ORIGINAL RESEARCH

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Prevalence and Relationship of Metabolic Syndrome and Vitamin D Deficiency Among Postmenopausal Women Seeking Check-ups

Check-up için Gelen Postmenopozal Kadınlar Arasında Metabolik Sendrom ve D Vitamini Eksikliğinin Prevalansı ve İlişkisi

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Abstract

Objective: To investigate the relationship between serum vitamin D levels and metabolic syndrome (MetS) in postmenopausal women, and to evaluate how factors such as educational status, parity, and vitamin D supplementation affect vitamin D status and the prevalence of MetS.

Method: This cross-sectional, observational, analytical study included 270 postmenopausal women aged 45-75 years with at least one year of amenorrhea, evaluated at the Check-up Unit of İstanbul Medipol Mega University Hospital (May 2022-February 2023). Participants were classified into three groups based on serum 25-hydroxyvitamin D levels: Sufficient (≥30 ng/mL), insufficient (20-29 ng/mL), and deficient (<20 ng/mL). MetS diagnosis was established using NCEP ATP III criteria. Demographic data, vitamin D supplementation habits, laboratory values (lipid profile, fasting glucose), waist circumference, and blood pressure were recorded. Chi-square and correlation analyses were performed; p-values <0.05 were considered significant.

Results: Vitamin D deficiency was observed in 46.7%, insufficiency in 25.9%, and sufficiency in 27.4% of participants. MetS prevalence was 45.6%, significantly higher in the vitamin D deficient group (50.8%) compared to the sufficient group (36.5%) (p=0.05). There was a negative correlation between vitamin D level and waist circumference (p=0.017), parity (p=0.029), and presence of MetS. A positive correlation was observed between vitamin D and high-density

Öz

Amaç: Postmenopozal kadınlarda serum D vitamini düzeyi ile metabolik sendrom (MetS) arasındaki ilişkiyi araştırmak; eğitim durumu, parite ve D vitamini takviyesinin D vitamini statusü ve MetS prevalansı üzerindeki etkisini değerlendirmektir.

Yöntem: En az bir yıl amenoresi olan, 45-75 yaş arası 270 postmenopozal kadın çalışmaya dahil edildi. Katılımcılar serum 25-hidroksivitamin D düzeylerine göre yeterli (≥30 ng/mL), yetersiz (20-29 ng/mL) ve eksik (<20 ng/mL) olmak üzere üç gruba ayrıldı. MetS tanısı NCEP ATP III kriterlerine göre konuldu. Demografik veriler, D vitamini takviye alışkanlıkları, laboratuvar değerleri, bel çevresi ve kan basıncı kaydedildi. Ki-kare ve korelasyon analizleri uygulandı; p<0,05 anlamlı kabul edildi.

Bulgular: Katılımcıların %46,7'sinde D vitamini eksikliği, %25,9'unda yetersizlik, %27,4'ünde yeterli düzey saptandı. MetS prevalansı %45,6 olup, D vitamini eksik grubunda (%50,8), yeterli gruba (%36,5) kıyasla anlamlı düzeyde yüksek bulundu (p=0,05). D vitamini düzeyi ile bel çevresi (p=0,017), parite (p=0,029) ve MetS varlığı arasında negatif korelasyon saptandı. D vitamini ile yüksek yoğunluklu lipoprotein düzeyi arasında pozitif korelasyon gözlemlendi. Yüksek eğitim düzeyi, daha sık ve yeterli D vitamini kullanımıyla ilişkiliydi; takviye kullanımı öncelikli olarak hekim tavsiyesiyle başlandı (%80,7).

Sonuç: Postmenopozal kadınlarda serum D vitamini düşüklüğü ile MetS prevalansı arasında anlamlı bir ters ilişki saptanmıştır. Eğitim durumunun hem D vitamini takviyesi hem de serum düzeyleri

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Abstract

lipoprotein levels. Higher educational attainment was associated with more frequent and adequate vitamin D supplementation, which was primarily recommended by physicians (80.7%). As a single-center, cross-sectional study, causal relationships cannot be established, and the findings may not be generalizable to all populations.

Conclusion: Low serum vitamin D levels are significantly associated with higher prevalence of MetS in postmenopausal women. Educational status appears to influence both vitamin D supplementation and serum levels. Promoting vitamin D supplementation, especially under medical guidance, may help reduce MetS-related morbidity in this population.

Keywords: Education, metabolic syndrome, post-menopause, supplementation, vitamin D

Öz

üzerinde etkili olduğu görülmüştür. Özellikle hekim gözetiminde D vitamini takviyesinin yaygınlaştırılması, postmenopozal kadınlarda MetS ile ilişkili morbidite ve mortaliteyi azaltmaya katkı sağlayabilir.

Anahtar kelimeler: D vitamini, eğitim, metabolik sendrom, post-menopoz, takviye

Introduction

The gradual decline of estrogen during the postmenopausal period contributes to central obesity, alterations in lipid metabolism, and an increased incidence of risk factors for metabolic syndrome (MetS) (1). MetS is a life-threatening endocrinopathy characterized by a cluster of systemic disorders including insulin resistance-induced abdominal obesity, diabetes mellitus, dyslipidemia, hypertension, and ischemic heart disease. The diagnostic criteria for MetS are defined by the National Cholesterol Education Program Adult Treatment Panel III, which requires the presence of at least three of the following: Abdominal obesity, hypertriglyceridemia, low high-density lipoprotein (HDL) cholesterol, hypertension, and hyperglycemia.

The prevalence of MetS increases after menopause and significantly contributes to cardiovascular morbidity and mortality in postmenopausal women (2). With the growing postmenopausal population, shifts toward industrial dietary habits, decreased physical activity, and rising obesity rates, MetS represents an emerging public health challenge. Until recently, hormone replacement therapy (HRT) was considered a treatment option to reduce postmenopausal metabolic risk factors, as it improved many metabolic abnormalities. However, recent data revealing increased cardiovascular risk in HRT users have led to the discontinuation of HRT as a preventive approach for cardiovascular diseases (3).

Beyond its classical roles in calcium homeostasis and bone metabolism, vitamin D (vitD) has been shown to be inversely associated with glucose homeostasis, lipid profiles, and blood pressure (4). Epidemiological studies have consistently reported low vitD levels among postmenopausal women in many countries. While the importance of vitD supplementation for osteoporosis prevention and treatment is well recognized, emerging evidence suggests that higher vitD levels in middle-aged and elderly populations may be associated with reduced risks of cardiovascular diseases, type 2 diabetes, and MetS beyond musculoskeletal conditions (5).

Objectives

The aim of this study was to determine the prevalence of vitD deficiency and MetS among postmenopausal women in our local population, and to assess the association between vitD levels and the components of MetS. Identifying a correlation between vitD deficiency and MetS may highlight the potential benefits of vitD supplementation as a preventive measure against MetS.

Materials and Methods

Study Design

This study was designed as a single-center, observational, cross-sectional analytical study. Ethical approval was obtained from the Institutional Review Board of İstanbul Medipol University (approval no: E-10840098-772.02-2755, date: 05.05.2022). Informed consent was obtained from all individual participants included in the study.

Study Setting

The study was conducted at the check-up unit of İstanbul Medipol Mega University Hospital. Data collection took place between May 2022 and February 2023.

Participants

The study population consisted of 270 women aged between 45 and 75 years who had been amenorrheic for at least one year and presented for routine health screening during

the study period. All participants were postmenopausal and provided relevant sociodemographic and clinical information as part of their medical evaluations.

Variables

Variables collected included age, place of residence, duration of menopause, number of births, education level, and vitD supplementation status. Participants were asked whether they used vitD supplements, and if so, under whose recommendation they began using them. Based on intake habits, vitD usage was categorized into three groups: Regular users (daily intake of 400 IU over the past three months), occasional users (weekly intake of 800 IU), and non-users.

Data Sources/Measurement

Anthropometric and biochemical data were collected using standardized procedures. Measurements included waist circumference (WC), blood pressure, fasting blood glucose (FBG), total cholesterol, HDL cholesterol, triglycerides (TG), and serum 25-hydroxyvitamin D [25(OH)D] levels. MetS was diagnosed according to the NCEP ATP-III criteria, which require the presence of at least three of the following five conditions: Abdominal obesity (WC >88 cm), hyperglycemia (FBG ≥100 mg/dL or treatment for diabetes), hypertension (blood pressure ≥130/85 mmHg or antihypertensive treatment), hypertriglyceridemia (TG >150 mg/dL), and low HDL cholesterol (<50 mg/dL).

vitD status was classified based on serum 25(OH)D levels as sufficient (≥30 ng/mL), insufficient (20-29 ng/mL), or deficient (<20 ng/mL). Participants were divided into three corresponding groups, and comparisons were made in terms of education level, vitD use, source of recommendation, presence of chronic disease (hypertension and/or diabetes mellitus), and MetS status.

Bias

To minimize measurement bias, all clinical and laboratory assessments were conducted using standardized protocols as part of the hospital's routine check-up procedures.

Study Size

A total of 270 participants who met the eligibility criteria were included in the final analysis. No formal sample size calculation was performed due to the descriptive and cross-sectional nature of the study.

Quantitative Variables

Quantitative variables such as WC, fasting glucose, serum lipids, and vitD levels were analyzed both as continuous variables and according to clinically defined categories.

Statistical Analysis

Statistical analyses were performed using SPSS version 27.0. Categorical variables were compared using the chi-square test. Continuous variables were summarized using medians and ranges, given their non-normal distribution. Frequency distributions were calculated for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results

Participants

A total of 270 postmenopausal women were included in the study. The mean age of participants was 57.8±8 years, with an average menopause duration of 9.4±8 years. The mean parity was 3.38±2. Regarding education level, 14.5% of participants were illiterate, 72.7% had completed primary or secondary education, and 12.9% had completed high school or higher education.

Descriptive Data

Among the participants, 54.4% reported not using vitD supplements, while 7% were regular users, and 38.5% were occasional users. Among those who used vitD, 80.7% had started supplementation upon a physician's recommendation, 11% were influenced by media sources, and 8.3% by advice from close contacts.

The average serum 25(OH)D level among postmenopausal women was 24.5±15 ng/mL. When classified by vitD status, 46.7% of participants were in the deficient group (<20 ng/mL), 25.9% were insufficient (20-29 ng/mL), and 27.4% had sufficient levels (≥30 ng/mL).

Mean anthropometric and biochemical values were as follows: WC 94.74±12.07 cm, FBG 112.52±35.55 mg/dL, total cholesterol 213.34±41.47 mg/dL, HDL cholesterol 56.63±15.06 mg/dL, TG 139.98±77.17 mg/dL, and LDL cholesterol 136.76±37.33 mg/dL.

vitD status was significantly associated with education level. Only 6.6% of participants in the vitamin D–deficient group (<20 ng/mL) had completed higher education, compared to 14.3% in the vitamin D–sufficient group (≥30 ng/mL) (p=0.015). (Table 1).

Outcome Data

MetS was present in 45.6% of the total sample. When stratified by vitD level, the prevalence of MetS was 50.8% in the deficient group (<20 ng/mL), 45.7% in the insufficient group (20-29 ng/mL), and 36.5% in the sufficient group (≥30

ng/mL), revealing a statistically significant trend (p=0.05) (Table 1).

Regardless of serum 25(OH)D level, physicians were the leading source of recommendation for vitD use. Among participants who regularly used vitamin D, 27.8% had completed higher education, whereas this proportion was only 7.9% among non-users, indicating a significant association between education level and vitD use (p<0.001) (Table 2).

Correlation analysis revealed a significant negative correlation between serum vitD level and the presence of MetS, as well as WC (p=0.017) and parity (p=0.029). A positive correlation was observed between vitD level and HDL cholesterol concentration.

Discussion

Globally, increased life expectancy has led women to spend more than one-third of their lives in the postmenopausal period. This phase is characterized by central obesity, insulin resistance, hypertension, and alterations in lipid metabolism, all of which contribute to a higher risk of developing MetS (6). Studies conducted in various countries have reported the prevalence of MetS in postmenopausal women to range from 16% to 69%. These differences may stem from variations in diagnostic criteria, genetic and cultural factors, lifestyle differences, and environmental influences across populations. In our study, we observed that nearly half of the postmenopausal women (45.9%) had MetS.

Comparative prevalence rates reported in other studies include 16.97% in Thailand, 29% in Canada, 36.1% in Germany, 49.8% in Brazil, and 69% in Iran (7-10). MetS is recognized as a major risk factor for type 2 diabetes and cardiovascular diseases, and it is associated with a twofold increase in the risk of myocardial infarction and cerebral ischemia (11). In efforts to reduce MetS-related morbidity and mortality, attention has been directed not only toward lifestyle modifications and hormonal treatments but also toward the correction of micronutrient deficiencies, including vitamin D.

Table 1. Clinical characteristics of the study population according to vitamin D levels

Variable	<20 ng/mL	20-29 ng/mL	≥30 ng/mL	p-value
Education level				
Illiterate	19.0%	10.8%	10.0%	**0.015**
Primary/secondary school	74.4%	66.2%	75.7%	
High school and higher	6.6%	23.1%	14.3%	
Vitamin D supplementation				
No	76.2%	45.7%	25.7%	**<0.001**
Occasional	21.4%	51.4%	55.4%	
Regular	2.4%	2.9%	18.9%	
Supplement recommendation source				
Physician	81.5%	81.8%	79.6%	0.829
Media	7.4%	9.1%	14.3%	
Social circle	11.1%	9.1%	6.1%	
Metabolic syndrome				
Absent	49.2%	54.3%	63.5%	**0.05**
Present	50.8%	45.7%	**36.5%**	

Vitamin D levels were categorized as deficient (<20 ng/mL), insufficient (20-29 ng/mL), and sufficient (≥30 ng/mL). Metabolic syndrome was diagnosed according to NCEP ATP III criteria
NCEP ATP III: National Cholesterol Education Program Adult Treatment Panel III

Table 2. Comparison of vitamin D use according to education level in the study population

Vitamin D use	Illiterate (%)	Primary-secondary education (%)	High school and higher (%)	p-value
Not using vitamin D	19.4	72.7	7.9	**<0.001**
Using vitamin D occasionally	10.1	72.7	17.2	
Using vitamin D regularly	0.0	72.2	**27.8**	

Vitamin D use was categorized as no use, occasional use, and regular use

High serum vitD levels have been associated with a 55% reduction in diabetes risk, a 51% reduction in the risk of MetS, and a 33% reduction in cardiovascular disease risk (5). With advancing age, serum vitD levels tend to decrease. Contributing factors in older individuals include reduced dietary intake, decreased sun exposure, limited outdoor activity, and age-related declines in renal hydroxylation, all of which impair the synthesis of active calcitriol (12).

In our study, 46.7% of postmenopausal women were vitD deficient (<20 ng/mL), and 25.9% were insufficient (20-29 ng/mL). These findings suggest a high prevalence of suboptimal vitD levels in this population. Particularly, women with higher parity tended to have lower vitD levels, and a weak negative correlation was observed between parity and serum vitD (r=-0.1077, p=0.078). Furthermore, we identified a statistically significant inverse correlation between vitD levels and the presence of MetS: 50.8% of women in the deficient group had MetS, compared to only 36.5% in the sufficient group (p=0.05). These findings are consistent with other studies reporting an inverse relationship between serum vitD levels and MetS prevalence (5,13).

A study conducted in China reported deficiency and insufficiency rates of 50.1% and 25%, respectively, with a higher prevalence of MetS in vitamin D–deficient individuals (14). In a study from Madrid, vitD deficiency was present in 56.3% of participants, and MetS prevalence in this group was 43.4%, compared to 26.8% in those without deficiency (15). A cross-sectional study from Korea also demonstrated an inverse linear association between vitD levels and MetS (16). Similarly, research in Thailand found that vitD levels were significantly lower in the MetS group compared to non-MetS individuals (p=0.016) (17). In Brazil, deficiency and insufficiency rates were 35.4% and 32.6%, respectively, with MetS prevalence of 57.8% in these groups compared to 39.8% in the sufficient group (p=0.003) (18). Although country-specific prevalence rates of vitD deficiency and MetS differ, their inverse association has been consistently observed.

The relationship between vitD and individual components of MetS has yielded mixed results across studies. A study from Saudi Arabia (2017) and the United States (2020) reported an inverse association between vitD and WC, whereas a study from India (2017) found a positive correlation, and one from Egypt (2020) found no association. Regarding TG, inverse relationships with vitD were observed in Korea (2013), Saudi Arabia (2017), Brazil (2018), and Iran (various studies). Contrastingly, studies on HDL cholesterol have been inconsistent: An Egyptian study reported an inverse correlation, whereas a Brazilian study reported a positive correlation (Table 3) (13,18-22).

Some studies have reported an inverse association between vitD and hypertension (e.g., a study from the UK), while others have found no such relationship (23-25). As seen, although associations between vitD and some MetS components are evident in the literature, the relationship is not consistent across all components.

In our study, vitD levels were positively correlated with HDL cholesterol and inversely correlated with WC, but no significant association was found with the other components of MetS. One possible explanation is that increased abdominal fat may act as a storage site for vitamin

Table 3. Relationship between vitamin D and metabolic syndrome components in different population studies

Study (year, country)	Population (n, characteristics)	MetS prevalence (%)	Relationship between vitamin D and MetS components
Song and Park (13) 2013, Korea	778 adults, cross-sectional	18.9	Vit D inversely correlated with BP and TG
Srimani et al. (20) 2017, India	222 postmenopausal women	46	Negative but non-significant correlation between Vit D and MetS (p=0.65); Vit D positively correlated with WC (**p=0.004**), negatively correlated with FBG (**p=0.02**); no significant relation with TG, HDL, BP
Khoja et al. (19) 2017, Saudi Arabia	82 individuals aged 20-50, cross-sectional	Not reported	Significant negative correlation between Vit D and MetS; negative correlations with WC, TG, and BG
Mirhoseini et al. (22) 2018, Iran	192 individuals, mean age 51.33	Not reported	No significant relation between Vit D and WC; positive correlation with HDL; negative correlations with TG, BG, and SBP
Schmitt et al. (18) 2018, Brazil	465 individuals aged 45-75	Not reported	Vit D deficiency associated with increased MetS prevalence; deficiency linked to higher TG and lower HDL
Shamy et al. (21) 2020, Egypt	96 individuals, mean age 45.9	Not reported	No significant difference in Vit D between MetS and non-MetS groups; Vit D inversely correlated with HDL; no significant relation with WC, BP, BG, or TG

BG: Blood glucose, BP: Blood pressure, FBG: Fasting blood glucose, HDL: High-density lipoprotein, MetS: Metabolic syndrome, SBP: Systolic blood pressure, TG: Triglycerides, Vit D: Vitamin D, WC: Waist circumference

D, which is fat-soluble, thereby reducing its availability in the circulation.

As shown in Table 3, participant demographics and sample sizes differ across studies, which may influence outcomes. Furthermore, varying definitions for vitD sufficiency and differences in regional climate and dietary patterns may affect the generalizability of results. Although a consistent relationship between vitD and all MetS components could not be established, improving vitD levels in postmenopausal women may help reduce MetS prevalence.

Several studies have demonstrated that vitD supplementation in postmenopausal women may reduce the incidence of MetS. Beyond its established benefits for bone health, vitD replacement may offer modest but meaningful reductions in cardiovascular risk (26). Given the low cost and minimal side effects associated with vitD supplementation, its use presents a potentially valuable public health intervention.

In our study, women who received vitD supplements had significantly higher serum levels. Those with higher education levels were more likely to use vitD and had significantly greater serum concentrations. Moreover, supplementation in this group was predominantly initiated following physician recommendations. This suggests that individuals with higher education levels may have better health literacy, be more likely to attend regular medical checkups, and adhere more closely to physicians' preventive health advice.

Study Limitations

As a single-center, cross-sectional study, causal relationships cannot be established, and the findings may not be generalizable to all populations.

Conclusion

In this study, an inverse association was found between serum vitD levels and the prevalence of MetS in postmenopausal women. vitD was positively correlated with HDL cholesterol and negatively correlated with WC. The significant association between vitD levels and educational status highlights the importance of raising awareness and encouraging regular supplementation in postmenopausal women. Doing so may help prevent the development of MetS, a condition linked to significant morbidity and mortality. Further studies are needed to identify the optimal threshold of vitD for preventing MetS and to explore its associations with MetS components across different populations.

Ethics

Ethics Committee Approval: This study was designed as a single-center, observational, cross-sectional analytical study. Ethical approval was obtained from the Institutional Review Board of İstanbul Medipol University (approval no: E-10840098-772.02-2755, date: 05.05.2022).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: G.P., Concept: G.P., A.S.Y., İ.P., Design: G.P., A.S.Y., F.D., İ.P., Data Collection or Processing: G.P., Analysis or Interpretation: G.P., A.S.Y., İ.P., Literature Search: G.P., F.D., Writing: A.S.Y., F.D.

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