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Original Article

Awareness, Knowledge, and Health Beliefs Regarding Osteoporosis among Hypothyroid Patients in Turkey: An Observational Study

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Background: Hypothyroidism is the most common thyroid dysfunction, and current evidence suggests that it increases the risk of osteoporosis in these patients. Assessing the level of osteoporosis awareness and understanding among hypothyroid patients is an important requirement for implementing preventive interventions to maintain bone health. **Methods:** Thyroid-stimulating hormone, thyroxine, and 25-hydroxy-vitamin D levels were recorded along with the patients' demographics. Osteoporosis awareness was assessed with the osteoporosis awareness scale (OAS), and knowledge level was assessed with the revised osteoporosis knowledge test (R-OKT). Health beliefs related to osteoporosis were evaluated using the osteoporosis health belief scale (OHBS). **Results:** The median (interquartile range) values for OAS and R-OKT of 348 patients were calculated as 66.0 (32.0) and 9.0 (5.0), respectively. Female patients had higher OAS scores ($P<0.001$), OHBS benefits of exercise ($P=0.002$), and calcium intake ($P<0.001$) subscores compared to males. The distribution of OAS, R-OKT, and OHBS total and susceptibility scores differed significantly across education categories ($P<0.001$). The linear regression model revealed significant predictors of OAS score variation, including gender ($\beta=-0.27$, $P<0.001$), education ($\beta=0.09$, $P=0.045$), and osteoporosis knowledge ($\beta=0.49$, $P<0.001$). **Conclusions:** Patients with hypothyroidism, particularly males and those with lower educational attainment, lack adequate knowledge and awareness regarding osteoporosis. To better comprehend and manage osteoporosis, targeted educational initiatives are required for this vulnerable group.

Key Words: Awareness · Hypothyroidism · Knowledge · Osteoporosis

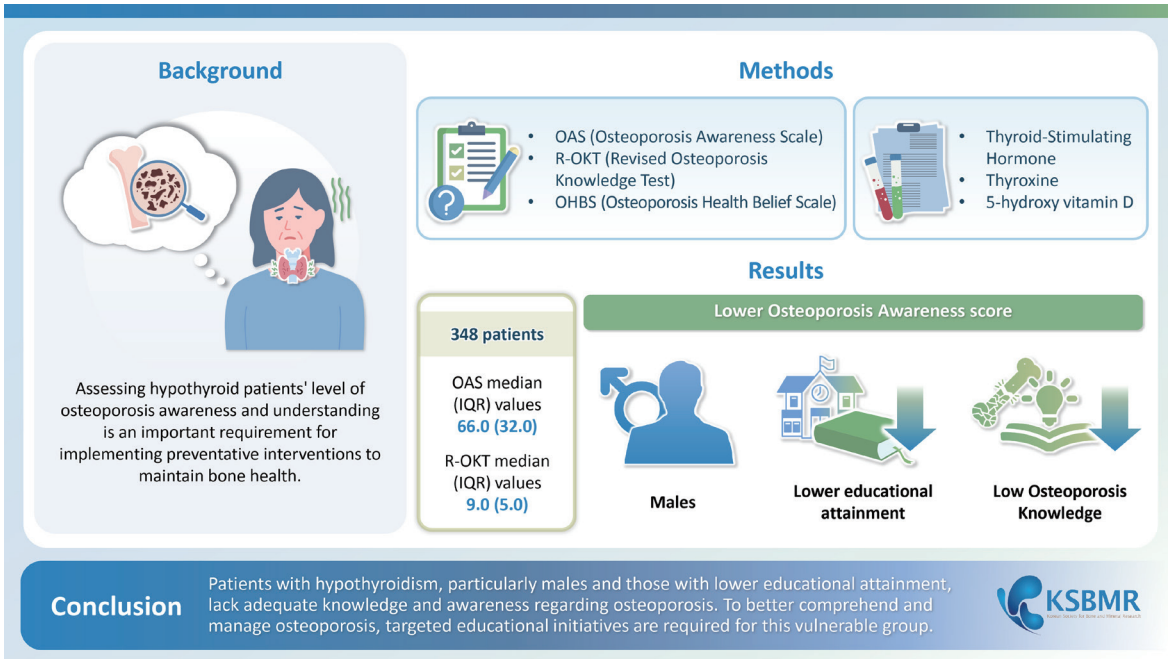
INTRODUCTION

Thyroid diseases are one of the most frequently treated endocrinological diseases by clinicians.[1] Thyroid hormones regulate bone metabolism by affecting the rate of bone turnover or bone remodeling. Thyroid dysfunction is expected to impair bone structure as thyroid hormones are necessary for normal skeletal growth and bone metabolism. Due to a combination of decreased osteoblastic activity and decreased osteoclastic bone resorption, hypothyroidism in adults results in deprived bone turnover and prolonged remodeling.[2] In addition to the

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Graphical Abstract



effect of this change in thyroid hormone levels on bone metabolism, it has been shown that thyroid-stimulating hormone (TSH) levels also have a negative function on skeletal remodeling and can affect bone metabolism independently of thyroid hormone.[3] Thyroid autoimmunity has been proposed as a possible indicator of increased fracture risk in individuals with subclinical hypothyroidism, and femoral bone mineral density has been found to decline in these patients.[4]

Osteoporosis can be defined as increased bone fragility resulting from low bone mineral density and/or microarchitectural deterioration, which may elevate the risk of fracture.[5] Estrogen deficiency in the postmenopausal period is the primary cause of osteoporosis. However, half of the peri- and postmenopausal women who apply to osteoporosis clinics have one or more risk factors that will cause secondary osteoporosis. Secondary osteoporosis risk factors include endocrine diseases such as diabetes mellitus and hyperthyroidism.[6] Osteoporosis has not yet been fully addressed in the context of hypothyroidism due to the paucity of research and evidence in this patient group. There was only one study in the literature investigating osteoporosis knowledge and awareness in hypothyroid patients, and it was limited to 80 patients. This does not seem to be sufficient to reach definitive conclusions about the subject.[7]

The worldwide literature on osteoporosis in thyroid diseases focuses mainly on hyperthyroidism.[2] However, it is now widely known that hypothyroidism increases the risk of osteoporosis and is more common than hyperthyroidism.[8] The typical phenotypes of thyroid dysfunction conditions, including hypothyroidism, increase the risk of osteoporosis and associated fractures, according to a study conducted by Qi et al. [9] In light of this finding, the authors recommend proactive steps to prevent and treat osteoporosis as well as early bone density assessment in patients with thyroid dysfunctions. The fundamental step in preventing and effectively managing osteoporosis in hypothyroid individuals is raising physicians' and patients' awareness of this potential issue. Increasing the knowledge and awareness of osteoporosis in thyroid patients can enable early diagnosis and treatment by taking precautions when necessary. The initial stage in this process is to ascertain the patients' level of awareness and knowledge. Therefore, this study aims to use internationally validated questionnaires to assess the awareness and knowledge of osteoporosis among hypothyroid patients in Turkey. We hypothesized that osteoporosis knowledge and

awareness levels were insufficient in hypothyroid patients.

METHODS

This cross-sectional study enrolled patients who attended the tertiary center's endocrinology outpatient clinic between July and December 2023 and who met the inclusion and exclusion criteria. The study's inclusion criteria include being at least 18 years old, having a diagnosis of hypothyroidism, agreeing to participate in the study, being literate (education level at least primary school level), and possessing the mental capacity to respond to the study's questions. All patients included in the study were under levothyroxine treatment, and their thyroid functions were under control. Exclusion from the study included patients having a history of severe psychological disorders, dementia or cognitive impairment, or other chronic bone diseases that would have an impact on assessment outcomes or study participation. Those who fulfilled the study's eligibility criteria were notified about it and asked to complete a digitally generated survey (created using Google Forms) by selecting the response that most closely fit their answers. Access to the form was granted to participants once the informed consent section was approved. After collecting demographic information from the patients (such as age, height, weight, gender, education level, marital status, and occupation), an assessment was conducted to determine the patients' levels of osteoporosis knowledge and awareness. The TSH, thyroxine and 25-hydroxy-vitamin D (25[OH] D) levels of the patients were recorded as clinical measures. Local ethics committee approval was obtained (Approval no. 25/29). The study was carried out in accordance with the STROBE Statement and was registered with ClinicalTrials.gov (ClinicalTrials.gov identifier: NCT05760131).

1. Outcome measures

1) Osteoporosis awareness scale (OAS)

OAS was developed in 2008 to investigate the relationship between young women's osteoporosis knowledge and self-efficacy levels. The scale consists of 31 items and 5 sub-dimensions and is scored on a 4-point Likert scale, with a total score ranging from 31 to 124. There is no specific cut-off point for interpretation of the OAS, with higher scores being associated with greater osteoporosis awareness.[10] In the Turkish population, the validity and reliability of OAS was established (Cronbach's α, 0.94).[11]

2) Revised osteoporosis knowledge test (R-OKT)

A modified version of the original 24-item OKT, the 32-item R-OKT, was developed by Gendler et al. [12] in 2015. The total score ranges from 0 to 32, with higher scores indicating greater osteoporosis knowledge. A score in the R-OKT is interpreted as follows: a score above 25.6 indicates a high level of knowledge, a score between 25.6 and 19.2 indicates a moderate level of knowledge, and a score below 19.2 indicates a low level of knowledge.[13] The Turkish version of R-OKT was reported to be valid and reliable (Cronbach's α, 0.71-0.76).[14]

3) Osteoporosis health belief scale (OHBS)

To assess individual's health beliefs around osteoporosis, the OHBS was developed by Kim et al. [15]. OHBS consists of 42 items and 7 sub-dimensions, scored on a 5-point Likert-type scale, and the total score for each sub-category is between 0 and 30. The items of the OHBS are classified under the subheadings of susceptibility, seriousness, calcium benefits, calcium barriers, exercise benefits, exercise barriers, and health motivation. OHBS scores can be divided into two categories, low and high OHBS, using a cutoff point of 169.[16]

2. Data analysis

A formula was utilized to ascertain the sample size, taking into account numerous factors, including the Likert scale's number of options (k), pairwise correlation coefficient (ρ), and coefficient of variation (C). A calculation was performed using the OAS with $k=4$. With $\rho=0.5$, $C=1$, and $D=0.1$ assumed, the necessary sample size was computed as 240. The minimum required number of subjects to be recruited was 264, taking into account a 10% rejecting rate. [17]

Using histogram plots, skewness, kurtosis, and Kolmogorov-Smirnov, the normality of the data was examined. As a result of the Kolmogorov-Smirnov test ($P>0.05$) and complementary normality assessments, the data exhibited a non-parametric distribution pattern. Descriptive statistics, such as median (interquartile range [IQR]) for continuous variables and percentage (n) for categorical data, were used to summarize patient variables. The Mann-Whitney U test was used for pairwise group comparisons, and the

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Kruskal-Wallis test was employed for multiple group comparisons, given the non-normal distribution of continuous data. For multiple comparisons between groups, the Bonferroni post hoc correction was performed. Spearman correlation analysis was used to examine the association between OAS and R-OKT scores and other continuous variables. In the last step, hierarchical linear regression models were constructed to predict the OAS and R-OKT scores using possible predictor variables. Clinical rationale, results of previous research, and correlation analysis were considered when deciding which variables to include in the model and in what sequence.[18] Before constructing the model, we examined assumptions related to linear regression analysis, including homoscedasticity, multicollinearity, linearity, and the independence and normality of residuals. The variance inflation factor (VIF) was used to assess the potential for multicollinearity in all explanatory factors. While gender, education level, OAS, and R-OKT scores were included in the hierarchical regression models, OHBS subscores were excluded because they caused multicollinearity and violated the model. In the model generated with the OAS, specifically, "barriers to calcium intake" had a VIF of 7.5, and "benefits of calcium intake" showed a VIF of 6.2. Additionally, "barriers to exercise" and "susceptibility" also showed moderately high VIF values of 4.9 and 4.5, respectively. In the R-OKT model, multicollinearity was again evident. "Barriers of calcium intake" (VIF=7.1) and "benefits of calcium intake" (VIF=6.5) showed high collinearity, with "barriers of exercise" (VIF=5.2) and susceptibility (VIF=4.8) also contributing to the issue. A *P* value less than 0.05 was considered statistically significant for all analyses conducted with SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Of the 348 participants, 300 (86.2%) were female, and the median (IQR) age was 52.0 (18.0). The median (IQR) values of patients for OAS, R-OKT, and OHBS were calculated as 66.0 (32.0), 9.0 (5.0), and 143.0 (14.0), respectively. The demographic and clinical characteristics of patients are summarized in Table 1.

The Mann-Whitney U test revealed significant gender differences in the following measures. TSH levels were higher in men ($P=0.001$), while thyroxine levels did not differ between groups ($P>0.05$). Females had higher levels of 25(OH)D than males did ($P=0.001$). Female patients had higher OAS scores compared to males ($P<0.001$). Females also had higher scores for benefits of exercise ($P=0.002$) and calcium intake ($P<0.001$). Males showed higher scores for barriers to calcium intake ($P=0.001$). Disease duration was longer for females compared to males ($P=0.047$). Gender differences were not found to be statistically significant

Table 1. Demographic and clinical characteristics of study participants

	Value (N=348)
Age (yr)	52.00 (18.0)
BMI (kg/m^2)	23.27 (10.65)
Gender, female	300 (86.2)
Marital status	
Single	90 (25.9)
Married	204 (58.6)
Widowed	54 (15.5)
Education	
Primary school	42 (12.1)
Middle school	42 (12.1)
High school	90 (25.9)
University	156 (44.8)
Postgraduate, doctorate	18 (5.2)
Occupation	
Worker	78 (22.4)
Retired	54 (15.5)
Student	12 (3.4)
Civil servant	84 (24.1)
Housewife	90 (25.9)
Unemployed	30 (8.6)
Disease duration (mon)	10.00 (11.0)
25-hydroxy-vitamin D (ng/dL)	25.00 (14.0)
TSH (mIU/L)	1.80 (1.60)
Thyroxine (mcg/dL)	1.30 (0.3)
Osteoporosis awareness scale	66.00 (32.0)
Revised osteoporosis knowledge test score	9.00 (5.0)
Osteoporosis health belief scale	
Susceptibility	21.50 (6.0)
Seriousness	21.00 (6.0)
Benefits exercise	24.00 (4.0)
Benefits calcium intake	23.50 (2.0)
Barriers exercise	16.00 (5.0)
Barriers calcium intake	15.00 (6.0)
Health motivation	24.00 (5.0)
Total	143.00 (14.0)

The data is presented as median (interquartile range) or N (%).
BMI, body mass index; TSH, thyroid-stimulating hormone.

Table 2. Comparison of clinical characteristics and between male and female hypothyroid patients

	Female (N=300)	Male (N=48)	*P*-value
Disease duration (mon)	10.0 (11.0)	6.5 (12.0)	0.047[a]
25-hydroxy-vitamin D (ng/dL)	26.5 (16.0)	18.0 (11.75)	0.001[a]
TSH (mIU/L)	1.7 (1.5)	2.15 (3.7)	0.001[a]
Thyroxine (mcg/dL)	1.3 (0.3)	1.31 (0.43)	0.228
Osteoporosis awareness scale	68.0 (29.0)	48.5 (20.0)	<0.001[a]
Revised osteoporosis knowledge test score	9.0 (5.0)	9.5 (5.0)	0.933
Osteoporosis health belief scale			
Susceptibility	21.5 (6.0)	21.5 (5.0)	0.385
Seriousness	20.5 (6.0)	21.5 (7.0)	0.521
Benefits exercise	24.0 (6.0)	23.0 (4.0)	0.002[a]
Benefits calcium intake	24.0 (2.0)	21.5 (8.0)	<0.001[a]
Barriers exercise	16.0 (5.0)	17.0 (10.0)	0.146
Barriers calcium intake	15.0 (7.0)	16.0 (5.0)	0.001[a]
Health motivation	24.0 (5.0)	24.0 (5.0)	0.736
Total	143.5 (14.0)	142.0 (19.0)	0.126

The data is presented as median (interquartile range) or N (%).
TSH, thyroid-stimulating hormone.
[a] $P<0.05$.

for any additional measures ($P>0.05$). Table 2 presents a comparison of clinical variables based on gender.

The results of the Kruskal-Wallis test showed that there were significant differences in an array of factors pertaining to osteoporosis knowledge, awareness, health beliefs, and other health metrics among different educational levels. The distribution of the R-OKT score differed significantly across education categories ($P<0.001$). Patients with a primary or middle school education had considerably lower R-OKT scores than those with a university education, according to post-hoc analysis ($P<0.001$). Similarly, the OAS score showed significant variation by education level ($P<0.001$), as did the OHBS total score ($P<0.001$) and the OHBS susceptibility score ($P<0.001$). According to post-hoc analysis, patients with primary or middle school education had significantly lower OAS scores than those with a university education ($P<0.001$ and $P=0.046$, respectively).

Furthermore, the distribution of disease duration (months) showed a significant variation across education levels ($P<0.001$), as did the distributions of TSH ($P=0.007$), thyroxine ($P<0.001$), and 25(OH)D levels ($P<0.001$). In post-hoc analysis, it is shown that participants with middle school education had significantly lower 25(OH)D levels compared to those with university education ($P=0.036$), and participants with high school education had significantly lower 25(OH)D levels compared to those with university education ($P<0.001$). The Kruskal-Wallis test and post-hoc analysis results are summarized in Table 3.

The R-OKT score was positively correlated with OAS score ($r=0.512$, $P<0.01$), OHBS-susceptibility score ($r=0.320$, $P<0.001$), thyroxine levels ($r=0.110$, $P=0.039$), and OHBS-benefits of exercise score ($r=0.201$, $P<0.001$), but negatively correlated with OHBS-barriers of exercise score ($r=-0.368$, $P<0.001$) and OHBS-barriers of calcium intake score ($r=-0.241$, $P<0.001$). The correlation of OAS with other clinical measures is illustrated in Figure 1. Significant correlations were also found between TSH levels and OHBS-benefits of exercise score ($r=-0.190$, $P<0.001$), thyroxine levels and OHBS-susceptibility score ($r=0.292$, $P<0.001$), and OHBS-barriers of exercise score with OHBS-barriers of calcium intake score ($r=0.374$, $P<0.001$). Significant correlations were also noted between thyroxine levels and OHBS-health motivation scores ($r=0.142$, $P=0.008$).

A hierarchical multivariate regression analysis was conducted to examine the predictive value of gender, education, and knowledge about osteoporosis on osteoporosis awareness. In model 1, the OAS score was significantly predicted by gender alone ($\beta=-0.267$, $t(346)=-5.16$, $P<0.001$), indicating that awareness levels were significantly lower for men. This model explained 7.1% of the variance in OAS ($R^2=0.071$). The prediction was significantly improved when education level was added to the model ($\Delta R^2=0.068$,

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Table 3. Clinical features and post-hoc results of patients according to the educational attainment

	Education levels (N=348)					*P*-value[b]	Post-hoc (*P*-value[c])
	Primary school (I) (N=42)	Middle school (II) (N=42)	High school (III) (N=90)	University (IV) (N=156)	Postgraduate (V) (N=18)		
R-OKT	4.0 (8.0)	8.0 (4.0)	8.0 (5.0)	11.0 (3.0)	5.0 (9.0)	<0.001[a]	I vs. IV (<0.001[a]) II vs. IV (<0.001[a]) IV vs. V (<0.001[a])
OAS	55.0 (39.0)	57.0 (31.0)	56.0 (35.0)	68.5 (25.0)	42.0 (59.0)	<0.001[a]	I vs. IV (<0.001[a]) II vs. IV (0.046[a])
OHBS-total	137.0 (7.0)	146.0 (16.0)	149.0 (22.0)	141.0 (15.0)	130.0 (65.0)	<0.001[a]	I vs. II (0.001[a]) I vs. III (<0.001[a]) I vs. IV (0.036[a]) II vs. IV (0.001[a])
OHBS-susceptibility	18.0 (4.0)	21.0 (7.0)	21.0 (6.0)	22.0 (4.0)	18.0 (10.0)	<0.001[a]	I vs. III (<0.001[a]) I vs. IV (<0.001[a])
OHBS-seriousness	20.0 (6.0)	22.0 (4.0)	21.0 (6.0)	19.5 (7.0)	22.0 (14.0)	0.006[a]	
OHBS-benefits of exercise	23.0 (6.0)	23.0 (8.0)	24.0 (2.0)	24.0 (5.0)	22.0 (17.0)	<0.001[a]	I vs. III (0.008[a]) I vs. IV (0.008[a]) III vs. IV (0.004[a])
OHBS-benefits of calcium intake	24.0 (2.0)	24.0 (4.0)	24.0 (2.0)	23.0 (2.0)	18.0 (17.0)	0.020[a]	
OHBS-barriers of exercise	20.0 (7.0)	18.0 (11.0)	18.0 (3.0)	14.0 (4.0)	24.0 (7.0)	<0.001[a]	I vs. III (<0.001[a]) I vs. IV (<0.001[a]) I vs. V (<0.001[a])
OHBS-barriers of calcium intake	18.0 (6.0)	17.0 (8.0)	18.0 (6.0)	13.0 (3.0)	20.0 (10.0)	<0.001[a]	I vs. IV (<0.001[a]) II vs. IV (<0.001[a]) IV vs. V (<0.001[a])
OHBS-health motivation	22.0 (6.0)	24.0 (8.0)	24.0 (4.0)	23.5 (5.0)	24.0 (8.0)	<0.001[a]	I vs. III (0.001[a]) I vs. IV (0.009[a])
Disease duration (mon)	18.0 (15.0)	8.0 (11.0)	10.0 (13.0)	10.0 (11.0)	5.0 (12.0)	<0.001[a]	I vs. II (0.001[a]) I vs. III (0.008[a]) I vs. IV (0.008[a]) I vs. V (<0.001[a])
TSH	2.2 (3.0)	2.1 (6.1)	1.8 (1.3)	1.65 (2.3)	1.7 (2.6)	0.007[a]	II vs. IV (0.008[a])
Thyroxine	1.0 (0.4)	1.0 (0.3)	1.3 (0.2)	1.35 (0.3)	1.5 (0.1)	<0.001[a]	I vs. IV (<0.001[a]) I vs. V (<0.001[a]) II vs. V (<0.001[a]) III vs. V (0.008[a])
25-hydroxy-vitamin D	26.0 (21.0)	17.0 (17.0)	19.0 (12.0)	28.0 (15.0)	28.0 (21.0)	<0.001[a]	II vs. IV (0.036[a]) III vs. IV (<0.001[a])

R-OKT, revised osteoporosis knowledge test; OAS, osteoporosis awareness scale; OHBS, osteoporosis health belief scale; TSH, thyroid-stimulating hormone.
[a] $P<0.05$.
[b] Kruskal-Wallis test.
[c] Bonferroni correction.

F(1, 345)=27.47, $P<0.001$). Education (β=0.263, $P<0.001$) and gender (β=-0.297, $P<0.001$) were both significant predictors, with higher education related to increased awareness of osteoporosis. The model improved significantly after the R-OKT score was added in the final step ($\Delta R^2=0.210$, F(1, 344)=111.06, $P<0.001$), and it explained 35.0% of the total variance ($R^2=0.350$, Adjusted $R^2=0.344$). All predictors remained significant ($P<0.05$). Table 4 presents the findings of the regression analysis in detail.

DISCUSSION

This study examined the level of osteoporosis awareness and knowledge among hypothyroid patients. The study's findings demonstrated that these patients' awareness and understanding of osteoporosis were inadequate and varied by gender and educational attainment. Female patients had higher OAS scores and 25(OH)D levels; the OAS, OHBS, and R-OKT scores showed significant variation by

Table 4. Hierarchical regression analysis results examining the relationship between the osteoporosis awareness scale, revised osteoporosis knowledge test, and selected variables

Predictors	OAS						R-OKT					
	B	β	R^2	*P*	95% CI for B		B	β	R^2	*P*	95% CI for B	
					Lower	Upper					Lower	Upper
Step 1			0.07						0.00			
Gender, male	-14.46	-0.27		<0.001[a]	-19.98	-8.95	-0.22	-0.02		0.720	-1.40	0.97
Step 2			0.14	<0.001[a]					0.11	<0.001[a]		
Gender, male	-16.06	-0.30		<0.001[a]	-21.41	-10.71	-0.65	-0.06		0.253	-1.77	0.47
Education, high school and above	4.45	0.26		<0.001[a]	2.78	6.11				<0.001[a]	0.86	1.56
Step 3			0.34	<0.001[a]					0.33	<0.001[a]		
Gender, male	-14.52	-0.27		<0.001[a]	-19.19	-9.85	1.00	0.09		0.53	-0.02	2.03
Education, high school and above	1.58	0.09		0.045[a]	0.04	3.13	0.75	0.22		<0.001[a]	0.44	1.07
R-OKT	2.37	0.49		<0.001[a]	1.93	2.81						
OAS							0.10	0.50		<0.001[a]	0.08	0.12

OAS, osteoporosis awareness scale; R-OKT, revised osteoporosis knowledge test; CI, confidence interval.
[a] $P<0.05$.

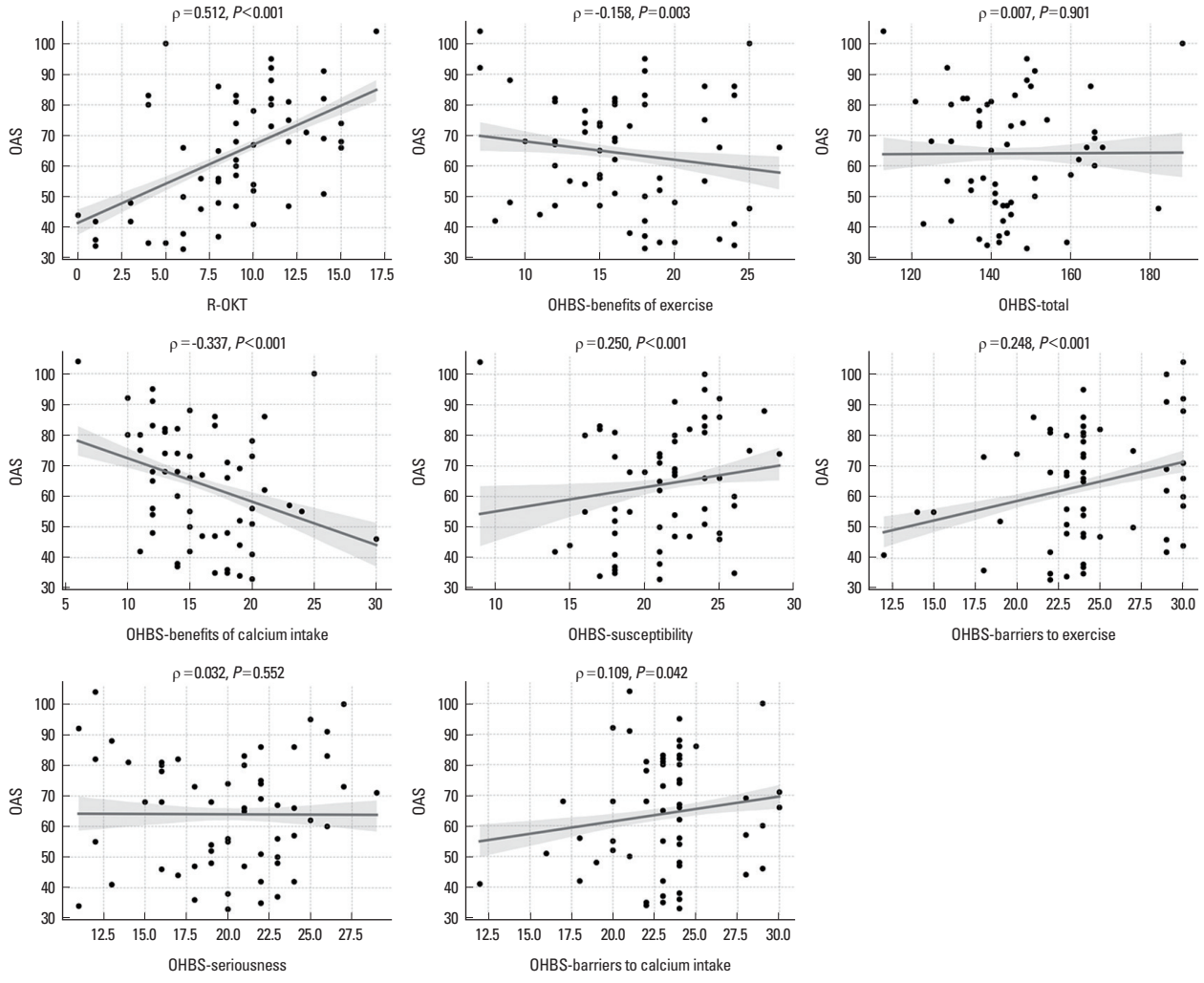


Fig. 1. Scatter plots show the relationship between the osteoporosis awareness scale (OAS), revised osteoporosis knowledge test (R-OKT), and osteoporosis health belief scale (OHBS). ρ, Spearman's rho.

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educational attainment.

Normal adult bone metabolism depends on thyroid hormones, and bone turnover can be affected by thyroid dysfunctions. Hypothyroidism, the most prevalent thyroid disease, affects 5% of the general population and has a causal relationship with an increased risk of osteoporosis.[19] Hypothyroidism is thought to pose a risk for osteoporosis through different mechanisms. Thyroid hormones control the progress of bone development, maturation, and mineralization by regulating endochondral ossification in chondrocytes and osteoblasts. Osteoclast and osteoblast activity have been demonstrated to decrease in hypothyroidism, which also causes a slowing in bone metabolism and an acceleration of bone loss.[9] Another theory is the existence of a local TSH circuit that controls macrophage-mediated bone remodelling and emphasizes the relationship between osteoporosis and altered TSH levels in thyroid disorders.[20] There are views suggesting that levothyroxine treatment in hypothyroidism, especially at higher doses, may cause osteoporosis in the long term, but the evidence supporting this notion currently appears to be insufficient and contradictory.[21] Given all of these detrimental effects on bone structure, hypothyroidism seems to be associated with a higher risk of osteoporosis, which makes it necessary to raise patients' awareness and understanding of the condition.

It has been demonstrated that higher levels of osteoporosis awareness and knowledge are associated with specific elements that improve the effectiveness of disease management, such as a greater implementation of osteoprotective behaviors like exercise and calcium intake, consistent treatment compliance, and regular follow-up.[22] The mean OAS score reflecting the osteoporosis awareness of hypothyroid patients was found to be 63.97 in this study. In a similar study conducted with 80 Turkish hypothyroid patients, this value was found to be 110.89, and 86.2% of the patients were reported to have sufficient osteoporosis awareness.[7] This discrepancy between the results may be attributed to differences in patient characteristics included in the studies. The higher OAS score average reported in the previous study seems to be primarily related to the fact that the majority of the patient group is composed of highly educated individuals. Additionally, the mean OAS score of participants in a study examining osteoporosis awareness in Turkish women over 45 was reported as 55.33.[23] Numerous studies highlight that one of the primary factors influencing an individual's understanding and quality of information about osteoporosis is their educational attainment.[22,24] The study's findings indicate that, in addition to gender, educational attainment influences hypothyroid patients' awareness of osteoporosis. Even across higher education groups, there was heterogeneity in OAS and R-OKT scores; however, it was more noticeable in patients with lower educational attainment. Studies involving various patient populations have highlighted low educational attainment as a risk factor for insufficient awareness of osteoporosis.[22,25] While this finding is not surprising, it is significant since it indicates that, in practical applications, individuals with poor educational attainment should receive more attention when it comes to osteoporosis-related measures.

In this study, the mean R-OKT score in hypothyroid patients was found to be 8.81, which corresponds to a low level of osteoporosis knowledge. In the study comparing the osteoporosis knowledge levels of Turkish rheumatoid arthritis patients and healthy controls, the mean R-OKT score was found to be 15.06 and 15.44, respectively.[26] Similarly, the median R-OKT value of 27 patients with Parkinson's disease was reported as 16.[27] The findings of this study indicate that hypothyroid patients have inadequate knowledge about osteoporosis compared to healthy individuals and other chronic disease populations examined. One of the important components of increasing osteoporosis awareness is that the target population has sufficient knowledge about the disease. It enables individuals to recognize risk factors, understand preventive measures, and seek appropriate medical advice.[22] The results of the regression analysis of the bidirectional and positive relationship between osteoporosis knowledge level and awareness support this assumption.

There are notable gender-based variations in the osteoporosis and hypothyroidism-related metrics this study investigated. Similar findings were seen in the Alani et al. study [28], which found that women were more aware of osteoporosis. However, osteoporosis awareness, as measured by OAS, was found to be comparable for both genders of Turkish multiple sclerosis patients.[18] Njeze Ngozi et al. [29] also reported that osteoporosis awareness was equally distributed between male and female genders. Despite being a condition that affects both genders, os-

teoporosis is more prevalent in females, which is why practices and preventative measures are more specifically targeted at this population. Although gender differences in osteoporosis knowledge and awareness levels vary according to patient groups and societies, it is known that osteoporosis awareness is insufficient among males.[30] The results of the study show that being male poses a risk in terms of insufficient osteoporosis awareness, but its effect on the level of knowledge is minimal. This implies that other elements, such as education and personal experience of the condition, may have a greater impact on an individual's understanding of osteoporosis.

Barriers to calcium intake were higher in male hypothyroid patients, while understanding of the benefits of exercise and calcium intake was lower. Men's self-efficacy and knowledge about physical activity and intake of calcium are low and tend to decline with age, according to a study by Ercan et al. [31]. Furthermore, it was found that male hypothyroid individuals had lower vitamin D levels than female ones. Bozkurt et al. [32] reported that serum vitamin D levels in female hypothyroid patients were lower than in male patients and the control group. Similarly, different population-based studies performed in Turkey have shown that females' vitamin D levels are significantly lower than males'.[33,34] Females may be more aware of osteoporosis than males, which could explain why their vitamin D levels were higher in this study compared to previous studies. As anticipated, there is evidence that educational strategies that raise awareness of osteoporosis lead to a boost in the use of calcium replacement and vitamin D.[35] Individual factors like sun exposure and dietary habits can also have an impact on a patient's vitamin D levels. Nevertheless, vitamin D-related factors were not thoroughly examined because they were not one of the study's primary objectives. According to our clinical observations, the higher compliance with follow-up and treatment in female hypothyroid patients is another factor associated with increased vitamin D levels. Within the scope of osteoporosis prevention policies, the vitamin D levels of selected patients who come to our center are checked and recommendations for replacement are made if necessary.[36]

An individual's attitude toward osteoporosis, preventive measures, and practices is largely determined by their level of understanding and awareness of the condition.[31] This knowledge may significantly impact an individual's motivation to make lifestyle adjustments, including improving their intake of calcium and vitamin D or regular exercise. The assumption was reinforced by the finding of a correlation between the OAS and R-OKT scores, patients' beliefs about exercise and calcium intake, and the OHBS-susceptibility subscore, which measures the perception of osteoporosis risk in hypothyroid individuals. This study also revealed a significant correlation between the patients' serum thyroxine levels and their OHBS-susceptibility and health motivation scores. When the influence of the patient's health beliefs on disease processes is considered, this relationship—which initially appears surprising—becomes plausible. An individual's overall propensity to adopt health behaviors is referred to as health motivation. Unlike the OHBS subscores, which reflect beliefs about behaviors, health motivation is directly related to an individual's behaviors.[15] It is suggested that increasing knowledge, awareness, and motivation about hypothyroidism may significantly improve treatment compliance and thereby reduce disease-related morbidities such as osteoporosis.[37] Serum thyroxine levels may be associated with these patients' improved health motivation, which is likely not just related to osteoporosis and leads to better treatment compliance for hypothyroidism.

Limitations of the study include the cross-sectional design, the fact that patient data were obtained from a single center, and the inability to determine possible confounding characteristics of the patient cohort, such as osteoporosis diagnosis, treatment, and fracture history, as well as socioeconomic factors, physical activity level, and nutritional and lifestyle habits. The study's uneven gender distribution in the patient cohort should be considered an additional drawback. The prevalence of hypothyroidism in females is almost six times higher than in males, so it is not surprising that females make up the majority of the patient population.[38] Selection bias is also a possibility when using online surveys. Patient selection was done proportionately to the outpatients' gender and educational attainment in order to reduce selection bias during the data-collecting phase and ensure that the study sample accurately represents Turkish hypothyroid patients. Nevertheless, selection bias cannot be totally ruled out by the authors.

The study's limitations may also include the fact that menopausal status, one of the possible confounding factors for female patients, was not specified. However, previ-

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ous studies have not shown any effect of menopause status on the level of osteoporosis knowledge and awareness in different patient groups.[39,40] Menopausal state was therefore disregarded in the data analysis process; nevertheless, more thorough research should determine whether hypothyroid patients exhibit similar results. One of the study's limitations is that, despite the identification of several correlations, the cross-sectional design precluded the inference of causality.

The study's strengths are its large patient population, the inclusion of male patients—who are typically overlooked in osteoporosis research—and its thorough assessment of patients' knowledge, awareness, and beliefs on osteoporosis using several clinical measures.

The lack of awareness of hypothyroidism may lead to inadequate prevention and treatment strategies, increasing the risk of osteoporosis and related complications in these patients. Therefore, targeted educational initiatives such as community-based osteoporosis education programs and endocrinology clinic workshops should be planned to help this vulnerable population better understand and address osteoporosis. Increasing knowledge and awareness of osteoporosis will help these patients take proactive steps in managing their bone health.

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Ethics approval and consent to participate

Ethics approval was obtained from the local ethics committee (Approval no. 25/29). The study was conducted in accordance with the STROBE Statement and was registered with ClinicalTrials.gov (ClinicalTrials.gov identifier: NCT05760131).

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Greenspan SL, Greenspan FS. The effect of thyroid hormone on skeletal integrity. Ann Intern Med 1999;130:750-8. https://doi.org/10.7326/0003-4819-130-9-199905040-00016.
2. Delitala AP, Scuteri A, Doria C. Thyroid hormone diseases and osteoporosis. J Clin Med 2020;9:1034. https://doi.org/10.3390/jcm9041034.
3. Abe E, Marians RC, Yu W, et al. TSH is a negative regulator of skeletal remodeling. Cell 2003;115:151-62. https://doi.org/10.1016/s0092-8674(03)00771-2.
4. Lee WY, Oh KW, Rhee EJ, et al. Relationship between subclinical thyroid dysfunction and femoral neck bone mineral density in women. Arch Med Res 2006;37:511-6. https://doi.org/10.1016/j.arcmed.2005.09.009.
5. Sobh MM, Abdalbary M, Elnagar S, et al. Secondary osteoporosis and metabolic bone diseases. J Clin Med 2022;11:2382. https://doi.org/10.3390/jcm11092382.
6. Stein E, Shane E. Secondary osteoporosis. Endocrinol Metab Clin North Am 2003;32:115-34, vii. https://doi.org/10.1016/s0889-8529(02)00062-2.
7. Karagül S, Kartaloğlu IF. The comparison of osteoporosis knowledge and awareness levels of patients with hypothyroidism and hyperthyroidism. Turk J Osteoporos 2023;29:117-23. https://doi.org/10.4274/tod.galenos.2023.31932.
8. Garmendia Madariaga A, Santos Palacios S, Guillén-Grima F, et al. The incidence and prevalence of thyroid dysfunction in Europe: A meta-analysis. J Clin Endocrinol Metab 2014;99:923-31. https://doi.org/10.1210/jc.2013-2409.
9. Qi W, Wang D, Hong Y, et al. Investigating the causal relationship between thyroid dysfunction diseases and osteoporosis: A two-sample Mendelian randomization analysis. Sci Rep 2024;14:12784. https://doi.org/10.1038/s41598-024-62854-x.
10. Choi E, Lee JY. A study on the level of awareness and self-efficacy of osteoporosis in young women. Korean J Women Health Nurs 2010;16:204-14. https://doi.org/10.4069/kjwhn.2010.16.2.204.
11. Aktürk SO, Meseri R, Özentürk MG. The psychometric prop-

erty evaluation of the Turkish version of the osteoporosis awareness scale. Turk J Osteoporos 2021;27:151-8. https://doi.org/10.4274/tod.galenos.2021.22590.
12. Gendler PE, Coviak CP, Martin JT, et al. Revision of the osteoporosis knowledge test: Reliability and validity. West J Nurs Res 2015;37:1623-43. https://doi.org/10.1177/0193945914537565.
13. Vered I, Werner P, Shemy G, et al. Nurses' knowledge and perceptions about osteoporosis: A questionnaire survey. Int J Nurs Stud 2008;45:847-54. https://doi.org/10.1016/j.ijnurstu.2007.01.011.
14. Atalay NŞ, Akkaya N, Şahin F. The psychometric properties of the Turkish version of revised 2011-osteoporosis knowledge test. Turk J Osteoporos 2015;21:127-31. https://doi.org/10.4274/tod.99609.
15. Kim KK, Horan ML, Gendler P, et al. Development and evaluation of the osteoporosis health belief scale. Res Nurs Health 1991;14:155-63. https://doi.org/10.1002/nur.4770140210.
16. Sahib MN. Psychometric properties and assessment of the Osteoporosis Health Belief Scale among the general Arabic population. Patient Prefer Adherence 2018;12:223-32. https://doi.org/10.2147/ppa.S155152.
17. Lo SST, Kok WM. Osteoporosis knowledge, health beliefs, and self-efficacy in Hong Kong Chinese men. Arch Osteoporos 2022;17:60. https://doi.org/10.1007/s11657-022-01104-x.
18. Temel MH, Taşdelen B, Demir S, et al. Assessing osteoporosis awareness and knowledge levels of Turkish multiple sclerosis patients: An observational study. Arch Osteoporos 2024;19:67. https://doi.org/10.1007/s11657-024-01426-y.
19. Leng P, Qiu Y, Zhou M, et al. Hypothyroidism correlates with osteoporosis: Potential involvement of lipid mediators. Front Med (Lausanne) 2024;11:1453502. https://doi.org/10.3389/fmed.2024.1453502.
20. Baliram R, Latif R, Zaidi M, et al. Expanding the role of thyroid-stimulating hormone in skeletal physiology. Front Endocrinol (Lausanne) 2017;8:252. https://doi.org/10.3389/fendo.2017.00252.
21. Tárraga López PJ, López CF, de Mora FN, et al. Osteoporosis in patients with subclinical hypothyroidism treated with thyroid hormone. Clin Cases Miner Bone Metab 2011;8:44-8.
22. Tan HC, Seng JJB, Low LL. Osteoporosis awareness among patients in Singapore (OASIS)-a community hospital perspective. Arch Osteoporos 2021;16:151. https://doi.org/10.1007/s11657-021-01012-6.
23. Uyanık H, Erkal Aksoy Y. Determination of the factors affecting the osteoporosis awareness levels and the quality of life of Turkish women. J Selcuk Health 2024;5:15-36.
24. Khan JA, McGuigan FE, Akesson KE, et al. Osteoporosis knowledge and awareness among university students in Saudi Arabia. Arch Osteoporos 2019;14:8. https://doi.org/10.1007/s11657-019-0560-y.
25. Nguyen NV, Dinh TA, Ngo QV, et al. Awareness and knowledge of osteoporosis in Vietnamese women. Asia Pac J Public Health 2015;27:Np95-105. https://doi.org/10.1177/1010539511423569.
26. Tomay Aksoy Ö, Kutluk Ö, Sezer İ. Osteoporosis knowledge and awareness among rheumatoid arthritis patients: A cross-sectional controlled study. Arch Rheumatol 2024;39:411-8. https://doi.org/10.46497/ArchRheumatol.2024.10171.
27. Şahin MA, Aydemir MD, Dönmez Çolakoğlu B, et al. The effect of osteoporosis education on osteoporosis knowledge level and daily life in Parkinson's disease patients: A 12-week, randomized-controlled trial. Turk J Phys Med Rehabil 2024;70:379-89. https://doi.org/10.5606/tftrd.2024.13026.
28. Alani Q, Yassir M, Mansoor R, et al. Knowledge, attitude, and practices towards osteoporosis among adults in the United Arab Emirates (UAE) in 2023. Cureus 2024;16:e56084. https://doi.org/10.7759/cureus.56084.
29. Njeze Ngozi R, Ikechukwu O, Miriam A, et al. Awareness of osteoporosis in a polytechnic in Enugu, South East Nigeria. Arch Osteoporos 2017;12:51. https://doi.org/10.1007/s11657-017-0342-3.
30. Cawthon PM. Gender differences in osteoporosis and fractures. Clin Orthop Relat Res 2011;469:1900-5. https://doi.org/10.1007/s11999-011-1780-7.
31. Ercan S, İnce Parpucu T, Başkurt Z, et al. Health belief model - male osteoporosis: A cross-sectional study. Cent Eur J Public Health 2023;31:184-90. https://doi.org/10.21101/cejph.a7789.
32. Bozkurt NC, Karbek B, Ucan B, et al. The association between severity of vitamin D deficiency and Hashimoto's thyroiditis. Endocr Pract 2013;19:479-84. https://doi.org/10.4158/ep12376.Or.
33. Göktaş O, Ersoy C, Ercan I, et al. Vitamin D status in the adult population of Bursa-Turkey. Eur J Gen Pract 2020;26:156-62. https://doi.org/10.1080/13814788.2020.1846712.
34. Tahiroğlu V, Alayunt NÖ. Change of vitamin D levels ac-

https://doi.org/10.11005/jbm.25.855

cording to age, gender and seasons in Şırnak province. Turk J Osteoporos 2023;29:17-21. https://doi.org/10.4274/tod.galenos.2022.48303.
35. Shaki O, Rai SK, Gupta TP, et al. To study the awareness of osteoporosis in postmenopausal Indian women in a North-east part of India: An evaluation of the Osteoporosis Health Belief Scale. J Family Med Prim Care 2021;10:1950-5. https://doi.org/10.4103/jfmpc.jfmpc_2133_20.
36. Weaver CM, Alexander DD, Boushey CJ, et al. Calcium plus vitamin D supplementation and risk of fractures: An updated meta-analysis from the National Osteoporosis Foundation. Osteoporos Int 2016;27:367-76. https://doi.org/10.1007/s00198-015-3386-5.
37. Kumar P, Khandelwal D, Mittal S, et al. Knowledge, awareness, practices and adherence to treatment of patients with primary hypothyroidism in Delhi. Indian J Endocrinol Metab 2017;21:429-33. https://doi.org/10.4103/ijem.IJEM_49_17.
38. Chaker L, Bianco AC, Jonklaas J, et al. Hypothyroidism. Lancet 2017;390:1550-62. https://doi.org/10.1016/s0140-6736(17)30703-1.
39. Okumus M, Ceceli E, Tasbas O, et al. Educational status and knowledge level of pre- and postmenopausal women about osteoporosis and risk factors: A cross-sectional study in a group of Turkish female subjects. J Back Musculoskelet Rehabil 2013;26:337-43. https://doi.org/10.3233/bmr-130389.
40. Abu Khurmah MH, Alkhatatbeh MJ, Alshogran OY. Assessment of osteoporosis knowledge, awareness, and risk factors among premenopausal and postmenopausal women from Jordan: A cross-sectional study. Arch Osteoporos 2023;18:121. https://doi.org/10.1007/s11657-023-01332-9.