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# ASSOCIATION OF SIX MINUTE WALK DISTANCE WITH DIFFERENT BODY MASS INDEX IN HEALTHY YOUNG ADULTS

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## ABSTRACT

**Introduction:** Normal health is state of complete physical, mental and social well-being and not merely the absence of disease or infirmity**.** Assessment of functional exercise capacity has gained importance in evaluation. Timed walking tests are widely used to evaluate functional exercise performance. The ability to walk for a distance is a quick, easy, and inexpensive way to assess the physical function and also an important component of quality of life as it reflects the ability to undertake day-to-day activities. According to the American Thoracic Society Guidelines for Six Minute walk test age, gender, height, and weight can affect 6-minute walk distance independently. So while measuring the distance these things should be considered and taken into account. This study was attempted to find association between six minute walk distance with different body mass index in healthy young adults. **Objective:** To find the association of different body mass index (Normal – group A, Underweight – group B and Overweight – group C) with six minute walk distance in healthy young individuals. **Method:** Ethic's approval and written informed consent of the subjects was taken prior to study. Procedure and purpose of the study was explained to the participants. In this study male & female between age group of 18 to 24 years who were willing to provide informed consent and medically fit for testing procedure were included. Any presence of musculoskeletal, neuromuscular and cardiovascular problems, and doing

significant physical daily acidities (i.e. yoga, aerobics, pranayama, gym activity, etc.) were excluded. Outcome measure was Six minute walk Distance. (Distance covered during six minute walk test) **Result:** When the whole data was analyzed it was found that BMI is weak negatively correlated with 6MWD. And statistically the result was not significant for any of the Body Mass Index. **Conclusion:** This study found that there is positive and non - statistical significant correlation of Six minute walk distance (6MWD) with BMI in Group A and Group C. There is negative and statistically non - significant correlation was found between 6MWD and Group B.

**KEY WORDS:** Six minute walk test distance, Body mass index, Rate of perceived exertion.

## INTRODUCTION

Our country is facing dual burden of underweight and overweight.[1] Approximately 43-48% of Indian man and woman of 15 - 45 years of age group are facing this dual burden, out of which 30-36% people are underweight and 9-13% people are overweight.[1] Underweight due to under-nourishment is most common problem in developing countries and it is burning issue in our country.[2.3] Though underweight is commonly seen in rural areas, it is not uncommon in urban areas.

India is a diverse country, and many states in India are passing through an epidemiological health transition with high rates of urbanization. Urbanization has led to economic improvement, the consequences of which are increased food consumption, tobacco-use, and decreased physical activity. One of the effects of this economic transition is a shift in the disease spectrum from communicable to non-communicable diseases (NCDs).[4] NCDs, especially cardiovascular disease, diabetes mellitus, and stroke, have emerged as a major public-health problem in India. The morbidity and mortality in most productive phase of life is posing serious challenges to Indian society and economy.[5] Some modifiable risk factors for the NCDs which were declared by WHO via Global Health Observatory are tobacco use, physical inactivity, unhealthy diet, and the harmful use of alcohol that lead to four key metabolic/physiological changes like raised blood pressure, overweight/obesity, raised blood glucose and raised cholesterol.

The prevalence of overweight and obesity is escalating rapidly worldwide. Some scientists concluded that obesity has already reached epidemic proportion in developed countries and their observation is that the developing world might fall into its grip very soon.[6]

Overweight is a problem of increasing prevalence in different age groups that may lead to many health problems in later life. It is becoming a serious problem which might be due to poor eating habits and sedentary lifestyle. Overweight population are at a risk for health problems that can follow them into adulthood, such as type 2 diabetes, high blood pressure, asthma, high blood lipids, sleep apnea, orthopedic problems and reduced functional capacity.

The assessment of functional capacity reflects the ability to perform activities of daily living that require sustained aerobic metabolism. The integrated efforts and health of the pulmonary, cardiovascular, and skeletal muscle systems dictate an individual's capacity. Numerous investigations have demonstrated that the assessment of functional capacity provides important diagnostic and prognostic information in a wide variety of clinical and research settings.[7]

The individual response to exercise is an important clinical assessment tool because it provides a composite assessment of respiratory, cardiac, and metabolic system. Several maximal and submaximal tests are used for assessing cardiopulmonary function. The current gold standard for assessing one's aerobic exercise response is the maximum incremental cardiopulmonary exercise test performed at maximal levels of exertion. It puts more loads on physiological systems of human body and may pace externally.

The level of exertion may decide the intensity of any physical activity.

The measurement of maximal oxygen uptake ($VO_2$max) can be measured directly. But its indirect measurement during the maximal exercise test continues to be a gold standard for determining the cardio vascular fitness. As there are numbers of limitations to directly measuring $VO_2$max. these limitations includes logistical issues (eg., cost, time, staffing).

However, most daily activities are performed at submaximal level of exertion; thus, using submaximal functional tests would be a more realistic simulation of one's physical capability.[8]

Assessment of functional exercise capacity has gained importance in evaluation of patients in various disease states. Timed walking tests are widely used to evaluate functional exercise performance. The ability to walk for a distance is a quick, easy, and inexpensive way to assess the physical function of an individual. It is also an important component of quality of life as it reflects the ability to undertake day-to-day activities.[9]

These simple tests require minimal equipment and within their limitations, provide valuable information about general exercise capacity and measure therapeutic changes.

Patients with cardiac and pulmonary diseases often present with limited activity level and exercise capacity, walk test is typically performed as a means of evaluating functional status, monitoring treatment effectiveness and establishing prognosis. A 12-minute performance test was then developed to evaluate the physical fitness of healthy individuals.[10]

This test was subsequently modified for use in patients with chronic bronchitis.[11] To allow patients with respiratory diseases for whom walking a 12-minute distance was too demanding, a shortened version of 6 minutes, was found to provide comparable clinical information.[12]

According to the American Thoracic Society Guidelines for Six Minute walk test age, gender, height, and weight can affect 6-minute walk distance independently. So while measuring the distance these things should be considered and taken into account. Some studies suggest the relation with height, weight.[13, 14, 15]

Whenever using any diagnostic tests, it should compare with normal population with specific demographics. That can give an idea about how much disparity is present in patients compared to age and gender matched normal population.

**AIM**

To find the association of different body mass index with six minute walk distance in healthy young individuals.

**MATERIALS AND METHODOOGY**

Normal health is state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.[16] Young is considered as 18 to 24 year old male & female according to standard provisional classification for age.[17]

The 6-minute walk test has been frequently used to measure outcomes before and after treatment in patients with moderate to severe heart and lung diseases. It has also been used to measure cardiopulmonary functional status and in epidemiologic research. The distance covered in 6 minutes (6 MWD) has been shown to accurately predict morbidity and mortality from cardiopulmonary diseases.[18]

Previous studies involving children using 6-minute walk test were performed in groups of diseased patients with physical dysfunction.[19, 20, 21, 22] Even it is known to reliable for physically disabled population.[23]

The test is used in many kinds of population and for the different ages and with different anthropometry values.[13, 14]

The Body Mass Index (BMI), or Quetelet Index, is a statistical measurement which compares weight and height. Though it does not actually measure the percentage of body fat, it may be a useful tool to estimate the healthy body weight based on height of a person. Due to its ease of measurement and calculation, it is the most widely used diagnostic tool to identify amount of body mass within a population including: underweight, overweight and obese. The formula is universally used in produced a unit of measure of $kg/m^2$.[24]

| **CLASSIFICATION** | **International classification of WHO, 2000[25] BMI ($Kg/m^2$)** | **Asian classification of WPRO, 2000[26] BMI ($Kg/m^2$)** |
|---|---|---|
| UNDER WEIGHT | <18.5 | <18.5 |
| NORMAL RANGE | 18.5-24.5 | 18.5-22.9 |
| PREOBESE | 25-29.9 | 23-24.9 |
| OBESE CLASS 1 | 30-34.9 | 25-29.9 |
| OBESE CLASS 2 | 35-39.9 | ≥30 |
| OBESE CLASS 3 | ≥40 | |

According to Current Comments by the American College of Sports Medicine "Rate of perceived exertion" is a psychophysiological scale, meaning it calls on the mind and body to rate one's perception of effort. It measures feelings of effort, strain, discomfort, and/or fatigue experienced during both aerobic and resistance training. One's perception of physical exertion is a subjective assessment that incorporates in formation from the internal and external environment of the body. The greater the frequency of these signals, the more intense is the perceptions of physical exertion.

Rating of Perceived Exertion: The Borg's RPE scale[SS] .[27]

| |
|---|
| 6 No exertion at all |
| 7 |
| 8 Extremely light |
| 9 Very light |
| 10 |
| 11 light |
| 12 |
| 13 somewhat hard |
| 14 |
| 15 hard (heavy) |
| 16 |
| 17 very hard |
| 18 |
| 19 extremely hard |
| 20 maximal exertion |

This Cross sectional study was conducted in the physiotherapy department of municipal hospital, Ahmedabad. Single session of the study was conducted over period of 4 months. Minimum sample size required for this study was calculated to be 24 subjects in each group according to 80% power of study.

Sample size was obtained using following formula.[28]

$n = (\sigma / \Delta)^2 (Z\alpha + Z\beta)^2$

Where σ = standard deviation, Δ=critically evaluable difference, Zα =level of significance, Zß = power of study.

According to pilot study the 6 MWD of underweight and overweight was taken in account to calculate sample size.

The 6 MWD in underweight was 674.29 ± 54.99 meters and 6 MWD in overweight was 624.48 ± 85.66 meters.

So, $n = (85.66 / 49.81)^2 (7.84)$

$= 23.18$

$= 24$

So, minimum sample size required for this study was calculated to be 24 subjects in each group according to 80% power of study.

Total of 75 subjects were taken.

Purposive sampling was used. The young healthy individuals from Ahmedabad community who met with our selection criteria and who were willing to participate in the study, they were offered the opportunity to participate in the study.

- **INCLUSION CRITERIA**

- Healthy young adults
- Age: 15 to 24 years.
- Willing to provide informed consent
- Medically fit for testing procedure**.**

- **EXCLUSION CRITERIA**

- Presence of any musculoskeletal, neuromuscular and cardiovascular problems which significantly decrease walking performance.
- Other significant clinical condition which could aggravated with physical function.
- Other significant physical daily acidities (i.e. yoga, aerobics, pranayama, gym activity, etc.) – that significantly can improve physical function.

Six minute walk distance (6 MWD) was taken as an outcome measure.

Ethical approval was obtained from the Institutional review board of General Hospital, Ahmedabad prior to the study. Those who fulfilled the inclusion criteria were included in the study. Whole procedure was explained to the participants. Written informed consent was obtained prior to the participation from all the subjects.

- **According to BMI subjects were divided into three groups**.

| | |
|---|---|
| Group A | Normal |
| Group B | Underweight |
| Group C | Overweight |

**RESULT**

In this study, the correlation test Bivariate analysis was used to analyze association of Six Minute Walk Distance with different Body Mass Index. Level of significance was kept at 5%. The following are the pie charts showing females and males distribution in different groups.

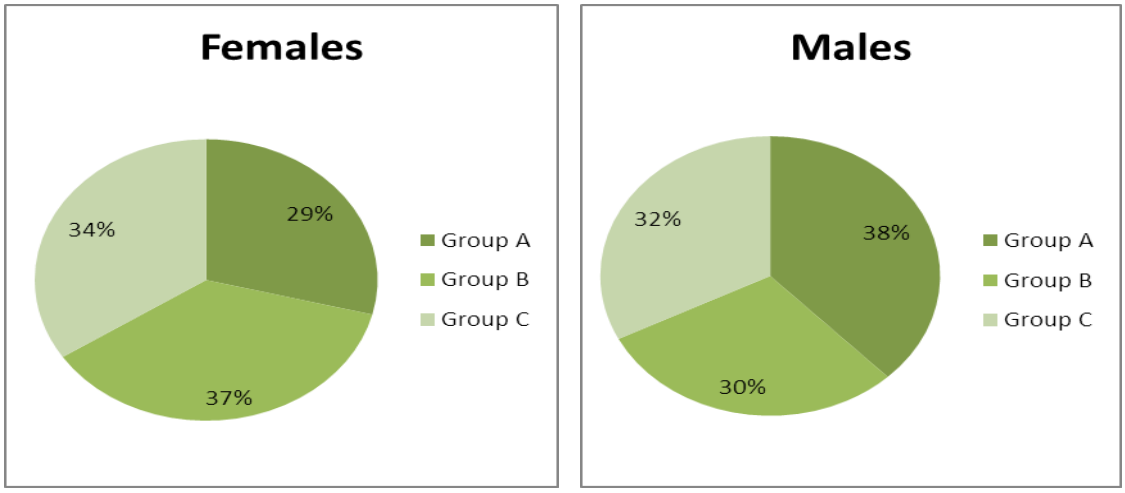


**Table - 1: Demographic data of subjects.**

**(**Mean ± Standard Deviation**).**

| Variables | Group A (n=25) | | Group B (n=25) | | Group C (n=25) | |
|---|---|---|---|---|---|---|
| | Females (11) | Males (14) | Females (14) | Males (11) | Females (13) | Males (12) |
| **Age (in years)** | 20.72 ± 2.170 | | 21.04 ± 2.071 | | 21.08 ± 1.7776 | |
| **Height (in meters)** | 1.70 ± 0.1024 | | 1.645 ± 0.078 | | 1.6436 ± 0.0976 | |
| **Weight (in Kilograms)** | 59.5 ± 8.640 | | 45.68 ± 4.828 | | 65.28 ± 8.9420 | |
| **BMI (in Kg/m$^2$)** | 20.2847 ± 1.221 | | 16.8846 ± 1.3624 | | 24.0439 ± 0.8080 | |

**Table - 2: 6MWD in different group.**

| Groups | (in meters) |
|---|---|
| **Group A** | 645.2716 ± 61.9864S |
| **Group B** | 630.2376 ± 64.2090 |
| **Group C** | 618.6632 ± 60.3366 |

**Table – 3: For Correlation of 6MWD with BMI.**

| Groups | Correlation Coefficient | Interpretation | Significance Level | Interpretation |
|---|---|---|---|---|
| **Group A** | 0.237 | Positive | 0.254 | Not Significant |
| **Group B** | -0.188 | Negative | 0.369 | Non-Significant |
| **Group C** | 0.222 | Positive | 0.287 | Non-Significant |

**DISSCUSSION**

The present study was conducted to find association of 6MWD with different BMI (Normal, Under and Overweight) and gender in healthy young adults with mean age of 20.72 ± 2.170 years in Group A, 21.04 ± 2.071years in Group B and 21.08 ± 1.777years in Group C. The mean 6MWD by subjects of Group A was 645.27 ± 61.986 meters, of Group B was 630.23 ± 64.209 meters and of Group C was 618.66 ± 60.336 meters.

The demographic characteristics of subjects in all three groups were similar. There were 25 subjects in all three groups.

In **Group A** 6MWD had statistically non-significant positive correlation with BMI (as correlation coefficient = 0.237 and p = 0.254) i.e., when BMI is increasing the 6MWD is increasing.

In **Group B** 6MWD had statistically non-significant negative correlation with BMI (as correlation coefficient = -0.188 and p = 0.369), i.e., when BMI is increasing the 6MWD is decreasing.

In **Group C** 6MWD had statistically non-significant positive correlation with BMI (as correlation coefficient = 0.222and p = 0.287), i.e., when BMI is increasing the distance covered is decreasing.

This might be due to the age that affects the physical parameters of individual. Younger subjects may be more motivated and anyways having more energy reserve than that of the elderly.

This study is in accordance with the study by Andrea L et al.[29] entitling the influence of the body mass index on self-report and performance-based measure of physical function in adult women. They concluded that women with severe obesity were most impaired. Adult women with less severe obesity also demonstrated significant decrements in physical function compare to normal and overweight women. Also conclude that Normal weight and Overweight shows similar physical function.

Body mass index appeared to have an influence on perception of functional abilities. The discrepancy between perception and ability may have resulted from greater perceived effort, the influence of symptoms such as pain, and/or lower physical activity level in the obese.[28, 30, 31, 32]

A study by J. Błaszczyk et al., shows Impact of excess of body weight on walking at the preferred speed and they showed that subjects from every experimental groups walked with a very similar speed (1.08 ± 0.2 m/s) and cadence (106 ± 10 steps/min). Their stance time was not affected by body weight. The temporal stride characteristics and the stance-to-swing ratio were substantially modified in obese individuals due to attenuation of the swing time. As a

consequence, phases of stride: the stance and the double support were relatively longer. While the swing time negatively correlated with the body mass index (BMI), while the normalized stance and the double support exhibited strong positive correlation (r=0.46) with the BMI. The increase of leg swing velocity seems the main and unique adaptation mechanism that is utilized in the preferred walking gait in obese women.[33]

Sahar A. et al., studied on Gait Parameters in Children with Different Weight Abnormalities with two hundred children with four weight categories of underweight, normal, overweight and obese, and found out that the obese children walked little distance with significantly slower gait speed by taking shorter steps with decrease in average step cycle than the other subjects when compared to normal weight children. While the results of the underweight children were better than the other groups but still less than the normal weight group.[34]

Body mass index, body composition may be used as a measure of risk factor for physical functioning was evaluated by Jean W. et al., showed that Fat mass seems to be a more important factor than appendicular muscle mass in determining walking speed in community-living older adults, even after adjusting for BMI which was measured with gold standard technique.[35]

The other study by Geiger R. et al.[36] also supports this result. They studied on Six-Minute Walk Distance in Overweight Children and Adolescents for seeing the effect of weight reduction program and found out that the exercise program is helpful to reduce weight and significant increase in 6MWD suggesting the improved physical capacity in them. The probable reason for this may be decreased metabolic demand for walking and enhanced physical fitness.

Iwama A. M. et al., studied on The 6MWT and body weight-walk distance product in healthy Brazilian subjects shows 6MWD and 6MWw variances were adequately explained by demographic and anthropometric attributes. Also mentioned Age, height, BMI, and gender significantly influenced the 6MWD.[37]

The model used by Enright and Sherrill[13] has demonstrated significance by correlating the body mass index with the distance covered. Troosters and colleagues,[38] have explained the variability of the walked distance as a consequence of the variation in weight and height as

well as in sex and age. These observations suggest that weight and height should be taken into account when the test results of different individuals are compared.

## CLINICAL IMPLICATION

The six minute walk test gives the important information about one's functional capacity. It is safer, easier to administer, better tolerated, and better reflects activities of daily living than other walk tests.

The result of present study suggests that while performing and comparing the test the demographics, i.e., height and weight, and gender should be taken into consideration. As the distance walked during six minute walk test may alter with alteration of these variables.

## LIMITATIONS

Daily activity level was not taken into consideration, though the subjects who were performing daily strenuous physical activities (like gym, yoga, pranayama, etc) were excluded. Age-range was smaller so the generalizability cannot be done to larger population. With Body mass index, the fat free mass of the body cannot be measured – which was not gold standard.

## FUTURE STUDIES

The same study can be carried out with selecting subjects on bases of their daily activities level. Different obesity classes can be taken into account. Higher age-ranges can be taken. Body fat analyzer can be used to measure fat free mass.

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## REFERENCES

1. National Family Health Survey (NFHS-3) 2005-06.
2. Shah C, Diwan J, Rao P, Bhabhor M, Gokhale P, Mehta H. Assessment of Obesity in School children. Calicut Medical Journal, 2008; 6(3): e2.
3. H. Shukla, P. Gupta, H. Mehta and J. Herbert. Descriptive epidemiology of body mass index of an urban adult population in Western India. Journal of Epidemiology and Community Health, 2002; 56: 876-880.

4. Mohan V, Deepa R. Risk factors for coronary artery disease in Indians. J Assoc Physicians India, 2004; 52: 95-7.
5. Reddy KS. Prevention and control of non-communicable diseases: status and strategies. New Delhi: Indian Council for Research on International Economic Relations, 2003; 30. (working paper no. 104).
6. Sharda Sindhu and Harleen Kaur Tatla. Prevalence of Overweight and Obesity among Adult Urban Females of Punjab: A Cross-Sectional Study. Anthropologist Special Issue, 2002; 1: 101-103.
7. Fleg JL, Pina IL, Balady GJ, Chaitman BR, Fletcher B, Lavie C, Limacher MC, Stein RA, Williams M, Bazzarre T. Assessment of functional capacity in clinical research applications: an advisory from the Committee on exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association Circulation, 2000; 102: 1591-97.
8. Salway S, Brook D Laccusse Y, Thomas S. A qualitative systemic overview of the measurement properties of functional walk tests used in the cardiopulmonary domain. Chest, 2001; 119: 256-70.
9. Guyatt GH, Sullivan MJ, Thompson PJ, Fallen EL, Pugsley SO, Taylor DW. The six minute walk: a new measure of exercise capacity in patients with chronic heart failure. Can Med Assoc J, 1995; 132: 919-23.
10. Cooper KH. A means of assessing maximal oxygen intake: correlation between field and treadmill testing. JAMA, 1968; 203: 201-4.
11. Mcgavin CR, Gupta SP, Mchardy GRJ. Twelve-minute walking test for assessing disability in chronic bronchitis. BMJ, 1976; 1: 822-23.
12. Butland RJA, Pang J, Gross ER, Woodcock AA, Geddes DM. Two-, six-, and 12-minute walking test in respiratory diseases. BMJ, 1982; 284: 1607-8.
13. Enright PL, Sherrill DL. Reference equation for six- minute walk in healthy adults. Am J Respir Crit Care Med, 1998; 158: 1384-87.
14. Gulman VAM, Van Veldhoven NHMJ, de Mecrk, Helders PJM. The six minute walk test in children with cystic fibrosis: reliability and validity. Pediatr Pulmonal, 1996; 22: 85-89.
15. Nixon PA, Jabwalk ML, Fricker FJ. A six minute walk test for assessing exercise tolerance in severely ill patients. J Pediatr, 1996; 29: 362-6.
16. Upton CJ, Tyrrell JC, Hiller EJ. Two minute walking distance in cystic fibrosis. Arch Dis Child, 1988; 63: 1444-48.

17. Mangell JPF, Hainswarth R. Assessment of respiratory function in patients with chronic obstructive airway disease. Thorax, 1979; 34: 254-58.
18. Hatem Alameri, Sulaiman Al-Majed, Abdelrahman Al-Howaikan. Six minute walk test in healthy adults Arab population. Respi Medicine, 2009; 103: 1041-1046.
19. Alfredo Chetta, Andrea Zaninib, Giovanna Pisic, Marina Aielloa, Panagiota Tzania, Margherita Nerib, Dario Olivieria . Reference value for 6 minute walk test in healthy subject 20-50 years. Respi Medicine, 2006; 100: 1573-1578.
20. Pier SR, Oliveira AC, Parreira VF, Britto RR. Six minute walk test at different ages and body mass indexes. Rev. Bras. Fisioster, 2007; 11: 131-34.
21. World Health Organization 2006.Constitution of world health organization- Basic documents, 45th edition, supplement, October 2006.
22. Provisional guidelines on standard international age classifications, series M, no.74, New York, 1982.
23. Albert M. Li, Jane yin, Jun T Au, Hung K So, Tony Tsang, Eric Wong, Tai F Fok, PakC Ng. Standard reference for 6 minute walk test in healthy children aged 7 to 16 years. AJRCCM, 2007.
24. World health organization, 2008; obesity and overweight.
25. World health organization: Obesity. Preventing and managing the global endemic. WHO technical report series no 894. WHO, Genava, 2000.
26. Annurad E, Shiwaku K, Nogi A, Kitajima K, Enkhmaa B, Shimono K, Yamane Y The new BMI criteria for Asians by the regional office for western pacific region of WHO are suitable for screening of overweight to prevent metabolic syndrome in elder Japanese workers. Journal of occupation health, 2003; 45: 335-343.
27. Karte G. Heart Disease. In: Susan BO, Thomas JS. Physical Rehabilitation; 5th edition. Jaypee, 2007; 616.
28. Hulens M, Vansant G, Claessens AL, et al. Predictors of 6-minute walk test results in lean, obese and morbidly obese women. Scand J Med Sci Sports, 2003; 13(2): 98-105.
29. Andrea L., Patrick J., et al. The Influence of Body Mass Index on Self-report and Performance-based Measures of Physical Function in Adult Women. Car Pul, 2011; 22(3): 11-20.
30. Mattsson E, Larsson UE, Rossner S. Is walking for exercise too exhausting for obese women? Int J Obes Relat Metab Disord, 1997; 21(5): 380-386.

31. Simonsick EM, Guralnik JM, Fried LP. Who walks? Factors associated with walking behavior in disabled older women with and without self-reported walking difficulty. J Am Geriatr Soc, 1999; 47(6): 672-680.
32. Browning RC, Kram R. Energetic cost and preferred speed of walking in obese vs. normal weight women. Obes Res, 2005; 13(5): 891-899.
33. J. Błaszczyk, M. Plewa, J. Cieślińska-Świder, B. Bacik, B. Zahorska-Markiewic, A. Markiewicz. Impact of excess body weight on walking at the preferred speed. Acta Neurobiol Exp, 2011; 71: 528–540.
34. Sahar A Khairy, Sahar A Ibrahim, Gihan A Fouad. Hoda A Abdel Salam. Gait Parameters in Children with Different Weight Abnormalities. Researcher, 2013; 5(1): 73-84.
35. Woo, Jean, Jason Leung, and Timothy Kwok. BMI, body composition, and physical functioning in older adults. Obesity, 2007; 15: 1886 –1894.
36. Geiger R, Strasak A, Treml B, Gasser K, Keinsasser A, Fischer V, Geiger H, Loekckinger A, Stein J. Six minute walk test in children and adolescents. Pediatr, 2007; 154: 395-399.
37. Knox AJ, Morrison JF, Muers MF. Reproducibility of walking test results in chronic obstructive airways disease. Thorax, 1988; 43: 388–392.
38. Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. Eur Respir J., 1999; 14s: 270-4.