ORIGINAL ARTICLE

Is Cardiopulmonary Fitness Level a Risk Factor in Young Saudi Females?

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Abstract
Low physical fitness is one of the all-cause mortality risk factors. This study aims to estimate cardiopulmonary fitness (VO_2 max) in young Saudi females and correlate it to anthropometric and hemodynamic parameters. Forty-eight young Saudi females completed an exercise stress test until exhaustion. Basal and maximum pulse rate, arterial blood pressure, VO_2 max and other anthropometric data were measured. The population was divided into low and high VO_2 max groups and a comparison was run using student t-test. Correlation was tested between VO_2 max and other measured parameters. The mean VO_2 max of the sample population was low (33.6 ± 8.2 mL/(kg·min) with 37.5% exhibiting fair to very poor VO_2 max value. The low VO_2 max group was characterized by higher body mass index, exercise diastolic and mean arterial blood pressure when compared to normal VO_2 max group, indicating a strong negative correlation. This study revealed a low cardiopulmonary fitness in young Saudi females and showed a strong association between VO_2 max and increased body fat and maximum exercise diastolic blood pressure. These findings provide reliable indicators of increased all-cause mortality risk in young Saudi females and increase the urgency of prompt action.

Keywords
Cardiopulmonary fitness; VO_2 max; Bruce protocol; Exercise stress test; Young female

Introduction

Physical inactivity is one of the major risk factors that threaten the public health[1]. Recent epidemiological studies demonstrated a significant impact of moderate physical activity on lowering the incidence of all vascular diseases including coronary vascular, cerebrovascular and thromboembolic diseases[2].

Few studies were performed in Saudi Arabia aimed at estimating the extent of physical inactivity in our population. Most of these studies utilized a physical activity questionnaire for the assessment of physical fitness. In a study performed on 1064 subjects of both sexes across a wide range of age (15-78 years), there was a high incidence of physical inactivity that is more obvious in females than males[3]. It is also found that the engagement in frequent exercise activities about three times per week diminishes early in life more commonly in females compared to males (45.6% male engagement versus 33.7% female engagement)[4].

Most of the studies performed in our country focused on males, specifically young teenagers

and children, whether sedentary or athletic[5,6]. Concurrently, we believe that females in Saudi Arabia are more prone to an extreme reduction of physical activity due to cultural beliefs, city structure, and family responsibilities.

Although using a standardized physical activity assessment questionnaire helps in providing an insight to the extent of the physical inactivity, some studies revealed an overestimate of physical fitness using the questionnaire, and hence an amelioration of the encountered health hazard[7]. The most accurate and reliable method for estimating physical fitness is using the standard cardiopulmonary exercise testing[8]. Data collected from different populations revealed differences in the standard values and showed consistently lower female parameters[9,10].

Therefore, in the current study we aim to evaluate cardiopulmonary fitness in young Saudi females by estimating VO_2 max using exercise stress test, compare the finding with other population fitness values, and find the possible correlation of cardiopulmonary fitness represented by VO_2 max with anthropometric and hemodynamic parameters.

Subjects and Method

The current cross-sectional study was approved by the Institutional Review Board (IRB) at University of Dammam (IRB certificate number 2015-01-065) according to the revision of Declaration of Helsenki[11].

A sample of young Saudi college female students from different colleges of the University of Dammam was recruited on a voluntary basis following the general announcement.

Those who were pregnant or lactating within the last two years were excluded. Any subject with a history of smoking or disease that is considered contraindicative of stress exercise testing such as cardiovascular, respiratory, hematological or musculoskeletal disorders was excluded. Forty-eight female students were found eligible to enter the study. The study procedure was explained carefully to the subjects and they signed a written informed consent. The study examinations and tests were performed in the physiology laboratory, College of Medicine, University of Dammam. All tests were performed in the period from October 2014 to April 2015 from 9 a.m.-1 p.m., excluding exam periods.

Anthropometric Measurement

Weight was determined for each subject using a portable platform scale with an accuracy within 0.1 kg. Height was assessed using a cm scale with an accuracy to the nearest 0.25 cm. Body mass index (BMI) was calculated using the formula (weight kg/height m^2). Determinants of central obesity were also assessed, including waist (at the level of umbilicus using non-stretchable measuring tape while wearing light clothes) and hip circumference (determined as the largest diameter of the hip) and the ratios waist/hip and waist/height were calculated. These measurements were performed before the subject performed the cardiopulmonary exercise testing (CPET).

Cardiopulmonary Exercise Testing

A clear explanation of the procedure of CPET was introduced to the subject before starting the test. The subjects were encouraged to perform at maximum effort, however the participant had the right to stop the test when fatigued.

Baseline pulse rate, oxyhemoglobin (HbO_2) saturation, arterial blood pressure (systolic and diastolic) and electrocardiograph (ECG) were recorded.

Continuous monitoring of pulse rate, HbO_2 saturation, arterial blood pressure and ECG was performed during the exercise procedure and carefully observed by an expert.

Each subject performed the treadmill Bruce protocol[12] using exercise physiology laboratory (ADInstruments, Bella Vista NSW, Australia). In the Bruce protocol, the subject starts with speed of 1.7 mph at a 10% grade. Consequently, both speed and inclination are increased every three minutes until exhaustion.

Simultaneously the increment in pulse rate was observed and compared to the calculated maximal heart rate of the subject as predicted by age, using the formula:

Predicted maximum heart rate = 208 - 0.7 x age[13].

An achievement of 85% of the predicted maximum heart rate or above was set as the criterion of reaching maximum effort.

Maximal oxygen consumption (V - volume, O_2 - oxygen, max - maximum (VO_2 max)) was estimated

from the total time until exhaustion T (min) using the following formula (Pollock Formula)

VO_2 max = 4.38 × T - 3.9[14]

Mean arterial blood pressure was determined using the following formula:

MAP = Diastolic blood pressure+ 1/3 (systolic blood pressure – diastolic blood pressure)[15]

Statistical Analysis

IBM SPSS Statistics for Windows, Version 20 (IBM Corp., Armonk, NY USA) was used to analyze the data. Maximum oxygen cosumption values were normally distributed based on the results of Shapiro-Wilk and Kolmogorov-Smirnov tests, therefore, parametric tests were used for comparison. All data were expressed as Mean ± SD.

The Bivariate (Pearson) Correlation was used to find out the possible correlation of VO_2 max, anthropometric and hemodynamic data. Linear regression models were generated when a significant correlation was found. The level of significance was set at *P*- value < 0.05.

Results

Descriptive data for all participants, including age, anthropometric, exercise and hemodynamic parameters, are shown in Tables 1 and 2. All CPETs ran uneventfully, no signs of ischemia or arrhythmias were detected in ECG at baseline or during the exercise test. A comparison of hemodynamic data including heart rate, blood pressure and HbO_2 saturation percentage revealed significantly higher maximum exercise heart rate, systolic and mean arterial blood pressure vs the corresponding resting values (Table 2).

The participants were classified based on their VO_2 max value into six categories according to the specification of the physical fitness specialist certification manual[16] (Table 3): 17% very poor (VO_2 max < 23.6 mL/(kg·min); 17% poor (VO_2 max = 23.6-28.9 mL/(kg·min); 4% fair (VO_2 max = 29.0-32.9 mL/(kg·min); 17% good (VO_2 max = 33.0-36.9 mL/(kg·min); 27% excellent (VO_2 max = 37.0-41.0 mL/(kg·min); 19% superior (VO_2 max > 41.0 mL/(kg·min).

The participants were then divided into two main groups to simplify comparison. The first group includes very poor to fair categories, considered the low VO_2 max group, and accounts for 37.5% of the sample. The second group includes good to superior categories, considered the high VO_2 max group, and accounts for 62.5% of the sample. Using independent samples "student's" *t* test, the anthropometric and hemodynamic data were compared and revealed significantly higher values for weight, BMI, waist/height ratio (Table 4), last diastolic blood pressure, and mean arterial blood pressure (Table 5) in the low VO_2 max group compared to the high VO_2 max group. Conversely, VO_2 max, and time until exhaustion were lower in the low VO_2 max group (Table 5).

Maximum oxygen cosumption showed a significant negative correlation with anthropometric data including body weight (r = (-0.554, *P* = 0.001), BMI (r = -0.535, *P* = 0.001), waist (r = -0.497, *P* = 0.001), and hip circumference (r = -0.519, *P* = 0.001) (Fig. 1). Similarly, a negative correlation was found between VO_2 max and last diastolic blood pressure (r = -0.304, *P* = 0.036) and mean arterial blood pressure (r = -0.325, *P* = 0.024) (Fig. 2). Correlation of VO_2 max with age was insignificant (r = -0.009, *P* = 0.950).

Table 1. Age, anthropometric and exercise test data of young Saudi female college students (n=48).

Parameters	Mean ± SD	Min-Max
Age (years)	20.58 ± 1.90	19.00-27.00
Body weight (kg)	59.26 ± 16.36	37.20-115.80
Height (cm)	158.65 ± 7.50	143.50-176.50
Body mass index (kg/m^2)	23.34 ± 5.15	16.81-38.91
Waist circumference (cm)	71.90 ± 11.23	59.00-116.00
Hip circumference (cm)	97.77 ± 12.12	78.00-133.00
Waist/hip ratio (W/H)	0.73 ± 0.05	0.63-0.89
Waist/height ratio (W/S)	0.45 ± 0.06	0.36-0.67
VO_2 max (mL/(kg·min))	32.00 ± 8.12	13.38-44.01
Time of exercise till exhaustion (min)	8.40 ± 1.87	4.21-11.14

VO_2 max: Maximum oxygen consumption

Table 2. Hemodynamic parameters of young Saudi female college students (n= 48).

Hemodynamic Parameter	Resting	Last	Significance
Systolic blood pressure (mmHg)	120.10 ± 12.27 (98.00-150.00)	144.96 ± 31.47 (102.00-247.00)	0.0001
Diastolic blood pressure (mmHg)	78.70 ± 7.29 64.00-92.00	76.81 ± 7.30 62.00-93.00	0.054
Mean arterial blood pressure (mmHg)	92.51 ± 8.13 76.00-108.67	99.54 ± 12.27 78.00-134.00	0.0001
HbO_2 saturation (%)	97.70% ± 2.93% 90.00% - 100.00%	95.79% ± 6.85% 73.00% - 100.00%	0.091
Heart rate (beats/min)	103.6300 ± 13.86 77.00-144.00	178.44±8.89 164.00-201.00	0.0001

Data expressed as mean ± standard deviation. Comparison between each pair of variables was made using paired "student's" t test. HbO_2 = Oxyhemoglobin.

Table 3. Classification of VO_2 max[16]

VO_2 max Category	Number (%) of Participants
Very Poor (VO_2 max< 23.6 mL/(kg·min)	8 (17.00%)
Poor (VO_2 max = 23.6-28.9 mL/(kg·min)	8 (17.00%)
Fair (VO_2 max = 29.0-32.9 mL/(kg·min)	2 (4.00%)
Good (VO_2 max = 33.0-36.9 mL/(kg·min)	8 (17.00%)
Excellent (VO_2 max = 37.0-41.0 mL/(kg·min)	13 (27.00%)
Superior (VO_2 max > 41.0 mL/(kg·min)	9 (19.00%)

VO_2 max: Maximal oxygen consumption

Table 4. Comparison of anthropometric data between subjects with low and high VO_2 max.

Parameters	Low VO_2 max (n = 18)	High VO_2 max (n = 30)	P-value
Age (years)	20.39 ± 1.69	20.70 ± 2.04	0.588
Weight (Kg)	69.04 ± 20.28	53.39 ± 9.87	0.006
Height (cm)	161.00 ± 6.26	157.24 ± 7.91	0.093
BMI[a] ($kg.m^2$)	26.33 ± 6.08	21.55 ± 3.52	0.006
Waist Circumference (cm)	78.11 ± 14.14	68.17 ± 6.98	0.011
Hip Circumference (cm)	104.39 ± 14.12	93.80 ± 8.81	0.002
Waist/Hip circumference	0.74 ± 0.05	0.72 ± 0.06	0.288
Waist/Height ratio	0.48 ± 0.08	0.43 ± 0.05	0.018

Data expressed as mean ± standard deviation. Comparison between the two groups was made using unpaired "student's" t test. BMI = Body mass index; VO_2 max: Maximal oxygen consumption

Table 5. Comparison of exercise test and hemodynamic parameters between subjects with low and high VO_2 max.

Parameters	Low VO_2 max (n = 18)	High VO_2 max (n = 30)	*P*-value
VO_2 max mL/(kg·min)	24.10 ± 4.40	39.30 ± 2.80	0.001
Time of exercise till exhaustion (min)	6.24 ± 1.00	9.69 ± 0.67	0.001
Resting systolic blood pressure (mmHg)	123.78 ± 11.85	117.90 ± 12.18	0.108
Last systolic blood pressure (mmHg)	155.94 ± 37.53	138.37 ± 25.68	0.060
Resting diastolic blood pressure (mmHg)	80.56 ± 7.16	77.60 ± 7.26	0.177
Last diastolic blood pressure (mmHg)	79.72 ± 6.70	75.07 ± 7.20	0.031
Baseline mean arterial blood pressure	94.96 ± 7.23	91.03 ± 8.40	0.106
Last mean arterial blood pressure	105.17 ± 13.02	96.17 ± 10.64	0.012
Resting HbO_2 saturation%	97.72% ± 2.99%	97.97% ± 2.92%	0.437
Last HbO_2 saturation%	96.39% ± 7.29%	95.43% ± 6.67%	0.645
Resting heart rate (beats/min)	107.39 ± 12.62	101.37 ± 14.28	0.147
Last heart rate (beats/min)	179.11 ± 8.20	178.03 ± 9.39	0.689

Data expressed as mean ± standard deviation. Comparison between the two groups was made using unpaired "student's" t test HbO_2 = Oxyhemoglobin; VO_2 max: Maximal oxygen consumption

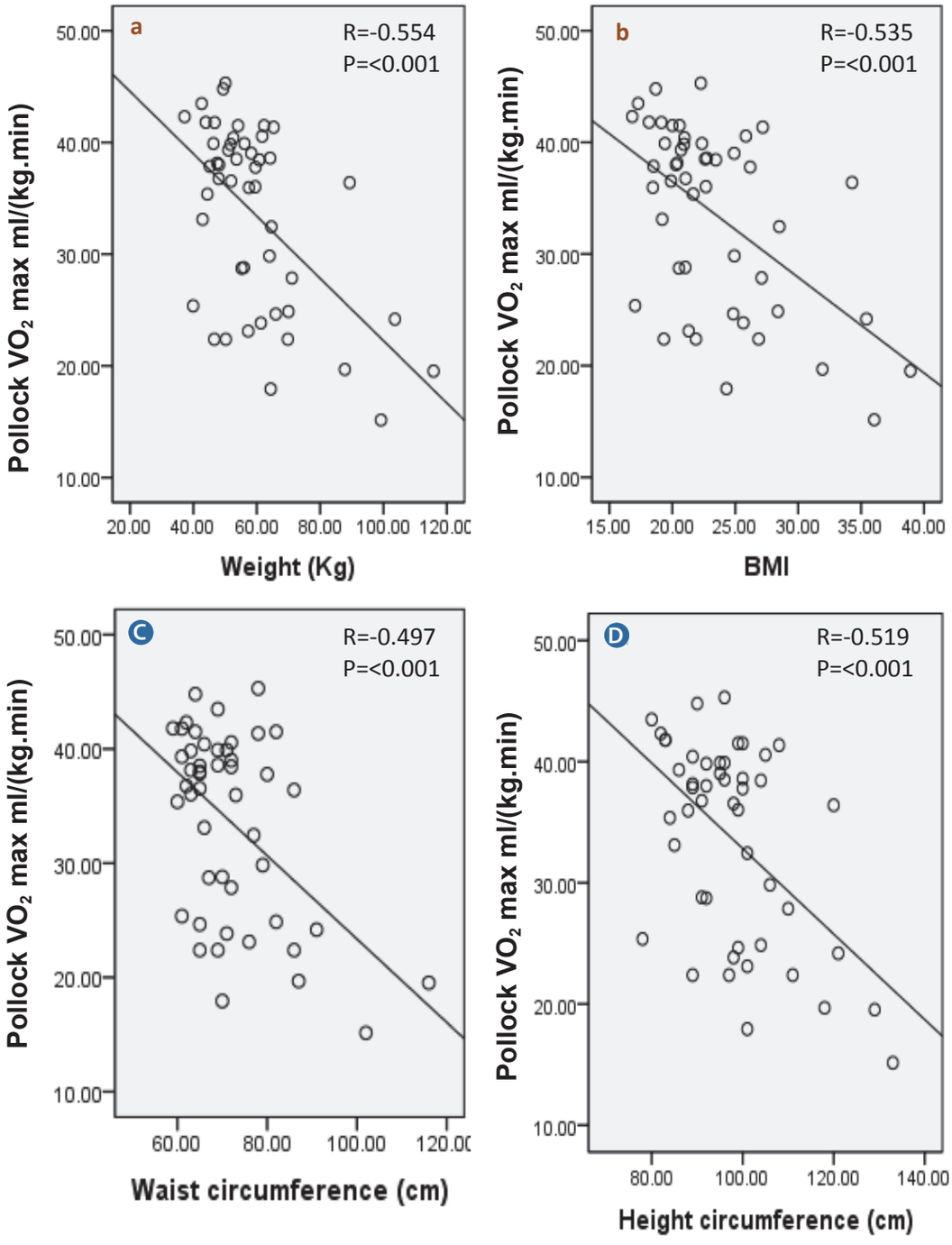

Figure 1. Bivariate correlation and linear regression relationship of VO_2 max and anthropometric data: (a) Body weight, (b) BMI, (c) Waist circumference, (d) Hip circumference.

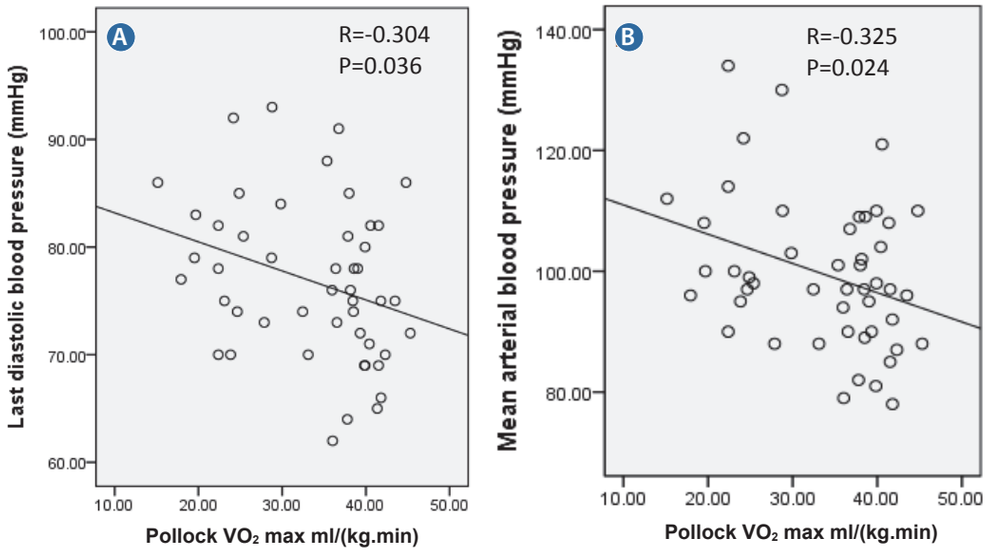

Figure 2. Bivariate correlation and linear regression relationship of VO_2 max and Hemodynamic data: (a) Last diastolic blood pressure, (b) Mean arterial blood pressure.

Discussion

The main finding of the current study is the low VO_2 max and time until exhaustion obtained from young Saudi females. 37.50% of the currently recruited Saudi females were at the category of fair or below based on the classification of the physical fitness specialist certification manual[16]. To our knowledge, this is the first Saudi study that determines VO_2 max in young females.

The current findings indicate first, an objective and reliable estimate of the cardiopulmonary fitness status of young Saudi females, since these data were obtained by standard exercise stress test[8]. When the value of VO_2 max of our studied group was compared to the international value obtained from a large European study, it displays a generalized reduction in the indicator of cardiopulmonary fitness in young Saudi females, 33.6 ± 8.2 mL/(kg·min) compared to 42.8 ± 7.6 mL/(kg·min) from 92 females age 20-29 of HUNT fitness study[9]. Similarly, in a study performed on college female students in Spain, VO_2 max of the studied sample was 41.25 ± 8.5 mL/(kg·min) for non-health colleges and 35.7 ± 7.4 mL/(kg·min) for nursing students[17]. A small study of the aerobic capacity of Mexican-American individuals revealed VO_2 max of females equal to 44.69 mL/(kg·min)[18]. Furthermore, VO_2 max determination of Indian college females revealed a value of 35.9 ± 3.46 mL/(kg·min)[19]. Variations in the values of physical fitness among different studies might be attributed to the variation in the methodology and techniques used for the determination of VO_2 max. However, other important factors might be involved including differences in body mass[20,21], age groups, environmental, and genetic factors[10].

In this study the low VO_2 max group was found to be characterized by higher BMI, waist and hip circumference, when compared to the high VO_2 max group. In addition, significant negative correlations were found between VO_2 max and body weight, BMI, waist and hip circumference. Adiposity is reported in the literature as one of the factors that lead to a deterioration of physical fitness. In an observational study in South Korea of young healthy individuals, BMI was negatively correlated with cardiorespiratory fitness[22]. Similarly, VO_2 max of young healthy Iranian children was adversely correlated with BMI, waist to height ratio, waist circumference and fat mass[23]. Besides being a causative factor of reduced physical fitness, increased body adiposity is believed to work adversely with the low physical fitness to cumulatively increase the health burden upon the cardiovascular and metabolic systems[2].

Hemodynamic parameter comparison between resting and maximum exercise values revealed significantly higher maximum exercise systolic, mean blood pressure and heart rate *vs.* the corresponding resting values. Laukkanen *et al.*[24] studied the potential risk of exercise blood pressure, heart rate and VO_2 max

to sudden cardiac death in a prospective study and their data revealed weak correlation of the exercise hemodynamic values including SBP at 2 min recovery to cardiac mortality but strong correlation of low VO_2 max with sudden cardiac death[24]. Studies that reported reference values and normal ranges of exercise heart rate and blood pressure are few. One large-scale community-based study in Germany revealed reference values of exercise hemodynamic parameters for 88 young females with normal BMI as maximum SBP 173 ± 21, maximum DBP 88 ± 12, and maximum HR 171 ± 13[25]. Our reported exercise hemodynamic data were slightly lower than the corresponding German reference data, particularly the systolic blood pressure.

Furthermore, the current study revealed higher last mean and diastolic blood pressure in the group of low VO_2 max, and negative correlation between VO_2 max and last mean and diastolic blood pressure. The increased diastolic and mean arterial blood pressure induced by exercise stress test in the low fitness group might be an early sign of a future risk of developing hypertension[26]. Therefore, we might conclude that the stress test is a useful tool to elucidate the risk for future cardiovascular disorders[27]. In addition, the strong negative association between VO_2 max and diastolic and mean arterial blood pressure might indicate the importance of physical fitness in regard to cardiovascular risk[28]. In this study systolic blood pressure was not elevated or correlated with VO_2 max. It might be explained by the structure of the recruited sample *i.e.,* young age group and female only, where the association of high systolic blood pressure and reduced fitness is less frequently developed[29,30].

One proposed mechanism of the relationship of reduced physical fitness, increased fat and increased arterial blood pressure is a claimed increase in sympathetic stimulation and improper balance between sympathetic and parasympathetic discharge whether at rest or during exercise[31,32]. Improvement in physical fitness is found to be associated with enhancement and a reversing of sympathetic parasympathetic imbalance[33,34].

Last but not least, there was no significant correlation between VO_2 max and age. The reason might be due to the relatively small sample size and the narrow age range of the involved sample.

Conclusion

In conclusion, our cross-sectional study revealed low cardiopulmonary fitness level in young Saudi females indicated by low VO_2 max. We assume that increased body fat might be one of the main causative factors for the currently discovered low VO_2 max. However, we recommend future studies to reveal other possible underlying mechanisms. Moreover, the currently demonstrated reduced fitness was also associated with high exercise diastolic blood pressure, which might be an initial sign for potential risk of future cardiovascular morbidity. A large national plan is urgently needed to study the physical fitness of different age groups of our population, to increase the awareness of the need for better physical fitness among females in Saudi Arabia and to provide opportunities to enhance the fitness in schools, educational institutes, community and recreational centers.

Limitations

The current study might be limited by the relatively small sample size and the narrow age group. Based on the obtained data from young educated Saudi females, we believe large national studies of the female population of different age and cultural groups are highly recommended. However, the current obtained data would serve as a good reference and baseline data for future studies.

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Conflict of Interest

The author has no conflict of interest.

Disclosure

The author did not received any type of commercial support either in forms of compensation or financial for this study. The author has no financial interest in any of the products or devices, or drugs mentioned in this article.

Ethical Approval

Obtained.

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هل معدل اللياقة البدنية لدى السيدات الشابات في المملكة العربية السعودية يشكل مصدر خطر صحي لهن؟

لبنى إبراهيم عبدالعزيز العسوم

قسم وظائف الأعضاء، كلية الطب، جامعة الدمام
الدمام – المملكة العربية السعودية

المستخلص. يعد انخفاض اللياقة البدنية إحدى عوامل الخطورة للإصابة بأمراض القلب والشرايين ومتلازمة الاعتلال الأيضي. لذا نود في هذا البحث دراسة معدل اللياقة البدنية لدى السيدات السعوديات الشابات ودراسة العلاقة بين هذا المعدل ومعايير البدانة ومؤشرات الجهاز الدوري.

تم جمع عينة من ٤٨ طالبة من جامعة الدمام خضعن لاختبار الجهد البدني الأقصى وتم قياس المؤشرات الحيوية للجهاز الدوري كمعدل النبض وضغط الدم قبل الاختبار وخلاله. كما تم تحديد معدل كتلة الجسم ومحيط الخصر والحوض لهن.

أظهرت النتائج أن متوسط حجم الأكسجين الأقصى للسيدات المشاركات ٣٣,٦ مل/ كيلوجرام. وأن ٥ر٣٧٪ من العينة المدروسة تعاني من انخفاض في معدل اللياقة البدنية. وعند مقارنة مجموعة اللياقة البدنية الطبيعية والمنخفضة، وجد أن الأخيرة تتصف بكتلة بدنية وضغط دم انبساطي ومتوسط عند أقصى جهد، أعلى من المجموعة الأولى. كما وجدنا علاقة سلبية قوية بين حجم الأكسجين الأقصى ومعدل كتلة الجسم وضغط الدم الانبساطي والمتوسط عند أعلى جهد.

من هنا نستخلص أن معدل اللياقة البدنية لدى طالبات جامعة الدمام منخفض بصورة عامة وأن هناك علاقة سلبية قوية بين معدل اللياقة البدنية ومعدل كتلة الجسم والضغط الانبساطي والمتوسط عند أعلى جهد، مما يعني زيادة احتمالات الاصابة بالأمراض المزمنة في المستقبل وهذا يستلزم زيادة الوعي ودراسة أسباب الانخفاض وأخذ تدابير وقائية لرفع مستوى اللياقة البدنية لدى النساء في السعودية.