Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

CORRELATION OF ADIPOSITY WITH SERUM PARATHYROID AND HYPOVITAMINOSIS D AMONG FEMALE POPULATION OF LAHORE

LAIBA SHEHZADI
Department of Basic & Applied Chemistry, University of Central Punjab, Lahore, Pakistan.

Dr. SADIA ZULFIQAR*
Department of Basic & Applied Chemistry, University of Central Punjab, Lahore, Pakistan.
*Corresponding Author Email: sadia.zulfiqar@ucp.edu.pk

AFSHAN SAEED
Department of Basic & Applied Chemistry, University of Central Punjab, Lahore, Pakistan.

SYEDA FATIMA HAIDER
Department of Basic & Applied Chemistry, University of Central Punjab, Lahore, Pakistan.

ANUM SAEED
Department of Biotechnology, University of Central Punjab, Lahore, Pakistan.

ANEELA ANJUM
Department of Basic & Applied Chemistry, University of Central Punjab, Lahore, Pakistan.

Abstract

The purpose of study was to find the effect of hypovitaminosis D on concentration of parathyroid hormone (PTH) & its correlation with anthropometric measures in obese women residing in Lahore, Punjab Pakistan. A total of 128 women aging 20-50 years were selected from the outdoor patient's department, Mayo Hospital Lahore. Non-obese women (n=25) were selected as control. This was a cross- sectional study and sampling was done according to random sampling technique. A written and informed consent of participation was taken from each woman before selecting as sample. Collection of blood sample was done to examine 25(OH)D and PTH by radioimmunoassay (RIA) and immunoradiometric assay (IRMA). Mean, standard deviation, student t-test and Pearson's correlation coefficient were used for data analysis at 95% confidence interval and *p*-value <0.05. The average age of the sample and control group was 33.19±7.9 and 32.16±6.52 years, respectively. The mean 25(OH)D concentration in sample (14.91±6.16 ng/mL) verses control was (17.05±10.72; *p*<0.05). Serum PTH levels (26.12±17.94 vs.20.57±6.92 pg/mL) was approximately 5% higher in obese group as compared to control. Hypoparathyroidism was observed in 12.5% (sample) and 4% (control) population respectively. PTH shows negative correlation with weight (r=0.00011), height (r=-0.106), waist circumference (r=-0.147) and positive with BMI (r=0.05) and age (r=0.16). Vitamin D shows negative relation with BMI (r=-0.02), PTH (r=-0.015) and age (r=-0.14) and positive with weight (r=0.24), height (r=0.12), waist circumference (r=0.10) and hip circumstances (r=0.12). This data indicates frequent vitamin D inadequacy which is significantly altering the PTH level in female population.

Keywords: Immunoradiometric Assay (IRMA), Obesity, 25(OH)D, Parathyroid Hormone, Radioimmunoassay (RIA).

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

INTRODUCTION

Obesity is the abnormal fat deposition in body that threatens the health of individual and is major health risk factor for cardiovascular disease, type 2 diabetes, hypertension, hyperchlolestolemia, osteoarthritis, gastroesophageal reflux disease, sleep apnea, chronic kidney disease and cancer [1]. Excessive weight gain is more frequent in females than males due to a large number of factors like hormonal influences, multiple pregnancies, societal expectations, caregiving roles, and barriers to physical activity. Body Mass Index (BMI) is the most common tool used to calculate the body fat. Women with BMI between 25 to less than 30 are categorized as overweight. A BMI of 30 or higher than 30 are considered as obese. Women who possess a waist measurement over 35 inches became more likely to experience various health issues. High-grade obesity frequently give rise to hyperparathyroidism and hypovitaminosis D [2,3].

For adults, a daily intake of 600 IU of vitamin D is advised whereas overweight and obese people may require its greater doses (20 ng/ml). There is currently less information available on how vitamin D response affects PTH levels in people with extra body fat. Numerous reasons for the low level of 25(OH)D in obese people have been suggested, including reduced food intake, decreased cutaneous production, less intestinal absorption, and change in metabolism etc. After being exposed to natural sunlight, the skin essentially synthesizes vitamin D. An average 10 -120 min sunlight exposure is adequate for its production. If adiposity combines with insufficient sunlight exposure, the extent of problem increases as obesity causes changes in the endocrine system that regulates vitamin D production [4].

Obesity-related vitamin D deficiency may result from the reduced accessibility of vitamin D_3 stored in cutaneous & adipose tissue. Vitamin D deficiency decreases PTH to the greatest extent at a concentration of about 30 ng/ml [5].

The status of vitamin D and parathyroid have been measured in most of the developed countries and their data are available for taking various initiatives by government and private institutions but in a developing country like Pakistan very less statistics are available yet. In Lahore, like other cities, the prevalence of vitamin D deficiency and obesity among women are attributed to a combination of lifestyle, cultural, and environmental factors. Their days are mostly devoted to cooking, cleaning, laundry and other domestic tasks. As a result, there is little time available for outdoor activities and self-care. They wear the headscarf and spend very little time in sunlight.

Moreover it is also associated with diet lacking in foods high in vitamin D. Their preference for a fair complexion, melasma, and fear of being tanned restrict their exposure to sunlight as well [6]. Furthermore, literature reveals that vitamin D deficiency is highly linked with anomalies in PTH. So, the objective of current study was to determine the level of vitamin D and parathyroid hormone in obese women aging 20-50 years and explore the current situation of these parameters with reference to anthropometric measures in obese female populations of Lahore.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

MATERIALS AND METHODOLOGY

Study Design, Place and Time

A cross-sectional study was conducted in females aging 20-50 years residing in Lahore, during the period from October 2023 to march 2024.

Participants

A sample of 128 subjects were considered for this study. Only those females were selected who had BMI ≥25kg\m^2 for sample group. This obese group was subdivided into four classes according to BMI (class 1: BMI: 25-29.9 kg/m^2, class 2: BMI: 30-34.9kg/m^2, class 3: BMI: 35-40 kg/m^2 and class 4: BMI > 40 kg/m^2**)** [1]. The control group consisted of 25 females of the same age group. Elaborative consent of participation was obtained from each subject participants considering her for study. A thorough anthropometric examination was done from both the groups. The bioethical approval for the study was taken from the center of nuclear medicine Mayo Hospital Lahore.

Exclusion criteria

Exclusion criteria consisted of any current acute or chronic illness**;** osteoporotic fracture; intestinal malabsorption and medication influencing bone metabolism such as vitamin D supplements, untreated thyroid disease and family history of metabolic bone diseases or vitamin D disorders. Subjects who had previously diagnosed with diabetes or on anti-hyperglycemic therapy were not included in the study group [1].

Clinical Examinations

Anthropometric data (body weight and height) was collected using a commercial scale (Seca 284, Germany) throughout the study with an accuracy of ±100 [7]. Subjects were weighed (wearing light clothing and without shoes) to the nearest 0.1 kg. Standing height was measured with shoulder in relaxed position and arms hanging freely in bare feet to the nearest 0.5cm. To overcome technical errors, the same technician performed all measurements to reduce inter-rater error. Measurements were taken with calibrated digital scale and recalibrated after each measurement. BMI was calculated as weight in kilograms (kg) divided by squared height in meters. Waist circumference was assessed to the nearest 0.1cm by using the measuring tape horizontally midway between the lowest rib and the iliac crest [8]. Hip circumference was measured at the point resulting maximum circumference over the greater trochanter.

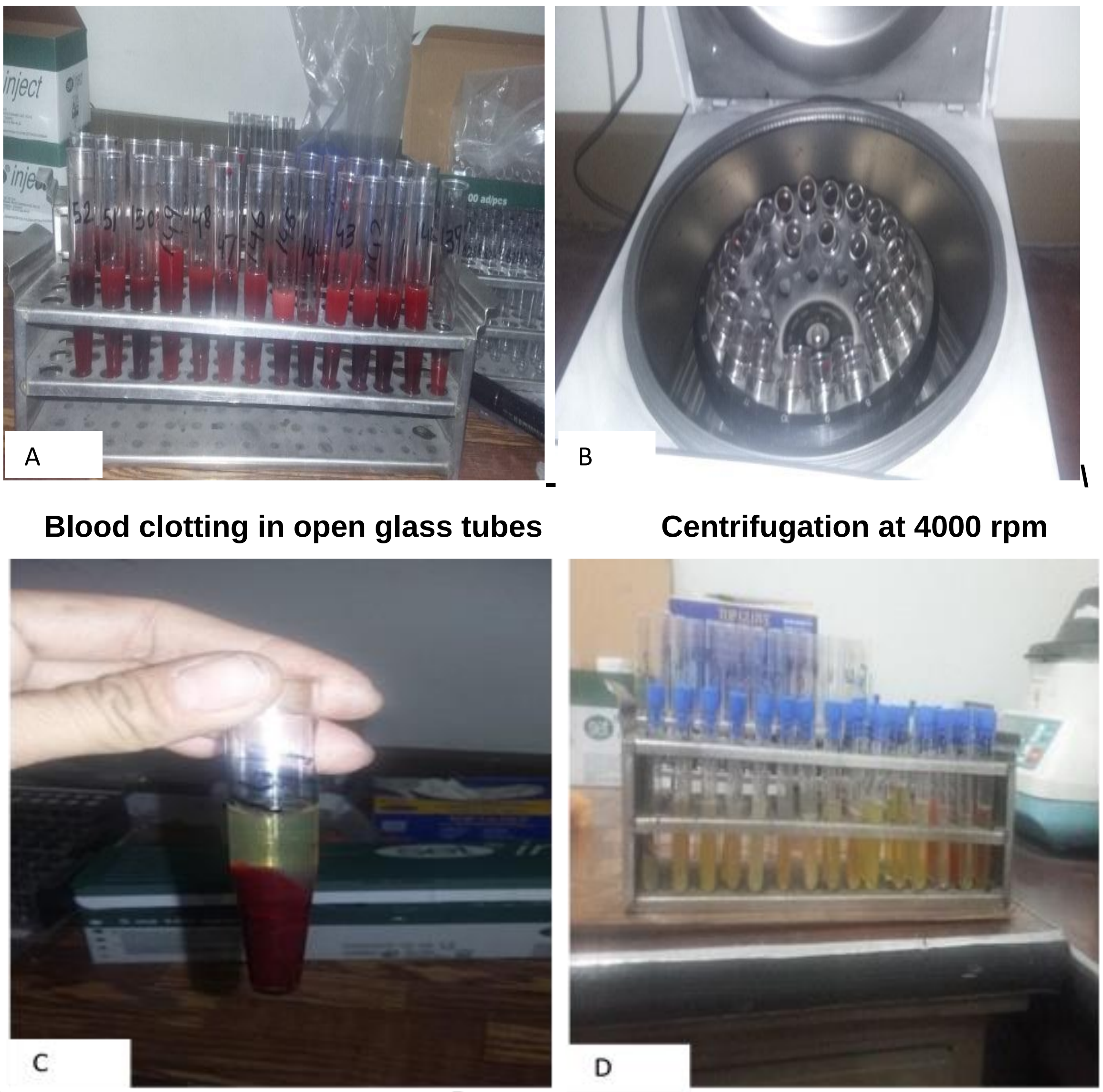
Blood Testing

Blood sample (5-7 ml) was collected intravenously from each woman by a disinfectant syringe and transferred into an open tube (by a qualified nurse under the supervision of a Physician). It was left to clot for 30 minutes and then each sample was centrifuged for 10 minutes at 4000 rpm. Before process initiation, each glass centrifugal tube was checked closely for the presence of any crack or fissure. Rifted tubes rupture during

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

centrifugation causing the wastage of the sample. Serum was decanted in another vial with lid as shown in figure 1 and kept at -80 °C until analysis.

25(OH)D was determined by ^{125}I-radioimmunoassay (RIA). The detection limit of the assay is 5 nmol/L and cross sensitivity is 100%. The intra and inter assay coefficients of variation (CV) was 4.2% and 6.6% respectively [9].



Blood clotting in open glass tubes **Centrifugation at 4000 rpm**

Blood partitioned into serum and blood cells **Serum after separation into vials**

Figure 1: A-D: Various Stages of blood Segregation

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

PTH was measured using an immunoradiometric assay (IRMA). The detection limit of the assay is 1 pg/mL and the manufacturer's normal range is 7 to 53 pg/mL. The intra and inter assay coefficients of variation (CV) were 2.9% and 5.0% respectively.

Statistical Analysis

Results had been presented as mean, percentage (%) with the corresponding standard deviations (SD) [1].

A posterior statistical analysis (descriptive statistics, Pearson's correlation coefficient, & student t-test using unequal variances) as per requirement were executed using the program statistical packages for the Social Sciences version 20.0 (Chicago, IL, USA) [3]. Statistical significance will only be acceptable when *p*-value is <0.05 [1].

RESULTS AND DISCUSSION

A total of 128 women aging 20-50 years were enrolled in this cross-sectional study. The mean age of the study population was 33.19±7.9 and 32.16±6.52 (range = 21-44) for sample & control groups respectively.

They were divided in two groups, first being sample group, consisted of n= 103 women while second consisted of n= 25 women of same age and socioeconomic status with normal body weight.

The BMI of sample group was 35.98±4.71 (29.55-50.36) and that of control population was 17.25±1.75 (14.81-21) respectively. No statistically significant difference was observed in the age of sample and control population (p=0.5) as shown in table 1. The BMI of the two groups showed clear difference (p<0.001) as given table 1. The average height of the sample and control were 156 ± 4.64 (137-168.5) and 154.84±8.31 (140-171) respectively with (p=0.48).

The weight of sample group was 87.509±11.95 (68-122) and that of control group was 53.48±5.05 (45-62) with p value < 0.01 as presented in table 1.

The waist circumference of sample group was 106.53±11.02 (86-135) and that of control group was 85.76±7.20 (76-103) (p<0.01). The hip circumstances of sample and control group were 117±10.38 (98-150) and 93.72±4.67 (86-105) with significant variation (p<0.01).

The PTH level of sample group and control group was 26.12±17.94 (3.47-106.5) and 20.57±6.92 (8.65-33.52) with a statistical difference of (p<0.02) respectively.

The vitamin D level of the sample group and control group was 14.91±6.16 (3-29.08) and 17.05±10.72 (6.91- 40.44) demonstrates no statistical difference of (p=0.35) as shown in table 1.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

Table 1: ***Study characteristics of 128 women took part in study***

Parameters	Sample Group Mean ±SD Range	Control Group Mean ±SD Range	*p*-value of Sample and Control Group
Age	33.19±7.90 20-50	32.16±6.52 21-44	0.5
BMI	35.98±4.71 29.55-50.36	17.25±1.75 14.81-21	0.01
Height	154.84±8.31 140-171	154.84±8.31 140-171	0.48
Weight	87.509±11.95 68-122	53.48±5.05 45-62	0.01
Waist Circumference	106.53±11.02 86-135	85.76±7.20 76-103	0.01
Hip Circumference	117±10.38 98-150	93.72±4.67 86-105	0.01
Weight to Height Ratio	0.00±0.08 0.74-1.21	0.91±0.069 0.8-1.04	0.87
PTH	26.12±17.94 3.47-106.5	20.57±6.92 8.65-33.52	0.02
Vitamin D	14.91±6.16 3-29.08	17.05±10.7 6.91-40.44	0.35

Table 2 demonstrates the BMI (as divided into various categories) between sample and control population. As shown in table 2, 100% of sample population is having BMI value belonging to obese category. In sample population there was no participant who belong to underweight category i.e., <18.5kg/m^2, while in control group 72% participants belong to this category. Similarly, in normal weight class 84% control population belongs to it while no one from sample group was in this range. There appeared 5.82% participants of sample group as over weight (25 – 29.9 kg/m^2). Similarly, 46%, 34% and 17% population of sample group were in obesity classes' Ⅰ, Ⅱ, and Ⅲ respectively.

Table 4.2: ***BMI of study population in various categories***

Sample Group					Control Group				*p*-value
Parameters	**Mean ±SD**	**Range**	**No.**	**%**	**Mean ±SD**	**Range**	**No.**	**%**	
BMI (total) kg/m^2	35.98±4.69	29.9-49.18	103	100	17.25±1.75	14.81-21	25	100	0.01
<18.5	-	-	-	-	16.37±0.170	16.55-16.21	3	12	
18.5-24.9	-	-	-	-	17.50±1.84	21-14.81	21	84	
25-29.9	29.84±0.14	29.6-29.97	6	5.82	-	-	-	-	
30-34.9	32.66±1.49	30.0-34.85	46	44.66	-	-	-	-	
35-40	37.51±1.37	35.4- 39.9	34	33	-	-	-	-	
>40	44.24±2.90	40.9-50.36	17	16.5	-	-	-	-	

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

Table 3: ***PTH concentration in sample and control population***

Sample Group (PTH)					Control Group				*P*-value
Parameters	**Mean ± SD**	**Range**	**No.**	**%**	**Mean ± SD**	**Range**	**No.**	**%**	
Total	26.12±17.94	3.47-106.5	103	100	20.57±6.92	8.65-33.52	25	100	0.02
Normal (10-55)	25.79±11.54	10-51.4	85	82.5	21.07±6.59	11.6-33.52	24	96	0.01
Hyper (>55)	80.78±17.39	58.7-106.5	5	4.85	-	-	-	-	
Hypo (<10)	7.04±1.92	3.47-9.5	13	12.6	8.65±0.00		1	4	

The mean concentration of PTH in sample population was 26.12±17.94 ranging from 3.47 to 106.5 compared to PTH in control population i.e 20.57±6.92, with $p<0.05$. In 82.5% of the sample group, PTH level was in normal range where as in 96% of the control group it appeared in the same range with clearly significant difference between the two (p=0.01). In sample group approximately 5% population had hyperparathyroidism with no-one in the control group belonging to this category. Hypoparathyroidism was shown by 12.6% of the sample and 4 % of the control group respectively. Figure 2 is representing the concentration of PTH as vary in different number of subjects.

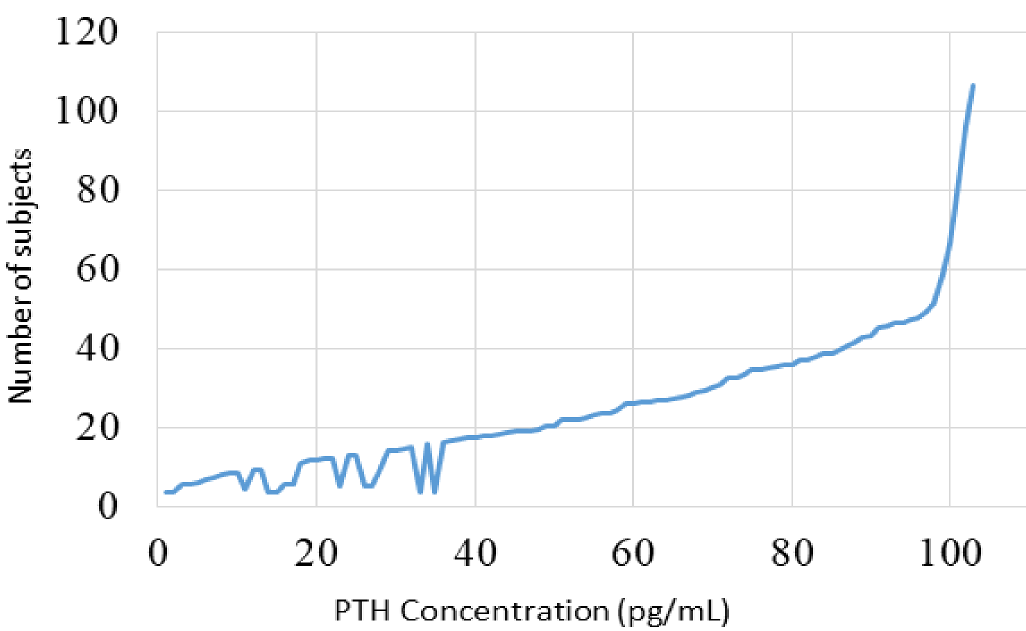


Figure 2: Distribution of PTH among Sample Population

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

Table 4: PTH concentration in various age groups among study population

		Sample Group				Control Group				p-value
Age	PTH	Mean±SD	n	%age	Range	Mean±SD	n	%age	Range	
20-30	<40	20.04±9.64	42	40.78	5.71-39.4	15.45±4.49	11	44	8.65-2.58	0.03
	40-55	43.42±1.89	3	2.91	41.6-45.38	-	-	-	-	-
	>55	82.6±33.79	2	1.94	58.7-106.5	-	-	-	-	-
31-40	<40	18.63±10.10	29	28.15	3.47-36.03	22.103±4.74	10	40	11.6-27.9	0.16
	40-55	46.54±4.03	6	5.82	40.7-47.1	-	-	-	-	-
	>55	65.6±13.7	3	2.91	66.5-78.9	-	-	-	-	-
41-50	<40	24.16±10.01	15	14.6	6.76-38.01	30.83±2.06	4	16	28.6-33.5	0.03
	40- 55	46.05±0.49	2	1.94	45.7-46.4	-	-	-	-	-
	>55	96.3±0	1	0.97	-	-	-	-	-	-

Table 4 shows PTH level as vary in different age group (20-40) of sample versus control population. It appeared that 41% of the sample population showed PTH level <40 ng/mL while only 2% showed abnormally high PTH whereas all the females of control group in this specific age appeared with PTH in normal range. There appeared a clear difference in parathyroid of sample versus control in this particular age (p<0.05). Age group (31-40) demonstrates that 28% of the sample population had PTH levels below 40 ng/dl, while just 3% showed excessive PTH levels. In contrast, all the control group's female members in this age range looked to be within the normal range as showed in table 4. In this particular age, there was no noticeable difference between the PTH of the sample and the control (p > 0.05). Table 4 for those in the age bracket of 41 to 50 years revealed that 14% of the sample population had PTH levels below 40 ng/dl, meanwhile only 1% had significantly elevated PTH levels. There appeared a significant difference in PTH level of sample and control in this specific age group (p< 0.05).

DISCUSSION

Obesity is a persistent, complicated and deteriorating condition that will influence one out of 5% subject in 2030 [10]. It is a major health problem with a consequence reduction in life expectancy [11]. A report submitted by world health organization (2022) in which 650 million adults (1 out of 5 women) are living with obesity and overweight. It is regarded as a major preventable cause of morbidity worldwide, so finding factors that may be related to or responsible for it has a significant effect on global health.

This cross-sectional study assessed the correlation of obesity with 25(OH)D and serum PTH levels. The mean age in the sample and control group was similar (33.19±7.9 and 32.16±6.52, p=0.5) and the mean serum PTH level is higher in obese group than that of the control while the 25(OH)D was observed higher in normal weight subjects than that of the obese subjects.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

Reduced physical activities are the cause of higher PTH levels in obese people [12]. Current study also elaborates that elevation in PTH is positively associated with obesity. Identical results have also been reported by Jumaahm *et al* [1]. The present study showed that 82.5 % of the sample group had normal PTH level while 96% of the control group appear in the same category (25.79±11.54 and 21.07±6.59, p=0.01). Approximately 5% population of obese people was suffering with hyperparathyroidism whereas no one from non-obese group (80.78±17.39) has such issues.

In sample group 12.6% subjects and 4% of control were observed with hypoparathyroidism (7.04±1.92 and 8.65±0.00, p<0.05). A minor data is available in which vitamin D deficiency is contributing to hypoparathyroidism. According to the most modern perspective on management of hypoparathyroidism, initial evaluations of serum 25(OH)D and active vitamin D supplementation are recommended to reach and maintain serum levels of 25(OH)D in the 30–50 ng/mL range in order to control hypoparathyroidism [15]. Serum PTH level was positively associated with BMI and similar outcome was also reported in a study by Jumaahm *et al.* [1].

Around the world, vitamin D deficiency or insufficiency is currently a significant nutritional concern. In our study, insufficient dietary intake and people attire choices are mainly responsible for vitamin D deficiency [14]. Low vitamin D levels have been related to an increased risk of cancer, diabetes, obesity, gastrointestinal infections, heart disease, and multiple other conditions.

In the present study high prevalence of results showing inadequate level of 25(OH)D was observed in around 99% of subject population. Approximately 63% of the obtained values of sample group and 56% of the control group were classified as deficient (11.0±4.21 and 9.18±1.39, p=0.56) and 34% of the sample and 12% of control population as vitamin D (13.43±5.89 and 22.65±5.16, p=0.05) insufficient.

Approximately 2% subjects of the sample and 32% of the control group have normal vitamin D. This data showed that 98% of the sample population seems to have low serum 25(OH)D concentration in sample group and 68% in the control group respectively. Identical results have also been reported by Hassan *et al* [15]. where he observed that inadequate level of serum 25(OH)D was highly prevalent (90.1%) in obese population. 25(OH)D and BMI were negatively associated with each other [41].

Subjects with increased body weight were reported to have a lower level of vitamin D than normal weight individuals, possibly due to greater vitamin D accumulation in subcutaneous adipose tissue [16]. BMI was found to be a strong precursor of serum 25(OH)D concentrations, with higher BMI linked with lower 25(OH)D [13]. Current data analysis presenting a significant inverse relationship between PTH and 25(OH)D which are greatly associated with obesity. In addition, it is well known that hypovitaminosis D is associated with hyperparathyroidism. These findings explain that obesity has a direct role in the elevation of PTH with decrease in vitamin D.

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

CONCLUSION

This cross-sectional study aimed to investigate whether obesity has an impact on PTH and 25(OH)D in female population residing in Lahore, Punjab Pakistan or not. The research suggested that there is an inverse correlation between PTH and 25(OH)D level with greater BMI, waist and hip circumference in obese population. Results also showed that obese individuals tend to have lower 25(OH)D and higher PTH level as compared to control. The mean concentration of PTH level in sample and control population was (20.57±6.92 and 26.12±17.94, $p<0.05$). Females aging 40-50 are suffering most from vitamin D inadequacy while females in 31-40 were observed with highest PTH level among the sample population.

Current findings show a significant prevalence of 25(OH)D deficiency (63%) and insufficiency particularly in the elderly population of Lahore. It is imperative that people become more knowledgeable about the sources, health benefits, and indications of vitamin D deficiency. The population in the current study had an overall 25(OH)D deficiency, which suggests an elevated demand for vitamin D supplements. It is suggested that to repeat this research for awareness after every 5 years. A result that supports the need for new guidelines in the treatment of vitamin D insufficiency and the significance of PTH testing is that all people with vitamin D deficiency were observed with high levels of PTH.

Acknowledgment

The authors wish to thanks Dr. Shan Elahi, principal scientist, Centre of Nuclear medicine Mayo hospital Lahore, Pakistan for his guidance & facilitation in sampling & analysis.

References

1) Jumaahm, M. K., Alhamza, A. H. A., and Mansour, A. A., "The Study of the Association of Serum Parathyroid Hormone Level with Obesity in Patients Admitted to a Tertiary Care Center in Basrah," *Dubai Diabetes and Endocrinology Journal*, vol. 27, no. 4, pp. 143–149, 2021.

2) Grethen, E., McClintock, R., Gupta, C. E., Jones, R. M., Cacucci, B. M., Diaz, D., Fulford, A. D., Perkins, S. M., Considine, R. V., and Peacock, M., "Vitamin D and Hyperparathyroidism in Obesity," *The Journal of Clinical Endocrinology & Metabolism*, vol. 96, no. 5, pp. 1320–1326, 2011.

3) Ministrini, S., Ricci, M. A., Daviddi, G., Scavizzi, M., De Vuono, S., D’Abbondanza, M., and Lupattelli, G., "Determinants of High Parathyroid Hormone Levels in Patients with Severe Obesity and Their Relationship with the Cardiometabolic Risk Factors, Before and After a Laparoscopic Sleeve Gastrectomy Intervention," *Obesity Surgery*, vol. 30, no. 6, pp. 2225–2232, 2020.

4) Durá-Travé, T., Gallinas-Victoriano, F., Malumbres-Chacon, M., Ahmed-Mohamed, L., Chueca-Guindulain, M. J., and Berrade-Zubiri, S., "Are there any seasonal variations in 25-hydroxyvitamin D and Parathyroid Hormone Serum Levels in Children and Adolescents with Severe Obesity?" *European Journal of Pediatrics*, vol. 180, no. 4, pp. 1203–1210, 2017.

5) Shapses, S. A., Lee, E. J., Sukumar, D., Durazo-Arvizu, R., and Schneider, S. H., "The Effect of Obesity on the Relationship between Serum Parathyroid Hormone and 25-Hydroxyvitamin D in Women," *The Journal of Clinical Endocrinology & Metabolism*, vol. 98, no. 5, pp. E886–E890, 2013.

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 03 | 2025
DOI: 10.5281/zenodo.15130017

6) Chandler, P. D., Agboola, F., Ng, K., Scott, J. B., Drake, B. F., Bennett, G. G., and Giovannucci, E. L., "Reduction of Parathyroid Hormone with Vitamin D Supplementation in Blacks: A Randomized Controlled Trial," *BMC Nutrition*, vol. 1, no. 1, pp. 1–16, 2015.

7) Al-Sultan, A. I., Amin, T. T., Abou-Seif, M. A., and Al Naboli, M. R., "Vitamin D, Parathyroid Hormone Levels and Insulin Sensitivity among Obese Young Adult Saudis," *European Review for Medical and Pharmacological Sciences*, vol. 15, no. 2, pp. 135–147, 2011.

8) Ha, J., Jo, K., Lim, D. J., Lee, J. M., Chang, S. A., Kang, M. I. L., and Kim, M. H., "Parathyroid Hormone and Vitamin D are Associated with the Risk of Metabolic Obesity in a Middle-Aged and Older Korean Population with Preserved Renal Function: A Cross-Sectional Study," *PLOS One*, vol. 12, no. 4, e0175132, 2017.

9) Foo, L. H., Zhang, Q., Zhu, K., Ma, G., Trube, A., Greenfield, H., and Fraser, D. R., "Relationship between Vitamin D Status, Body Composition and Physical Exercise of Adolescent Girls in Beijing," *Osteoporosis*, vol. 20, no. 3, pp. 417–425, 2009.

10) World Obesity Federation. (2022). *World Obesity Atlas 2022*. Retrieved from https://www.worldobesity.org/resources/resource-library/world-obesity-atlas-2022

11) Ministrini, S., Ricci, M. A., Daviddi, G., Scavizzi, M., De Vuono, S., D'Abbondanza, M., and Lupattelli, G., "Determinants of High Parathyroid Hormone Levels in Patients with Severe Obesity and Their Relationship with the Cardiometabolic Risk Factors, Before and After a Laparoscopic Sleeve Gastrectomy Intervention," *Obesity Surgery*, vol. 30, no. 6, pp. 2225–2232, 2020.

12) Bischof, M. G., Heinze, G., and Vierhapper, H., "Vitamin D Status and Its Relation to Age and Body Mass Index," *Hormone Research*, vol. 66, no. 5, pp. 211–215, 2006.

13) Cipriani, C., and Cianferotti, L., "Vitamin D in Hypoparathyroidism: Insight into Pathophysiology and Perspectives in Clinical Practice," *Endocrine*, vol. 25, no. 7, pp. 106–112, 2023.

14) Tamer, G., Mesci, B., Tamer, I., Kilic, D., and Arik, S., "Is Vitamin D Deficiency an Independent Risk Factor for Obesity and Abdominal Obesity in Women?" *Endokrynologia Polska*, vol. 63, no. 3, pp. 196–201, 2012.

15) Hassan, R., Abazid, N. and Alourfi, Z. "Relationship between 25-Hydroxyvitamin D Concentrations, Serum Calcium, and Parathyroid Hormone in apparently Healthy Syrian People". *Archives of Osteoporosis,* vol 9, no 1, pp. 176-184, 2014.

16) Arabi, A., Baddoura, R., El-Rassi, R.and El-Hajj Fuleihan, G. "Age but not Gender Modulates the Relationship between PTH and Vitamin D". *Bone,* vol 47, no 2, 408– 412, 2010.