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The Effects of the 6-Minute Walk Test on Physiological Responses in the Young Obese Population Compared with Healthy Individuals and Their Interaction Effects with Demographic Characteristics

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Abstract

Background: 6-minute walk test are widely used in healthcare settings due to their simplicity of management, resemblance to everyday tasks, and absence of special tools. The six-minute walk test is frequently applied to evaluate functional ability in both healthy and ill persons.
Objective: To determine the Effects of 6-minute walk test on Physiological Responses in the Young Obese population compared with healthy individuals and their interaction effects with demographic characteristics
Methods: A Quasi-experimental study design was carried out in Gyms and colleges after being approved by the Institution. The study group consists of 70 participants, which were divided into two groups of 35 in each group (Healthy and obese young adults). According to BMI, the Normal subject is between 18.5-24.9 Kg/m2 and the Obese is >30 Kg/m2 and age limit is from 20 to 40 years.

$$\text{Body mass index (BMI)} = \frac{\textbf{Weight}}{\textbf{Height}^2}$$

Participants of both genders (Male and Female) were selected, who are readily available and meet the inclusion criteria from Gym, and colleges. Written informed consent was obtained by all of the participants. information such as their name, age, gender, religion, marital status, employment, educational qualification, height, weight, medication usage, medical history, and physical examination. Participants were excluded if they had a resting heart rate (HR) of ⩾100 beats per minute, systolic blood pressure >139 mmHg, diastolic blood pressure > 89 mmHg, any illness or medication use that may interfere with standard walking proficiency (such as compromised sensation or reasoning, digestive, cardiovascular and cardiac, or the use of walking aids), participated in typical strong sports, or had uncontrollable heart arrhythmias. Ethical concerns were taken into account during the operation.
Results: In our study, the BP, HR, Temperature, SPO2, rate of perceived exertion (RPE) and blood sugar random BSR was used to assess physiological responses. The baseline vitals test showed a significant difference between the two groups. At baseline, there was a significant difference ($p<0.05$) between the two groups except RPE which was not significantly different for healthy and obese group**.**
Conclusion: But more precisely in terms of physiological responses as determined by the 6-Minute Walk Test (6MWT), healthy individuals outperformed obese ones. Blood pressure, heart rate, RPE, SPO2 and BSR were altered in both groups, but only SPO2 was the same after 6MWT in healthy individuals.

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Keywords: BMI, physiological responses, and demographic characteristics

Introduction

Obesity and overweight have become one of the most emerging global domestic health issues that are closely linked to morbidity and early death (1-4). Obesity rates have increased significantly not only in the developed but also in the developing world, including that of Pakistan. The accelerated urbanization, lack of physical exercise, high level of intake of high-calorie processed foods, and decrease in physical activity have also served as a great contribution to this ever-increasing epidemic (5, 6).

Obesity has been strongly associated with non-communicable illnesses, including hypertension, type 2 diabetes mellitus, dyslipidemia, and cardiovascular disease, and all these diseases carry significant health and economic consequences (7, 8). Body mass index (BMI) is extensively utilized to categorize the nutritional status, and the range between 18.5 and 24.9 kg/m 2 is regarded as normal, and the range of 30 and above as obese (9-11). Obesity and, more so, central adiposity are linked to poor cardiopulmonary efficiency and high demands as well as low exercise tolerance (12, 13). Obese people also have a lot of dyspnea, premature fatigue, higher heart rate response, and perceived exertion with exercise. Such physiological changes could affect their functional ability and quality of life (14, 15). Functional capacity is a combined reaction of the cardiovascular, respiratory, and musculoskeletal systems to physical exercise. The six-minute walk test (6MWT) is a cheap, secure, and easy submaximal exercise test that is used extensively to measure functional performance of normal individuals and chronic disease patients (13, 16). It captures the capacity to conduct day-to-day exercise and gives valuable data on the tolerance of exercise and physiological response, such as alterations in heart rate, blood pressure, oxygen saturation, and perceived exertion (16).

There may be increasing concern about the increased prevalence of obesity, especially among young people, and the resulting health disparities among persons who are considered healthy. The objective of this research is to find out more regarding how bodily reactions differ among the two groups undergoing common standardized exercise tests, such as the 6MWT, and additionally how demographic variables might influence this, so as to provide improved clinical assessment and management choices for obese people. This can help medical professionals customize therapeutic strategies and actions to improve functional results in this population. There may be little information on how weight affects proficiency on this test in young individuals. Investigating this can reveal knowledge on the therapeutic utility of the 6MWT in the context of obesity. Evaluating the physiological responses to six minutes of walking in obese and normal populations, in addition to how they connect to demographic factors, to encourage healthy behaviors. (In obese individuals, body mass index, hypertension, respiration rate, saturation of oxygen, temperature, gender as well, height, weight, and blood sugar levels).

Literature Review

One of the most commonly used anthropometric measurements for nutrition status and body composition of various populations is body mass index (BMI). Previous research has shown that BMI is strongly correlated with multiple physiological responses such as cardiac output, ventilatory efficiency, metabolic rate and exercise capacity. People with higher BMI tend to have higher resting heart rate, higher blood pressure, higher oxygen consumption during physical activity, and lower cardiorespiratory fitness than people who have normal BMI (17, 18). On the other hand, an underweight person can have diminished physical strength, reduced stamina and metabolic reaction. BMI has been shown in numerous studies to affect the physiological response to exercise and thus is a significant predictor of physiological outcomes such as functional capacity (12, 13). Demographic factors like age, gender, socioeconomic factors, education, and lifestyle factors also have a substantial influence on BMI and/or physiological responses. Growing age has been associated with changes in body composition, decreased metabolic rate, and changes in cardiovascular responses in studies, reported. Gender differences have also been noted, in that males and females exhibit different fat distribution, muscle mass, and physiological response to exercise (5, 6). Moreover, there is a relationship between socioeconomic and cultural factors and dietary patterns, physical activity, and access to health services, which impacts BMI as well as physiological health outcomes. The relationship between BMI, physiological responses and socio-demographic variables is critical to identifying population-specific health risks and targeted interventions to optimize health and wellbeing (5, 6).

Objectives

To determine the Effects of 6-minute walk test on physiological responses in the young obese population compared with healthy individuals and their interaction effects with demographic characteristics

Hypothesis

Research Hypothesis

After the 6-minute walk test, there will be a difference in physiological responses between healthy and obese adults.

Null Hypothesis

After a 6-minute walk test, there will not be a difference in physiological responses between healthy and obese adults.

Materials and Methods

Sixty participants were recruited in this quasi-experimental study, and the study was undertaken over a span of six months after the institutional research board gave the go-ahead. The sample was chosen by convenience and split into two equal groups of obese and a healthy control group comprising 35 people each. The research was conducted in gyms and colleges. Both male and female subjects between 20 and 40 years were involved. The classification of body mass index was based on world health organization, and normal weight was a bmi between 18.5 and 24.9 kg/m 2 and obesity was a BMI above 30kg/m 2. Individuals were not included in the study when their rest heart rate was 100 or more, systolic pressure was higher than 139mmhg, or diastolic pressure was more than 89mmhg. Patients having any health condition or drug use that might disrupt normal walking capacity such as metabolic, cardiac, neurologic, or orthopedic diseases, impaired cognition or sensation or the use of walking aids were also excluded. Besides, the study did not involve individuals who did regulated exercises or sports activities on a regular basis. The six-minute walk test (6mwt), self-administered demographic survey and physical exams were used as the data collection methods. The parameters measured physiologically were the bmi, blood pressure, heart rate, oxygen saturation, body temperature, and random blood glucose levels. Measurement equipment consisted of pulse oximeter, weighing scale, a sphygmomanometer, a thermometer, a stopwatch, a measuring tape, and cones to mark the walking distance.

Data collection procedure

This quasi-experimental study was carried out in gymnasiums and colleges in Abbottabad, KPK, Pakistan, upon receiving the permission of the Institutional Ethical Research Council. Convenience sampling was used to recruit 70 participants who were separated into two categories, 35 obese young adults and 35 healthy controls. The participants were both male and female between the age of 20 and 40 years. Body mass index (BMI) was determined as a weight (kg)/height (m 2), where normal weight was considered to be 18.524.9 kg/m and obesity was considered to be more than 30kg/m 2 in accordance with the World Health Organization standards. The inclusion criterion was that the participants should have appeared healthy and should have had the BMI and age criteria met. The exclusion criteria were a resting heart rate of 100 beats per minute or higher, systolic blood pressure of 139 mmHg or more, diastolic blood pressure of 89 mmHg or more, or any medical history or drug use that could affect the performance in walking. Those who participated in organized sporting activities on a regular basis were also not included. All the participants provided informed consent before data collection in written form.

The measurement of height and weight was done with the subjects in light clothes and barefoot. Prior to the test, the participants were allowed to rest in a seated position for 10 minutes, and baseline measurements of blood pressure, heart rate, oxygen saturation (SpO 2), temperature, and random blood glucose were taken. The Six-Minute Walk Test (6MWT) was conducted as per the American Thoracic Society with the help of a 30-meter marked course. They were instructed to walk at their usual and fastest possible speed for six minutes, and regular encouragement of the participants was given with standardized encouragement. They were free to pause when they needed to, but they were advised to continue walking within the shortest time possible. Heart rate, blood pressure, oxygen saturation, temperature, blood glucose, and rate of perceived exertion (RPE) in the Borg scale were measured immediately after the test completion. Floor markings and measuring tape were used to measure the total distance that was covered in six minutes. The used equipment was a sphygmomanometer, pulse oximeter, glucometer, weighing scale, thermometer, stopwatch, measuring tape, and cones.

Results

35 of the 70 people in our study were in good health, while the remaining 35 were obese. Table 1 shows that there were 34 women and 36 men in our data. Thirty-four married people and thirty-six single people participated. There was one unskilled participant and 69 educated participants. The average participant age was 28.01±5.98. 41.4% were students, making up the majority.

Table 1: Demographics

Variable		Frequency (n)	Percentage %
Gender	Female	36	51.4
	Male	34	48.6
Marital Status	Married	34	48.6%
	Unmarried	36	51.4%
Qualification	Educated	69	98.6%
	Uneducated	1	1.4%
Occupation	Married	06	33.3%
	Unmarried	12	66.7%
Mean Age	N	Mean±**SD**	
	70	28.01±5.98	

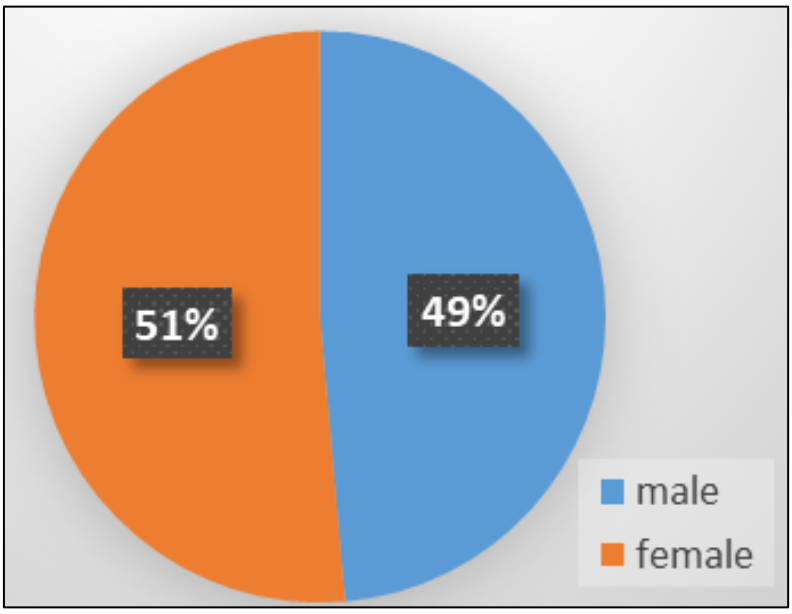

Figure 1: Distribution of gender in the data

Depending on the normality of data, for within-group changes Wilcoxin sign rank was used, and for between-group comparison, Mann Whitney U test was used.

Table 2: Normality Tests

Variable	Normality P value (Kolmogrov)
BP	.001
HR	.001
TEMP	.001
SPO2	.001
RPE	.001
BSR	.001

Between Group Analysis

In our study, the BP, HR, Temperature, SPO2, rate of perceived exertion (RPE) and blood sugar random BSR was used to assess physiological responses. The baseline vitals test showed a significant difference between the two groups. At baseline, there was a significant difference ($p<0.05$) between the two groups except RPE which was not significantly different for healthy and obese group**.** (Table 3) Following 6MWT intervention, there was still a significant difference($p<0.05$) between the two groups' BP, HR, SPO2, RPE, Temp and BSR. (table4).

Table 3: Between the group difference at baseline values in Both group at baseline (Mann whitney U test)

Characteristic	Group	Mean Rank	P value
BP	Obese	41.33	0.012
	Healthy	29.67	
HR	Obese	46.11	0.001
	Healthy	24.89	
TEMP	Obese	49.50	0.001
	Healthy	21.50	
SPO2	Obese	23.71	0.001
	Healthy	47.29	
RPE	Obese	35.50	1.00
	Healthy	35.50	
BSR	Obese	42.44	0.004
	Healthy	28.56	

Table 4: Between the group difference in Both group after 6MWT (Mann whitney U test)

Characteristic	Group	Mean Rank	P value
BP	Obese	40.87	0.023
	Healthy	30.13	
HR	Obese	48.81	0.001
	Healthy	22.19	
TEMP	Obese	47.86	0.001
	Healthy	23.14	
SPO2	Obese	26.39	0.001
	Healthy	44.61	
RPE	Obese	52.03	0.001
	Healthy	18.97	
BSR	Obese	41.64	0.011
	Healthy	29.36	

Within Group Analysis

BP, HR, Temp, BSR and RPE scores were significantly improved ($p<0.05$) in healthy individuals after 6MWT.Value of oxygen saturation(spo2) did not showed significant difference before and after 6MWT. In obese group all vital scores were improved after 6MWT. ($p>0.05$) (Table 5,6)

Table 5*:* Difference between BP, HR, Temp, SPO2, RPE and BSR at different times of measurement in Healthy group (Wilcoxin sign rank-test)

Characteristic	Time	Mean Rank	P value
BP	Pre	.00	0.001
	post	18.00	
HR	Pre	.00	0.001
	post	18.00	
TEMP	Pre	31.50	0.001
	post	15.50	
SPO2	Pre	21.73	0.413
	post	13.06	
RPE	Pre	.00	0.001
	post	18.00	
BSR	Pre	18.49	0.001
	Post	1.50	

Table 6: Difference between BP, HR, Temp, SPO2, RPE and BSR at different times of measurement in Obese group (Wilcoxin sign rank-test)

Characteristic	Time	Mean Rank	P value
BP	Pre	.00	0.001
	post	18.00	
HR	Pre	.00	0.001
	post	18.00	
TEMP	Pre	.00	0.001
	post	15.50	
SPO2	Pre	21.80	0.005
	post	9.62	
RPE	Pre	.00	0.001
	post	18.00	
BSR	Pre	18.00	0.001
	Post	.00	

Discussion

The mean age of the participants was 28.01±5.98. Both groups' physiological responses changed after completing 6MWT; however, there was no discernible difference between pre and post oxygen saturation in healthy adults. However, healthy individuals significantly outperformed the obese in terms of maintaining physiological responses.

In 2021, JP Porcari and colleagues created formulas to forecast VO2peak and VT based on walking performance and terminal RPE during the 6MWT. In accordance with the American Thoracic Society's standards, 63 clinically stable individuals enrolled in a cardiac rehabilitation program completed the 6MWT. On a scale of 6 to 20, the participant gave their terminal RPE at the conclusion of each walk. Their findings, which mirrored our findings that RPE changed in both healthy and obese persons after a 6-minute walk test, showed that terminal RPE improved following the walk test regimen(19).

In 2016, M Lang *et al*. sought to evaluate the blood pressure response to submaximal exercise in hypertensive lowlanders who had recently been exposed to high altitude. In three different conditions, 89 study participants with moderate hypertension completed a six-minute walk test: at sea level off-treatment; at sea level following 6 weeks of double-blind therapy, the distance walked in 6 minutes at high altitude decreased by roughly 10% in both groups ($p < 0.001$), with no therapy-related differences. Both groups' blood pressure rose with height, although it was still lower on telmisartan/nifedipine than on placebo before and after exercise ($p < 0.001$). Compared to a placebo, active therapy mitigated the elevation-induced rise in systolic blood pressure brought on by exercise. Acute exposure to high altitude improves the blood pressure response to a 6-minute walk test in mild hypertensives. In our study, BP responses were already different at baseline in healthy and obese adults, they significantly altered in both group after 6MWT (20).

J Huang *et al*. examined these correlations in 2024 in 98 AHF patients who were part of the ROSE study. Any death or readmission to the hospital within six months of randomization was the main outcome. Hazard ratios, which are determined by dividing blood pressure immediately after 6MWT by blood pressure prior to 6MWT, were calculated to assess the risks associated with a rise in post-exercise blood pressure levels and BP ratios. Average blood pressure was 110.6/117.5 mm Hg for SBP and 61.9/64.7 mm Hg for DBP prior to and following 6MWT.The likelihood of negative health outcomes was reduced by higher blood pressure levels and blood pressure ratios just after 6MWT. According to our findings, 6MWT-related blood pressure levels and responses may help improve risk assessments for patients admitted with AHF and may support additional research into the creation of HF prevention measures. Our results were reproduced in this investigation, which demonstrated positive effects on blood pressure and heart rate functional ability that were on par with pre-6MWT levels. Because the identical exercises and protocol were followed by all 70 of our supervised individuals, blood pressure changed in both the healthy and obese groups(21).

According to DJ Lachant's 2020 study Patients receiving PAH treatments, stable PAH patients, and healthy controls all underwent paired 6MWT with continuous ECG monitoring. They measured changes in peak heart rate, duration above age-adjusted maximum projected heart rate, and heart rate at 6 minutes. They also computed heart rate expenditure (HRE) by integrating pulse during 6MWT and dividing the result by walk distance. Vital physiological information that accounts for effort is provided by continuous heart rate monitoring during 6MWT. In stable patients, Heart rate seems to improve test reliability when detecting change after therapy is added, in contrast to walk distance alone. Our results, however, indicated that after 6MWT, patients healthy or obese both had improved cardiopulmonary physiological responses with a 6MWT noticeably better result. which is solely due to the 6-minute walk test being developed in the hospital. Home environments can be distracting and make it challenging to finish such challenging assessments, which makes direct supervision challenging(22).

The goal of H. Du *et al*.'s 2017 study is to present the findings of the application of the 6MWT to evaluate physiological response in chronic heart failure (CHF). Peak VO2 is not accurately reflected by 6 min WT distance. There aren't many clinically significant variations in the 6MWT distance, and further metrics like heart rate recovery can help understand the results so that therapy choices can be made. By using information technology and mobile apps to measure the 6MWT distance, the utility of this straightforward walk test is increased, and patients with CHF can be monitored remotely more effectively. However, care must be taken when interpreting the 6MWT distance. The 6MWT has the potential to make it easier to monitor residents of rural and isolated locations thanks to technological advancements. Our findings reflected findings of this investigation and showed that 6MWT produced even better results in healthy persons than in obese ones (23).

In 2024, Giontella *et al*. conducted a cross-sectional study with the goal of comparing the performance and

hemodynamic parameters of children who were obese or overweight vs those who were normal weight before and after a 6MWT. Trans fatty acids, body mass index, waist-to-height ratio, and fat mass by all exhibited inverse relationships with oxygen saturation and direct relationships with pre- and post-test hemodynamic measures like RPP. In this moderate-intensity test, Obese children performed worse and showed an increased hemodynamic response. Obesity in childhood may be a risk factor for hemodynamic stress, which may have detrimental effects in later life. Early action is necessary to disrupt this loop. Similarly, in our study, following 6MWT, healthy participants' BP, HR, Temp, BSR, and RPE ratings significantly improved ($p<0.05$). Scores Before and after 6MWT, there was no discernible change in oxygen saturation (spo2), which might be because healthy people already had higher spo2. Following 6MWT, all vital scores improved in the obese group.($p>0.05$)(24).

Limitations of Study

- It was challenging to attempt cardiopulmonary system assessment, exercise supervision, patient reactions in all conditions, in obese individuals. Additionally, this strategy required additional work to adjust for rules, technology, and the training of many therapists.
- First off, the sample size is somewhat constrained and heavily "convenience-based." It might be difficult to extrapolate this to adults of different ages and places. The study's o nature and cross-sectional methodology preclude any inferences on causal relationships between the associations that were found.
- When it was necessary to conduct an examination or intervention in a room that was also used by other family members. It wasn't comfortable.

Conclusion

But more precisely in terms of physiological responses as determined by the 6-Minute Walk Test (6MWT), healthy individuals outperformed obese ones. Blood pressure, heart rate, RPE, SPO2 and BSR were altered in both groups but only spo2 was same and after 6MWT in healthy individuals.

Recommendations

- Following sufficient training and monitoring to enable safe and efficient use of 6MWT should be taught to therapist as well as patients.
- Larger population with other comorbidities of DM and HTN will help generalize results in future
- Since the primary focus of our study was 6MWT, more research is necessary to fully comprehend other characteristics and limitations that might account for distractions in cardiac endurance and physiological responses.
- Future studies should also focus on analyzing the persistence and adherence of these protocols in rehabilitation programs.

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