



## THE ROLE OF VITAMIN D, OBESITY, PHYSICAL EXERCISE, SLEEPING AND QUALITY OF LIFE IN REGULATION OF BLOOD PRESSURE

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**Abstract:** The aim of the study is to evaluate the effect of lifestyle modification, nutritional and mental behaviours, physical activity, weight, sleeping, fasting, blood sugar, vitamin D and the biochemistry profile among hypertensive patients. **Materials and methods:** This cross-sectional study was based on 1154 subjects. Data analysis included sociodemographics, life-style habits, anthropometric, body mass index (BMI), hypertension, clinical biochemistry, systolic and diastolic blood pressure, Pittsburgh Sleep Quality Index (PSQI) and quality of life questionnaire. Univariate and multivariate statistical analyses were performed. **Results:** Out of 1154 subjects, 528 (45.8%) were males and 626 (54.2%) were females. There were statistically significant differences between uncontrolled hypertensive and well-controlled hypertensive patients regarding; gender, educational level, household income, BMI, smoking habits, alcohol use, physical exercise, sport activity, co-morbid complications, associated symptoms, hypertension treatment mode, PSQI, vitamin D, blood glucose, HbA1c level, calcium, urea, bilirubin, and systolic and diastolic blood pressures, hours of sleeping and BMI respectively. The principal component extraction, promax rotation indicated that total variances explained was 73.8%, Cronbach's alpha 0.81, KMO value was 0.70 and significant with  $p < 0.001$ . The correlation between the factors was high:  $r = 0.467$  and  $p < 0.001$ . Multivariate stepwise regression predicted that systolic (mmHg) ( $p < 0.001$ ) and diastolic blood pressure (mmHg) ( $p < 0.001$ ), HbA1c ( $p < 0.001$ ), lack of physical exercise ( $p < 0.001$ ), vitamin D deficiency ( $p < 0.001$ ), quality of life ( $p = 0.029$ ), social relationship ( $p = 0.033$ ), sleeping ( $p = 0.049$ ) were identified as statistically significant risk factor for hypertensive. **Conclusion:** The present study determines lifestyle modification with vitamin D supplement, diet, regular physical exercise and sleeping can substantially lower blood pressure and improve blood pressure control of hypertensive patients.

### INTRODUCTION

Hypertension is typically diagnosed and managed in family medicine, primary health care and hospital settings and it is one of the most common reasons for visits to physicians in Turkey.(1-2) Currently, hypertension is a major global disease, affecting 1.13 billion people worldwide; unfortunately, still half of people are unaware that they have hypertension and uncontrolled.(3,4,5) Developing countries appear to be at greater risk of non-communicable diseases such as hypertension, diabetes and obesity.(1,2) Hypertension, type 2 diabetes mellitus [T2DM] and cardiovascular diseases have become the leading cause of disability and death in many developing countries.(1-2,6) Life-style have a strong positive effect on hypertensive and diabetic patients.(7-8) Recent studies provide evidence that the *Pro12Ala* polymorphism is linked to obesity, T2DM and hypertension.(9-10)

The fast economic growth in Turkey has brought substantial changes both in the lifestyle and in the patterns of health and disease. For instance, hypertension has become a main major public health problem. More recently, several studies (11-13) have suggested adopting strictly healthy lifestyles, being active with physical exercise, losing weight in the presence of obesity, consuming a diet rich in fruits and

vegetables, lowering alcohol use and cigarette smoking to prevent or control hypertension. In recent years, multiple studies have reported the effectiveness of short and long-term lifestyle modification programmes in adult populations.(12-16) Each country and region has different cultural, sociodemographic and individual characteristics which have an impact on the effectiveness of lifestyle programmes and their success.(17-19) Furthermore, Vitamin D deficiency is known to be associated with hypertension, can lower blood pressure and improve blood pressure control.(1-2,10,13,20-22). Masked uncontrolled hypertension (MUCH) is diagnosed in patients treated for hypertension who are normotensive in the clinic but hypertensive outside. Furthermore, there are limited studies on MUCH in patients with treated and apparently well-controlled BP.(3-5,7,14)

### AIM

The aim of this study is to evaluate the effect of lifestyle modification, nutritional behaviours, physical activity, anthropometric measurements, sleeping, fasting, blood sugar, vitamin D and biochemistry profile among hypertensive patients.

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## MATERIALS AND METHODS

This cross-sectional study was carried out among hypertensive patients aged 25-65 years, registered at the Medipol International Hospitals and Primary Health Care Centre receiving care during the study period from August to December 2020. IRB ethical approval for this study was provided by the Medipol International School of Medicine, Istanbul Medipol University.

### Data collection methods Questionnaire and Blood Pressure Measurement:

In daily life, the prevalence of “masked uncontrolled hypertension” (MUCH) in people with treated and seemingly well-controlled BP is unknown. The sample size was based on previous reported prevalence of hypertension ranging from 20% to 25% (1-2,19) among patients visiting PHC. Therefore, patients as sample proportion likely to be considered of the prevalence of about 25%, assuming 99% confidence interval with 3% error of estimation and finally computed sample size needed to be 1,644 subjects. A multi-stage a total of 1,644 males and females and aged 25-65 years old persons were approached and 1,154 (70.2%) patients agreed to give consent to participate in this study. Data analysis included sociodemographics, life-style habits, anthropometrics, body mass index (BMI), hypertension, blood pressure, clinical biochemistry and quality of life questionnaire. Blood pressure was measured two times on the right arm of the selected subject and blood pressure was categorized according to previous reported guidelines studies.(1,14)

### Laboratory Blood collection and serum measurements of vitamin D

A blood sample of 10 ml was collected from each subject after fasting for 10 hours using ROCHE COBAS 6000 auto-analyser and Glycosylated hemoglobin (HbA1c) was analysed using a high-performance liquid chromatography (HPLC) method.(1-2,21-22) Serum 25-OH D was measured using a direct competitive chemiluminescent immunoassay (Elecsys; Roche Diagnostics, Mannheim, Germany). Vitamin D patients were classified into three cut-off groups: 1. vitamin D deficiency; 2. insufficiency, and 3. normal/optimal level.(13,21-25) The Spanish hypertension Quality of Life Questionnaire (MINICHAL) (26-27) conducted was based on 2 groups: Mental Status (10 questions, domain is 30) and Somatic Manifestations (6 questions, domain is 18).

We have conducted Pittsburgh Sleep Quality Index (PSQI) which was developed by Buysse et al.(28) to evaluate subjective sleep disturbance over the past month. Based on the total PSQI score, patients were divided into three groups; the “good; “average”; and “poor” sleep quality.(1,9,28)

The Shapiro-Wilk test and/or histograms were used to evaluate the normality of the variables. Student-t test for two continuous variables and Chi-square test was used to test for

differences in proportions of categorical variables. Principal component analysis (PCA) with Varimax rotation was performed to examine the factor structure of the Quality of life among hypertensive patients. Multivariate stepwise regression analysis method was used to predict risk factors for MUCH patients. The level  $p < 0.05$  was considered as the cut-off value for significance.

## RESULTS

Table no. 1 is on the comparison of sociodemographic and lifestyle characteristics of the uncontrolled and well controlled hypertensive subjects. Out of 1154 patients, 528 (45.8%) were males and 626 (54.2%) were females. The mean age of hypertensive patients was  $50.44 \pm 14.10$  and normal was  $50.18 \pm 14.78$ . There were statistically significant differences between hypertensive and normotensive patients regarding; gender, educational level, household income; BMI, smoking habits, alcohol use, physical exercise and sport activity, respectively.

Table no. 2 presents clinical characteristics of the studied uncontrolled and well-controlled hypertensive subjects. As it can be seen from this table, there were statistically significant differences between uncontrolled and well-controlled hypertensive subjects regarding co-morbid complications, associated symptoms, hypertension treatment mode and PSQI (as good, average and poor sleeping), and Vitamin D.

Table no. 3 shows the comparison of the uncontrolled and well controlled hypertensive subjects. As it can be seen from table no. 3, vitamin D, blood glucose, HbA1c level, calcium, urea, bilirubin, and systolic and diastolic blood pressures, hours of sleeping and BMI revealed statistically significant differences regarding the biochemistry parameters, respectively.

Table no. 4 gives the Assessment of Quality of Life in Hypertensive Patients using Factor analysis. The principal component extraction, promax rotation indicated that total variances explained were 73.8%, Cronbach's alpha 0.81. Further, the sampling adequacy was 0.70, and Bartlett's test of sphericity was significant ( $p < 0.001$ ). The correlation between the factors was high:  $r = 0.467$  and  $p < 0.001$ .

Table no. 5 shows clinical variables associated with masked uncontrolled hypertension in treated, well-controlled hypertensive patients, by multivariable stepwise regression analysis. As it can be seen from table no. 5, SBP (mmHg) ( $p < 0.001$ ), DBP (mmHg) ( $p < 0.001$ ), HbA1c ( $p < 0.001$ ), lack of physical exercise ( $p < 0.001$ ), vitamin D deficiency ( $p < 0.001$ ), quality of life ( $p = 0.029$ ), having difficulty of maintaining usual social relationship ( $p = 0.033$ ), less hours of sleeping ( $p = 0.049$ ) were identified as statistically significant predictors of hypertension.

**Table no. 1. Comparison of sociodemographic characteristics of the uncontrolled and well controlled hypertensive patients (N=1154)**

Variables	Uncontrolled Hypertensive= 302 n (%)	Well Controlled Hypertensive= 852 n (%)	p value
<b>Age in years</b>			
30-39	69(27.8)	220(28.1)	0.535
40-49	80(26.5)	150(24.8)	
50-59	69(22.8)	192(22.5)	
60 and above	84(27.8)	246(28.94)	
<b>Gender</b>			
Males	115(38.1)	413(48.5)	0.002
Females	187(69.9)	439(51.5)	
<b>Marital status</b>			
Single	59(19.5)	160(18.8)	0.773
Married	243(80.5)	692(81.2)	
<b>BMI</b>			
<25 (Kg/m <sup>2</sup> )	77(25.5)	284(33.3)	0.040
25-29.9 (Kg/m <sup>2</sup> )	125(41.4)	310(36.4)	

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30 (Kg/m <sup>3</sup> ) and above	100(33.1)	258(30.3)	
<b>Level of education</b>			
Elementary	51(16.9)	164(19.2)	0.029
Intermediate	84(27.8)	197(23.2)	
Secondary	68(22.5)	255(29.9)	
University	99(32.8)	236(27.7)	
<b>Occupational status</b>			
Housewife	41(13.6)	111(13.0)	0.223
Sedentary	90(29.8)	216(25.4)	
Manual	76(25.2)	203(23.8)	
Businessman	29(9.6)	127(14.9)	
Arm/police/security	25(8.3)	66(7.7)	
Clark	41(13.6)	129(15.1)	
<b>Household income</b>			
Low	105(34.8)	303(35.5)	0.013
Medium	134(44.4)	308(36.26)	
High	63(23.9)	241(28.3)	
<b>Eating frequency</b>			
2 times	85(28.1)	220(25.8)	0.431
3 times	217(71.9)	632(74.2)	
<b>Smoking status</b>			
Yes	45(21.5)	124(14.6)	0.005
No	237(78.5)	728(85.4)	
<b>Nargile - Sheesha smoking</b>			
Yes	43(14.2)	112(13.1)	0.632
No	259(85.8)	740(86.9)	
<b>Alcohol use</b>			
Yes	23(7.6)	32(3.8)	0.007
No	279(92.4)	820(96.29)	
<b>Physical exercise</b>			
Yes	55(18.2)	219(25.7)	0.009
No	247(81.8)	633(74.3)	
<b>Sport activity</b>			
Yes	28(9.3)	132(15.5)	0.007
No	274(90.7)	720(84.5)	

**Table no. 2. Clinical characteristics of the uncontrolled and well controlled hypertensive patients (N=1154)**

Variables	Uncontrolled Hypertensive=302 n (%)	Well Controlled Hypertensive= 852 n (%)	p value
<b>Co-morbid complications</b>			
Hypoglycemia	63(20.9)	207 (24.3)	0.226
Gastrointestinal	51(16.9)	71(8.3)	0.001
Respiratory	39(12.9)	63(7.4)	0.004
Headache	78(25.8)	168(19.75)	0.026
Dizziness	62(20.5)	65(7.6)	0.001
Vision problem	66(21.9)	120(14.1)	0.002
Stroke	37(15.2)	66(7.2)	0.012
Nervousness	39(12.9)	62(7.3)	0.003
Chest pain	37(12.3)	63(7.4)	0.010
Coronary Heart Disease	47(15.6)	84(9.9)	0.007
Fatigue	68(22.5)	87(11.4)	0.645
Stress	39(12.9)	49(5.8)	0.001
Sweating	38(12.6)	103(12.1)	0.822
<b>Associated symptoms</b>			
Excessive passing of urine	59(19.5)	124(14.6)	0.021
Excessive hungry	85(13.1)	112(13.1)	0.001
Excessive thirst	57(18.9)	151(17.7)	0.615
Weight loss	68(22.5)	125(14.7)	0.016
Loss of appetite	83(27.5)	200(23.5)	0.164
Dry mouth	41(13.6)	86(10.1)	0.097
<b>Hypertension treatment mode</b>			
Herbal plant	61(20.2)	86(16.6)	0.882
Vigorous activity	38(12.6)	151(24.1)	0.090
Garlic use	79(26.2)	164(26.2)	0.696
Drug tablet use	105(34.8)	240(38.3)	0.770
Green tea use	72(23.8)	158(26.8)	0.248
Supplement vitamin	54(17.9)	227(36.3)	0.918
<b>Sleep quality</b>			
Good sleep (PSQI≤5)	92(30.5)	344(40.4)	0.006
Average sleep (5<PSQI<8)	96(31.8)	252(29.6)	
Poor sleep (PSQI ≥8)	114(37.7)	256(30.0)	
<b>Vitamin D levels</b>			
Deficiency 25(OH)D 10-19 ng/ml	191(63.2)	416(49.1)	0.001
Insufficiency 25(OH)D 20-29 ng/ml	71(23.5)	271(31.8)	
Sufficiency 25(OH)D 30-80 ng/ml	40(13.3)	163(19.1)	

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**Table no. 3. The comparison of clinical biochemistry uncontrolled and well controlled hypertensive subjects (N=1154)**

Biochemistry investigations	Uncontrolled Hypertensive Mean ± SD	Well Controlled Hypertensive Mean ± SD	Mean differences	p value *
Age in year	50.44±14.10	50.18±14.78	-2.65(-1.65; 2.18)	0.788
Vitamin D	18.01±8.95	21.09±9.46	-3.08(-4.31; 1.85)	<0.001
Blood glucose (mmol/L)	9.78±2.06	9.95±1.59	1.13(0.84; 1.28)	<0.001
HbA1c	9.43±1.18	8.83±0.64	0.59(0.48; 0.70)	<0.001
Calcium (mmol/L)	1.92±0.10	1.97±0.10	-0.07(-0.07; 0.09)	<0.001
Urea (mmol/L)	5.52±2.82	5.17±2.32	0.16(-0.18; 0.67)	0.038
Creatinine(mmol/L)	75.62±14.71	73.03±13.72	1.00(-0.18; 0.70)	0.077
Bilirubin (mmol/L)	7.81±2.56	7.37±2.62	0.44(0.10; 0.78)	0.011
Albumin (mmol/L)	42.18±5.04	42.02±4.95	0.33(-0.49; 0.80)	0.640
Cholesterol (mmol/L)	4.84±0.913	4.76±0.81	0.06(-0.04; 1.85)	0.191
Triglycerides (mmol/L)	1.60±0.37	1.63±0.89	0.05(-0.06; 0.02)	0.542
HDL-C (mmol/L)	1.10±0.32	1.09±0.27	0.02(-0.02; 0.05)	0.490
LDL-C (mmol/L)	1.93±0.95	1.99±0.94	0.07(-0.10; 0.18)	0.630
Uric acid (mmol/L)	278.7±65.2	282.3±68.2	-3.97(-12.90; 4.96)	0.383
<b>Blood pressure (BP)</b>				
Systolic BP (mmHg)	145.2±7.06	127.7±7.15	0.37(16.70; 18.19)	<0.001
Diastolic BP (mmHg)	88.1±7.69	79.1±7.41	0.50(8.10; 10.06)	0.001
Hours of Sleep	6.41±0.95	6.656±0.96	-0.15(-0.28; -0.30)	0.015
BMI (Male & female)	28.27±4.42	27.3361±4.83	0.66(0.04; 1.28)	0.036

**Table no. 4. Assessment of Quality of Life in Hypertensive Patients: Factor analysis**

	Components and Eigen Values							Cronbach's Alpha if item deleted
	1	2	3	4	5	6	7	
Q.2.Difficult Relation	0.808							0.791
Q.3.Difficult Interact	0.806							0.792
Q.13.Frequent Urinating	0.826							0.792
Q.14.MouthDry	0.813							0.790
Q.1.Sleep		0.554						0.812
Q.6.Distressed		0.773						0.794
Q.7.Const Stragle		0.780						0.794
Q.10.Felt Sick			0.885					0.799
Q.11.Difficult Breath			0.883					0.798
Q.8.Faceup prob				0.872				0.801
Q.9.Felt Worn Out				0.815				0.797
Q.15.Felt Pain					0.866			0.806
Q.16.Numbnes					0.877			0.812
Q.4.Useful Role						0.882		0.798
Q.5.Unable Decide						0.828		0.792
Q.12.Ankle Swolen							0.560	0.804
Q.17.HypTreat Affect							0.900	0.819
<b>Factor Eigen values</b>	4.527	2.052	1.462	1.323	1.145	1.044	1.000	
<b>Cronbach alfa</b>	0.858	0.590	0.807	0.785	0.749	0.781	0.152	
<b>Variances (%)</b>	26.629	12.069	8.600	7.780	6.734	6.144	5.885	

Method - principal component extraction, promax rotation; Cronbach Alfa = 0.81  
Total Variances Explained (%) = 73.8; KMO value = 0.70; p<0.001

**Table no. 5. Multivariate stepwise regression analysis of the predictors of masked uncontrolled hypertension' (MUCH) patients**

Independent variables	Regression Coefficient (β)	Standard Error (SE)	Beta	t-test	p value
Systolic BP (mmHg)	1.408	0.021	1.023	67.413	<0.001
Diastolic BP (mmHg)	0.123	0.016	0.078	7.754	<0.001
HbA1c	-0.152	0.014	-0.301	10.719	<0.001
Lack of physical exercise	4.195	0.425	0.143	9.876	<0.001
Vitamin D deficiency	0.700	0.142	0.144	4.935	<0.001
Effect on quality of life	0.244	0.112	0.019	2.186	0.029
Difficulty maintaining your usual social relationship	0.238	0.111	0.019	2.138	0.033
Less hours of sleeping	0.660	0.340	0.017	1.970	0.049

### DISCUSSIONS

The current study revealed that lifestyle modification could have a positive impact on healthy lifestyle behaviours, sleep, dietary intake and weight in addition to BMI, blood pressure and serum lipid profile TG, and HDL values among adults. Although pharmacological treatment of high BP is very effective in a very large proportion of patients, medication or drug therapy can be expensive and may produce adverse side effects.(1,8,12,19) A study (8,12) has suggested that exercise, diet and weight loss (1-2,8,12) is also recommended for BP reductions in SBP and DBP of 5.5 and 3.0 mmHg,

respectively.(29) These results are consistent with our findings.

Hypertension in Turkey is a growing public health burden. Age, gender, economic condition, obesity, variations in lifestyle, sleeping, smoking, and unequal health care system performance may each contribute to hypertension as a risk factor.

The morbidity and mortality of hypertension are increasing dramatically worldwide. Similar to our study, the Korean research (14) reported that multivariate logistic regression results identified systolic BP and diastolic BP, high heart rate, prior stroke, dyslipidemia, left ventricular

hypertrophy for both men and for women, and single antihypertensive drug use as independent predictors of MUCH. The current study revealed that lifestyle factors such as physical inactivity, obesity, abnormal systolic and diastolic blood pressure, lack of sleeping, alcohol use, cigarette smoking and dietary factors as main risk factors. This is confirmative with the previous reported studies.(1-1,8-12,17,21)

These behavioural interventions have been shown to reduce SBP and DBP. The physical activity in lowering BP has been the subject of numerous reported reviews and studies.(8,13,16,18,29) Several studies (8,13,29) reported that physical exercise can produce a 10 mmHg reduction in both SBP and DBP. Those obese patients, a combined exercise/weight-loss therapy has been seen to be more effective than treatment.(1,13)

The current study confirmed that outcome results indicate us to conclude that the reliability and validity of the MINICHAL quality of life assessment instruments (26-27) is appropriate for Turkish hypertensive adults.

Vitamin D deficiency is the most common nutritional deficiency in current study. Observational data reported that vitamin D is involved in the pathogenesis of arterial hypertension and even cardiovascular failure.(13) We showed that D levels were lower in uncontrolled hypertensive patients than in well-controlled hypertensive patients whose current results are comparable to the literature.(13,20-22,25) Bener et al. (1-2), Yilmaz et al. (20), Cakal et al. (23), and Alagacone et al. (25) showed that Vitamin D deficiency is highly prevalent in newly diagnosed essential hypertension and diabetic patients.(13-21)

Overall, in summary, this study reveals that behavioural interventions, such as vitamin D supplement, physical exercise, HbA1c monitoring, diet, increasing the quantity of fruits and vegetables, and decreasing the amount of saturated fat eaten, alcohol, and weight loss, may complement or provide an alternative to anti-hypertensive medications.

The present study has some limitations. First, this cross-sectional design does not allow the determining of any cause-effect relationship. Second, the sample of hypertension individuals was recruited from different hospitals and PHC, there may be sampling bias. Third, the tools used for the assessment of quality of life among hypertension are self-reported, therefore they must be interpreted with caution. This may have caused recall bias and underreporting. However, the strength of the present study is that it presents an investigation among a large sample in a critical period during the outbreak of the COVID-19 in Turkey.

### CONCLUSIONS

The present study determines lifestyle modification with vitamin D supplement, diet, regular physical exercise and sleeping substantially lower blood pressure and improve blood pressure control of hypertensive patients.

#### Key Messages

1. The pharmacological treatment of high BP is effective in a large proportion of patients, drug therapy may be inconvenient and expensive, and may be associated with adverse effects.
2. Current study results support the role of behavioural interventions in the treatment of patients with elevations in BP.

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*Informed Consent:* Written and verbal informed consent

was obtained for this study.

*Authors' contributions:* AB, BS, CCB and MÖ, organized study, collected data, performed statistical analysis and wrote the first draft of the article, and contributed to the interpretation of the data and writing the final draft of manuscript.

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### REFERENCES

1. Bener A, Al-Hamaq AOAA, Öztürk M, Güllüoğlu S. Does Ramadan fasting have effects on sleep, fatigue and blood pressure among patients with hypertension? *Blood Press Monit.* 2021;26:108-12.
2. Bener A, Al-Hamaq AOAA, Zughair SM, Öztürk M, Ömer A. Assessment of the Role of Serum 25-Hydroxy Vitamin D Level on Coronary Heart Disease Risk with Stratification Among Patients with Type 2 Diabetes Mellitus. *Angiology.* 2021 Jan;72(1):86-92.
3. Hung MH, Shih LC, Wang YC, Leu HB, Huang PH, Wu TC, Lin SJ, Pan WH, Chen JW, Huang CC. Prediction of Masked Hypertension and Masked Uncontrolled Hypertension Using Machine Learning. *Front Cardiovasc Med.* 2021 Nov 19;8:778306. doi: 10.3389/fcvm.2021.778306.
4. Kim HJ, Shin JH, Lee Y, Kim JH, Hwang SH, Kim WS, Park S, Rhee SJ, Lee EM, Ihm SH, Pyun WB, Shin J. Clinical features and predictors of masked uncontrolled hypertension from the Korean Ambulatory Blood Pressure Monitoring Registry. *Korean J Intern Med.* 2021;36(5):1102-1114.
5. Aksoy I, Deinum J, Lenders JW, Thien T. Does masked hypertension exist in healthy volunteers and apparently well-controlled hypertensive patients? *Neth J Med.* 2006;64:72-77..
6. Bener A, Obineche E, Gillett M, Pasha MAH, Bishawi B. Association between blood levels of lead blood pressure and risk of diabetes and heart diseases in workers. *Int Archives Occup Environ* 2001;74:375-8.
7. Banegas JR, Ruilope LM, de la Sierra A, de la Cruz JJ, Gorostidi M, Segura J, Martell N, García-Puig J, Deanfield J, Williams B. High prevalence of masked uncontrolled hypertension in people with treated hypertension. *Eur Heart J.* 2014 Dec 7;35(46):3304-12.
8. Bacon SL, Sherwood A, Hinderliter A, Blumenthal JA. Effects of exercise, diet and weight loss on high blood pressure. *Sports Med.* 2004;34:307-16.
9. Bener A, Al Suwaidi J, Al-Jaber K, Al-Marri S, Elbagi IAE. The epidemiology of hypertension and its associated risk factors in the Qatari population. *J Human Hyper.* 2004;18:529-30.
10. Bener A, Darwish S, Al-Hamaq AOAA, Mohammad RM, Yousafzai MT. Association of PPAR $\gamma$ 2 gene variant Pro12Ala Polymorphism with hypertension and obesity in the aboriginal Qatari population known for being consanguineous. *Appl Clin Genet.* 2013;6:103-11.
11. Ozemek C, Tiwari S, Sabbahi A, Carbone S, Lavie CJ. Impact of therapeutic lifestyle changes in resistant hypertension. *Prog Cardiovasc Dis.* 2020;63:4-9.
12. Mouodi S, Hosseini SR, Ghadimi R, Cumming RG, Bijani A, Mouodi M, et al. Lifestyle Interventions to Promote Healthy Nutrition and Physical Activity in Middle-Age (40-60 Years) Adults: A Randomized Controlled Trial in the North of Iran. *J Res Health Sci.* 2019;19:e00434.
13. Bener A, Al-Hamaq AOAA, Kurtuluş ME, Abdullatef WK, Zirie M. The role of vitamin D, obesity and physical

- exercise in regulation of glycemia in Type 2 Diabetes Mellitus patients. *Diabetes Metab Syndr.* 2016;10:198-204.
14. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. *J Am Coll Cardiol.* 2018;71:e127-e248.
  15. Baillot A, Romain AJ, Boisvert-Vigneault K, Audet M, Baillargeon JP, Dionne IJ, et al. Effects of lifestyle interventions that include a physical activity component in class II and III obese individuals: a systematic review and meta-analysis. *PLoS One.* 2015;10:e0119017.
  16. Webb VL, Wadden TA. Intensive lifestyle intervention for obesity: principles, practices, and results. *Gastroenterology.* 2017;152:1752–64.
  17. Khosravi A, Kelishadi R, Sarrafzadegan N, Boshtam M, Nouri F, Zarfeshani S, et al. Impact of a community-based lifestyle intervention program on blood pressure and salt intake of normotensive adult population in a developing country. *J Res Med Sci.* 2012;17:235–41.
  18. Bener A, Al-Hamaq AOAA, Agan AF, Öztürk M, Ömer A. Sleeping disturbances and predictor risk factors among type 2 diabetic mellitus patients. *Ann Afr Med.* 2020 Oct-Dec;19(4):230-236.
  19. Bener A, Keskin FE, Kurtuluş EM, Guzel M, Çekirdekçi EI, Kadioğlu P, et al. Essential parameters and risk factors of the patients for diabetes care and treatment. *Diabetes Metab Syndr.* 2017;11:S315-20.
  20. Yılmaz F, Sözel H. Relationship between 25-hydroxyvitamin D and microalbuminuria in patients with newly diagnosed essential hypertension. *Clin Exp Hypertens.* 2020;17:1-6.
  21. Bener A, Al-Hamaq AOAA, Öztürk M, Tewfik I. Vitamin D and Elevated Serum Uric Acid as Novel Predictors and Prognostic Markers for Type 2 Diabetes Mellitus. *J Pharm Bioallied Sci.* 2019 Apr-Jun;11(2):127-132.
  22. Bener A, Ozdenkaya Y, Al-Hamaq AOAA, Barisik CC, Ozturk M. Low Vitamin D Deficiency Associated with Thyroid Disease Among Type 2 Diabetic Mellitus Patients. *J Clin Med Res.* 2018;10:707-14.
  23. Cakal S, Çakal B, Karaca O. Association of vitamin D deficiency with arterial stiffness in newly diagnosed hypertension. *Blood Press Monit.* 2021;26:113-7.
  24. Holick M, Binkley N, Bischoff-Ferrari H, Gordon C, Hanley D, Heaney R, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab.* 2011;96:1911–30.
  25. Alagacone S, Verga E, Verdolini R, Saifullah SM. The association between vitamin D deficiency and the risk of resistant hypertension. *Clin Exp Hypertens.* 2020;42:177-80.
  26. Schulz RB, Rossignoli P, Correr CJ, Fernández-Llimós F, Toni PM. Validation of the short form of the Spanish hypertension quality of life questionnaire (MINICHAL) for Portuguese (Brazil). *Arq Bras Cardiol.* 2008;90:127-31.
  27. Badia X, Roca-Cusachs A, Dalfó A, Gascón G, Abellán J, Lahoz R, et al. Validation of the short form of the Spanish hypertension Quality of Life Questionnaire (MINICHAL). *Clin Ther.* 2002;24:2137-54.
  28. Buysse DJ, Reynolds 3rd CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28:193–213.
  29. Writing Group of the PREMIER Collaborative Research Group. Effects of comprehensive lifestyle modification on blood pressure control: main results of the PREMIER clinical trial. *JAMA.* 2003;289:2083-93.