Sapporo Medical Journal
Volume 55, Issue12, December, 2021

Correlation of physical exercise, bone mineral density with Osteoporosis in Saudi females

Halima Mohamed Sabri Hawesa, Huda Ibrahim Almohammad

Abstract— **Introduction:**Osteoporosis defined as the low bone density disease, causing an increase in fragility of the bone skeleton. The impact of lifestyle, such as physical exercise, has shown a strong linkage with the osteoporosis. Females in modern Saudi society are also exposed to such heightened risks as they adopt a more sedentary lifestyle due to economic affluenceand technological advancement. **Objective:**Evaluate the relationship between the instance of osteoporosis and habit of physical exercise among a cross-sample of Saudi women. **Methods:** A cross-sectional study with sample consisted of 100 Saudi females in the age group of 19 to 58 years. The T-test of independence determined the relationship between bone mineral density and physical exercise. The measurements consisted of values of broadband ultrasound attenuation (BUA) and speed of sound (SOS). The DMS Pegasus Smart Bone Densitometer, with a Caucasian setting and measurement of the right calcaneus bone. The participants placed into two categories, one with no regular exercise used as a control group where the second one was the target group. This study was approved by the Ethical and Research Committee of Princess Nourah University.
Result and Conclusion: Participants with higher BMI had reduced bone density. Therefore, the adoption of healthier diets and the inclusion of active physical exercise habits in daily lives would help improve bone health. Middle-aged females who were doing high exercise levels had better bone density. Current study suggests that regular exercise started at an early age, would reduce the risk of osteoporosis later in life.

Keywords: Bone mineral density (BMD), Broadband ultrasound attenuation (BUA), speed of sound (SOS), osteoporosis, osteopenia, low bone density, exercise, quantitative ultrasound (QUS).

INTRODUCTION

Osteoporosis is characterized bydeterioration in bone mass, which causes alterations in bone thickness and articulations, followed by mechanical variation in bone strength and bone tissue. Therefore, this increases vulnerability to bone fractures(Annapoorna, 2012). The relationship between physical force and bone density was first established by Galileo in 1683, while in 1892, Julius Wolff perceived that mechanical force applied to the bone over a period eventually causes bone-strengthening (Todd & Robinson, 2003). Over 200 million women worldwide havesuffered bone fractures, while one-tenth are over sixty-year-old(Health, 2015). Previous studies gave evidence that in pre and postmenopausal women, bone fractures can be maintained or increased with restorative exercises(Pfeifer & Minne, 2020). However, “physical activity which is defined by (WHO, 2014) as any bodily movement produced by skeletal muscles that require energy expenditure” (WHO, 2014). These activities are beneficial in scaling down osteoporosis.Exercise, more formally, defined as a “subset of physical activity that is planned structured and repetitive and has a final aim to improve physical fitness”(Caspersen, Powell, & Christenson, 1974).Various studies revealed that greater bone mass shown in the lumbar region of female athletes over the age of 50 years, especially weight-bearing activities, are related to high bone density(Todd & Robinson, 2003).

There are certain factors in Saudi society due to which paradigm of inactivity is prevailing,especially in Saudi women(Al-Eisa & Al-Sobayel, 2012), for instance, socio-cultural, health beliefs, hot

weather,excessive snacking,large portion size, economical and tremendous growth in technology. This sedentary lifestyle, fast food eating and soft drink consumption harm health. These intense habits contribute to obesity.In Saudi communities, women have a high prevalence of obesity than men, 24% and16%, respectively(Al-Nuaim & et al, 1996). The barriers to exercise and obesity are the cultural and traditional, daily things like clothing, diet,hospitality, normsand less reduced outside access and lack of nutritional awareness(Al-Hazzaa, 2018). Obesity could be a leading cause of osteoporosis, just as it is for certain other non-communicable diseases.

Furthermore, high obesity in individuals showed low bone mineral density and susceptibility to fractures(Albrahim, 2018). Late adolescence is the time when 90% of bone mass develops,so correct lifestyle choices and nutritional awareness must be well understood and adopted at this time as part of daily routine to achieve healthy bones. Meanwhile, if we look around,most of our youth and adults are mostly involved in activities usingcomputers, electronic gadgets and mobile phones while preferring to sit all day indoors hence avoiding movements that induce physical exercise and adequate exposure to sunlight.Lack of physical activity, coupled with consumption of low nutritional value fast food causesand high intake of carbonated sugary soft drinks, causes deficiencies of the essential minerals like Calcium and Vitamin D,thus weakening the bone(Hammad & Benajiba, 2017).

Osteoporosisis a silent killer whose diagnosis at early stages is often difficult due to a lack of a clear clinical indication or symptoms. Mostly it is diagnosed due to its after-effects in terms of increased fractures and pain. Usually fracture sites are the spine, hip, distal forearm and proximal humerus bone, while the severity could be partial to very demented in which reassembling of a fractured bone is almost impossible.In severe cases and advanced age groups, Kyphosis and height loss are the indicators. Diagnosis is made through osteoporotic scales and radiographic scansby using a bone densitometer or non-radiative scan using ultrasound (De Souza & Passini, 2010). State of bone structure and density are measured through different parameters like ultrasound attenuation (BUA), speed of sound (SOS), the velocity of sound (VOS), the qualitative index (QUI) and stiffness index (SI)(Alkahtani & et al, 2018).Bone mineral density (BMD) in this study was measured through a portable Pegasus ultrasound device. This device is easy to carry and is safe to use.

This study aims to focus on regular exercise for healthier bones. Hence, extensive research and analysis must be conducted in this area to develop an understanding of various factors that influence osteoporosis and its prevention.Ageing plays a vital role as a significant risk factor for osteoporosis. Some other risk factors that are gender especially being a female, menopause,and the individual's hormone situation, smoking, having a low body weight than typical and finally side effects of certain medications cause lowering of bone density and alsointerfere with the composition of a bone material(Zahra, Sardar, & Neelam, 2015). Regular light exercises such as tennis, aerobics, light jogging and steps would improve the BMD(Tønnesen & al, 2016); however, some other types of tasks, such as cycling, walking for long distances and swimming,do not affect improving BMD(Tønnesen & al, 2016).

MATERIAL AND METHOD

A cross-sectional qualitative study involving 100 Saudi females,between the age group of19 to 58 years, was conducted. Before initiating the survey, the participants were given an introductory workshop on Osteoporosis awareness, its risk factors and prevention. Following the signing of the voluntary consent form, the participants filled the questionnaire,which included information on demographics, behavioural and physical attributes like height and weight measurements of each participant. The population sample

was split into two groups: Group 1, which identified themselves as doing no regular exercises, and Group 2 was engaged in a regular exercise program.

The portable DMS Pegasus smart bone Densitometer, manufactured by Manguio (France), was used to measure bone mass density at mid calcaneus bone. Bone density measurementsin terms of bone Broadband Ultrasound Attenuation (BUA) in decibels per megahertz (dB/MHz). Furthermore, Speed of Sound (SOS), measured in m/s, was used as a measurement of osteoporosis threshold using the WHO guidelines,i.e. reading of -1 and above is considered average bone density, between -1 and -2.5 is osteopenia while -2.5 and below is confirmed osteoporosis.

To find the normality of bone density, the BUA,was divided into four categories, as per the following details:

i. Bone Mass Density with BUA > 70 dB/MHz, was normal
ii. Bone Mass Density with BUA in the range 65 to 69.9, was considered below average
iii. Bone Mass Density with BUA in the 55 to 64,9, indicates osteopenia
iv. Bone Mass Density with BUA less the 55, shows osteoporosis

The study proposalwas reviewed by the Institutional Review Board of the Princess Nourah bint Abdulrahman University which gave Ethical approval for the study. The study (IRB Log No. 18-0164) isregistered with King Abdul Aziz City for Science & Technology (KACST), Riyadh, vide registration number H-01-R-059.

STATISTICAL ANALYSIS

In this current study, simple random technique was used to collect samples froma total of100 Saudi female populations in which 60 were practicing light exercise as light walking for 25 minutes and aerobic for 30 minutes — post awareness workshop on Osteoporosis. SPSS ver 22.0 software was used to perform statistical analysis Data normality was checked by Kolmogorov-Smirnov and Shapiro-Wilk test for SOS, which showed that the data set as to be normally distributed.

Descriptive analysis was performed for bone density by determining BUA and age group. BUA categories and BMI are summarized as percentages and frequencies. BUA analyzed in the form of mean, standard deviation and range. The inferential analysis usesthe Chi-square test of independence between total BMI and total BUA (dB/MHz). A correlation test measured the strength and direction of the relationship between BUA, SOS and BMI.For exercise and the BUA Chi-square test showed no statistical relationship. T-test of independence also showed no statistical correlation between exercise and speed of sound (SOS).

RESULT

The mean age of participants was 29.62 years (± 10.25), range (19 to 58 years). The BUA range between 40.54 dB/MHz and 91 dB/MHz, with a mean of 72.2 dB/MHz (±8.6). Table 1shows the categories and percentages of BUA (dB/MHz), BMI (kg/m2) and exercise.

Table 1 Categories and percentages of BUA, BMI & Exercise

Variables	Categories	Percentages	Mean ± SD

Age	19 to 32 33 to 45 46 to 58	67% 23% 10%	29.62 ±10.25
BUAdB/MHz	Osteoporosis Osteopenia Below average Normal	5 % 15 % 16 % 64 %	72.1935 ±8.57293
BMI kg/m2	Underweight Normal Overweight Obese	13% 41% 29% 17%	24.7268 ± 5.93786
Exercise	Low Exercise High Exercise	32% 68%	

Table 2shows the SOS normality test:

Table 2 Test of Normality

Tests of Normality						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
SOSm/s	0.201	100	0.000	0.583	100	0.000

From Table 2,the normality of the data regarding bone mass density (BMD) was tested by the Kolmogorov test. SOS m/s (P = 0.000< 0.05, 100 degree of freedom). While Shapiro-Wilk test of SOS m/s (P=0.000<0.05, 100 degrees of freedom).Table 3showed a significant association between BMI_Cat and BUA_Cat (P=0.45<0.05). Cramer's V or effect size = 0.24, which is small to medium effect size.

Table 3 Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.148(a)	9	0.046
Likelihood Ratio	17.472	9	0.042
Linear-by-Linear Association	2.172	1	0.141
N of Valid Cases	100		

(a) Ten cells (62.5%) have expected count less than 5. The minimum expected count is 0.65.

Table 4 cross-tabulation tableshowed that 5% had osteoporosis, 15% had osteopenia while 16% were below average, only 64% were normal

Table 4 BMI_CAT * BUA_CAT Crosstabulation

			BUA_CAT			
			osteoporosis	osteopenia	below average	normal
BMI_CAT	1	Count	0	4	2	7
		% within BMI_CAT	0.0%	30.8%	15.4%	53.8%
	2	Count	0	6	3	32
		% within BMI_CAT	0.0%	14.6%	7.3%	78.0%
	3	Count	2	3	7	17
		% within BMI_CAT	6.9%	10.3%	24.1%	58.6%
	4	Count	3	2	4	8
		% within BMI_CAT	17.6%	11.8%	23.5%	47.1%
Total		Count	5	15	16	64
		% within BMI_CAT	5.0%	15.0%	16.0%	64.0%

Table 5showsa significant correlation between SOS and BMI, while the correlation coefficient (p=.001>0.01,r=-0.331 for BMI and SOS) while the strength is less than 0.5, so there is enough evidence to showa moderate relationship between body weight and bone density. Furthermore, it also indicatesa negative direction, which means increasing body weight, causes bone density reduction.

Table 5 Nonparametric Correlations

			BUAdB/MHz	BMIKg/m2	SOSm/s
	BMIKg/m2	Sig. (2-tailed)	.	.360	.000
		N	100	100	100
		Correlation Coefficient	-.092	1.000	-.331**
		Sig. (2-tailed)	.360	.	.001
		N	100	100	100
	SOSm/s	Correlation Coefficient	.463**	-.331**	1.000
		Sig. (2-tailed)	.000	.001	.
		N	100	100	100

**Correlation is significant at the 0.01 level (2-tailed).

Error! Reference source not found. shows thatthe low exercise group was showing 6.2% osteoporotic participants, while the high exercise group showed 4.4% osteoporotic. However, 59.4% were normal, and 66.2% were normal in the respective groups.

Table 6 Exercise and BUA_CAT Crosstabulation

		BUA_CAT				Total
		Osteoporosis	Osteopenia	Below Average	Normal	
Low exercise	Count	2	4	7	19	32
	Percentage	6.2%	12.5%	21.9%	59.4%	100%
High exercise	Count	3	11	9	45	68
	Percentage	4.4%	16.2%	13.2%	66.2%	100%

However, Table 7showed no statistical significance between exercise and BUA_CAT (p=0.679 >0.05)

Table 7 Chi-Square Test for Exercise and BUA_CAT

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.516	3	0.679
N of Valid Cases	100		

Table 8showedthe T-test of independence performed between exercise and SOS. Levene's test was significant for equality of variance (p = 0.878 >0.05);no statistical significance was found between exercise and SOS.

Table 8 Independent Samples Test between SOS_s and Exercise

	Levine's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
SOS m/s Equal variances assumed	.024	.878	-.158	98	0.875	-3.89627	24.62508	-52.76393	44.97139

DISCUSSION

Osteopenia and osteoporosis are considered as an epidemic problem with an estimated impact of 200 million people worldwide (A. Alswat, 2017) and (Dan Xiong & Yi-Qun, 2015). Female gender is more prone to osteoporosis due to hormonal imbalances post-menopause (Berry, Samelson, & Pencina, 2014). Other risk factors include excessive alcohol and caffeine consumption, smoking, sedentary lifestyle and lack of physical activity, unhealthy nutrition and low body weight (Berry, Samelson, & Pencina, 2014). A study recommended that regular exercise and a balanced diet with Protein, Calcium, Vitamin A and Vitamin K can prevent osteoporosis (Advani & Wimalawansa, 2003). Many studies suggested that practicing regular exercises such as aerobics, walking, jogging and light weightlifting will improve the BMD.The negative impacts of osteoporosis are not just limited to individual lives and its quality, but also the broader economic stake of the entire country, as the health delivery systems across the society has to

somehow bear the cost of its actual treatment and the societal impact of an increasingly unfit population (J. Compston & al., 2017).

In modern Saudi society, many of the same global trends which have impacted women's health across the world have also become relevant and impose similar risks. A positive trend among many young and middle-aged females is that theyare relatively better informed about their health issues, and the awareness of positive body image is also increasing, mostly motivated by the show business and fashion industry. But some of the significant negative trends like consumption of fast foods, lack of proper vitamin and micronutrient sufficient diet, indisposition to engage in outdoor activities(Al-Hazzaa, 2018) and increasing use of household technological aides which prevent much physical exercise are also on the rise. Therefore, there is a legitimate need to understand the various factors related to osteoporosis and its risk factors specific to Saudi females.

In the current study, a population sample of Saudi women in the age group of 19 to 58 years was selected; this group included both pre- and post-menopausal females.The availability of Bone Densitometers makes it convenient to study the linkages between various factors that are impacting the occurrence of osteoporosis in the target population. Our current study revealed that in the selected sample of Saudi females, almost 36% had below normal BUA – out of which 5% had osteoporosis and another 15% had osteopenia – these are alarming numbers. In previous studies, evidence has suggested that obesity harms bone health. Proinflammatory cytokines, which are induced by adipose tissues, contribute to bone resorption(Chen, 2018). Therefore, in this study, we explored the linkage of an increased instance of osteoporosis with a higher Body Mass Indicator (BMI).The results present a statistically significant relationship between high BMI and BUA ($P = 0.45 < 0.05$). A correlation test was done to find out the strength of this relationship ($P = 0.001 > 0.01$, $r = -0.331$) indicated a moderate negative correlation, which implies body weight causes a reduction in BMD, hence making the person more vulnerable to osteoporosis. Interestingly, the age group comprising females of 46 to 50 years showed the highest percentage (70%) of those who were doing a high level of exercise, when compared with all other age groupings. Perhaps this indicates a higher level of concern about health in older Saudi females (age> 45 years).

In the current study, low exercise group showed 6.2% osteoporotic participants, while in the group which claimed a high level of physical exercise, this number was lower at 4.4%. Furthermore, in the 'low exercise' category, only 59.4% had normal BUA, while in the 'high exercise' category, the percentage of normal BUA was much higher at 66.2%. Therefore, it can be ascertained that females performing a high level of physical exercise had healthier bones as compared to those who were not doing exercises. Our results showed an agreement with some previous studies (Moreira, Oliveira, & Lirani-Galvão, 2014), (Bonaiuti, Shea, Iovine, & Negrini, 2002)and (Xu, Lombardi, Jiao, & Banfi, 2016). While the statistical results of this study did not show a relationship between exercises and BMD ($P = 0.679 > 0.05$), but it can be a topic of further investigation with a bigger sample size.

CONCLUSION

The results of this study present a significant relationship between the bodyweight offemales who exercise regularly and their bone density. Furthermore, with an increase in body weight,the bone density reduced, thuscausing a weakening of the boney skeleton with bones becoming fragile. Those participants who were diagnosed with Osteoporosis or Osteopenia were encouraged to follow up with their physician for further investigation. Further work is required to investigate more subjects and carry on the evaluation

for a more extended period. Meanwhile, efforts must be made to increase knowledge amongst the benefits of including exercises in their daily routine.

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