Journal of Taibah University Medical Sciences (2018) 13(1), 51–57

Taibah University

Journal of Taibah University Medical Sciences

www.sciencedirect.com

Original Article

The association of adiposity, physical fitness, vitamin D levels and haemodynamic parameters in young Saudi females

Lubna I. Al Asoom, PhD * and Mohammad T. Al Hariri, PhD

Physiology Department, College of Medicine, Imam Abdulrahman bin Faisal University, Dammam, KSA

Received 22 February 2017; revised 30 April 2017; accepted 7 May 2017; Available online 15 June 2017

الملخص

أهداف البحث: قمنا في هذه الدراسة بتقييم الارتباط المحتمل بين السمنة، واللياقة البدنية، ومستويات فيتامين ”د“ ومؤشرات الدورة الدموية، كعوامل خطر وسيطة لصحة القلب والأوعية الدموية لدى النساء السعوديات الشابات.

طرق البحث: ضمت هذه الدراسة المقطعية ما مجموعه ٨٧ من النساء السعوديات الشابات الصحيحات، خلال الفترة من ٢٠١٤ إلى ٢٠١٥. وقد تم قياس وزن الجسم والطول ومحيطي الخصر والورك ومستوى ٢٥-هيدروكسي فيتامين د في البلازما. أُجري تمرين الجهد لتحديد معدل النبض، وضغط الدم، وتخطيط القلب والاستهلاك الأقصى للأكسجين. كما قمنا بإنشاء نماذج انحدار خطي متعددة لكل من ضغط الدم الشرياني، والنبض في حالتي الراحة والقصوى، وعلامات الدهون، والاستهلاك الأقصى للأكسجين ومستويات ٢٥ هيدروكسي فيتامين د في البلازما.

النتائج: كان نموذج الانحدار الخطي المتعدد ذا قيمة بالنسبة لضغط الدم الانبساطي عند الراحة ومتوسط ضغط الدم الانبساطي وضغط الدم الانقباضي عند الراحة ومتوسط ضغط الدم الانقباضي مع معامل التحديد المعدل (٦.٥ و ١٠.٢ و ٨.٣ و ٤.٥ ٪ على التوالي). وباستثناء الاستهلاك الأقصى للأكسجين في نموذج ” متوسط ضغط الدم الانبساطي “، لم تظهر أي من عوامل خطورة مشمولة أي تغيّر ذي قيمة في اختبار ” تي “.

الاستنتاجات: أظهرت هذه الدراسة ارتباط السمنة العالية وانخفاض اللياقة البدنية بمؤشرات الدورة الدموية لدى النساء الشابات السعوديات. قد ينبئ ضغط الدم الانبساطي الناتج عن التمارين الشديدة عن الخطورة المستقبلية على القلب والأوعية الدموية في النساء الشابات غير اللائقات رياضيا.

الكلمات المفتاحية: الخطورة على القلب والأوعية الدموية؛ فيتامين د؛ الاستهلاك الأقصى للأكسجين؛ ضغط الدم الانبساطي؛ ضغط الدم الانقباضي

Abstract

Objectives: In this study, we assessed the possible association of adiposity, physical fitness, vitamin D levels and haemodynamic parameters as intermediate risk factors for cardiovascular health in young Saudi women.

Methods: A total of 87 young healthy Saudi women were recruited in this cross-sectional study during 2014–2015. The body weight, height, waist and hip circumference, and plasma 25-hydroxyvitamin D (25[OH] D) levels were measured. The exercise stress test was performed to determine the pulse rate, blood pressure (BP), ECG, and VO_{2max}. Multiple linear regression models were generated for the resting (r) and maximum (m) diastolic (D) and systolic (s) arterial BP and pulse rate (PR), adiposity markers, VO_{2max}, and plasma levels of 25(OH) D.

Results: A multiple linear regression model was significant for the rDBP, mDBP, rSBP, and mSBP with adjusted R^2 (6.5, 10.2, 8.3, and 4.5%, respectively). Except for VO_{2max} in the mDBP model, none of the included risk factors were significant according to the t-test.

Conclusion: This study showed the association of high adiposity and decreased physical fitness with haemodynamic parameters in young Saudi women. An exaggerated exercise DBP might predict future cardiovascular risk in unfit young women.

Keywords: Cardiovascular risk; Diastolic blood pressure; Systolic blood pressure; Vitamin D; VO_{2max}

* Corresponding address: Physiology Department, College of Medicine, Imam Abdulrahman bin Faisal University, Dammam, KSA.

E-mail: lasoom@uod.edu.sa (L.I. Al Asoom)

Peer review under responsibility of Taibah University.

Production and hosting by Elsevier

1658-3612 http://dx.doi.org/10.1016/j.jtumed.2017.05.004

Introduction

Non-communicable diseases are a major health problem in KSA and are considered one of the leading causes of death. According to the 2014 report of World Health Organization (WHO), they account for 78% of mortality. In particular, cardiovascular disease accounts for 46% of all deaths.[1] Furthermore, a recent epidemiological study revealed that 15.2 and 40.6% of Saudis were hypertensive or borderline hypertensive, respectively.[2]

Multiple risk factors have been identified, including a sedentary lifestyle, diminished outdoor activity, and increased intake of fatty foods as well as the resultant obesity, reduced physical fitness, and vitamin D deficiency.[3] There is evidence of associations between each of the latter risk factors and cardiovascular morbidity and mortality.

Obesity is a major cardiovascular risk factor that has dramatically increased worldwide, including in KSA.[4] Obesity has been found to be associated with hypertension in young children[5] and adults[6]; however, the mechanisms explaining obesity-mediated hypertension or elevated arterial blood pressure (BP) remain controversial. Several mechanisms have been suggested. An elevation of sympathetic stimulation in obese and overweight patients has been demonstrated through experimental and clinical evidence.[7] Other mechanisms might include impaired renal natriuresis and diuresis, leading to water retention and the expansion of venous return and cardiac output, and metabolic and hormonal mechanisms, which include an impaired renin-angiotensin system (RAS), fat deposition, insulinism, and leptinemia.[8]

Reduced physical activity and cardiopulmonary fitness are also associated with a higher risk of cardiovascular morbidity and mortality.[9] The risk of physical inactivity for the population in KSA is estimated to be 45% compared to 35% in the United States and 38% in the United Kingdom.[10] Additionally, 75% of Saudi women were reported to be insufficiently active by WHO by the year 2010.[11] Diminished physical fitness might lead to higher vascular resistance, reduction in endothelial vasodilators, and increased sympathetic dominance, which ultimately increase the cardiovascular risk.[12] Moreover, comparing exercise capacity to physical activity as predictors to the cardiovascular mortality revealed superior prediction based on the exercise capacity in both males and females.[13]

Vitamin D deficiency is a common health problem and a cardiometabolic risk factor. However, experimental and clinical studies have shown conflicting data regarding the involvement of vitamin D deficiency in the pathophysiology of hypertension and heart failure.[14] Vitamin D deficiency is considered endemic in KSA, with an incidence exceeding 90% in some regions.[15]

Studying the combined effects of multiple risk factors that threaten public health by resulting in a high incidence of non-communicable disease might increase our understanding of the net risk more than studying individual risk factors.[16] Some studies have already estimated the combined effect of increased body weight (BW) and reduced physical activity on the cardiovascular health of different populations. One such study on Finnish male and female participants found that the combination of physical inactivity and obesity was associated with higher cardiovascular mortality.[17]

Although female gender has been identified in epidemiological studies as a protective factor against cardiovascular complications,[18] prospective studies have failed to confirm this protection and have yielded conflicting data, particularly in relation to the impact of risk factors, such as obesity and physical inactivity, on female cardiovascular health. This conflict might be from studies that assessed females in a wide age range and included pre- and post-menopausal women.[17]

In this study, we explored the independent and cumulative influences of three health risk factors, BW and adiposity, physical fitness, and plasma vitamin D level, on haemodynamic parameters using the resting (r) and maximum (m) arterial BP, pulse rate (PR) at rest and maximum exercise as indicators of cardiovascular health. The target population was young females in KSA. This target group was prone to obesity, physical inactivity, and vitamin D deficiency that might be missed in large surveys.

Materials and Methods

Eighty-seven Saudi female college students were voluntarily recruited from a female-only campus. The sample size was calculated using G-power software depending on the mean value of the VO_{2max} of Saudi females obtained from a previous study (VO_{2max} = 33.6 mL/kg min),[19] effect size = 0.25 and power = 0.85. Volunteers were accepted irrespective of their body mass index (BMI) or degree of physical activity. All subjects were apparently healthy and lacked contraindications for the exercise stress test, such as cardiovascular, respiratory, haematological, or musculoskeletal disorders. Subjects were excluded if were pregnant or had lactated within the last two years. None of the participants had received vitamin D supplements in the previous six weeks. The recruitment process and all study procedures were performed between October 2014 and April 2015 in a physiology laboratory. All study procedures were explained to the subjects (exercise test and blood extraction), and the participants signed written informed consents.

This cross-sectional study was approved by the Institutional Review Board (IRB certificate number 2015-01-065). Ethical approval was obtained and followed the principles of the Helsinki Declaration.

Anthropometric data

The BW was determined for each subject using a portable platform scale with an accuracy within 0.1 kg. The height (stature S) was assessed without shoes using a centimetre stadiometer with an accuracy to the nearest 0.25 cm. The BMI was calculated using the formula weight (kg)/height (m)^2 and classified according to the WHO classification (underweight$<$18.5, normal 18.5–24.9, overweight 25–29.9, and obese $\geq$30). The determinants of central obesity were also assessed, including the waist circumference (WC) (at the umbilicus using unstretchable measuring tape while the subject wore light clothes), hip circumference (HC) (the largest diameter of the hip), and waist/hip (W/H) and waist/stature (W/S) ratios. These measurements were performed before the subject engaged in cardiopulmonary exercise testing.

Exercise test

The test procedure was clearly introduced to each subject before starting the test. The subjects were also encouraged to expend their maximal effort. However, the participants had the right to stop the test at any time. The baseline and exercise PR and BP (systolic and diastolic) were determined using an automated monitor (Welch Allyn vital signs monitor, United States). The baseline and continuous electrocardiogram (ECG) were recorded during the exercise and carefully observed by an expert.

Each subject performed The Bruce Protocol on a treadmill.[20] In this protocol, the subject starts at 1.7 mph and a 10% grade. Both the speed and inclination are increased every 3 min until exhaustion. All participants were encouraged to continue exercise until exhaustion, and their heart rates were continually observed and compared to the maximal heart rates predicted by age using the formula[21]:

$$\text{Predicted maximum heart rate} = 208 - 0.7 \times \text{age}$$

Achieving 85% and above of the predicted maximum heart rate was used as an indicator of maximum exercise. The VO_{2max} was calculated by the Pollock formula for active and sedentary women using the total run time[22]:

$$VO_{2max} = 4.38 \times T - 3.9$$

VO_{2max} was classified according to the physical fitness specialist certification manual[23] into very poor ($VO_{2max} < 23.6$ mL/(Kg min); poor ($VO_{2max} = 23.6–28.9$ mL/(Kg min); fair ($VO_{2max} = 29.0–32.9$ mL/(Kg min); good ($VO_{2max} = 33.0–36.9$ mL/(Kg min); excellent ($VO_{2max} = 37.0–41.0$ mL/(Kg min); superior ($VO_{2max} > 41.0$ mL/(Kg min).

Determining vitamin D levels

Blood samples were collected by a nurse through venipuncture between 12:00 and 13:00 for all subjects. Blood was collected in ethylenediaminetetraacetic acid (EDTA) vacutainers and centrifuged, and the plasma was kept at −80° C for a maximum of one week before analysis. Plasma 25(OH) D is the metabolite clinically used to assess the vitamin D levels,[24] and it was measured using the ClinRep high performance liquid chromatography (HPLC) complete kit (Recipe, Germany).[25] Linearity was defined as 2.6–500 μg/l, the detection limit was 1.0 μg/l, and the quantitation limit was 2.6 μg/l. The inter- and intra-assay coefficients of variation were 3.1–4.7 and 2.3–4.9, respectively. The Vitamin D levels were classified according to the Endocrine Society clinical practice guidelines for vitamin D deficiency.[26] The guidelines include the following five categories: normal and sufficient levels (≥30 ng/ml), normal and insufficient levels (≥20 and < 30 ng/ml), mild deficiency (≥10 and < 20 ng/ml), moderate deficiency (≥5 and < 10 ng/ml), and severe deficiency (<5 ng/ml).

Statistical analysis

Data were analysed using IBM − Statistical analysis software package − SPSS version 20 and expressed as the mean ± standard deviation (SD). The Pearson correlation was used to test the relationship of multiple risk factors, including the BW, BMI, WC, HC, W/H, W/S, 25(OH) D, and VO_{2max}. The haemodynamic parameters included the resting and maximum diastolic and systolic BP and PR (rDBP, mDBP, rSBP, mSBP, rPR, and mPR). Risk factors with a significant correlation with certain haemodynamic parameters were entered into multiple linear regression models to test the interaction effect among these factors on the selected haemodynamic parameter. Multiple linear regression models were used to predict the correlation between multiple risk factors and haemodynamic parameters.

Results

Eighty-seven Saudi females successfully participated in the study and completed all tests and procedures. Their age range was 18–32 years. The mean age, anthropometric data, haemodynamic parameters, VO_{2max}, and plasma 25(OH) D of all participants are presented in Table 1. According to the WHO BMI classification, 11 (12.5%) were underweight, 53 (60.2%) were normal, 17 (19.3%) were overweight, and 7 (8.0%) were obese. Their level of physical fitness was based on the value of VO_{2max}; 16 (34.0%) were poor and very poor, 10 (21.0%) were fair and good, and 22 (46.0%) were excellent and superior according to the Physical Fitness Specialized Certification Manual.[23] The assessment of the 25(OH) D levels revealed that 7 subjects (8.0%) had normal and sufficient levels, 8 (9.0%) had normal and insufficient levels, 52 (59.0%) had mild deficiency, 18 (20.0%) have moderate deficiency, and 2 (2.0%) had severe deficiency.

Pearson correlations

The result of Pearson correlations between the haemodynamic parameters and the risk factors, BW, BMI, WC,

Table 1: Age, anthropometric, haemodynamic data, VO_{2max}, and plasma 25(OH) D levels for all participants (n = 87).

Characteristics	Mean ± SD
Age (years)	20.8 ± 2.4
Weight (kg)	58.1 ± 14.8
Height (cm)	158.3 ± 6.3
BMI (kg/m^2)	23.0 ± 4.8
WC (cm)	72.2 ± 10.8
HC (cm)	97.5 ± 11.5
W/H	0.7 ± 0.1
W/S	0.4 ± 0.1
rPR (beats/min)	101.0 ± 14.0
rDBP (mmHg)	78.0 ± 7.5
rSBP (mmHg)	118.0 ± 16.0
mPR (beats/min)	163.0 ± 22.0
mDBP (mmHg)	76.0 ± 9.0
mSBP (mmHg)	148.0 ± 35.0
VO_{2max} (ml/Kg min)	33.7 ± 11.0
25 (OH) D (ng/ml)	15.2 ± 7.2

BMI = body mass index, WC = waist circumference, HC = hip circumference, W/H = waist/hip, W/S = waist/stature (height), r = resting, m = maximum, PR = pulse rate, DBP = diastolic BP, and SBP = systolic BP.

HC, W/H, W/S, VO_{2max}, and 25(OH) D, had a significant correlation between the rSBP and the BW, BMI, and W/S. The mSBP had a significant correlation with the WC and W/S. The rDBP revealed significant correlation with the BW and VO_{2max}. The mDBP had a significant correlation with the BW, BMI, WC, W/S, and VO_{2max}. Finally, the rPR and mPR had a significant correlation with the VO_{2max} (Table 2).

Multiple linear regression

The results of the multiple linear regression models are shown in Tables 3 and 4. Multiple linear regression models were run using the rDBP, mDBP, rSBP, and mSBP as dependent variables. The risk factors included in each model were those that were significantly correlated with the dependent variable, as demonstrated by the Pearson correlation. Model 1 was for the rDBP and the independent variables BW and VO_{2max}. The F-test for model 1 was significant with p-value = 0.021 and adjusted R^2 value = 6.5%. However, the t-tests for both the BW and VO_{2max} were insignificant (Table 2). Model 2 was for the mDBP and the BW, BMI, WC, W/S, and VO_{2max} independent variables. The F-test of model 2 was significant with p-value = 0.034 and adjusted R^2 = 10.2%. The VO_{2max} was the only variable with significant predictive value for the dependent variable mDBP in the presence of other variables. Model 3 was for the rSBP and the independent variables BW, BMI, and W/S. Model 3 was significant with p-value = 0.016 and adjusted R^2 = 8.3%. According to the results of the t-tests, none of the independent variables had significant predictive value when combined. Model 4 was for the mSBP and the independent variables WC and W/S. The F-test of this model was insignificant with p-value = 0.052.

Table 3: Results of multiple linear regression for the resting and maximum diastolic BP using the BW, BMI, WC, W/S, and VO_{2max} as predictors (n = 87).

	rDBP		R^2	mDBP		R^2
	B	SE B		B	SE B	
BW	0.065	0.058	0.065	0.085	0.266	0.102
BMI	–	–		0.077	0.884	
WC	–	–		−0.137	0.285	
W/S	–	–		20.182	53.301	
VO_{2max}	−0.147	0.122		−0.251*	0.094	
constant	78.9	5.2		78.7	8.5	
P-value	0.021*			0.016*		

* P < 0.05.
r = resting, m = maximum, DBP = diastolic BP, BW = body weight, BMI = body mass index, WC = waist circumference, and W/S = waist/stature ratio.

Discussion

This study analysed the combined effects of multiple risk factors—adiposity, physical fitness, and vitamin D levels—on cardiovascular health in young Saudi females. The dependent variables were the resting and maximum exercise systolic and diastolic BP and PR. The risk factors with a significant Pearson correlation with one of the cardiovascular variables were combined in multiple linear regression models to test their cumulative effects.

The most prominent effect was shown through the multiple linear regression model of maximum diastolic BP. All adiposity indicators were included in this model—BW, BMI, WC, W/S, and the physical fitness indicator, VO_{2max}. According to the model, the included risk factors explained 10.2% of the change in maximum exercise diastolic BP with a level of significance at p = 0.016. Of note, however, is that none of the individual adiposity indices was a significant predictor of the maximum diastolic BP. On the other hand, the VO_{2max} significantly predicted the maximum diastolic BP, even when combined with other risk factors. Therefore, it seems that no specific indicator of adiposity is superior to the others. In other words, any of the measures of adiposity may be used to predict the maximum diastolic BP.[27]

On the other hand, the current result of a significant prediction of the maximum diastolic blood pressure by VO_{2max} in an inverse manner demonstrates the importance of physical fitness as an indicator of cardiovascular health. Furthermore, this relationship reflects the significance of utilizing exercise test parameters to predict future cardiovascular risk. The use of the exercise BP values as predictors of future cardiovascular risk has also been performed in

Table 2: The Pearson correlation of multiple risk factors and haemodynamic parameters.

	rDBP	mDBP	rSBP	mSBP	rPR	mPR
Weight	R = 0.221* P = 0.038	R = 0.282** P = 0.008	R = 0.327** P = 0.002	NS	NS	NS
BMI	NS	R = 0.273* P = 0.01	R = 0.293** P = 0.006	NS	NS	NS
WC	NS	R = 0.226* P = 0.035	NS	R = 0.257* P = 0.015	NS	NS
W/S	NS	R = 0.215* P = 0.044	R = 0.210* P = 0.049	R = 0.248* P = 0.020	NS	NS
25(OH) D	NS	NS	NS	NS	NS	NS
VO_{2max}	R = −0.271* P = 0.011	R = −0.360** P = 0.001	NS	NS	R = −0.304 P = 0.005	R = −0.400 P = 0.00

* P < 0.05; ** P < 0.01.
r = resting, m = maximum, DBP = diastolic BP, SBP = systolic BP, PR = pulse rate, BMI = body mass index, WC = waist circumference, and W/S = waist/stature ratio.

Table 4: Results of multiple linear regression for the resting and maximum systolic BP using the BW, BMI, WC, and W/S as predictors (n = 87).

	r-SBP		R^2	m-SBP		R^2
	B	SE B		B	SE B	
BW	0.354	0.255	0.083	–	–	0.045
BMI	−0.106	0.956		–	–	
WC	–	–		0.615	0.853	
W/S	−23.330	37.884		38.833	149.249	
Constant	111.8	8.967		86.0	26.4	
P-value	0.016*			0.052		

* $P < 0.05$.
r = resting, m = maximum, SBP = systolic BP, BW = body weight, BMI = body mass index, WC = waist circumference, and W/S = waist/stature ratio.

other studies. For example, Buar et al. found that fireworkers with low physical fitness developed exaggerated arterial BP in response to the exercise stress test.[28] Unfit children undergoing the handgrip exercise also showed higher arterial BP values than their fit counterparts.[29] Most previous studies have focused on the exaggerated SBP response to exercise.[30] However, recent evidence has also indicated an association between increased exercise DBP and the future development of hypertension and other cardiovascular disease.[31] Furthermore, Sing et al. referred to the specific association of exaggerated exercise DBP rather than the SBP as a risk factor for hypertension in females.[32]

The diastolic BP in normal healthy subjects commonly shows trivial increases during exercise due to skeletal peripheral vasodilatation. Therefore, any marked increase in the exercise DBP might reflect an abnormally increased peripheral vascular resistance and the impaired exercise capacity of vasodilation due either to hyperreactivity of the sympathetic system or to an impaired endothelial vasodilator system[33]. Therefore, this study's demonstration of the association between young Saudi females' reduced physical fitness with the maximum exercise DBP might be used as a screening tool for determining the future prognosis of hypertension and cardiovascular disease, particularly in female subjects with reduced physical fitness as they are the most vulnerable.

The rDBP model was also significant for two risk factors, the BW and VO_{2max}. However, these risk factors only predicted 6.5% of the expected change in the rDBP. Some earlier studies ameliorated the significance of isolated, elevated DBP in young individuals in the prediction of future risk and considered it as a benign condition.[34] However, a more recent study demonstrated that 82.5% of participants with baseline isolated diastolic hypertension developed systolic/diastolic hypertension within 10 years.[35]

The multiple linear regression of SBP models was significant, albeit with less predictive ability, at 8.3% and 4.5% for the rSBP and mSBP, respectively. The only risk factors included were indicators of adiposity, including the BW, BMI, WC, and W/S for the rSBP and WC and W/S for the mSBP. In all models, none of the adiposity markers had individual significance with the targeted haemodynamic parameters when adjusted with the other adiposity markers. This suggests that any measure of increased adiposity can predict a higher arterial BP in the target group.

The association of BW with a high resting arterial BP was previously reported in other populations. An Australian study on the cardiovascular risk of youth aged 15–24 revealed a significant positive association of being overweight and obese with hypertension, which is defined as SBP >140 mmHg and/or DBP >90 mmHg.[36] Similarly, a large Framingham study of 21,732 individuals (52% women with a mean age of 38 years) revealed an association of all BP measures—systolic, diastolic, mean, and pulse BP—with the BW.[37] Similarly, a previous national survey in KSA demonstrated a positive association between obesity and high BP in a large group of male and female participants aged 15 years and above.[2] These previous studies emphasized the association of obesity and hypertension in males and elderly patients. However, our study demonstrated that this relationship is also strong in young females. No previous studies have demonstrated the influence of the combined effects by objectively measuring the physical fitness and vitamin D levels and their association with obesity and hypertension as in this study.

This study failed to demonstrate any specific, significant correlation between the vitamin D levels and tested haemodynamic parameters. Some experimental and clinical evidence in the literature has indicated the involvement of vitamin D deficiency in cardiovascular morbidity and mortality.[38,39] Low plasma 25(OH) D levels in some studies have also been found to be associated with an elevated diastolic BP[40] and increased prevalence of hypertension.[41] However, large longitudinal studies might be required to explore the influence of vitamin D deficiency on the cardiovascular health status of females in this population.

Conclusion

This study demonstrated evidence for cardiovascular risk in young Saudi females. The association of increased BW and reduced physical fitness with some intermediate indicators of cardiovascular morbidity, such as the resting and exercise DBP and SBP, suggest a need to address lifestyle factors. We need to promote healthy lifestyles in KSA and to encourage the achievement of ideal BW and physical fitness. Furthermore, the obtained data might address the valuable utilization of exercise test parameters in predicting the future risk of hypertension or other cardiovascular diseases, especially in young apparently healthy individuals. Finally, the 25(OH) D data in this study do not exclude the possible risk of vitamin D hypovitaminosis; however, larger studies are needed to evaluate such a risk.

Strengths and limitations

This study was limited by its relatively small sample size and convenient recruitment of subjects. However, it represents a narrow age group in the female sample, which reduces the confounding effect of age. Another strength of this study is its assessment of the influence of the risk factors of adiposity, reduced physical fitness, and vitamin D deficiency on the cardiovascular findings of the exercise stress test. An additional strength is the objective assessment of cardiopulmonary fitness with the exercise stress test.

Conflict of interest

The authors have no conflict of interest to declare.

Authors' contributions

LIA conceived and designed the study, conducted the research, provided research materials, and collected the data. MTA analysed and interpreted the data. LIA wrote the initial and final drafts of the article. All of the authors have critically reviewed and approved the final draft and are responsible for the manuscript content.

Acknowledgments

I would like to thank Dr. Sulaiman Bah for his assistance with the statistical analysis. The project was executed through grant number 2013183 provided by the Deanship of Scientific Research at the University of Dammam in Dammam, KSA.

References

1. *Noncommunicable diseases (NCD) country profiles*. World Health Organization; 2014.
2. El Bcheraoui C, Memish ZA, Tuffaha M, Daoud F, Robinson M, Jaber S, et al. Hypertension and its associated risk factors in the Kingdom of Saudi Arabia, 2013: a national survey. **Int J Hypertens 2014**; 2014564679.
3. Bauer UE, Briss PA, Goodman RA, Bowman BA. Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. **Lancet 2014**; 384(9937): 45–52.
4. DeNicola E, Aburizaiza OS, Siddique A, Khwaja H, Carpenter DO. Obesity and public health in the Kingdom of Saudi Arabia. **Rev Environ Health 2015**; 30(3): 191–205.
5. Jansen MA, Uiterwaal CS, Visseren FL, van der Ent CK, Grobbee DE, Dalmeijer GW. Abdominal fat and blood pressure in healthy young children. **J Hypertens 2016**; 34(9): 1796–1803.
6. Almeida JB, Kian KO, Lima RC, Souza MC. Total and abdominal adiposity and hypertension in indigenous women in midwest Brazil. **PLoS One 2016**; 11(6)e0155528.
7. Lavie CJ, McAuley PA, Church TS, Milani RV, Blair SN. Obesity and cardiovascular diseases: implications regarding fitness, fatness, and severity in the obesity paradox. **J Am Coll Cardiol 2014**; 63(14): 1345–1354.
8. Kotsis V, Stabouli S, Papakatsika S, Rizos Z, Parati G. Mechanisms of obesity-induced hypertension. **Hypertens Res 2010**; 33(5): 386–393.
9. Korpelainen R, Lämsä J, Kaikkonen KM, Korpelainen J, Laukkanen J, Palatsi I, et al. Exercise capacity and mortality – a follow-up study of 3033 subjects referred to clinical exercise testing. **Ann Med 2016**: 1–8.
10. Al-Hazzaa HM. The public health burden of physical inactivity in Saudi Arabia. **J Fam Community Med 2004**; 11(2): 45–51.
11. *Global status reports on noncommunicable diseases*. World Health Organization; 2010. pp. 120–121.
12. Thosar SS, Johnson BD, Johnston JD, Wallace JP. Sitting and endothelial dysfunction: the role of shear stress. **Med Sci Monit 2012**; 18(12). RA173-80.
13. Myers J, Kaykha A, George S, Abella J, Zaheer N, Lear S, et al. Fitness versus physical activity patterns in predicting mortality in men. **Am J Med 2004**; 117(12): 912–918.
14. Kao KT, Abidi N, Ranasinha S, Brown J, Rodda C, McCallum Z, et al. Low vitamin D is associated with hypertension in paediatric obesity. **J Paediatr Child Health 2015**; 51(12): 1207–1213.
15. Hussain AN, Alkhenizan AH, El Shaker M, Raef H, Gabr A. Increasing trends and significance of hypovitaminosis D: a population-based study in the Kingdom of Saudi Arabia. **Arch Osteoporos 2014**; 9(1): 190.
16. Carlsson AC, Ärnlöv J, Sundström J, Michaëlsson K, Byberg L, Lind L. Physical activity, obesity and risk of cardiovascular disease in middle-aged men during a median of 30 years of follow-up. **Eur J Prev Cardiol 2015**; 23(4): 359–365.
17. Hu G, Tuomilehto J, Silventoinen K, Barengo N, Jousilahti P. Joint effects of physical activity, body mass index, waist circumference and waist-to-hip ratio with the risk of cardiovascular disease among middle-aged Finnish men and women. **Eur Heart J 2004**; 25(24): 2212–2219.
18. Reckelhoff JF. Sex steroids, cardiovascular disease, and hypertension: unanswered questions and some speculations. **Hypertension 2005**; 45(2): 170–174.
19. Al-Asoom L. Is cardiopulmonary fitness level a risk factor in young Saudi females? **JKAU Med Sci 2015**; 22(3): 19–28.
20. Froelicher VF, Thompson AJ, Davis G, Stewart AJ, Triebwasser JH. Prediction of maximal oxygen consumption. Comparison of the Bruce and Balke treadmill protocols. **Chest 1975**; 68(3): 331–336.
21. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. **J Am Coll Cardiol 2001**; 37(1): 153–156.
22. Pollock ML, Foster C, Schmidt D, Hellman C, Linnerud AC, Ward A. Comparative analysis of physiologic responses to three different maximal graded exercise test protocols in healthy women. **Am Heart J 1982**; 103(3): 363–373.
23. Heyward V. *Advance fitness assessment and exercise prescription*. 6th ed. 2010.
24. Sadat-Ali M, Al-Elq AH, Al-Shaikh IH, Al-Turki HA, Al-Ali AK, Al-Othman AA. Assessment of low vitamin D among Saudi Arabians. Did we overshoot the runway? **Saudi Med J 2014**; 35(10): 1243–1249.
25. George JA, Norris SA, van Deventer HE, Crowther NJ. The association of 25 hydroxyvitamin D and parathyroid hormone with metabolic syndrome in two ethnic groups in South Africa. **PLoS One 2013**; 8(4)e61282.
26. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. **J Clin Endocrinol Metab 2011**; 96(7): 1911–1930.
27. Dipla K, Kousoula D, Zafeiridis A, Karatrantou K, Nikolaidis MG, Kyparos A, et al. Exaggerated haemodynamic and neural responses to involuntary contractions induced by whole-body vibration in normotensive obese versus lean women. **Exp Physiol 2016**; 101(6): 717–730.
28. Baur DM, Leiba A, Christophi CA, Kales SN. Low fitness is associated with exercise abnormalities among asymptomatic firefighters. **Occup Med (Lond) 2012**; 62(7): 566–569.
29. Mota J, Flores L, Ribeiro JC, Santos MP. Relationship of single measures of cardiorespiratory fitness and obesity in young schoolchildren. **Am J Hum Biol 2006**; 18(3): 335–341.
30. Fazio S, Palmieri EA, Izzo R, Affuso F, Romano M, Riccio G, et al. An exaggerated systolic blood pressure response to exercise is associated with cardiovascular remodeling in subjects with prehypertension. **Ital Heart J 2005**; 6(11): 886–892.
31. Miyai N, Arita M, Miyashita K, Morioka I, Shiraishi T, Nishio I. Blood pressure response to heart rate during exercise test and risk of future hypertension. **Hypertension 2002**; 39(3): 761–766.

32. Singh JP, Larson MG, Manolio TA, O'Donnell CJ, Lauer M, Evans JC, et al. Blood pressure response during treadmill testing as a risk factor for new-onset hypertension. The Framingham heart study. **Circulation 1999**; 99(14): 1831–1836.
33. Ha J-W, Oh JK, Pellikka PA, Ommen SR, Stussy VL, Bailey KR, et al. Diastolic stress echocardiography: a novel noninvasive diagnostic test for diastolic dysfunction using supine bicycle exercise Doppler echocardiography. **J Am Soc Echocardiogr 2005**; 18(1): 63–68.
34. Fang J, Madhavan S, Cohen H, Alderman MH. Isolated diastolic hypertension. A favorable finding among young and middle-aged hypertensive subjects. **Hypertension 1995**; 26(3): 377–382.
35. Franklin SS, Pio JR, Wong ND, Larson MG, Leip EP, Vasan RS, et al. Predictors of new-onset diastolic and systolic hypertension: the Framingham heart study. **Circulation 2005**; 111(9): 1121–1127.
36. Esler D, Raulli A, Pratt R, Fagan P. Hypertension: high prevalence and a positive association with obesity among Aboriginal and Torres Strait Islander youth in far north Queensland. **Aust N Z J Public Health 2015**; 40(suppl 1): 565–569.
37. Cheng S, Xanthakis V, Sullivan LM, Vasan RS. Blood pressure tracking over the adult life course: patterns and correlates in the Framingham heart study. **Hypertension 2012**; 60(6): 1393–1399.
38. Sundersingh F, Plum LA, DeLuca HF. Vitamin D deficiency independent of hypocalcemia elevates blood pressure in rats. **Biochem Biophys Res Commun 2015**; 461(4): 589–591.
39. Wang L, Manson JE, Buring JE, Lee IM, Sesso HD. Dietary intake of dairy products, calcium, and vitamin D and the risk of hypertension in middle-aged and older women. **Hypertension 2008**; 51(4): 1073–1079.
40. Pilz S, Tomaschitz A, Ritz E, Pieber TR. Vitamin D status and arterial hypertension: a systematic review. **Nat Rev Cardiol 2009**; 6(10): 621–630.
41. Martins D, Wolf M, Pan D, Zadshir A, Tareen N, Thadhani R, et al. Prevalence of cardiovascular risk factors and the serum levels of 25-hydroxyvitamin D in the United States: data from the Third National Health and Nutrition Examination Survey. **Archives Int Med 2007**; 167(11): 1159–1165.

How to cite this article: Al Asoom LI, Al Hariri MT. The association of adiposity, physical fitness, vitamin D levels and haemodynamic parameters in young Saudi females. J Taibah Univ Med Sc 2018;13(1):51–57.