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RESEARCH ARTICLE

Study of relationship between physiological factors and handgrip strength on bone mineral density in healthy men and women – A cross-sectional study

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ABSTRACT

Background: Age, gender, diet, and body mass index (BMI) are important physiological factors that can affect muscle strength and bone mineral density (BMD). Obesity and osteoporosis are two important and developing public health problems worldwide. **Aims and Objectives:** This study aims to know the relationship between physiological factors such as age, gender, diet, BMI, and handgrip strength (HGS) on BMD in healthy men and women. **Materials and Methods:** A total of 198 participants of age 30–70 years were included in the study. BMI was calculated using Quetelet index. Measurement of HGS was done using a handgrip dynamometer following standard methods. HGS max in kg and endurance time (ET) in seconds were recorded. BMD was recorded using bone sonometer, in the distal end of tibia. **Results:** Age had a weak negative correlation with BMD, HGS max, and ET. BMD had a weak negative correlation with BMI though statistically not significant. BMI among vegetarian (V) and non-vegetarian (NV) group with normal BMI range, occurrence of osteoporosis was higher among vegetarian. In overweight/obese, osteoporosis was higher among NV, though statistically not significant. There was no significant gender difference in BMD between V and NV. ET was statistically significant in NV females. HGS max and ET were higher among NV males but statistically not significant. **Conclusion:** There is no significant relation between BMI, diet, and HGS max on BMD in V and NV. Hence, we can conclude that well-planned and balanced vegetarian diet is equally nutritious as NV diet for good muscle strength and bone composition.

KEY WORDS: Body Mass Index; Handgrip Strength; Bone Mineral Density; Vegetarians; Non-Vegetarians

INTRODUCTION

Age, gender, diet, and body mass index (BMI) are important physiological factors that can affect muscle strength and bone mineral density (BMD). Obesity and osteoporosis are two important and developing public health problems worldwide.[1] Metabolic bone disease is underestimated in our country due to unawareness of the same. Early identification of reduction in bone mass may be helpful in preventing bone loss and future fracture risk.[2] It is well known that advanced age is a risk factor for bone loss and osteoporosis. In aging people, diet is thought to be one of the leading causes of bone mineral loss. Most people believe that food from animal sources is more nutritious than that from plants,[3] whereas vegetarian diets may not support bone health because of low intake of protein, calcium, and Vitamins D and B12, but vegetarian diets are alkaline which may favor BMD.[4] Furthermore, vegetarian diet is associated with health benefits such as lower rates of obesity, diabetes, hypertension, cardiovascular disease, and some cancers.[5,6] There is a need to verify this association

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and hence we are trying to explore the potential impact of vegetarian and non-vegetarian (NV) diet on BMD in adults. BMI is a good indicator for measurement of BMD and also it is an independent predictor of osteoporosis.[1] Furthermore, low BMI and low weight are interrelated with occurrence of osteoporosis.[7] Handgrip strength (HGS) is a potentially useful parameter to predict osteoporosis and also it is an indicator of general muscle strength. The previous study compared HGS and BMD on incident fractures. HGS can predict future fracture and prediction is independent of BMD.[8] Hence, our primary objective of this study is to know the relationship between physiological factors such as age, gender, diet, and BMI on BMD in healthy subjects and also to know the relationship between HGS and BMD.

MATERIALS AND METHODS

The study was approved by the research and ethical committee of the institution (IEC/HIMS/RR98/18-10-2019). One hundred and ninety-eight participants comprising both males and females of age group 30–70 years were included in our study. This is a cross-sectional study done after obtaining informed consent from the subjects who were attending BMD camp at private clinic, Hassan. The duration of our study was 3 months.

Inclusion Criteria

All apparently healthy vegetarians and non-vegetarians were included in the study. The subjects who were hypertensives, alcoholics and smokers, and bedridden/fracture patients and those who were on drugs known to affect bone mineral metabolism were excluded from the study. Body height was measured standing against a wall without shoes using a measuring tape in nearest centimeters. Weight was obtained with light indoor clothing in kilograms. BMI was calculated using Quetelet index, BMI (Kg/m^2 = wt (Kg)/Ht (m^2). According to the WHO classification of BMI, participants were then categorized into three groups as normal weight BMI 18.5–24.9 kg/m^2, overweight BMI 24.9–29.9 kg/m^2, and obese >30 kg/m^2.

Measurement of HGS was done using a handgrip dynamometer (Jagson India make). HGS was measured in subjects in seated position with elbow by their side and flexed to right angles and a neutral wrist position and provision of support underneath the dynamometer. In this position, the participant is asked to compress the HGS dynamometer with maximum strength. HGS can be quantified by measuring the amount of static force that the hand can compress/squeeze around a dynamometer. The mean of three trials of grip strength is taken. This is referred to as maximum isometric tension, T max in kg and endurance time (ET) are measured by the time of onset of fatigue for 70% of the in Tmax expressed in seconds.[9-12]

BMD is recorded using the Sunlight MiniOmni™ bone sonometer – Adults Configuration, in the distal end of tibia, over the shin region. The results were analyzed on the basis of WHO – compliant T-score and Z-score. T-score measure is most directly applicable to patient risk assessment. The T-score relates a speed of sound (SOS) value to the scores obtained for subjects in our study. The T-score value is the number of standard deviations by which the current patient's SOS value exceeds or falls below the mean. T-score above −1.0 is normal. T-score between −1.0 and −2.5 is osteopenic and osteoporosis with T-score below −2.5. Osteopenia and osteoporosis were considered as abnormal BMD. Bone ultrasound has high sensitivity and specificity in predicting low bone mass and hence can be used as a screening tool.[1]

Statistical Analysis

It was done using SPSS version 20 software. Statistical analysis was done using descriptive statistics and inferential statistics. Descriptive statistics include mean, standard deviation, frequency, and percentages. Inferential statistics: Mean scores between two groups were compared using unpaired "*t*-test" and Student's "*t*-test." BMD scores between V and NV were assessed using Chi-square test. Pearson's correlation was used to assess correlation between all variables. $P < 0.05$ is considered as significant value.

RESULTS

In the present study, there were 78 (39.4%) of males and 120 (60.6%) of females. In the present study, there were 42 (21.2%) of V and 156 (78.8%) NV [Tables 1].

Pearson's correlation showed that there was a weak positive correlation ($r = 0.161$) between age and BMI, and correlation was statistically significant ($P = 0.023$). There was a weak negative correlation between age and BMD, age and HGS max, and age and ET, and correlation was statistically significant ($P < 0.001$). There was a weak negative correlation ($r = -0.116$) between BMI and BMD, and correlation was not statistically significant ($P = 0.105$), there was a weak negative correlation ($r = -0.273$) between BMI and HGS max, and correlation was statistically significant ($P < 0.001$),

Table 1: Descriptive statistics

Variables	Mean±SD
Age	46.9242±9.08753
Height	1.5970±0.12903
Weight	68.6414±10.93347
BMI	27.0505±4.13580
HGS max	27.4091±9.03683
ET in sec	17.1364±6.26460
BMD	−1.2364±1.03908

BMI: Body mass index, BMD: Bone mineral density, HGS: Handgrip strength, ET: Endurance time

there was a weak negative correlation ($r = -0.095$) between BMI and ET, and correlation was not statistically significant ($P = 0.182$). There was a weak positive correlation ($r = 0.202$) between BMD and HGS max, and correlation was statistically significant ($P = 0.004$), there was a weak positive correlation ($r = 0.090$) between BMD and ET, and correlation was not statistically significant ($P = 0.206$), there was a weak positive correlation ($r = 0.140$) between HGS max and ET, and correlation was statistically significant ($P = 0.048$) [Table 2].

In the present study, BMI, HGS max, ET, and BMD were compared among V and NV subjects; the results showed that there was no statistically significant difference. However, ET in NV was more compared to V subjects and was statistically significant, $P = 0.026$ [Table 3].

Between V and NV males, there was no statistically significant difference in mean BMI, HGS max, ET, and BMD (i.e., $P = 0.923$, $P = 0.344$, $P = 0.550$, and $P = 0.497$, respectively). Between V and NV females, there was no statistically significant difference in mean BMI, HGS max, and BMD (i.e., $P = 0.792$, $P = 0.436$, and $P = 0.905$, respectively), whereas there was a statistically significant difference in mean ET between V and NV females (i.e., $P = 0.010$) [Table 4].

Table 2: Pearson's correlation

Variables	BMI	BMD	HGS max	ET in sec
Age				
r	WPC (0.161)	WNC (−0.305)	WNC (−0.372)	WNC (−0.098)
P	SS *(0.023)	SS *(<0.001)	SS *(<0.001)	NS (0.170)
n	198	198	198	198
BMI				
r		WNC (−0.116)	WNC (−0.273)	WNC (−0.095)
P		NS (0.105)	SS *(<0.001)	NS (0.182)
n		198	198	198
BMD				
r			WPC (0.202)	WPC (0.090)
P			SS *(0.004)	NS (0.206)
n			198	198
HGS max				
r				WPC (0.140)
P				SS *(0.048)
n				198

WNC: Weak positive correlation, WNC: Weak negative correlation, SS: Statistically significant, NS: Not significant, r: Pearson's correlation, *P*: Significance (two tailed), n: Total number. BMI: Body mass index, BMD: Bone mineral density, HGS: Handgrip strength, ET: Endurance time

Among V and NV, distribution of subjects with different BMD grading among different BMI grade was done using Chi-square test and there was no statistically significant difference between distribution of subjects with different BMD grading among different BMI grade(i.e., V, $P = 0.222$ and NV, $P = 0.156$) [Table 5].

DISCUSSION

In the present study, when age when compared with BMD, HGS max, and ET, age had a weak negative correlation, also it shows statistically significant relation with BMD and HGS max. When compared with BMI and BMD of same age and gender group, there was a weak negative correlation between them though statistically not significant. When we

Table 3: Student's *t*-test

Variables	DIET	Number	Mean±Std. deviation	*P*
BMI	V	42	26.8500±4.19345	0.724
	NV	156	27.1045±4.13211	
HGS max	V	42	27.6667±7.77007	0.836
	NV	156	27.3397±9.37016	
ET	V	42	15.2381±7.35447	0.026*
	NV	156	17.6474±5.85943	
BMD	V	42	−1.1952±1.01716	0.773
	NV	156	−1.2474±1.04785	

BMI: Body mass index, BMD: Bone mineral density, HGS: Handgrip strength, ET: Endurance time, NV: Non-vegetarian, V: Vegetarian

Table 4: Unpaired *t*-test

Variables	Diet	Number	Mean±Std. deviation	*P*
Males				
BMI	V	18	25.516±3.304	0.923
	NV	60	25.598±3.089	
HGS max	V	18	31.777±8.735	0.344
	NV	60	33.916±8.238	
ET in sec	V	18	17.888±7.752	0.550
	NV	60	18.866±5.478	
BMD	V	18	−0.977±0.969	0.497
	NV	60	−1.153±0.990	
Females				
BMI	V	24	27.850±4.565	0.792
	NV	98	28.117±4.411	
HGS max	V	24	24.583±5.299	0.436
	NV	98	23.316±7.485	
ET in sec	V	24	13.250±6.509	0.010*
	NV	98	16.877±5.929	
BMD	V	24	−1.358±1.041	0.905
	NV	98	−1.328±1.101	

BMI: Body mass index, BMD: Bone mineral density, HGS: Handgrip strength, ET: Endurance time, V: Vegetarian, NV: Non-vegetarian

Table 5: Chi-square test

BMI grade *BMD Remark *Diet	BMD remark			*P*
	N	OPE	OPO	
V				
BMI grade				
Normal				
Number	6	2	2	0.222
BMD %	30.0	12.5	33.3	
Overweight				
Number	13	12	2	
BMD %	65.0	75.0	33.3	
Obese				
Number	1	2	2	
BMD %	5.0	12.5	33.3	
Total				
Number	20	16	6	
BMD %	100.0	100.0	100.0	
NV				
BMI grade				
Normal				
Number	19	26	2	0.156
BMD %	29.7	36.1	10.0	
Overweight				
Number	34	32	11	
BMD %	53.1	44.4	55.0	
Obese				
Number	11	14	7	
BMD %	17.2	19.4	35.0	
Total				
Number	64	72	20	
BMD %	100.0	100.0	100.0	

OPE: Osteopenia, OPO: Osteoporosis, N: Normal. BMI: Body mass index, BMD: Bone mineral density, NV: Non-vegetarian, V: Vegetarian

compared BMI among V and NV subjects, we found that the subjects with normal BMI range, occurrence of osteoporosis was higher among V, whereas subjects were overweight/obese, the percentage of osteoporosis was higher among NV, though statistically not significant. In our study, there was no significant gender difference in BMD between V and NV. The present study shows statistically significant results of ET among females in NV. HGS max and ET were higher among NV males but statistically not significant.

In our study, physiological parameters such as age when compared with BMD, HGS max, and ET, age had a weak negative correlation, also it shows statistically significant relation with BMD and HGS max. As age advances, BMD and HGS decrease. Mishra *et al*. and Gourlay *et al*.[1,13] in their study also found that as age advances, BMD and HGS were associated with decreased BMD. The chance of low BMD among people with age 60 and above was several times higher when compared to low age group. When compared with BMI and BMD of same age and gender group, there was a weak negative correlation between them though statistically not significant. Similar findings were noted by Zhao *et al*.[14] On the other hand, many previous studies show inconsistent results between various grades of BMI and BMD.[15] Premaor *et al*.[16] in their study found that increasing fat mass may not have a beneficial effect on bone mass. They also concluded that morbid obesity may not be protective against fracture and might even be a risk factor for fracture. Compston[17] in their study has suggested that BMI is an unreliable indicator of osteoporosis and fracture risk and also found that high BMI was not protective against BMD in postmenopausal women. On the contrary, some studies show that high BMI had a protective effect against bone fracture.[18-20] Rexhepi *et al*.[21] concluded, total hip BMD values in obese menopausal and premenopausal women as well as men were significantly higher compared to overweight or normal weight subjects. BMI was shown to be a significant independent associate of BMD in both menopausal women and men. When we compared BMI and BMD among V and NV subjects, we found that the subjects with normal BMI range, occurrence of osteoporosis was higher among V, whereas subjects were overweight/obese, the percentage of osteoporosis was higher among NV and also incidence of osteopenia was higher among overweight V, though statistically not significant. This result is in accordance with the findings noted by Wang *et al*. and Kunrick *et al*.[3,4] There was no significant gender difference in BMD between V and NV. There is a general belief that foods from animal sources are more nutritious than from plant sources. There are many evidences demonstrating the importance of dietary protein on bone formation and reducing fracture risk in elderly individuals. Hence, vegetarian diets are of particular concern because of comparatively low protein content in them. However, Kunrick *et al*. in their study have suggested that plant-based diets are not detrimental to bone metabolism as these diets are alkaline which favors BMD. Wang *et al*.[3] noted in their study that dietary differences were not found to be significantly associated with BMD between V and NV, though vegetarians consumed significantly fewer total calories, less protein, less fat, and more calcium, sodium, and potassium than non-vegetarian. Appleby *et al*.[22] concluded that fracture risk was similar for both V and NV in their study and the higher fracture risk among vegans appeared to be a consequence of their considerably lower mean calcium intake which can be supplemented by adequate calcium intake from suitable sources. The study of Ambroszkiewicz *et al*.[23] shows that a well-planned vegetarian diet with proper dairy and egg intake does not lead to significantly lower bone mass. Its positive correlations with BMD might be important for the protection of vegetarians from bone abnormalities. Same findings were supported by Ho-Pham *et al*.[24] in their prospective study who found no significant difference in the rate of bone loss between vegans and omnivores. The present study shows statistically significant results of ET among females in NV. HGS max

and ET were higher among NV males but statistically not significant. The previous studies have observed higher HGS max and ET among NV in contrast to V.[25] Whereas when HGS was compared with BMD between V and NV, males and females, there was no statistically significant difference. The previous studies found equally that the vegetarian subjects had similar physical performances compared to the non-vegetarian subjects and also, a vegetarian food pattern can be considered as complete with intake of all required nutrients in sufficient amounts. Appropriately planned and balanced vegetarian diets are healthy and also nutritionally adequate for the muscular performance.[26,27]

Strengths

Strength of our study is that there is no significant difference between age- and sex-matched V and NV with regard to BMI, HGS max, and BMD. ET was statistically significant among NV female. However, HGS max and ET were higher among NV males though statistically not significant.

Limitations

First, in this study, we did not consider various dietary components that would affect bone mineral content to know the exact impact of diet on bone health among vegetarians. Second, the level and type of physical activity which may be different among individuals were also not considered in our study. Third, we have measured BMD on only one site, measuring BMD on multiple sites may give clear insight.

CONCLUSION

In our study, there is no statistically significant difference between age- and sex-matched V and NV groups with regard to HGS max and BMD with similar grades of BMI with only a significant difference in ET among female NV. There was a weak negative correlation between BMI and BMD. Hence, we can conclude that well-planned and balanced vegetarian diets are equally nutritious as NV diet for good muscle strength and bone composition.

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