International Journal of Multidisciplinary Research and Development
www.allsubjectjournal.com
Online ISSN: 2349-4182, Print ISSN: 2349-5979
Received: 19-02-2021, Accepted: 18-03-2021, Published: 24-04-2021
Volume 8, Issue 4, 2021, Page No. 94-97

Correlation between cardiorespiratory health and waist-hip-ratio in young healthy adults

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Abstract
Objectives: Physical fitness is defined as 'the ability to carry out daily tasks without undue fatigue', and essentially depends on cardiorespiratory fitness. This can be assessed by measuring aerobic capacity of a person- indicated by Maximum oxygen capacity (VO2 max), which is the maximum volume of oxygen that the body processes during intense exercise. Factors that determine VO2max include age, gender, heart and lung function, aerobic muscle metabolism, exercise, genetics and nutritional status such as BMI, abdominal circumference, and percent body fat.
This study assesses the correlation between anthropometric parameter of Waist-Hip-Ratio (WHR) and VO2max in young healthy subjects.
Methodology: 50 young adults (between 18-21 years) were randomly selected and health status assessed from history and clinical examination. After obtaining written, informed consent, anthropometric parameters like height, weight, waist and hip circumference were measured using standard procedure. The estimated VO2max was measured with the Queen's College step test (QCT), using the post-exercise heart rate.
Results: Among the 25 males and 25 females studied, the mean WHR was 0.87±0.03 in males and 0.79±0.03 in females. The mean VO2max was 42.69±0.94 mL/kg/min in males and 36.93±1.56 mL/kg/min in females. The findings showed significant negative correlation between WHR and VO2max (-0.651).
Conclusion: The greater the waist-hip-ratio, the lower the level of cardiorespiratory fitness. The presence of more fat tissue is not only as a place to store triglycerides, but is also a producer of bio- active substances called adipokines, namely leptin, which can affect the cardiovascular system and increase the risk of metabolic syndrome and insulin resistance, the development of which is strongly related to the accumulation of upper body fat than lower body fat in both sexes.

Keywords: WHR, VO2max, queen's college step test

Introduction

Physical fitness is defined as 'the ability to carry out daily tasks without undue fatigue [1]. And essentially depends on cardiorespiratory fitness. Physical fitness has 4 basic components, namely endurance of the heart and lungs, strength and endurance of muscles, flexibility and body composition. Cardio-respiratory fitness is the ability of body's circulatory and respiratory system tosupply fuel and oxygen during sustained physical activity. It is responsible for prolonged use of large muscle groups of the body with adequate efficiency for the required duration of exercise. Biological systems generally develop an adaptive increase in functional capacity in response to increased workloads and undergo a decrease in functional capacity or atrophy when subjected to inactivity. So, a low cardio-respiratory fitness status is a risk factorfor cardiovascular disease, morbidity and mortality. Cardiorespiratory fitness can be assessed by measuring aerobic capacity of a person-indicated by VO2max or Maximal Oxygen Consumption level, first defined by Hill and Lupton in 1923, is 'the oxygen uptake during maximum exercise intensity, which could not be increased despite further increase in exercise workload, while breathing air at sea level' which is the maximum volume of oxygen that the body processes during intense exercise [2]. VO2max is measured in millilitres per minute per kilogram of body weight. Factors that determine VO2max include age, gender, heart lung function, aerobic muscle metabolism, exercise, genetics, multivitamins, and nutritional status [3]. During exercise, oxygen consumption matches to the energy expenditure up to a particular point. The response of cardiovascular system to standardized exercise is single and the best test for assessing the efficiency of the heart. Queens' College step test (QCT) is proved by Chatterjee *et al* [4]. To be an ideal simple, non-invasive test for the Indian population to predict VO2max. It can also be used to assess and track improvement in fitness following physical training. Nutritional status can be assessed using body mass index, abdominal circumference and body fat percentage. But all body fat is not harmful. Essential fat is the type of fat found around most organs such as nerve sheaths, bone marrow and muscles, which is needed for normal functioning. According to American Council on Exercise (ACE), the percentage of essential fat should be on average 8-12% in women and 3-5% in men.Storage fat is the type of fat which gets stored subcutaneously (can be pinched over skin) and around abdominal viscera. It is used for metabolism and energy expenditure, but increase in body fat is associated with increase in abdominal circumference, resulting in central obesity, defined as excess buildup of fat tissue around viscera, and is considered to be a risk factor for various chronic diseases, all due to excessive secretion of

adipokines- the proinflammatory substances that are atherogenic in nature [5, 6]. There is increase in free fatty acid synthesis due to increase in number and size of fat cells resulting in increased insulin resistance. There is increase in prothrombin activator inhibitor-1 secretion from fat cells, which is a procoagulant and along with the endothelial dysfunction in obesity leads to cardiovascular disease, dyslipidemia etc [7].

Data indicates that health risks were more strongly related to the accumulation of upper body fat than lower body fat in both sexes. It was first recognized in France by Dr Jon Vague [8]. In the 1940-1950s.

He noted that accumulation of fat in the upper part of the body versus the lower part of the body was associated with an increased risk for coronary heart disease, diabetes, and also gallstones and gout. That is, individuals who accumulated excessive fat in the lower body segment were relatively spared from these complications.

The body fat distribution was referred to as being "android" if it occurred in the upper body and "gynecoid" when it occurred in the lower segment of the body. This is because men tend to accumulate fat in the abdominal (upper body) area, whereas women tend to accumulate it in the gluteal area and the thighs [9].

Accumulation of fat in the abdominal area appears to correlate best with triacylglycerol's accumulating in the liver and skeletal muscle [10, 11]. Rrelatively small accumulation of fat in these organs would not be detectible by BMI determinations, which is why the Waist-Hip-Ratio (WHR) would be an ideal tool to assess visceral fat accumulation.

Methodology

Source of data: The study sample was obtained from students studying under different courses in K.V.G. Medical, Ayurveda, Nursing and Physiotherapy Institutes. A sample of persons belonging to various geographical locations and cultural backgrounds was thus obtained. Ethical Clearance for the study protocol was obtained from Institute Ethical Committee.

Study design: Correlation study

Study area: Volunteers were asked to report to the P.G. Research Lab, Department of Physiology, and K.V.G. Medical College for collection of data. Readings were taken in small batches between morning hours (8-9AM) to avoid circadian variation.

Study period: The study was done in January 2020-February 2020.

Sample size: 50 healthy college students (n=50) between 18 to 23 years of age were selected for the study, which consisted of 25 males and 25 females. This age group was selected as 20-30 years of age is believed to be the age of peak cardiorespiratory endurance. The sample size was calculated from a previous similar study done in Faridabad in 2017 by Sharma *et al* [12]. To find out correlation between waist-hip-ratio and VO2max, where sample size was 30 subjects between 18-30 years.

Method of collection of data

Data collection: Students were selected by simple random sampling. Health status of the subjects was assessed by obtaining past and present medical and surgical history and by performing general and systemic examination. Written, informed consent was obtained from all subjects after explaining study procedures, including risk of injury during the step test and right to withdraw during course of data collection. The study involved non-invasive procedures with no financial burden/benefit to the subjects.

Anthropometric parameters of waist and hip circumference were measured as follows:

1. Waist measurements of all subjects were taken in centimetres by meter tape. The waist circumference is measured at a level midway between the lowest rib and the iliac crest in the standing position.
2. Hip measurement of all the subjects were taken in centimetres by meter tape from the hip circumference at the level of the great trochanters, with the legs close together in standing position [13].

Table 1: Reference Range Of Waist-Hip-Ratio (Http://Whqlibdoc.Who.Int/Publications/2011/9789241501491_Eng.Pdf)

Gender	Excellent	Good	Average	At risk
Male	<0.85	0.85- 0.89	0.90- 0.95	≤ 0.95
Female	<0.75	0.75- 0.79	0.80- 0.86	≤ 0.86

QCT was performed and post-exercise heart rate (QHR) in beats per minute (bpm) was used to calculate estimated VO2max (ml/kg/min) as follows:

Performance of Queen's College Step Test [14]. The step test was performed on a step of 16.25 inches (41.3 cm) height, on which the subject is asked to step up-and-down for a total duration of 3 minutes, at the rate of 24 cycles per minute for men and 22 cycles per minute for women, which will be set by a metronome (here audio recording of metronome beat was used). After completion of the exercise, the subject will be asked to remain standing and the carotid pulse rate will be measured from 5^{th}–20^{th}seconds of the recovery period. This 15 second pulse rate will be converted into beats per minute to obtain the Queen's Heart Rate (QHR). The estimated VO2max was calculated in mL/kg/min by substituting the QHR in the following formula:

Men: VO2max = 55.23- 0.09 x QHR (in beats per minute) [4].

Women: VO2max = 54.12- 0.13 x QHR (in beats per minute) [15].

From the obtained VO2max values, aerobic fitness for this particular age group was graded as follows:

Table 2: Maximal Oxygen Uptake Norms (Ml/Kg/Min) For Age Group 18-25yrs [16].

Grade	Males	Females
Excellent	>60	>56
Good	52-60	47-56
Average	47-51	42-46
Average	42-46	38-41
Average	37-41	33-37
Poor	30-36	28-32
Very poor	<30	<28

Inclusion criteria
Healthy male and female subjects within the age group of 18-23 years who were willing to participate in study.

Exclusion criteria
Persons with history of any cardiovascular disorder, diabetes mellitus, hypertension, bronchial asthma or other chronic illnesses on medication or those who have had any recent surgery were excluded from study as subjects were required to do short duration moderate physical exercise.

Statistical tests
Correlation analysis was done between the 2 parameters in the male and female subjects separately in Windows Excel 2007 using SPSS version 17 software.

Results and observations
Among the 25 males and 25 females studied, the mean WHR was 0.87±0.03 in males and 0.79±0.03 in females, falling within normal limits. The mean VO2max was 42.69±0.94 mL/kg/min in males and 36.93±1.56 mL/kg/min in females, which corresponds to an average level of aerobic fitness.It may be concluded from the readings of the present study that the subjects in this location had adequate nutrition, common socioeconomic status and normal life style.

Table 3: Mean Vo2max and WHR of Study Subjects

Subjects (n-=50)	VO2max	Waist Hip Ratio
Males (n=25)	42.69±0.94 mL/kg/min	0.87±0.03
Females (n=25)	36.93±1.56 mL/kg/min	0.79±0.03

Correlation study between the parameters showed significant negative correlation between WHR and VO2max (-0.651).

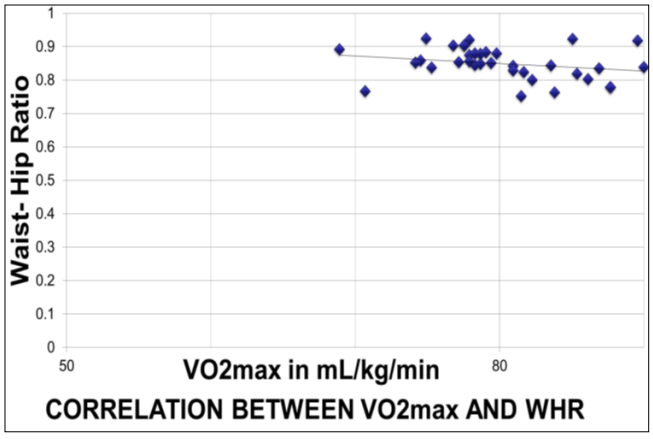

Fig 1: Correlation between VO2max and Waist Hip Ratio

Discussion
This study was undertaken to investigate the relationship between waist hip ratio and VO2max in both males and females age 18-25 years. The data obtained showed that there is negative correlation between WHR and VO2max which could be due to the fact that WHR is an index of fatness of an individual and as a general trend, fat individual are less fit and hence lower VO2max is expected. If the WHR of an individual is high, the body surface area is proportionately larger and hence more VO2 is needed to be delivered and hence the efficiency is lower.Thus this study shows that greater the waist hip ratios, the lower the level of VO2 max. With reference to other studies, there was a negative significant correlation between health related anthropometric measures and physical fitness factors as per Leila Jaafari *et al* [17]. (2012). Shrivastav *et al* [18]. (2013) conducted a similar study on 22 young subjects in the age group of 18 -25 years which concluded that there was a negative significant correlation between BMI and aerobic fitness (r= - 0.55). These findings are in support of present study. The reduction in aerobic fitness with increase in WHR could be because of the reason that when there is increase in body fat, there is an increase in type II muscle fiber and a decrease in type I muscle fiber which has the effect of reducing oxygen absorption. As the name implies the type 1 fibers are rich in mitochondria and glutamines enhancing the oxidative capacity of the skeletal muscles and also enhancing the glucose metabolism regulated by insulin [19]. The excessive amount of fat tissue will cause narrowing of the arteries and increase in peripheral resistance. As a result, the pumped blood becomes less so that the maximum oxygen capacity also decreases and causes a decrease in cardiovascular ability [20].

Conclusion
The maximal oxygen consumption of an individual is inversely proportional to waist-hip-ratio. The presence of more fat tissue is not only as a place to store triglycerides, but is also a producer of bio-active substances called adipokines, namely leptin, which can affect the cardiovascular system and increase the risk of metabolic syndrome and insulin resistance, the development of which is strongly related to the accumulation of upper body fat than lower body fat in both sexes. Improved cardiovascular fitness promotes muscle insulin sensitivity, insulin-mediated transport of glucose from blood to muscles, improved autonomic nervous system function, and lower heart rates, which each decrease the risk of developing diabetes, independent of body mass. The results of this study emphasizes the need for early identification of the risk factors leading to excessive weight gain and initiation of preventive measures in order to prevent the deterioration of cardiovascular performance in susceptible young adults. By knowing the aerobic fitness, students could be motivated toward physical activity.

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