. RECOMMENDATIONS

Recommended women should make DEXA scan to prevent fractures identifying low bone mineral density; and use it during the treating osteoporosis for follow-up can reduce the risk factor, for example, the fractures in this population. Family history plays a great effect on having osteoporosis so any woman who has maternal or paternal with osteoporosis should make a screening test to prevent osteoporosis. More research is needed to cover the various aspects

of osteoporosis. It is recommended to establish a professional society in Najaf that deal with osteoporosis as a public health problem. Assess the level of elements in foods consumed by old people. Study the effect of other elements on osteoporosis.

XIX. CONFLICT OF INTEREST

None. N

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