Cardiopulmonary Fitness and its Relation to Body Mass Index Among Female Students in Qassim University

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ABSTRACT

Background: Cardiorespiratory fitness is expressed by maximal oxygen consumption (VO₂max) which measures oxygen (O₂) capacity of an individual performing 6 minutes treadmill exercise test. In this study, the cardiopulmonary fitness among female healthy University students in Al-Qassim University, Saudi Arabia was assessed, along with its association with body mass index (BMI), blood pressure, and fat percentage.

Methods: In this cross-sectional study, a self-administered questionnaire was distributed. Heart rate, weight, height, waist circumference, BMI, O₂ consumption, blood pressure, and body fat percentage were measured before the participants underwent the exercise test and after 6 minutes treadmill exercise heart rate, O₂ and blood pressure were measured again to calculate the VO₂max. The subjects were divided into four groups (underweight, normal, overweight and obese).

Results: There was a significant negative correlation between VO₂max and heart rate after 6 minutes treadmill test for the underweight group (p = 0.0098) (r = -0.4716). A significant negative correlation was found after 6 minutes treadmill test between systolic blood pressure and VO₂max in normal group (p = 0.0216, r = -0.4177). In overweight group, a significantly positive correlation between VO₂max and systolic blood pressure after 6 minutes treadmill test (p = 0.0486) (r = 0.3631) was found. There was significant negative correlation between heart rate before 6 minutes treadmill test and VO₂max in obese group (p < 0.0001, r = -0.7711).

Conclusion: When BMI increases there is an increased level of VO₂max, thus an increase in BMI is associated with increase in the level of VO₂max in healthy young female students.

Keywords: Body mass index, oxygen, cardiopulmonary fitness, treadmill test.

Introduction

Cardiorespiratory fitness (CRF) is defined as the oxygen (O₂) delivery capacity to skeletal muscle mitochondria by the circulatory and respiratory systems for activity-related energy production [1]. CRF is generally expressed by the maximal oxygen consumption (VO₂max). VO₂max is the maximum amount of O₂ uptake by an individual to produce maximum energy (ATP) Adenosine triphosphate, aerobically [2]. It is one of the determinants of endurance performance which measures the cardiopulmonary capacity of an individual at a given degree of fitness and O₂ availability [2]. CRF plays an important role in reducing cardiovascular and all-cause mortality and the incidence of various cardiovascular diseases [3]. The submaximal exercise test could be used to predict VO₂max from heart rate during or immediately post-exercise or from performance during walking or running [4]. So, the low level of VO₂max is associated with increased cardiovascular...
Cardiopulmonary fitness and BMI

48 risk and morbidity rate in patients with and without
49 cardiovascular disease [5]. VO_{2\text{max}} is also a powerful
50 independent prognostic marker to the risk stratification
51 of patients with heart disease during a cardiopulmonary
52 exercise test [6].
53
54 Furthermore, there are other fitness factors such as body
55 composition which is closely related to aerobic fitness
56 and VO_{2\text{max}} [7,8]. Recent reports have shown that there
57 is a close relationship between the body composition and
58 cardiovascular aerobic fitness [9]. Therefore, evaluating
59 VO_{2\text{max}} in normal weight and obese people could help
60 in the early detection of physiological alterations and
61 accordingly help in designing the appropriate intervention
62 strategies. Thus, there is a need to assess the change in
63 cardio-respiratory efficiency at an early stage in life [10].
64
65 Increased body fat percentage is associated with low
66 level of VO_{2\text{max}} and in contrast increase in fat-free mass
67 helps in increasing the VO_{2\text{max}} in healthy young adults
68 [10,11], and high aerobic fitness is associated with low
69 cardiovascular disease risk [12]. Furthermore, physical
70 fitness could keep blood pressure in check rather than
71 high physical activity [13].
72
73 Despite the mounting evidence describing the association
74 of low VO_{2\text{max}} with cardiopulmonary capacity, studies
75 which determine their relationship are still lacking on
76 females in Saudi Arabia. This study aimed to fill the
77 knowledge gap and explore the relationship of CRF and
78 VO_{2\text{max}} and body mass index (BMI) among female
79 students in Al-Qassim University, Al-Qassim, Saudi
80 Arabia.

Subjects and Methods

81 A comparative cross-sectional study conducted between
82 January and July 2019 at AL-Qassim University,
83 Buraidah-Almelada main campus. Healthy female
84 students aged 18-30 years were included in the study. All
85 subjects who were athletes or had a history of diabetes,
86 hypertension, medication use, current symptoms (fever,
87 cough, and shortness of breath), symptoms of pathologies
88 and diseases, and history of diseases were excluded.
89
90 The sample of the study was calculated to be 120 subjects,
91 setting the confidence level at 95%. The subjects were
92 then divided into four groups according to their BMI.
93
94 Data collection was conducted in four steps. First, a self-
95 administered, validated questionnaire based on the Global
96 Physical Activity Questionnaire developed by WHO
97 [14] was hand-distributed to subjects. The questionnaire
98 collected data revealed the subjects’ participation in
99 physical activities as well as their sedentary behavior.
100
101 Then the heart rate (Geratherm, Germany), weight,
102 height, waist circumference (WC), BMI, O_{2} consumption
103 (beurer, Germany), blood pressure (Geratherm,
104 Germany), blood glucose, and body fat percentage
105 (using the skinfold caliper) were measured before the
106 participants took part in the exercise test. Then, the
107 subjects walked on the treadmill at gradually increasing
108 speed for 6 minutes. After the exercise test, heart rate,
109 O_{2} level, and blood pressure were measured again, and
110 VO_{2\text{max}} was calculated.
111
112 Statistical analysis was applied on categorical and
113 continuous data and the differences in data analyzed
114 using appropriate statistical analysis has been used e.g.,
115 one way analysis of variance (ANOVA). p value of 0.05
116 or less was used to indicate statistically significant.

Results

117 The questionnaire revealed that most of the participants’
118 work (86.6%) do not involve vigorous-intensity activity
119 that causes large increases in breathing or heart rate for
120 at least 10 minutes continuously. Around 8 (36.4%) did
121 vigorous-intensity activities for 3 days per week as a part
122 of their work. Only one participant had zero active
days. Most of the participants spent around 30 minutes
123 (31.8%) doing vigorously-intense activities at work on
124 their typical day. About 55.9% of all participants while
125 doing moderate-intensity activity for at least 10 minutes
126 had an increased breathing and heart rates. Only 12
127 participants (21.1%) were found to do moderate-intensity
128 activities for 4 days per week as a part of their work,
129 and 14 participants (19.7%) did 3 days, 12 participants
130 (16.9%) did 2 days, and 9 (12.7%) did 5 days. Most of
131 the participants were found to spent about 30 minutes
132 (22.2%) doing moderately- intense activity. Around
133 57.5% walk or use a bicycle (pelad cycle) for at least
134 10 minutes continuously to get to and from places. The
135 majority of the participants does not work or use bicycle
136 for 10 minutes per week. Regarding the time spent,
137 18 participant (14.4%) spent around 25-30 minutes
138 walking or use bicycle on their typical days. Most of
139 the participants (72.4%) does any vigorous-intensity sports,
140 fitness or recreational (leisure) activities that cause large
141 increases in their breathing or heart rate. The majority
142 of the participants spend about 2-3 days per week doing
143 vigorous sports. Most of the participants spent about 20-
144 30 minutes doing vigorous sports.

145 Several variables were tested before and after a 6 minutes
146 treadmill test (Table 1).

147 The correlation showed the significant relationship
148 between the factors and VO_{2\text{max}}. There were no significant
149 correlation between VO_{2\text{max}} and other variables (before
150 SBP, after SBP, before DBP, after DBP, after O_{2}, WC,
151 BMI, body fat) in underweight group. And, no significant
152 correlation was observed between VO_{2\text{max}} and the other
153 variables (After 6 minutes treadmill test O_{2}, after 6
154 minutes treadmill test O_{2}, BMI, WC, body fat) in normal
155 group. In the overweight group, there was a significantly positive correlation
156 between VO_{2\text{max}} and systolic blood pressure after 6
157 minutes treadmill test. There was significant negative
158 correlation between heart rate before 6 minutes treadmill
test and VO_{2\text{max}} in obese group (Table 2, Figures 1-4).
Table 1. Variables tested before and after the 6 minutes treadmill test.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Underweight (n = 30)</th>
<th>Normal (n = 30)</th>
<th>Overweight (n = 30)</th>
<th>Obese (n = 30)</th>
<th>p-value</th>
<th>Underweight (n = 29)</th>
<th>Normal (n = 30)</th>
<th>Overweight (n = 30)</th>
<th>Obese (n = 30)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (bpm)</td>
<td>84.55 (51-100)</td>
<td>85.70 (53-128)</td>
<td>83.10 (66-100)</td>
<td>86.37 (62-105)</td>
<td>0.7784</td>
<td>142.1 (124-170)</td>
<td>144.2 (190-122)</td>
<td>157.9 (180-136)</td>
<td>157.3 (187-136)</td>
<td>0.0001*</td>
</tr>
<tr>
<td>O₂%</td>
<td>95.38 (56-99)</td>
<td>96.50 (77-99)</td>
<td>97.93 (95-99)</td>
<td>96.17 (74-99)</td>
<td>0.3554</td>
<td>98.14 (99-84)</td>
<td>98.71 (99-95)</td>
<td>97.23 (99-87)</td>
<td>97.23 (99-87)</td>
<td>0.154</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>120.2 (94-143)</td>
<td>117.7 (88-145)</td>
<td>127.8 (68-158)</td>
<td>137.6* (103-173)</td>
<td>&lt;0.0001*</td>
<td>133.5 (175-108)</td>
<td>129.6 (160-74)</td>
<td>140.4 (205-100)</td>
<td>147.1 (197-114)</td>
<td>0.0056*</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>70.93 (53-84)</td>
<td>68.10 (53-84)</td>
<td>76.53 (58-95)</td>
<td>77.73* (62-94)</td>
<td>&lt;0.0001*</td>
<td>81.59 (154-160)</td>
<td>78.07 (141-52)</td>
<td>83.73 (178-64)</td>
<td>85.03 (158-63)</td>
<td>0.46</td>
</tr>
</tbody>
</table>

SBP = Systolic blood pressure, DBP = Diastolic blood pressure, O₂ = Oxygen percentage, HR = Heart rate.

Data are presented as mean (25%-75% SD).

Kruskal-Wallis test was used for ANOVA and post-ANOVA pairwise to compare between the groups.

* = Statistically significant at p ≤ 0.05.

Table 2. Pearson’s correlation coefficients between VO₂ max and other variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Underweight r-value</th>
<th>Underweight p-value</th>
<th>Underweight r-value</th>
<th>Underweight p-value</th>
<th>Underweight r-value</th>
<th>Underweight p-value</th>
<th>Underweight r-value</th>
<th>Underweight p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before SBP</td>
<td>0.05129</td>
<td>0.7916</td>
<td>-0.4559</td>
<td>0.0114*</td>
<td>-0.1662</td>
<td>0.3801</td>
<td>-0.006490</td>
<td>0.9728</td>
</tr>
<tr>
<td>After SBP</td>
<td>-0.1104</td>
<td>0.5686</td>
<td>-0.4177</td>
<td>0.0216*</td>
<td>0.3631</td>
<td>0.0486*</td>
<td>0.1481</td>
<td>0.4349</td>
</tr>
<tr>
<td>Before DBP</td>
<td>0.1439</td>
<td>0.4566</td>
<td>-0.4609</td>
<td>0.0104*</td>
<td>-0.3011</td>
<td>0.1059</td>
<td>-0.1667</td>
<td>0.3785</td>
</tr>
<tr>
<td>After DBP</td>
<td>-0.1717</td>
<td>0.3733</td>
<td>-0.2732</td>
<td>0.1440</td>
<td>0.3210</td>
<td>0.0837</td>
<td>0.05916</td>
<td>0.7562</td>
</tr>
<tr>
<td>Before O₂</td>
<td>-0.6371</td>
<td>0.0002***</td>
<td>0.1631</td>
<td>0.3891</td>
<td>0.3021</td>
<td>0.1047</td>
<td>0.08968</td>
<td>0.5374</td>
</tr>
<tr>
<td>After O₂</td>
<td>-0.2643</td>
<td>0.1660</td>
<td>0.2014</td>
<td>0.2858</td>
<td>0.3731</td>
<td>0.0423*</td>
<td>-0.1134</td>
<td>0.5507</td>
</tr>
<tr>
<td>Before HR</td>
<td>-0.9707</td>
<td>&lt;0.0001***</td>
<td>-0.9670</td>
<td>&lt;0.0001***</td>
<td>-0.9835</td>
<td>&lt;0.0001***</td>
<td>-0.7711</td>
<td>&lt;0.0001***</td>
</tr>
<tr>
<td>After HR</td>
<td>-0.4716</td>
<td>0.0098**</td>
<td>-0.8198</td>
<td>&lt;0.0001***</td>
<td>-0.3282</td>
<td>0.0766</td>
<td>-0.04117</td>
<td>0.8290</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>0.001676</td>
<td>0.9931</td>
<td>-0.08385</td>
<td>0.6595</td>
<td>0.1183</td>
<td>0.5337</td>
<td>0.1341</td>
<td>0.4799</td>
</tr>
<tr>
<td>BMI (kg/cm)</td>
<td>-0.06964</td>
<td>0.7196</td>
<td>0.06982</td>
<td>0.7139</td>
<td>-0.05882</td>
<td>0.7575</td>
<td>-0.2684</td>
<td>0.1515</td>
</tr>
<tr>
<td>Body fat</td>
<td>0.04048</td>
<td>0.8349</td>
<td>-0.2614</td>
<td>0.1630</td>
<td>-0.2209</td>
<td>0.2407</td>
<td>0.1973</td>
<td>0.2960</td>
</tr>
</tbody>
</table>

SBP = Systolic blood pressure; DBP = Diastolic blood pressure; O₂ = Oxygen percentage; HR = Heart rate; WC = Waist circumference; BMI = Body mass index.

* = Statistically significant at p ≤ 0.05.

Discussion

VO₂ max is best determinant of cardiopulmonary fitness which is the maximum rate of O₂ consumption measured during exercise test. This study showed higher correlation coefficient of VO₂ max and other variables in different BMI categories. In underweight group, significantly negative correlation was established between VO₂ max and O₂%, heart rate both before and after exercise test. Also, there were significant negative correlations between VO₂ max and SBP, DBP and heart rate before exercise test, and significantly negative correlation between the VO₂ max and SBP and heart rate after exercise test in normal group. While in overweight group significantly positive correlation was found between VO₂ max and O₂% and SBP after exercise test, and there...
Figure 1. Correlation between variables and VO$_2$max before and after the 6 minutes treadmill test in underweight group.
Figure 2. Correlation between variables and VO\textsubscript{2}max before and after the 6 minutes treadmill test in normal BMI group.
Figure 3. Correlation between variables and VO₂ max before and after the 6 minutes treadmill test in overweight group.
Figure 4. Correlation between variables and VO₂max before and after the 6 minutes treadmill test in obese group.
was a negative correlation between VO\textsubscript{2} max and heart rate before exercise test. As well, there was significant negative correlation between heart rate before exercise test and VO\textsubscript{2} max in obese.

The present study showed a significant increase in systolic and diastolic blood pressure in obese group as compared with other groups, this is in consistency with a previous study done by Shin and Ha [15]. The present study showed a significant increase in systolic blood pressure after exercise using 6 minutes treadmill test according to obese, overweight, and normal groups while in Trapé et al. [16], study using Functional Fitness battery Test the increased systolic blood pressure was not at the same level of increase. However, the diastolic blood pressure was increased only in the overweight group in the present study compared to the group of Trapé et al. [16], the study in which most of the cases were overweight; this might be due to the difference in the sample size of both the studies. In the present study, there was significant increase in systolic blood pressure in different BMI groups (underweight, normal, overweight, and obese) after performing a 6 minutes treadmill test which is in agreement with the study of Shaikh et al. [13].

In the present study, the heart rate before 6 minutes treadmill test was significantly higher in obese group than non-obese in contrast to Freitas Júnior who identified that, in children and adolescents, the chronological age is inversely related to (RHR) Resting heart rate, which is justified by a possible explanation that the alteration in the autonomic cardiac control, which is age dependent, the lower the age the lower is the cardiac sympathetic activity [17].

In the present study, the heart rate before 6 minutes treadmill test was significantly higher in obese group than non-obese consistent with a study about the effect of BMI on acute cardio-metabolic response to graded exercise testing in children, which showed that the obese children had higher resting heart rate than non-obese irrespective of sex that is boys or girls [18].

The present study showed significant change in heart rate and VO\textsubscript{2} max after exercise in overweight group in contrast to control group, as the heart rate after exercise and myocardial work capacity is reported to not limit the VO\textsubscript{2} max in healthy individuals [19].

The major limitations of this study were some of the participants of obese group were self-conscious about their weight so did not respond to us. Also, the participants were uncomfortable during measuring fat % with caliper as they need to expose their abdominal area. Limited equipments were present, as the data collecting consumed a lot of time. Having one treadmill made the process of data collection extremely hard on us as well as on the participants due to that a few of them decided to discontinue to participate in the study. For future studies, it is recommended to make the data more representative by including both sexes in the study.

**Conclusion**

It was found that as the BMI increases there is an increased level of VO\textsubscript{2} max, thus an increase in BMI is associated with increase in the level of VO\textsubscript{2} max in healthy young female students. This would help in the early detection of physiological alterations and defects in cardio pulmonary fitness, which could help in designing early appropriate intervention strategies to improve it.

**List of Abbreviations**

- **BMI** Body mass index.
- **CM** Centimeter.
- **CRP** Cardiorespiratory fitness.
- **DBP** Diastolic blood pressure.
- **Fig** Figure.
- **HR** Heart rate.
- **mmHg** Millimeters of mercury.
- **O2** Oxygen.
- **VO\textsubscript{2} max** Maximal oxygen consumption.
- **WC** Waist circumference.

**Conflict of interest**

The authors declare that there is no conflict of interest regarding the publication of this article.

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None.

**Consent to participate**

Written informed consent was obtained from all the participants.

**Ethical approval**

Ethical approval was obtained from the ethics committee in Qassim via reference number 20180907. Dated 1440-1-10.

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