Jurnal Kedokteran Methodist, Vol. 17 No.1 Tahun 2024
https://doi.org/10.46880/jkm.v17i1

RESEARCH ARTICEL

The Relationship Between Body Mass Index (BMI) and Waist Circumference on Cardiorespiratory Endurance in High School Students at Methodist 1 Medan, North Sumatra, 2023-2024

Jeremia Simanjuntak[1], Suryati Sinurat[2], Alexander Parlindungan Marpaung[3], Menang Bastanta Tarigan[4], Jekson Martiar Siahaan[5]

[1] *Undergraduate Medical Education Student, Faculty of Medicine, Methodist University of Indonesia*
[2] *Department of Public Health, Faculty of Medicine, Methodist University of Indonesia*
[3] *Department of Microbiology, Faculty of Medicine, Methodist University of Indonesia*
[4] *Department of Internal Medicine, Faculty of Medicine, Methodist University of Indonesia*
[5] *Department of Physiology, Faculty of Medicine, Methodist University of Indonesia*
Email[1] : xjeremia980@gmail.com

ABSTRACT
Currently, modern life, especially in urban areas, promotes an instant consumption lifestyle, particularly among teenagers. With technological advancements, teenagers can easily order fast food through delivery apps, making fast food a common choice. In addition to fast food, school snacks are also highly favored by teenagers. This excessive consumption pattern, if sustained over time, can lead to fat accumulation that affects body mass index (BMI) and waist circumference. According to the 2019 health profile, 35.4% of teenagers experience obesity, with the highest prevalence in urban areas at 25.1%. Excess fat accumulation puts pressure on cardiorespiratory function, reducing lung capacity as reflected in VO2Max or cardiorespiratory endurance. This decline in cardiorespiratory endurance significantly affects a person's quality of life, causing them to feel fatigued easily and limiting their ability to engage in prolonged physical activities.Conclusion: There is a significant relationship between body mass index and waist circumference on cardiorespiratory endurance among students of Methodist 1 High School, Medan, North Sumatra..

Keywords*: Body Mass Index, Waist Circumference, Cardiorespiratory Endurance, VO2Max, Fast Food, Snacks.*

INTRODUCTION

According to the World Health Organization (WHO) in 2022, the number of adults (aged ≥18 years) who are overweight reached 2.5 billion, with more than 890 million classified as obese. This represents a significant increase compared to 1990, when only 25% of the adult population was overweight. The prevalence of overweight varies across regions, ranging from 31% in the WHO South-East Asia and Africa Regions to as high as 67% in the Americas Region, indicating disparities in health conditions worldwide.[1]

The prevalence of obesity based on Body Mass Index (BMI) ≥25–27 and BMI ≥27, according to the 2019 health profile among individuals aged over 15 years, was 35.4%, while the prevalence of obesity (BMI ≥27) was 21.8%. Among individuals aged over 15 years, obesity prevalence was higher in females (29.3%) compared to males (14.5%). It was also higher in urban

RESEARCH ARTICEL

areas (25.1%) than in rural areas (17.8%). Based on age groups, the highest prevalence of obesity was observed in the 40–44 years age group (29.6%).[2]

Modern lifestyles, particularly in Medan, encourage people—especially adolescents—to adopt a more instant consumption pattern. Fast food, which is processed and served quickly, attracts consumers through appealing packaging and a variety of flavors. Adolescents can now easily order fast food through food delivery applications such as GoFood and GrabFood without leaving their homes. High fast food consumption among adolescents is influenced by factors such as online media, pocket money, knowledge, and attitudes toward such foods. Fast food generally contains high levels of fat, cholesterol, salt, and energy, but low fiber. Commonly consumed items such as hot dogs, pizza, hamburgers, fried chicken, French fries, and chips have become symbols of modern lifestyle. However, these foods are high in saturated fat, cholesterol, and salt, which may negatively affect adolescents' nutritional status if consumed over the long term.[4–5]

Snacking habits at school, in addition to fast food consumption, can also influence adolescents' BMI and waist circumference. Snacks refer to foods consumed outside main meals. Snack consumption continues to increase due to limited knowledge and time among family members to prepare home-cooked meals. Hunger during school hours encourages students to purchase snacks, while only a few bring food from home. School snacks are generally high in carbohydrates, which may lead to deficiencies in other essential nutrients. Changes in BMI are primarily caused by an imbalance between physical activity and food intake, increasing the risk of weight gain. When an individual consumes more calories than their daily energy requirement, the excess calories are stored as fat for future energy use.[6–8]

There are two main types of body fat distribution with different physiological, metabolic, and hormonal characteristics: visceral adipose tissue (VAT) and subcutaneous adipose tissue (SCAT). Excess energy stored in SCAT may lead to the accumulation of VAT, which is harmful and commonly associated with central obesity. Excess body fat also increases the burden on oxygen uptake and muscles, affecting cardiorespiratory function and limiting lung capacity. The greater the body fat mass or BMI, the lower the cardiorespiratory endurance or VO_2max.[9–10]

Decreased cardiovascular endurance has a direct impact on an individual's quality of life, as low endurance leads to rapid fatigue and reduced ability to sustain daily activities. Poor physical fitness also results in quicker exhaustion, causing individuals to prefer sedentary behavior over physical activity. In contrast, individuals with good cardiorespiratory fitness are less likely to experience fatigue after performing a series of activities.[11–12]

MATERIALS AND METHODS

To determine whether there is an association between body mass index (BMI) and waist circumference with cardiorespiratory endurance among students of Methodist 1 Senior High

RESEARCH ARTICEL

School Medan, North Sumatra (2023–2024), this study employed an observational analytic design with a cross-sectional approach.

In this study, measurements of height and weight were obtained and subsequently calculated using a formula to determine an individual's BMI. The formula for body mass index is as follows:[13]

Body Mass Index (BMI) Formula

$$BMI = \frac{\text{Body Weight (Kg)}}{\text{Height (m}^2\text{)}}$$

Waist circumference was measured using a measuring tape placed horizontally around the abdomen at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, at the end of normal expiration. The measurement result was recorded and expressed in centimeters (cm). The Harvard Step Test was used as the data collection method for the cardiorespiratory endurance variable (VO_2max). Respondents were instructed to step up and down on a platform following a metronome set at 120 beats per minute until they were unable to continue. Pulse rate was then measured progressively for 30 seconds during the first, second, and third minutes of recovery. The obtained data were calculated using the Harvard Step Test formula as follows:[14]

Harvard Step Test Formula

$$VO_2Max = \frac{\text{Duration of stepping (seconds)} \times 100}{2 \times (DN\ 1 + DN\ 2 + DN\ 3)}$$

Notes:
DN 1 = Pulse rate (30 seconds) in the first minute after the test
DN 2 = Pulse rate (30 seconds) in the second minute after the test
DN 3 = Pulse rate (30 seconds) in the third minute after the test

The sample size obtained for the correlation test using the Slovin formula was 74 participants. All students of Methodist 1 Senior High School Medan were willing to participate as respondents in this study. The independent variables in this study were body mass index (BMI) and waist circumference, while the dependent variable was cardiorespiratory endurance. The sampling technique used was purposive sampling. This study used an ordinal measurement scale. Data analysis was performed using Kendall's correlation test with a significance level of $p < 0.05$.

RESULTS

Tabel 1. Frequency Distribution and Percentage of Body Mass Index

Indeks Massa Tubuh	N	%
Underweight	14	18,9
Normal	23	31,1
Overweight	15	20,3
Obesity I	14	18,9
Obesity II	8	10,8
Total	74	100

Based on Table 1, the distribution of respondents by body mass index showed that 14 respondents (18.9%) were underweight, 23 respondents (31.1%) had normal BMI, 15 respondents (20.3%) were overweight, 14 respondents (18.9%) had obesity I, and 8 respondents (10.8%) had obesity II.

RESEARCH ARTICEL

Tabel 2. Frequency Distribution and Percentage of Waist Circumference

Lingkar Pinggang	N	%
Non-Central Obesity	47	63,5
Central Obesity	27	36,5
Total	74	100

Based on Table 2, 47 respondents (63.5%) had non-central obesity waist circumference, while 27 respondents (36.5%) had central obesity.

Tabel 3. Frequency Distribution and Percentage of Cardiorespiratory Endurance

Ketahanan Kardiorespirasi	N	%
Very Good	17	23
Good	14	18,9
Moderate	11	14,9
Poor	14	18,9
Very Poor	18	24,3
Total	74	100

Based on Table 3, 17 respondents (23.0%) had very good cardiorespiratory endurance, 14 respondents (18.9%) good, 11 respondents (14.9%) moderate, 14 respondents (18.9%) poor, and 18 respondents (24.3%) very poor.

Tabel 4. Kendall's Test: Relationship between Body Mass Index and Cardiorespiratory Endurance Variable

		Ketahanan Kardiorespirasi
Body Mass Index	*r*	-0,364
	p	0,000
	n	74

Based on Table 4, the analysis of the relationship between BMI and cardiorespiratory endurance using Kendall's tau test showed a p-value of 0.000 ($p < 0.05$), indicating that H_0 was rejected and H_1 was accepted. This result demonstrates a significant relationship between BMI and cardiorespiratory endurance. The correlation coefficient (r =-0.364) indicates a negative correlation with weak strength.

Tabel 5. Kendall's Test: Relationship between Waist Circumference and Cardiorespiratory Endurance Variable

		Ketahanan Kardiorespirasi
Waist Circumference	*r*	-0,540
	p	0,000
	n	74

Based on Table 5, the analysis of the relationship between waist circumference and cardiorespiratory endurance using Kendall's tau test showed a p-value of 0.000 ($p < 0.05$), indicating that H_0 was rejected and H_1 was accepted. This result demonstrates a significant relationship between waist circumference and cardiorespiratory endurance. The correlation coefficient (r = -0.540) indicates a negative correlation with moderate strength.

DISCUSSION

Kendall's statistical test was used to analyze the relationship between variables in this study. The test yielded a p-value of 0.000 ($p < 0.05$), leading to the rejection of H_0 and acceptance of H_1. This indicates a significant relationship between body mass index (BMI) and cardiorespiratory endurance. The correlation coefficient (r = -0.364) shows a negative correlation with weak strength, meaning that higher BMI is associated with lower cardiorespiratory endurance.

RESEARCH ARTICEL

These findings are consistent with a study conducted by Musdalifah, Irianto, and Dian AN (2023), titled "The Relationship between Body Mass Index and Cardiorespiratory Fitness among Senior High School Students", which used Kendall's tau-b correlation test and reported a significance value of p = 0.000 (< 0.05). The study concluded that BMI was significantly associated with VO_2max, with a correlation coefficient of -0.574, indicating a strong negative relationship. This suggests that as BMI increases, VO_2max decreases, and vice versa.[15]

Similarly, a literature review conducted by Nadya G (2021), titled "The Relationship between Body Mass Index and Cardiorespiratory Endurance Measured by VO_2max", reported an inverse relationship between BMI and cardiorespiratory endurance, where lower BMI is associated with higher VO_2max levels, and vice versa.[16]

Another study by Gusti PADDS, Agung WP, and Made AY (2022), titled "The Relationship between Body Mass Index and VO_2max Endurance in Badminton Players", using Pearson product-moment correlation, found a p-value of 0.004 (p < 0.05), indicating a significant relationship between BMI and cardiorespiratory endurance. The correlation coefficient (r = -0.612) demonstrated a strong negative relationship.[17]

In addition, research by Itmam Fuadi (2023), titled "The Relationship between Body Mass Index and VO_2max Levels in Sports Achievement Track Students of SMAN 2 Kebumen, Central Java", using Pearson correlation, showed a p-value of 0.002 (< 0.05), indicating a significant relationship between BMI and VO_2max. The correlation coefficient (r = -0.451) indicated a strong negative relationship, meaning that higher BMI is associated with lower VO_2max levels.[18]

Furthermore, the relationship between waist circumference and cardiorespiratory endurance also showed significant results, with a p-value of 0.000 (p < 0.05), leading to the rejection of H_0 and acceptance of H_1. The correlation coefficient (r = -0.540) indicates a moderate negative correlation, suggesting that an increase in waist circumference is associated with decreased cardiorespiratory endurance.

These results are consistent with a study by Ni Made, Ari W, I Putu GA, and I Nyoman A (2022), titled "Waist Circumference and Maximal Oxygen Consumption in Physiotherapy Students of the Faculty of Medicine, Udayana University", which used Spearman's rho test and reported a p-value of 0.000 (p < 0.05), indicating a significant relationship between waist circumference and VO_2max. The correlation coefficient (r = -0.526) showed a strong negative relationship, meaning that larger waist circumference is associated with lower VO_2max.[19]

A study by Yuan L, Xiaojian Y, Feng Z, et al. (2022), titled "Relationship between Waist Circumference and Cardiorespiratory Fitness in Chinese Children and Adolescents: Results from a Cross-Sectional Survey", also found a significant relationship. The study reported that cardiorespiratory endurance initially shows a slight increase but then declines rapidly as waist circumference increases,

indicating an overall negative association.[20]

Additionally, research by Andrew O, Samantha MM, Christina S, et al. (2020), titled "Differential Relationships between Waist Circumference and Cardiorespiratory Fitness among People with and without Type 2 Diabetes", using linear regression analysis, reported a p-value of 0.02 (< 0.05), indicating a significant relationship. The study found that a reduction in waist circumference was associated with improved cardiorespiratory endurance, particularly among individuals with type 2 diabetes.[21]

CONCLUSIONS AND RECOMMENDATIONS

Based on the data and results obtained from this study on the relationship between Body Mass Index (BMI) and waist circumference with cardiorespiratory endurance among students of Methodist 1 Senior High School Medan, the following conclusions can be drawn:

1. Of the 74 respondents, the majority were in the normal BMI category (31.1%), followed by overweight (20.3%), underweight (18.9%), obesity I (18.9%), and only 10.8% were in the obesity II category.
2. Of the 74 respondents, 63.5% were classified as non-central obesity, while 36.5% were classified as central obesity.
3. Of the 74 respondents, 24.3% had very poor cardiorespiratory endurance, 23% very good, 18.9% good, 18.9% poor, and 14.9% moderate.
4. There was a significant relationship between BMI and cardiorespiratory endurance, with a p-value of 0.000 ($p < 0.05$) and a correlation coefficient (r) of -0.364.
5. There was a significant relationship between waist circumference and cardiorespiratory endurance, with a p-value of 0.000 ($p < 0.05$) and a correlation coefficient (r) of -0.540.

Based on the conclusions above, several recommendations can be proposed. Future studies are expected to use a standardized Harvard Step Test and a metronome for pacing to obtain more accurate results. This test may also be complemented with echocardiography and spirometry to provide a more comprehensive and accurate assessment of cardiorespiratory endurance.

ACKNOWLEDGEMENTS

1. To the supervisors for their guidance and support throughout this research.
2. To the Faculty of Medicine, Methodist University of Indonesia, for granting permission to conduct this study.
3. To all academic members of the Faculty of Medicine, Methodist University of Indonesia, for their support and assistance in completing this research.

REFERENCES

RESEARCH ARTICEL

1. *World Health Organization. Obesity and overweight.WHO.https://www.who.int/news-room/fact-sheets/detail/obesity-and overweight. Diakses Tanggal 29 Maret 2024.*
2. *Oscar Primadi. Profil Kesehatan Indonesia Tahun 2019. Jalan HR Rasuna Said Blok X-5 Kav 4-9, Jakarta 12950. Kementerian Kesehatan Republik Indonesia. 2020*
3. *Alya S.B.M, Farahdina B, Condrowati, Fidyatul N. Hubungan antara Aktivitas Fisik dengan Indeks Massa Tubuh pada Remaja. Physiotherapy Health Science. 2022; Volume 4, Nomor 2.*
4. *Khudhriyatul U, Sugeng H. Konsumerisme Makanan Siap Saji Sebagai Gaya Hidup Remaja Di Kota Surabaya: Studi Kasus Siswi Sma Muhammadiyah 4 Kota Surabaya. Jurnal Analisa Sosiologi. 2022; 11 (1): 137 -156*
5. *Tri Susanti. Hubungan Pola Konsumsi Fast Food Dengan Kejadian Obesitas Pada Remaja Di Sma Muhammadiyah 3 Yogyakarta. Universitas Alma Ata Yogyakarta. 2019*
6. *Devi P, Farapti. Hubungan Konsumsi Makanan Jajanan Dengan Status Gizi Pada Mahasiswa. . Media Gizi Indonesia. 2020; 15(1): 45–51*
7. *Nova L.H, Wanda L, Saskiyanto M. Hubungan Keberagaman Makanan, Makanan Jajanan Dan Aktivitas Fisik Dengan Status Gizi Remaja Di Kabupaten Labuhan Batu. Nutrire Diaita. 2020; Vol.12, No.02, Oktober 2020 ,p.45-51*
8. *Ilham Kamaruddin. Indeks Massa Tubuh (IMT) Terhadap Daya Tahan Kardiovaskuler. SPORTIVE: Journal of Physical Education, Sport and Recreation. 2020; Volume 3 Nomor 2 Maret 2020*
9. *Asako Y, et al. Imaging Spectrum Of Abnormal Subcutaneous And Visceral Fat Distribution. Educational Review. 2020; 11:24*
10. *Cahyo W, Dennys C,D. Hubungan Indeks Masa Tubuh Dengan Vo2max Pada Atlet Bolabasket. Physical Education, Health and Recreation. 2019; Vol. 3, No. 2*
11. *Kadek S.P.D, Widnyana, Nila W. Anak A.N.T.N.D. Hubungan Indeks Massa Tubuh (IMT) Dan Aktivitas Fisik Dengan Daya Tahan Kardiovaskuler Pada Remaja Di Denpasar. Majalah Ilmiah Fisioterapi Indonesia. 2022; Vol 10 No 1 : 38-42*
12. *Yuli M, Cica M. Hubungan Antara Status Gizi Dan Aktivitas Fisik Dengan Kebugaran Kardiorespirasi Pada Siswa Umur 8 - 14 Tahun Smp Muhammadiyah Plus Kota Batam. MENARA Ilmu. 2022; Vol. XVI No 01*
13. *M Fauzan Abdillah Rasyid. Pengaruh Asupan Kalsium Terhadap Indeks Masa Tubuh (IMT). Jurnal Medika Hutama. 2021; Vol 02 No 04*
14. *Musdalifah. Hubungan Indeks Massa Tubuh Dengan kebugaran Kardiorespirasi Pada Siswa Sekolah Menengah Atas It Pondok Pesantren Putri Darul Istiqamah Maros. Universitas Hasanuddin Makassar. 2022*
15. *Musdalifah, Irianto, Dian A.N. Hubungan Indeks Massa Tubuh dengan Kebugaran Kardiorespirasi pada Siswa Sekolah Menengah Atas IT. Jurnal Fisioterapi dan Rehabilitasi. 2023; Vol. 7 No. 1 :53-67*
16. *Nadya Gantarialdha. Hubungan Indeks Massa Tubuh Terhadap Ketahanan Kardiorespirasi Dinyatakan Dalam Vo2max. Jurnal Medika Hutama. 2021; Vol 02 No-04*
17. *Gusti PADDS, Agung WP, Made AY. Hubungan Indeks Massa Tubuh terhadap Daya Tahan VO2Max pada Pemain Bulu Tangkis. Jurnal Pendidikan dan Konseling. 2022 ;Volume 4 No. 4*
18. *Itmam Fuadi. Hubungan Indeks Massa Tubuh Dengan Tingkat Vo2max Siswa Jalur Prestasi Olahraga Sman 2 Kebumen Jawa Tengah. Fakultas Ilmu Keolahragaan Dan Kesehatan Universitas Negeri Yogyakarta. 2023 ; Hlm 77-78*
19. *Ni Made R, Ari W, I Putu Gde Adiatmika, I Nyoman A. Lingkar Pinggang Dengan Tingkat Konsumsi Oksigen Maksimal Pada Mahasiswa Fisioterapi Fakultas Kedokteran Universitas Udayana. MIFI : Majalah ilmiah fisioterapi Indonesia. 2022 ;Volume 10 No. 2, Hlm 74-78*
20. *Yuan L, Xiaojian Y, Feng Z, dkk. Relationship between waist circumference*

and cardiorespiratory fitness in Chinese children and adolescents: Results from a crosssectional survei. Journal of Exercise Science & Fitness. 2020. Volume 20 No. 1; Hlm 1-8

21. *Andrew O, Samantha MM, Christina S, dkk. Differential relationships between waist circumference and cardiorespiratory fitness among people with and without type 2 diabetes. Preventive Medicine Reports. 2020.*