

SLEEP AND BONE DENSITY: A STUDY ON POSTMENOPAUSAL INDONESIAN WOMEN

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Abstract

Background: Low bone density has been known as one of the factors that increased fracture risk. Aging, estrogen deficiency, low BMI, and inadequate calcium intake are known factors that contribute to decreased bone density. Other than the known factors, some research show that sleep duration can also lower bone density. Sleep affects bone density in a way that it causes increased level of cortisol, proinflammatory cytokine, and decreased in physical activity.

Method: This study is an observational analytic study with cross-sectional design. It is conducted on menopausal patients that has been examined with bone mineral densitometry at Rheumatology Outpatient General Hospital Dr. Mohammad Hoesin Palembang in November 2017 to Oktober 2018. Samples are collected using total sampling technique.

Results: From 93 subjects that participated in this study, 20,4% of them had osteopenia, and 51,6% had osteoporosis. Patients with low bone density, mainly slept for 6 to 8 hours at night per day, 30 minutes of nap per day, and has a total sleep duration for less than 8 hours each day. This study shows no significant association between night-time sleep, daytime napping, and total sleep duration with bone density (p value = 0,168, p value = 0,831, p value = 0,984). Analysis on other risk factors show significant association between body mass index and low bone density (p value = 0,002).

Conclusion: There are no significant association between sleep duration and bone density in menopausal patients.

Keywords: Sleep duration, bone density, menopause

1. Background

Bone strength and risk of fracture are strongly related to bone density. Research shows that a continuous and progressive decrease in bone density causes an increased risk of fracture¹. The World Health Organization in 1994 made the value of bone density a reference in the diagnosis of osteoporosis². Osteoporosis is a disorder of the bones, which is characterized by reduced bone mass density and damage to micro-structural tissue of bone, causing vulnerability for bones to experience fractures³. It is estimated that every year there are 9 million cases of fractures due to osteoporosis. This number will increase three to four times in 2050⁴. The results of studies in Indonesia also show that osteoporosis can occur in both women and men, with a comparison of the prevalence of women 4 times higher than men⁵.

Aging, estrogen deficiency, low body mass index, and lack of calcium consumption are commonly known risk factors of decreased bone density⁶. Nutrition, physical activity, and lifestyle also have a role in maintaining bone health⁷. Decreasing estrogen levels or estrogen deficiency is most commonly found in menopausal women. In situations where estrogen levels are lacking, osteoblasts will experience a shortened life span, while osteoclasts will experience increased lifespan and activity resulting in an imbalance between bone formation and resorption⁸.

Besides the above factors, the results of the study show that there are other factors that influence the decrease in bone density, namely the duration of sleep³. Research on the relationship of sleep duration and bone density has varied results. Decreased bone density due to poor sleep duration is thought to be caused by increased cortisol and increased pro-inflammatory response activity^{9, 10}. Conversely, long sleep conditions, will cause low physical activity and decrease sun exposure so that it decreases bone density^{6, 11}.

Since similar research is still very limited in Indonesia, this research is expected to be a preliminary study related to the relationship between sleep duration and bone density in menopausal patients in the Internal Medicine Rheumatology Clinic Dr. RSUP Mohammad Hoesin Palembang.

2. Methods

This study is an observational analytic study with cross sectional design. In this study postmenopausal female patients who first underwent bone density examination in Rheumatology Outpatient General Hospital Dr. Mohammad Hoesin Palembang in the period November 2017 - October 2018 were included as subject. Sampling was carried out using total sampling techniques;

the minimum sample size needed was 49 respondents. The variables examined in this study were bone density as a dependent variable, sleep duration as an independent variable, and confounding variables consisting of BMI, comorbid factors, sun exposure, frequency of outdoor activity, sun protection, and physical activity.

The data collected consists of primary data that were obtained by conducting structured interviews. While secondary data obtained through observation of patient medical record data. Primary data includes sleep duration, duration of sun exposure, frequency of outdoor activities, the use of sun protection, physical activity, work, and comorbidities. Secondary data consists of identity, bone density, and BMI. Univariate analysis was conducted to determine frequency distribution based on the characteristics of the study. Bivariate analysis using the Chi-Square test was conducted to determine the relationship between variables.

3. Results

By applying the total sampling method to the population that fulfills the participation criteria, a sample of 93 people is obtained. Table 1 shows that the majority of respondents worked as housewives, namely 81 people (87.1%), from the table it was also found that more than half of the respondents were over 65 years old (51.6%).

Table 1. Distribution of Respondents based on Sociodemographic Characteristics

Characteristics	f	%
Profession		
Housewives	81	87,1
Government Employee	7	7,5
Laborer	2	2,2
Private Company Employees	1	1,1
Nurse	1	1,1
Entrepreneur	1	1,1
Total	93	100
Age		
>65 years old	48	51,6
<65 years old	45	48,4
Total	93	100

In table 2, it can be seen that more than half of the respondents slept at night for 6-8 hours, as many as 48 people (51.6%). In addition, based on the categorization of nap duration, respondents who took naps more than 60 minutes were at least 16 people (17.2%), while most of the other

respondents took naps for 30 minutes (33.3%). Research on total sleep duration shows that, more than half of the respondents only slept for less than 8 hours per day, as many as 53 people (57%).

Table 2. Distribution of Respondents based on Sleep Duration

Characteristics	f	%
Night Time Sleep		
Duration		
< 6 hours	22	23,7
6-8 hours	48	51,6
≥ 8 hours	23	24,7
Total	93	100
Nap Duration		
0 minute	19	20,4
> 0 – 30 minutes	31	33,3
> 30 – 60 minutes	27	29,0
> 60 minutes	16	17,2
Total	93	100
Total Sleep Duration		
< 8 hours	53	57,0
8-9 hours	21	22,6
≥ 9 hours	19	20,4
Total	93	100

The results of the research presented in table 3 show that the majority of respondents experienced a decrease in bone density as many as 48 people (51.6%) with osteoporosis, and 19 people (20.4%) with osteopenia. The results also shows that of the total respondents only 20 people (21.5%) had normal BMI, as many as 14 people (15.1%) other respondents had less BMI, and others had excessive BMI. In the table it can be seen that more than half of the respondents spent half an hour or more doing outdoor activities, while 46 people (49.5%) other respondents only spent a short time or almost never doing outdoor activities.

Respondents who reported never having activities outside the room were respondents who were aged or had severe osteoporosis so they were no longer able to carry out outdoor activities for long periods of time. Respondents who spent more than half an hour or more reported doing activities such as gardening, sweeping the yard, or just sitting on the lawn. A total of 47 people (50.5%) respondents had outdoor activities for less than 4 times a week. Based on the results of the study, 71 people (76.3%) respondents used sun protection in the form of a veil when doing outdoor activities.

The research data also shows that the majority of respondents in their daily activities carry out mild physical activity as many as 77 people (82.8%), and only as many as 2.1% of respondents do heavy physical activity in their daily lives. In the study it was found that a small proportion of respondents had concomitant diseases such as type 2 diabetes mellitus.

Table 3. Distribution of Respondents based on Bone Density and Confounding Factors

Characteristics	f	%
Bone Density		
Normal	26	28,0
Osteopenia	19	20,4
Osteoporosis	48	51,6
Total	93	100
BMI		
<i>Underweight</i>	14	15,1
Normal	20	21,5
<i>Overweight</i>	10	10,8
Obesity	49	52,7
Total	93	100
Sunlight Exposure		
Duration		
< 30 minutes	46	49,5
≥ 30 minutes	47	50,5
Total	93	100
Outdoor Activities		
Frequency		
1-3x/week	47	50,5
> 3x/week	46	49,5
Total	93	100
Sunlight Protection		
Yes	71	76,3
No	22	23,7
Total	93	100
Physical Activities		
Mild	77	82,8
Moderate	14	15,1
Heavy	2	2,1
Total	93	100
Comorbid Factor		
No	81	87,1
Yes	12	12,9
Total	93	100

Table 4 shows that based on the results of the Chi-square statistic between night sleep duration and bone density p value is 0.168 with a p value <0.05 (5%) which means there is no statistically relationship between night sleep duration and bone density. The same analysis was also conducted to analyze the relationship between nap duration and bone density, and produce a p value of 0.831, which means there is no statistically relationship between the two variables. Chi-square statistical test was performed on the analysis of the relationship between total sleep duration and bone density and getting a p value of 0.984 with a p value <0.05 (5%) which means there was no statistically relationship between total sleep duration and bone density.

Table 4. Relationship of Sleep Duration with Bone Density

Characteristics	Bone Density		Total	<i>p value</i>
	Abnormal	Normal		
Night Time Sleep Duration				0.168
< 6 hours	14	8	22	
≥ 8 hours	20	3	23	
6-8 hours	33	15	48	
Total	67	26	93	
Nap Duration				0.831
> 60 minutes	10	6	16	
> 30 – 60 minutes	20	7	27	
> 0 – 30 minutes	23	8	31	
0 minutes	14	5	19	
Total	67	26	93	
Total Sleep Duration				0.984
≥ 9 hours	14	5	19	
8-9 hours	15	6	21	
< 8 hours	38	15	53	
Total	67	26	93	

Table 5 shows that based on the results of the Chi-square statistical test, among the six confounding factors analyzed, the factor that has a statistically significant relationship with bone density is the body mass index, the BMI factor obtained p value of 0.002 with a value of $p < 0.05$ (5%). Other confounding factors were not statistically significant for bone density.

Table 5. Relationship of Confounding Factors with Bone Density

Characteristics	Bone Density		Total	p value
	Abnormal	Normal		
BMI				0.002*
Underweight	13	1	14	
Normal	18	2	20	
Overweight	9	1	10	
Obesitas	27	22	49	
Total	67	26	93	
Comorbid Factor				0.088
Yes	6	6	12	
No	61	20	81	
Total	67	26	93	
Sunlight Exposure Duration				0.767
< 30 minutes	32	14	46	
≥ 30 minutes	35	12	47	
Total	67	26	93	
Outdoor Activities Frequency				0.767
1-3x/week	35	12	47	
> 3x/week	32	14	46	
Total	67	26	93	
Sunlight Protection				0.463
Ya	53	18	71	
Tidak	14	8	22	
Total	67	26	93	
Physical Activities				0.296
Mild	58	19	77	
Moderate	8	6	14	
Heavy	1	1	2	
Total	67	26	93	

4. Discussions

This study found that the majority of female patients who had undergone menopause had a sleep duration of 6 to 8 hours per night which was 48 people (51.6%), followed by patients with a duration of more than 8 hours as many as 23 people (24.7%) and patients with sleep duration of less than 6 hours was 22 people (23.7%). These results are similar with previous studies which found that female patients who slept 6 to 8 hours per night as much as 40% of the total sample, patients who slept less than 6 hours as much as 29%, and patients who slept more than 8 hours as many as 33 %³. The results also showed that menopausal patients routinely take a nap each day, out of all 93 study respondents there were 74 people (79.6%) who sleep during the day, 19 other people (20.4%) reported that never slept during the day. The results obtained in previous studies also show that 71.3% of menopausal women have a nap habit¹². According to Milner and Cote this happen because older individuals tend to easily drowsy, and have plenty of time to sleep during the day after retirement¹³.

Total sleep duration is obtained by summing the patient's sleep duration at night and during the day. In this study, 53 patients (57%) slept for less than 8 hours per day, 21 people (22.6%) slept eight to 9 hours per day and 19 people (20.4%) slept for more than 9 hours per day. Differences in the distribution of patients based on total sleep duration can be found in previous studies which found that most patients (41.8%), slept for eight to 9 hours per day¹¹. This study found that menopausal women who had normal bone density were only 28% of the total subject. Previous research on menopausal women also showed similar things, namely, only 31.3% of menopausal women had normal bone density¹². This can be caused because after menopause there will be major decreased in estrogen levels, causing an increase in the process of bone resorption and a decrease in bone formation which results in a decrease in bone density⁸.

The results of this study indicate that the majority of respondents have outdoor activity one to three times a week, by spending more than 30 minutes, 76.3% of respondents use sun protection such as veil when doing outdoor activities. This result is similar to the previous studies, which found that the majority of respondents used sun protection when doing outdoor activities, most of the respondents also spent more than 30 minutes while doing outdoor activities but in more frequent frequencies which were more than three times a week¹⁴.

Based on research data more than half of the respondents had an excess body mass index of 52.7%, and only 21.5% of respondents had a normal body mass index. As many as 77 people (82.8%) respondents only did light activities in their daily lives, because most of the respondents were elderly and were unable to do heavy work. This study found that as many as 12 respondents had other comorbidities, type II DM, 82 other respondents did not have comorbidities associated with a decrease in bone density. Research conducted by Saetung et al. in 387 menopausal women, also showed that only a small proportion of the respondents were found to have diabetes (15.5%)¹². The relationship analysis conducted in this study found that there was no relationship between sleep duration and bone density, both at night time sleep duration, nap duration, and total sleep duration. The results obtained in this study are different with some of the studies that have been done previously in Chinese women and in Puerto Rican men and women, who said that there was a relationship between sleep duration at night and bone density. Both studies show a relationship to short sleep duration and long sleep duration with bone density^{9, 15}. The mechanisms underlying the relationship between the two are, changes in osteoblasts and osteoclasts circadian rhythm, increased activity of pro-inflammatory cytokines, secretion of the hormone cortisol, and changes in growth

hormone metabolism, which are important regulators in the process of bone formation and resorption^{16, 17}.

The chi-square statistical test conducted between nap duration and bone density showed a p value of 0.831 with a value of $p < 0.05$ (5%) which means there was no statistical relationship between the two. Other studies show different things about the relationship between nap duration and bone density. The study found that elongation of nap duration was directly proportional to the decrease in bone density value. The relationship between nap duration and a decrease in bone density values is associated with a decrease in physical activity in individuals who nap for a long time¹¹. Analysis of total sleep duration with bone density using the chi-square statistical test showed that there was no statistically relationship between the two variables. In the results of this study, the p value obtained was 0.984 with a value of $p < 0.05$ (5%). The results of previous studies also found that there was no significant relationship between total sleep duration and a decrease in bone density¹⁸. In contrast, research conducted by Chen et al. showed a relationship between long total sleep duration and a decrease in bone density values, the relationship between the two is said to be a result of a decrease in physical activity in individuals who have longer sleep duration¹¹.

No association between sleep duration and bone density can be caused by a significant difference in proportion between respondents with normal and abnormal bone density in all sleep duration categories, it can also indicate that the role of sleep duration is small compared to other factors in causing a decrease in bone density. In this study, it was found that there were other factors that were more influential in decreasing bone density, namely body mass index. One factor that is said to have a role in decreasing bone density is body mass index. In this study, body mass index proved to have a significant relationship to a decrease in bone density in female patients who experienced menopause. Previous research reported that obese women had higher bone density than women with normal body mass index, the relationship was found in women in the age group 55-75 years, and no similar relationship was found in women aged 25-45 years, so that It was concluded that a high body mass index could be a protective factor of a decrease in bone density caused by increasing age¹⁹.

In this study an analysis of other factors that are thought to play an important role in maintaining bone density, namely vitamin D, is described by the use of sun protection, frequency of sun exposure and prolonged exposure to sunlight. Based on the analysis conducted between the use of sun protection, frequency, and sun exposure to bone density, it was found that there was no significant relationship between the two. According to previous studies using sun protection, lack

of frequency and lack of sun exposure have an effect on decreasing vitamin D levels in the body¹⁴. No significant relationship can be obtained because the majority of respondents aged over 65 years, according to Gallagher in individuals aged 65 years of producing vitamin D in the skin will experience a decline. This condition is caused by a decrease in the concentration of 7-dehydrocholesterol in the epidermis and a decrease in the response to UV light, resulting in a reduction of pre-vitamin D3 formation by 50%²⁰.

Physical activity has an important role in maintaining bone density, in previous studies it was found that in women with mild activity bone density will have a lower value than women who carry out more activity²¹. However this study found no association between mild activity and decreased bone density. Mcmillan said that physical activity would induce the effects of anabolism or homeostasis through a process of mechanical transduction in the bone. Movement of fluid in the extracellular matrix will exert strength on osteocytes and bone cells which will then trigger the release of NO and prostaglandins so that osteoprogenitor cells will differentiate into pre-osteoblasts. Pre-osteoblasts will then undergo maturation into osteoblasts so that new bone cell formation occurs²². In this study an analysis of the relationship between the concomitant diseases of the respondents was also carried out, the comorbidities analyzed were type 2 diabetes mellitus. The results of the analysis showed that there was no significant association between comorbidities and decreased bone density. Research shows that patients suffering from type 2 diabetes mellitus tend to have higher bone density values, which can be caused because hyperinsulinemia conditions will cause activation of IGF-1 which is one factor in increasing bone density^{23, 24}.

The insignificant results in the analysis of confounding factors other than body mass index can be caused by considerable difference between patients with abnormal bone density and patients with normal bone density, especially in low risk categories, so that the relationship between variables is not statistically proved to be significantly related.

5. Conclusions

There is no relationship between total daily sleep duration and decreased bone density.

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