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A Study to find the association between Obesity and Osteoporosis according to distinct fat depots - A survey study

Research Article

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Abstract

Medodhara Kala is the zone of transition between Meda Dhatu (Adipose Tissue) and Asthi Dhatu (Bone Tissue). So, any pathology in *Medodhara kala* is responsible for deprived Asthi Dhatu (Osteoporosis). Obesity is the condition where there is abnormal built-up of Meda Dhatu (Adipose tissue) altering the osteogenic potential of Adipose tissue. Among the various types of Obesity based on the fat accumulation at different fat depots, abdominal obesity is identified as the risk factor for the lower bone mineral density and resulting fracture. The present study aims to find the prevalence of osteoporosis among various types of obesity like generalised obesity, abdominal obesity, isolated Abdominal Obesity etc. Cross sectional survey was designed in which 100 subjects fulfilling inclusion criteria, willing to participate were enrolled in the study after obtaining informed consent. Participants were divided into two groups i.e. 50 *Medoroga* (obesity) patients and 50 non-obese volunteers between age group of 20 and 50 irrespective of genders. The collected data comprising Waist Circumference, Waist Hip ratio, BMI classification and other anthropological measurements and T-score was analysed using GraphPad InStat Version 3.6 software. Chi-Square test showed significant association ($p<0.05$) of osteoporosis or osteopenia in patients of generalised with abdominal obesity and isolated abdominal obesity, indicating that the prevalence of osteoporosis rises with increasing waist circumference. Significant association between visceral fat depot (Abdominal Obesity) with the bone mineral density, suggesting the osteogenic potential of *Medodhara Kala* which gets minimised with increase BMI (Body mass index).

Keywords: *Medodhara Kala*, Obesity, Osteoporosis, BMI.

Introduction

Kala (Transitional Zone in between two consequent Dhatu) is the unique concept of Ayurveda, and is said to be exists between the consequent *Dhatus* (Fundamental Tissue) (1). As per Ayurveda *Prakrut Meda Dhatu* (Fatty tissues/ Adipose Tissues) is held responsible for the nourishment of *Asthi Dhatu* (bone tissue/ osteoblasts) as the former provide nourishment to later one (2). The zone of transition between *Asthi Dhatu* (bone tissue) and *Meda Dhatu* (adipose tissue) is defined as *Medodhara Kala*. *Udar* (Abdominal region) is the dwelling place of the *Meda Dhatu* in the form of *Medodhara Kala* (abdominal Visceral fat depot/ Mesentery or greater omentum) (3). Thus, any pathology in *Medodhara kala* like obesity is accountable for the deprivation of *Asthi Dhatu* (osteoporosis). And obesity is the condition where there is excessive accumulation of Adipose tissue which causes either Hypertrophy or excessive differentiation of adipose tissue altering the osteogenic potential of Adipose tissues (4). Among the different types of obesity based on the fat accumulation at different fat depots (5), abdominal obesity is identified as the risk factor for the lower bone mineral density and resulting fracture (6). Contrary to earlier claims that suggested the increased mechanical load brought on by obesity may play a significant role in BMD maintenance (7) or osteoporosis prevention (8) in postmenopausal (9) as well as in adolescents (10), multiple researches showed an antagonistic association between body mass and bone density (11).

Osteoporosis is a silent disease hampering the quality of life by simple fall. India is identified as the nation with the largest disease burden of disability-adjusted life-years DALYs in LBMD (Low bone mineral density) related fractures by the Global Burden of Disease Study 2019 (12). This highlights the need for healthcare professionals to be aware of secondary osteoporosis caused by obesity as the prevalence of obesity is rising in developing countries (13), which suggest the need of the study. The study aims to investigate the association between osteoporosis and the abnormal buildup of adipose tissue in distinct fat depots, with Medodhara Kala serving as the transition zone between adipose and bone tissue.

So, to make people aware about how increase body mass can be a cause of poor bone health and to

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offer suggestions for healthy lifestyle choices that can help postpone or prevent osteoporotic changes in Medoroga (obesity) and to highlights the need for healthcare professionals to be aware of secondary osteoporosis caused by obesity as the prevalence of obesity is rising in developing countries, the study was undertaken.

Materials and Methods

Method

Observational cross sectional survey design was employed for the study. A survey was conducted in total 100 participants, who were split into two groups: 50 *Medoroga* (Obese) patients and 50 non-obese volunteers, between the ages of 20 and 50 years. The criteria for inclusion for Group 'A' was *Medoroga* (obese) patients- BMI- between 30-40 kg/m2 and not suffering from metabolic and endocrine disorders like Diabetes, Hypothyroidism etc whereas for group B, non-obeys volunteers BMI – between 20 to 24.9 kg/m2 without any medical ailments confirmed by taking their medical history. In both the groups, patients taking calcium supplement for long duration were excluded from the study. Reliable, valid, and predesigned CRF (14) (Case Record Form) was used for diagnosis of *Medoroga* & non-obese volunteers as well as to ruled out any co-morbid condition like diabetes, hyper or hypothyroidism, hypertension etc.

Height, weight, waist circumference, and hip circumference (anthropometric analysis) were needed to compute BMI, waist hip ratio (WHR). BMI classification and other anthropological measurements were taken in accordance with WHO recommendations (15, 16). According to earlier studies, the waist circumference and the waist-hip ratio are more accurate indicators of the co-morbidities connected to BMI (17). Validated value of Waist circumference i.e., of 90 cm in males and 80 cm in female as per Asian Indian population was considered for statistical analysis (18). To achieve secondary objectives, the 100 subjects were divided into 5 groups based on the following criteria (19):

1. Generalised obesity with abdominal Obesity- Waist Circumference ≥90 cm for men, WC≥ 80 cm in women and BMI≥ 25 KG/M^2.
2. Generalised obesity without abdominal Obesity- Waist Circumference <90 cm for men, WC< 80 cm in women and BMI≥ 25 KG/M^2.
3. Isolated Abdominal Obesity: Waist Circumference ≥90 cm for men, WC≥ 80 cm in women and BMI< 25 KG/M^2.
4. Non-Obese without Abdominal obesity Group: Individual without GO and AO (Waist Circumference <90 cm for men, WC< 80 cm in women and BMI< 25 KG/M^2).

The camps were organised at the place of study to assess study participants' bone mineral density (BMD) by doing heel ultrasound using Calcaneum Quantitative ultrasonography (QUS) [SONOST 2000, software version 2.01.01, Documentation Version 012 (2003.03.17), Manufacturer-Osteosis Co.Ltd.], which has been demonstrated to be accurate, user-friendly, and practical at the same time without exposing patients to radiation (20, 21). The well-trained technician recorded the T- score. The Procedure to measure T- Score was adopted same as that of previous study (22). Participants were classified as normal BMD (T-score ≥-1 SD), osteopenia (T-score -1 to -2.5 SD), and osteoporosis (T-score >-2.5 SD) based on the T-score that was obtained (23).

The data on discrete variables have been represented as n (%) and Range. The data on continuous variables have been represented as Mean ± SD. GraphPad InStat Version 3.6 (www.graphpad.com) software was used for statistical analysis of data. P value < 0.05 was considered statistically significant.

This study was approved by Institutional review Board and Ethics Committee of Bharati Vidyapeeth of college of Ayurved, Deemed to Be University, Pune. [IEC Ref. No. BVDUCOA/EC/-3501/2020-21 Dated: 04/03/2021]. Prior to enrolment of subjects, all potential risks and benefits of the study were discussed verbally, and after assuring their voluntary participation, withdrawal, and data confidentiality, written informed consent was obtained.

Observations and Results

Data collected from 100 participants was evaluated. Table 1 describes the baseline characteristics such as age, height, weight, BMI, waist circumference, chest circumference, hip circumference of the participants.

In the obese and non-obese both the group (n = 50), the mean WC was 104.92±9.114 cm and 87.59±6.136 respectively with P<0.01. Age (p < 0.005), BMI (p < 0.0001), WC (p < 0.01), CC (p < 0.01), HC (p < 0.01) and WC/HC (p < 0.01) were significantly different between the two groups.

There was a statistically non-significant difference seen for the values between the groups for Height (p>0.05)

Table 1: The basic characteristics of obese and non-obese groups

Total N= 100			
n (weighted %)	**Group A (obese Patients)**	**Group B (Non-obese volunteers)**	**P- value**
Sample size (n)	**n=50**	**n=50**	
Mean ± SD			
AGE	38.08 ± 9.40	33.88 ± 8.86	p < 0.05
HEIGHT	158.92±7.914	159.29±9.348	p > 0.05
WEIGHT	84.12±12.432	59.32±7.308	p < 0.01
BMI	33.13 ± 3.13	22.87 ± 1.37	p < 0.0001
WC	104.92±9.114	87.59±6.136	p < 0.01
CC	102.38±7.349	85.95±4.719	p < 0.01
HC	111.61±10.307	94.18±5.611	p < 0.01
WC/HC	0.93376± .073737	0.90390 ± 0.062281	p < 0.05

Gender and osteoporosis distribution: The findings suggest that, females had higher level of osteoporosis as compared to males. Among males and females, prevalence of osteoporosis was 8.11% and 7.9 % and of osteopenia was 56.76% and 46.03% [Table 2].

Table 2: Gender wise distribution of osteoporosis

T – Score	Male		Female	
	n	%	n	%
+ 1 to - 1	13	35.14%	29	46.03%
-1 to – 2.5	21	56.76%	29	46.03%
-2.5 or less	3	8.11%	5	7.94%
Total	37	100%	63	100%

Association between WC and osteoporosis in female Participants

GO without AO was observed in none of the female subjects. GO with AO was observed in 33 female subjects, out of whom 09 had normal BMD values, 21 were osteopenic and 03 were osteoporotic. IAO was observed in 26 female subjects, out of whom 16 had normal BMD values, 08 were osteopenic and 02 subjects suffered from osteoporosis. In Non-obese group without abdominal obesity and BMI < 25 kg/m^2, all four subjects had Normal BMD. There was significant association between WC and osteoporosis ($p < 0.05$). Table 3 shows the association between BMD and Waist Circumference (GO, IAO and No-obese) in females was found to be statistically significant ($p = 0.0162$). The results suggest that, as the chances of osteoporosis increased the increase in waist circumference [Table 3].

Table 3: Associations Between waist circumference and osteoporosis by Different obesity Groups in Female participants

Female Volunteers											
T – Score	GO without AO	Percentage (%)	GO with AO	Percentage (%)	IAO	Percentage (%)	Non-obese without AO	Percentage (%)	Total	Chi square value	P- value
+ 1 to - 1	0	0%	9	27.27%	16	61.54%	4	100%	29	12.166	0.0162 (p < 0.05
-1 to – 2.5	0	0%	21	63.64%	8	30.77%	0	0%	29		
-2.5 or less	0	0%	3	9.09%	2	7.69%	0	0%	5		
TOTAL	0	0%	33	100%	26	100%	4	100%	63		

Note: GO- Generalised obesity, AO-Abdominal obesity, IAO- Isolated Abdominal Obesity.

Association between WC and osteoporosis in male Participants

GO without AO was observed in one male subjects. GO with AO was observed in 16 male subjects, out of whom 03 had normal BMD values, 10 were osteopenic and 03 were osteoporotic. IAO was observed in 03 female subjects, out of whom all 3 were osteopenic. In Non-obese group without abdominal obesity and BMI < 25 kg/m^2, out of 17 subjects, 9 had Normal BMD, 8 were osteopenic and no volunteers were osteoporotic. There was no significant association found between WC and osteoporosis ($p > 0.05$). Table 4 shows the association between BMD and Waist Circumference (GO with AO, GO without AO, IAO and No-obese) in males was found to be statistically insignificant ($p = 10.876$). Though P value does not show association between osteoporosis and waist circumference in male participants [Table 4].

Table 4: Associations Between waist circumference and osteoporosis by Different obesity Groups in Male participants

Male Volunteers											
T –	GO without	Percentage (%)	GO with	Percentage (%)	IAO	Percentage (%)	Non-obese	Percentage (%)	Total	Chi square	P- value
+ 1 to -	1	100%	3	18.75%	0	0%	9	52.94%	13	10.876	0.0923 (P>0.05
-1 to –	0	0%	10	62.5%	3	100%	8	47.06%	21		
-2.5 or	0	0%	3	18.75%	0	0%	0	0%	3		
TOTAL	1	100	16	100%	3	100%	17	100%	37		

Association between WC and osteoporosis

GO without AO was observed in only one subjects and their BMD values were normal. GO with AO was observed in 50 subjects, out of whom 12 had normal BMD values, 31 were osteopenic and 06 were osteoporotic. IAO was observed in 29 subjects, out of whom 16 had normal BMD values, 11 were osteopenic and 02 subjects suffered from osteoporosis. 21 non-obese volunteers were observed, out of which 13 had normal BMD values, 08 were osteopenic and none of the subjects suffered from osteoporosis. Chi-Square test shows that there was significant association between WC and osteoporosis ($p < 0.05$). The results suggest that, as the chances of osteoporosis increased the increase in waist circumference. [Table 4]

Table 5: Waist circumference wise BMD (osteoporosis/ osteopenia) assessment in study participants

W/H Ratio	Study participants							
	GO with AO	GO	IAO	NON-OBESE	Total	Percentage (%)	Chi-square value	P-value
Normal BMD	1	12	16	13	42	42%	14.129	0.0282 ($p < 0.05$)
Osteopenia	0	31	11	8	50	50%		
Osteoporosis	0	6	2	0	8	8%		
Total	1	50	29	21	100	100%		

Note: GO-Generalised obesity, AO-Abdominal obesity, IAO-Isolated Abdominal Obesity. χ^2 tests were used for categorical variables.

Association between W/H RATIO and osteoporosis

There was significant association seen between W/H ratio and osteoporosis in obese group (p=0.0006, p<0.05), whereas association between W/H ratio and osteoporosis was insignificant in non-obese group (p=0.2170, P>0.05). There was significant association seen between W/H ratio and osteoporosis in non-obese male (p=0.0055, P<0.05). From total 9 non-obese male volunteers with Normal T- Score (T-score-+ 1 to – 1), 7 i.e. 77.78% were of low-risk group (W/H ratio≤0.9) and 2 i.e., 22.22% were belongs to, in Moderate Risk group (W/H ratio 0.9- 1). From total 11 non-obese male volunteers with osteopenia (T-score--1 to – 2.5), only one i.e. 9.09% were of low-risk group (W/H ratio≤0.9) and 6 i.e., 54.55% were belongs to, in Moderate Risk group (W/H ratio 0.9- 1) and 04 i.e., 36.36% were belongs to High-Risk Group (W/H ratio>0.9- 1). There was significant association seen Waist hip ratio and osteoporosis in both non-obese and obese group in male (p=0.0055 and 0.0019 respectively). Table 6 shows the association between BMD and Waist Hip ratio in females which was found to be statistically insignificant (P = 0.1505, P>0.05) in female. [Table 6]

Table 6: W/H ratio wise BMD assessment in all subject

	W/H RATIO	NON-OBESE MALE (n=20)								
		Normal BMD		Osteopenia		Osteoporosis		TOTAL	Chi-square value	P-value
a.	≤0.9(LOW RISK)	7	77.78%	1	9.09%	0	0%	8	10.404	0.0055
	0.9- 1 (MODERATE RISK)	2	22.22%	6	54.55%	0	0%	8		
	>1 (HIGH RISK)	0	0%	4	36.36%	0	0%	4		
	TOTAL	9	100%	11	100	0	0%	20		
	W/H RATIO	NON-OBESE FEMALE (n=30)								
		NORMAL BMD		OSTEOPENIA		OSTEOPROSIS		TOTAL	Chi-square value	P-value
b.	<0.8 (LOW RISK)	0	0%	0	0%	0	0%	0	3.788	0.1505
	0.81- 0.85 (MODERATE RISK)	9	45%	1	12.5%	0	0%	10		
	>0.85 (HIGH RISK)	11	55%	7	87.5%	2	100%	20		
	TOTAL	20	100	8	100%	2	100%	30		
	W/H RATIO	NON-OBESE GROUP (n=50)								
		NORMAL BMD		OSTEOPENIA		OSTEOPROSIS		TOTAL	Chi-square value	P-value
c.	LOW RISK	7	24.18%	1	5.26%	0	0%	8	5.770	0.2170
	MODERATE RISK	11	37.93%	7	36.84%	0	0%	18		
	HIGH RISK	11	37.93%	11	57.90%	2	100%	24		
	TOTAL	29	100%	19	100	2	100%	50		
	W/H RATIO	MALE OBESE-PARTICIPANTS (MEDOROGA PATIENTS) (n=17)								
		NORMAL BMD		OSTEOPENIA		OSTEOPROSIS		TOTAL	Chi-square value	P-value
d.	≤0.9(LOW RISK)	4	100%	0	0%	0	0	4	17.057	0.0019
	0.9- 1 (MODERATE RISK)	0	0%	6	60%	2	66.67%	8		
	>1 (HIGH RISK)	0	0%	4	40%	1	33.33%	5		
	TOTAL	4	100%	10	100%	3	100%	17		
	W/H RATIO	FEMALE OBESE PATIENTS (MEDOROGA PATIENTS) (n= 33)								
		NORMAL BMD		OSTEOPENIA		OSTEOPROSIS		TOTAL	Chi-square value	P-value
e.	≤0.8 (LOW RISK)	1	11.11%	0	0	0	0%	1	15.459	0.0038
	0.81- 0.85 (MODERATE RISK)	5	55.56%	1	4.76%	0	0%	6		
	>0.85 (HIGH RISK)	3	33.33%	20	95.24%	3	100%	26		
	TOTAL	9	100	21	100%	3	100%	33		

	W/H RATIO	OBESE GROUP (MEDOROGA PATIENTS) (n=50)								
		NORMAL BMD		OSTEOPENIA		OSTEOPROSIS		TOTAL	Chi-square value	P-value
f.	LOW RISK	5	38.46%	0	0	0	0	5	19.511	0.0006
	MODERATE RISK	5	38.46%	7	22.58%	2	33.33%	14		
	HIGH RISK	3	23.08%	24	77.42%	4	66.66%	31		
	TOTAL	13	100%	31	100%	6	100%	50		

Assessment of T – Score in Two Groups

In the present study in group A, out of 50 obese patients 13 i.e., 26% subjects had normal BMD, 31 i.e. 62% subjects had osteopenia (T- score- -1 to – 2.5 and 06 i.e. 12% subjects had osteoporosis (T- Score--2.5 or less). In group B, out of 50 non-obese volunteers 29 i.e., 58% subjects had normal BMD, 19 i.e. 38% subjects had osteopenia (T- score- -1 to – 2.5 and 02 i.e. 04% subjects had osteoporosis (T- Score--2.5 or less). There was significant association between BMI and osteoporosis seen (chi-square value- 10.975 at 2 degree of freedom, p Value: 0.0041, p< 0.05). Both Obese and non-obese group shows significant difference in BMI and associated significantly different prevalence of osteoporosis in both the group with higher prevalence in Obese group. [Table 6]

Table 7: Association between osteoporosis and BMI

T – Score	Group A		Group B	
	No. of Participants	Percentage	No. of Participants	Percentage
+ 1 to - 1	13	26%	29	58%
-1 to – 2.5	31	62%	19	38%
-2.5 or less	6	12%	2	4%
Total	50	100%	50	100%
Chi-square: 10.975 (Degrees of Freedom: 2), The P value is 0.0041, statistically significant				

Discussion

Kala (24) and *Dhatuposhan Siddhanta* (25) are two important *Siddhantas* (principles) which deals with transportation and absorption of nutrients in the body. At the confluence of two dhatu (i.e. Meda [Adipose tissue] and Asthi [Bone tissues]) resides a structure called Medodhara kala which play significant role skeleton homeostasis. We can refer them as the transitional zone. But pathological adipose tissue either hypertrophied or hyper proliferation, resulted into impaired function of this transition zones, led to undernourished Bone tissue (Asthi Dhatu) i.e., osteoporosis or osteopenia. Therefore, the study was conducted to determine whether osteoporosis is more common in obese people based on the distribution of fat in various fat depot. Table 1 shows the clinical and anthropological characteristics of the study subjects. Group A had significantly higher weight, BMI, waist circumference than Group B. In the present study, Group A, has maximum 98% Generalised obesity with Abdominal obesity patients, only one patient of generalised without abdominal obesity were recorded with normal BMD (T-score>+1). Table 2 indicates that the prevalence of osteoporosis is higher in women than in men. Postmenopausal females were excluded in the study to avoid confounding variable. Table 3 represents prevalence of osteopenia and osteoporosis was found to be 0% in GO without AO and Non-obese without AO, whereas prevalence of osteopenia and osteoporosis was 63.64% and 9.09% respectively in subject having GO with AO and 30.77% and 7.69%, respectively, in subjects having IAO. There was significant association between WC and osteoporosis ($p < 0.05$). Finding suggest positive association between WC and Osteoporosis. Osteoporosis or osteopenia found to be more prevalent in Abdominal obesity subjects. Table 5 indicates that the risk of osteoporosis increases with increase waist circumference. Chi-square test shows significant association between WC and osteoporosis ($P< 0.05$) which suggest that chance of osteoporosis increased with increase in waist circumference. Table 6 shows in Group B (NON-obese Volunteers) insignificant association seen between W/H ratio and osteoporosis ($P>0.05$, $P= 0.2170$ with $x^2= 5.770$). Whereas significant association were identified between W/H ratio and BMD in Non-obese Male ($P<0.05$, $P= 0.0055$ with $x^2= 10.404$). In group A (Obese Patients), significant association was seen between W/H ratio and osteoporosis ($P>0.05$, $P= 0.0006$ with $x^2= 19.511$) which suggest. Significant association were identified between W/H ratio and BMD in both Male and Female Obese subjects (Male: $P<0.05$, $P= 0.0019$ with $x^2= 17.057$, Female: $P<0.05$, $P= 0.0038$ with $x^2= 15.459$). Which suggest that W/H ratio is significantly associated with BMD i.e., Chance of osteoporosis increases with increase in W/H ratio in obese patients. According to Table 7, the overall prevalence of osteopenia and osteoporosis is 62% and 12%, respectively, in the obese group and 38% and 12%, respectively, in the non-obesity group. There was significant association found between BMI and osteoporosis seen (chi-square value- 10.975 at 2 degree of freedom, P Value: 0.0041, $p< 0.05$).

The validation of the initial research question is provided below.

Research Question 1: Does the hypertrophied or hyper proliferation of adipose tissue lessen the efficacy of Medodhara kala [zone of transition between (Adipose tissue) and Asthi Dhatu (Bone tissue)] which could be the cause of bad bone health?

Chi-square test shows significant association between WC and osteoporosis (P< 0.05) which suggest that chance of osteoporosis increased with increase in waist circumference. Which is suggestive of decrease efficacy of Medodhara kala [zone of transition between (Adipose tissue) and Asthi Dhatu (Bone tissue)] which could be the cause of deprived Asthi Dhatu (bad bone health).

Though Table No. 4 show insignificant association between WC and osteoporosis in male participants, The results of Table No. 3 points towards a positive association between WC and osteoporosis in female subject and overall study participants. Subjects with abdominal obesity were shown to have a higher prevalence of osteoporosis or osteopenia. Table 5 shows that as waist circumference rises, so does the risk of osteoporosis. Therefore, we can conclude that among different fat depots, visceral fat depot may raise the risk of osteoporosis. Table No. 7 shows significant association between BMI and osteoporosis and depicts those chances of osteoporosis increases with increased BMI.

Limitations

Present study feasibility purpose Calcaneal scan was utilised for BMD score; the study can be conducted in future with DEXA scan as it yields the central BMD Score. For generalisation of the result multi-centric study should be conducted on the large sample.

Conclusion

Prevalence of osteopenia or osteoporosis is more in obese patients. Osteoporosis or osteopenia shows significant association with GO with AO and IAO. Significant association between visceral fat depot (Abdominal Obesity) with the bone mineral density, suggesting the osteogenic potential of Medodhara Kala which gets minimised with increase BMI (Body mass index).

Conflict of Interest: Nil

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