

DOES AGE, SEX, AND BODY MASS INDEX (BMI) AFFECT THE MAXIMUM CAPACITY FOR OXYGEN CONSUMPTION (VO₂MAX) IN UNIVERSITY STUDENTS?

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ABSTRACT

Keywords:

Anthropometry Properties, Body Mass Index, Exercise, Overweight, Obesity, Oxygen Consumption.

Original research



This study explored the connection between age, gender, and body mass index (BMI) and how they influence maximum oxygen consumption (VO₂max) among students at Gilgamesh University's College of Physical Education and Sports Sciences in Baghdad. The research involved 27 male and 14 female students aged 19 to 49, randomly selected. Physiological and anthropometric measurements such as height, weight, and BMI were taken using the World Health Organization's (2020) standards for assessing body mass, irrespective of gender differences. VO₂max was estimated without fitness tests, based on resting heart rate (HR_{rest}) and maximum heart rate (HR_{max}). Age-specific norms for peak oxygen consumption (VO₂max) in men and women were determined using Cooper's VO₂max criteria Heyward (1998). The findings revealed a significant negative correlation between weight gain percentage and VO₂max decrease in both genders, with a more pronounced impact on males. The study also highlighted a high prevalence of obesity, poor cardiorespiratory fitness, and an inverse link between BMI and VO₂max. Moreover, female students demonstrated higher VO₂max compared to male students, possibly due to older and heavier male students in the Evening Study Session compared to both male and female students in the Morning Study Session.

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1. INTRODUCTION

The greatest amount of oxygen that a person can transfer and use during intense exercise is known as VO₂max, and the VO₂max index is a recognized indicator of respiratory and cardiac function. Additionally, prior research has demonstrated that the typical computation of VO₂max kg | minute. According to studies, obese individuals have a substantially lower maximal oxygen energy rate than healthy individuals (Ghosh & Jahan, 2017). Moreover, the same writer mentioned that; more than the resting level. The most of

the adaptations occur in cardiovascular system and respiratory system.

Age, sex, body size and fitness, kind of exercise, and the presence or absence of heart disease all affect the adaptations to the rise in cardiac output. There are many factors that can influence VO₂max, e.g. heredity, training, age, gender, and body composition. Generally, VO₂max declines with age (about 2% per year after age 30) and males typically have a greater oxygen consumption value than females (Grant et al 1999; Mohajan, & Mohajan, 2023).

It is well knowledge that athletes with high oxygen energy can engage in physical activity for longer

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periods of time and with greater effectiveness, both of which are beneficial to their health. Individuals who possess maximal oxygen energy have a lower risk of heart disease, diabetes, stroke, and early death. VO2max represents the highest volume of oxygen a person can take in and use to generate energy (ATP) through aerobic respiration (Plowman & Smith, 2013). One of the most widely used measurements in exercise science is VO2max. It's one of the key indicators of endurance performance, measuring a person's cardio-pirate capacity at a given level of performance and oxygen availability (Levine, 2008). Risk of Cardiovascular Disease, Hypertension, Type II Diabetes mellitus, Osteoarthritis, Gall bladder disease, and many types of cancer increased with obesity. Low VO2max is independently associated with cardiovascular mortality (Lee et al., 2010).

VO2max is a measure of how much oxygen a person can take in during a high-intensity workout. It's widely regarded as the best measure of cardiovascular health and aerobic performance. Maximized Oxygen Consumption (MAXOC) is a term used to describe the amount of oxygen a person is able to consume during intense exercise. MAXOC is often used interchangeably with other terms related to circulatory endurance, aerobic capacity and aerobic endurance. It's important to note that VO2max is a measure of an athlete's endurance. An athlete's VO2max is determined by how much oxygen they're able to absorb. An athlete who runs medium and long distances, such as a cyclist, skier, or swimmer, has a high VO2max. Athletes who run different speeds, such as those who throw and jump, have a lower VO2max (Mondal & Mishra, 2017).

Recent research, along with information from the World Health Organization, shows that not getting enough aerobic physical activity can lead to a higher chance of dying early from various reasons, especially heart disease. On the other hand, doing intense aerobic exercises regularly can bring numerous health advantages, such as living longer, having a better life quality, reducing the risk of stroke, heart disease, diabetes, and cancer, enhancing mood and self-worth, and improving sleep (World Health Organization (WHO), 2020).

VO2 max, or the highest volume of oxygen an individual can utilize during intense physical activity, is typically seen as the most accurate gauge of heart health and the ability to sustain aerobic activity. The greater the volume of oxygen an individual can utilize during intense physical activity, the more energy they are able to generate. It's obvious that undergoing physical training results in an enhancement in the maximum oxygen consumption level, though the pace of this enhancement differs from person to person. It's important to mention that individuals who were already in a high level of fitness prior to starting their training will see a greater increase in their maximum oxygen consumption compared to those who were less fit. The opposite is also true. The VO2max test is considered the ultimate indicator of cardiorespiratory fitness since the

muscles require oxygen to carry out aerobic activities for extended durations, and the heart needs to circulate enough blood through the body's blood vessels to satisfy the needs of aerobic activities (Dhara & Chatterjee, 2015).

Research has demonstrated a strong link between gaining weight (Body Mass Index, BMI) and a reduction in the highest amount of oxygen one can use during exercise (VO2max) (Singh et al., 2023). Several of these studies have suggested that obesity raises the chance of heart disease, and this, in turn, lowers an individual's capacity for oxygen energy utilization (Sindall 2020).

The primary goal of this research is to understand how the maximum oxygen consumption (Vo2max) is related to the extent of body mass increase (PMI) in students from the College of Physical Education and Sports Sciences.

2. MATERIALS AND METHODS

The study group was chosen at random from the student body at Gilgamesh University's College of Physical Education and Sports Sciences in Baghdad. The group consisted of (14 female students) representing 40% of the female students (35 in total) and (27 male students) representing 14.75% of the male students. In total, this group had 148 students, with ages ranging from 19 to 49 years old, compared to the original research group of 183 male and female students.

2.1 Determination of Body Mass Index (BMI)

Body Mass Index (BMI) is a straightforward formula that involves dividing a person's weight in kilograms by their height in meters squared. The formula for BMI is $BMI = \text{Weight (in kilograms)} / \text{Height (in meters squared)}$. Essentially, kilograms represent the individual's weight, and meters squared denotes the length of the person in meters squared. This method was selected due to its widespread use and recognition by the World Health Organization as a standard tool for gauging body mass, without taking into account differences based on gender. Table 1 displays BMI ranges suggested by the World Health Organization, 2020 (World Health Organization (WHO), 2020).

Table 1. Displays the various BMI levels in young individuals

Typical division of body mass index (BMI)	BMI (kg/m) ²
Underweight	Less than 18.5
Normal weight	18.5-24.9
Overweight (pre-obese)	25.0-29.9
First degree of the classification of obesity	30.0-34.9
Second degree obesity	35.0-39.9
Third degree obesity	More than 40

2.2 Methods for measuring maximum oxygen consumption VO2max

Measuring VO2 max involves various methods, but most of them necessitate costly, specialized equipment and dedicated laboratory facilities. These resources are not always readily accessible and often require specialized scientific personnel for result interpretation and analysis, although few alternatives are highly accurate and efficient in measuring variables.

Such as a treadmill or a specially calibrated exercise cycle. Therefore, workers in the field of physical education resort to using other indirect methods that have a small financial cost, although they are less accurate, but they are sufficient for the purpose of research and are approved in much scientific studies. They do not require complex equipment or specialized staff, in addition to that, the ease of applying them at any time and place to save time and effort. Conducting it on large groups and using mathematical operations and equations, the value of the maximum oxygen energy index (VO2max) is extracted. Therefore, researchers have adopted the following method to measure the level of maximum oxygen energy (VO2 max), which is inexpensive and easy to meet its requirements and is approved in scientific research.

2.3 Calculate VO2max Without Conducting Fitness Test

This approach for calculating the highest rate of oxygen use relies on the heart rate when at rest and the peak pulse, and was developed by several scientists (Huo et al., 2023). To find the resting heart rate and pulse without any equipment, two fingers should be positioned on the artery located on the neck's side, just under the jaw as showing in figure 1.



Figure 1. Meredith Juncker, 2024

The individual should be able to detect their own pulse. Thus, it's essential to start a timer for 60 seconds and then multiply by (2) to figure out the number of the

individual's heartbeats at rest (Uth et al. 2004, Junita, Al-Rahmad, H., & Fajarna 2024).

To achieve the highest pulse rate during intense physical activity (HR max), this equation was utilized, which has been scientifically validated in numerous studies (Junita, Al-Rahmad & Fajarna2024):

$$HR \text{ max} = 220 - \text{age}$$

To calculate VO2max and the peak oxygen utilization, the equation below was applied:

$$VO2 \text{ max} = 15 \times (HR_{\text{max}} / HR_{\text{rest}})$$

The categorization Heyward (1998) was chosen according to the Cooper VO2max criteria listed in a tables no. (2, and 3), and also by age category: to establish the normal maximum oxygen consumption levels and to set the normal maximum oxygen consumption levels for the study participants based on their age.

Table 2. Displays the established norms for peak oxygen consumption (VO2max) in women, categorized by age (Heyward (1998))

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<25	25 - 30	31 - 34	35 - 38	39 - 41	>41
20-29	<24	24 - 28	29 - 32	33 - 36	37 - 41	>41
30-39	<23	23 - 27	28 - 31	32 - 36	37 - 40	>40
40-49	<21	21 - 24	25 - 28	29 - 32	33 - 36	>36
50-59	<20	20 - 22	23 - 26	27 - 31	32 - 35	>35
60+	<17	17 - 19	20 - 24	25 - 29	30 - 31	>31

Table 3. Displays the established norms for peak oxygen consumption (VO2max) in men, categorized by age (Heyward (1998))

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<35	35 - 37	38 - 44	45 - 50	51 - 55	>55
20-29	<33	33 - 35	36 - 41	42 - 45	46 - 52	>52
30-39	<31	31 - 34	35 - 40	41 - 44	45 - 49	>49
40-49	<30	30 - 32	33 - 38	39 - 42	43 - 47	>48
50-59	<26	26 - 30	31 - 35	36 - 40	41 - 45	>45
60+	<20	20 - 25	26 - 31	32 - 35	36 - 44	>44

3. RESULTS AND DISSECTION

Age, Sex, Height and Weight Measurements and Body Mass Indexes Determination of male and female groups were presented in table 4.

Table 4. Parameters obtained from male & female students and their body mass index

Subjects	Age	Sex	Height	Mean	Weight	Mean	BMI kg/m ²	Mean and SD Of BMI	Classification of BMI
1	30	F	160		82.25		32.1		
2	32	F	159		54.10		21.4		
3	31	F	162		57.80		22		
4	36	F	168		85.50		30.3		
5	29	F	162		77.75		29.6		
6	36	F	147		65.40		30.3		

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7	38	F	159	160.86	91.65	74.18	36.3	28.414±4.207	Overweight
8	33	F	159		68.85		27.2		
9	34	F	157		71.82		29.1		
10	27	F	155		66.25		27.6		
11	27	F	171		86.15		26.7		
12	29	F	164		86		32		
13	32	F	169		87		30.5		
14	22	F	160		58		22.7		
15	27	M	170	173.67	67.70	80.41	23.4	26.462±4.712	Overweight
16	23	M	172		59.75		20.2		
17	42	M	182		92.05		27.8		
18	43	M	170		68.25		23.6		
19	25	M	169		61.30		21.5		
20	21	M	169		54.50		19.1		
21	25	M	197		120		30.9		
22	35	M	163		62		23.3		
23	49	M	171		81.95		28		
24	26	M	193		138		37		
25	26	M	162		68.05		25.9		
26	40	M	184		86.55		25.6		
27	31	M	175		95		31		
28	43	M	176		89.30		28.8		
29	38	M	169		78.75		27.6		
30	43	M	182		86		26		
31	43	M	169		97.10		34		
32	44	M	170		98.55		34.1		
33	26	M	170		92.25		32.5		
34	23	M	181		86.15		26.3		
35	26	M	171		82.80		28.3		
36	26	M	170		75.10		26		
37	32	M	170		73		25.3		
38	39	M	160		68		26.6		
39	24	M	181		75		22.9		
40	19	M	170		58		20.1		
41	24	M	173		56		18.7		

Results of female age group ranged from 22 to 38 years, while age of the male group ranged from 19 to 49 years. The height of the females ranged from 1.47 m to 1.71m, while the height of the male group ranged from 160 m to 197 m which mean that the male students were taller than the female students. The mean value of the male weight was heavier than the mean value of the female

approximately 6.0 kg. The mean and (SD) of body mass index (BMI) for the female group are 28.414±4.207 kg/m², while the mean and (SD) of the male group was 26.462±4.712 kg/m².

Table 5 shows heart rate of male and female at rest (HR_{rest}) as well as their maximum heart rate (HR_{max}), their (VO₂max) based on the Cooper VO₂max criteria.

Table 5. Heart Rates and VO₂max Value based on Cooper VO₂max Criteria

Subjects	Sex	Age	Mean	HR _{rest} (beat/min)	HR _{max} (beat/min)	VO ₂ max Value	Mean and SD of VO ₂ max	Classification of VO ₂ max
1	F	30	31.142	86	190	33.14	34.224 ± 4.259	Good
2	F	32		98	188	28.78		
3	F	31		78	189	36.35		
4	F	36		77	184	35.84		
5	F	29		80	191	35.81		
6	F	36		66	184	41.82		
7	F	38		87	182	31.38		
8	F	33		82	187	34.21		
9	F	34		80	186	34.88		
10	F	27		86	193	33.66		
11	F	27		78	193	37.12		
12	F	29		108	186	24.28		
13	F	32		86	188	32.79		
14	F	22		76	198	39.08		
15	M	27		66	193	43.86		

16	M	23	31.963	96	197	30.78	37.459 ± 4.833	Fair
17	M	42		82	178	32.56		
18	M	43		60	177	44.25		
19	M	25		80	195	36.56		
20	M	21		76	199	39.28		
21	M	25		74	195	39.53		
22	M	35		76	185	36.51		
23	M	49		60	171	42.75		
24	M	26		66	194	44.09		
25	M	26		70	194	41.57		
26	M	40		80	180	33.75		
27	M	31		78	189	36.35		
28	M	43		94	177	28.24		
29	M	38		66	182	41.36		
30	M	43		60	177	44.25		
31	M	43		76	177	34.93		
32	M	44		60	176	44.0		
33	M	26		94	194	30.96		
34	M	23		76	197	38.88		
35	M	26		75	194	38.8		
36	M	26		90	194	32.33		
37	M	32		80	182	35.25		
38	M	39		94	181	28.88		
39	M	24		74	196	39.73		
40	M	19		88	201	34.26		
41	M	24		78	196	37.69		

Table 6 shows male and female heart rates at rest (HRrest) as well as their maximum heart rates (HRmax), their (VO2max) based on Cooper VO2max criteria. HRrest of the female group ranges from 66 beat | min to 108 beat | min, while their HRmax ranged from 182 beat | min to 198 beat | min. HRrest of the

male group ranges from 60 beat | min to 96 beat | min, while their HRmax ranged from 171 beat | min to 201 beat | min. The means and (SD) of VO2max of the female group are 34.224 ± 4.259, while for the male group are 37.459 ± 4.833, which means that The female group have better VO2max than the male group.

Table 6. The standard values for maximum oxygen energy (VO2max) for the research sample, based on Cooper's tabular standards (VO2max)

Research Sample	Number	Mean ± SD of age	Mean and SD Of BMI	Classification of BMI	Mean and SD of VO2max	Classification of VO2max	t-test, p-value
Female	14	31.143±4.26	28.414±4.207	Overweight	34.224 ± 4.259	Good	<0.0133**
Male	27	31.963±8.733	26.462±4.712	Overweight	37.459 ± 4.833	Fair	<0.0001**

4. DISCUSSION

The main purpose of this study was to explore the connection between age, gender, and body mass index (BMI) and how they influence maximum oxygen consumption (VO2max) among students. This study includes both male and female students from Gilgamesh University, College of Physical Education and Sports Sciences. It is important to note that a large number of studies have indicated that people suffering from obesity and severe obesity are suffering from a deficiency or lack of efficiency or oxygen capacity in their VO2max (Dhara & Chatterjee 2015, Singh et al. 2023).

Table 6 shows that the arithmetic mean for both research samples of male students (26.462±4.712) and female students (28.414±4.207) had a clear percentage

in the rate of increase in body mass BMI. Based on the obesity levels presented in Table 4 and 5, the weight gain had a detrimental effect on the reduction of the average and standard deviation in the percentage of maximum capacity for oxygen consumption (VO2max) in both groups of male students (37.459 ± 4.833) and female students (34.224 ± 4.259). When comparing the percentages of the decrease in the rate of maximum capacity for oxygen consumption in the two research samples, based on the Cooper VO2max tabular criteria and by age group, it was found that weight gain had a negative impact on the maximum capacity for oxygen consumption (VO2max) in both male and female student samples. This effect was deemed acceptable for the overall student sample and good for female students, as shown in Table 6.

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This phenomenon may be attributed to the fact that a considerable proportion of male students in the Evening Study Session are older and heavier compared to both male and female students in the Morning Study Session. Several studies have confirmed that the increase in average age and body mass index (BMI) is a crucial factor that affects the reduction in oxygen energy levels in individuals. In order to determine the impact of weight gain on the two research samples, the researchers conducted a Pearson correlation coefficient test to assess the relationship between VO₂max and the percentage increase in BMI in both male and female research samples. The results revealed a significant negative correlation for the female sample (<0.0133**) and the male sample (<0.0001**). Research has indicated a significant negative relationship between body mass index (BMI) and a decrease in the maximum rate of oxygen consumption (VO₂max) (van der Steeg & Takken 2021). Several studies conducted in various countries have confirmed that weight gain negatively impacts an individual's maximum ability to consume oxygen during high-intensity exercise (Fernández-Rodríguez et al. 2018, Singh et al. 2023).

5. CONCLUSION

In this research, the relationship between age, gender, and body mass index (BMI) and its influence on

maximum oxygen consumption (VO₂max) among students in the Faculty of Physical Education and Sports Sciences at Gilgamesh University was investigated. The study discovered a significant negative correlation between weight gain percentage in male and female participants and the reduction in VO₂max. However, this connection was more noticeable in the male group. The results also highlighted a high prevalence of obesity, poor cardiorespiratory fitness, and a reverse link between BMI and VO₂max. These outcomes emphasize the significance of participating in regular aerobic exercises to improve the overall health of university students. Additionally, the findings suggested that female students exhibit a higher capacity for oxygen consumption (VO₂max) compared to male students. This difference may be due to the fact that a considerable number of male students in the Evening Study Session are older and heavier than both male and female students in the Morning Study Session.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

References:

- Dhara, S., & Chatterjee, K. (2015). A study of VO₂ max in relation with body mass index (BMI) of physical education students. *Research Journal of Physical Education Sciences*, 2320, 9011.
- Fernández-Rodríguez, J. A., Ramos, H. S., Santamaría, O. M., & Ramos-Bermúdez, S. (2018). Relationship between oxygen consumption, percentage of body fat and body mass index in university students. *Hacia la Promoción de la Salud*, 23(2), 79-89.
- Ghosh, A., & Jahan, W. (2017). A study of VO₂max in relation to body mass index before and after exercise in healthy young adults. *Journal of Medical Science and Clinical Research*, 5, 20290-3. DOI: 10.18535/jmscr/v5i4.89
- Grant, J. A., Joseph, A. N., & Campagna, P. D. (1999). The prediction of VO₂max: a comparison of 7 indirect tests of aerobic power. *The Journal of Strength & Conditioning Research*, 13(4), 346-352.
- Heyward, V. H. (1998). *The physical fitness specialist certification manual*. Dallas, TX: The Cooper Institute for Aerobics Research, 48.
- Huo, Y., Grotle, A. K., McCuller, R. K., Samora, M., Stanhope, K. L., Havel, P. J., ... & Stone, A. J. (2023). Exaggerated exercise pressor reflex in male UC Davis type 2 diabetic rats is due to the pathophysiology of the disease and not aging. *Frontiers in Physiology*, 13, 1063326.
- Junita, D., Al-Rahmad, A. H., & Fajarna, F. (2024). Kajian Status Gizi dan Daya Tahan Kardiorespirasi (VO₂Max) pada Remaja Putri SMA di Banda Aceh: Study of Nutritional Status and Cardiorespiratory Endurance (VO₂Max) of High School Adolescent Girls in Banda Aceh. *JURNAL GIZI DAN KESEHATAN*, 16(1), 133-140.
- Lee, D. C., Artero, E. G., Sui, X., & Blair, S. N. (2010). Mortality trends in the general population: the importance of cardiorespiratory fitness. *Journal of psychopharmacology*, 24(4_suppl), 27-35.
- Levine, B. D. (2008). What do we know, and what do we still need to know?. *The Journal of physiology*, 586(1), 25-34.
- Mohajan, D., & Mohajan, H. (2023). Long-Term regular exercise increases VO₂max for cardiorespiratory fitness. MPRA Paper No. 116962
- Mondal, H., & Mishra, S. P. (2017). Effect of BMI, body fat percentage and fat free mass on maximal oxygen consumption in healthy young adults. *Journal of clinical and diagnostic research: JCDR*, 11(6), CC17. DOI: 10.7860/JCDR/2017/25465.10039.

- Plowman, S. A., & Smith, D. L. (2013). *Exercise physiology for health fitness and performance*. Lippincott Williams & Wilkins.
- Sindall, P. (2020). Physiological determinants of endurance performance: maximal oxygen uptake (VO₂max). *A Comprehensive Guide to Sports Physiology and Injury Management: an interdisciplinary approach*, 137.
- Singh, H., Esht, V., Shaphe, M. A., Rathore, N., Chahal, A., & Kashoo, F. Z. (2023). Relationship between body mass index and cardiorespiratory fitness to interpret health risks among sedentary university students from Northern India: A correlation study. *Clinical Epidemiology and Global Health*, 20, 101254. DOI: 10.1016/j.cegh.2023.101254.
- Uth, N., Sørensen, H., Overgaard, K., & Pedersen, P. K. (2004). Estimation of $\dot{V}O_{2\max}$ from the ratio between HR max and HR rest—the Heart Rate Ratio Method. *European journal of applied physiology*, 91, 111-115.
- van der Steeg, G. E., & Takken, T. (2021). Reference values for maximum oxygen uptake relative to body mass in Dutch/Flemish subjects aged 6–65 years: the LowLands Fitness Registry. *European Journal of Applied Physiology*, 121, 1189-1196.
- World Health Organization (WHO). (2020). A Healthy Lifestyle body mass index. <http://www.euro.who.int/en/health-topics/diseaseprevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi>

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