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Original Research Article

Correlation between Body Mass Index (BMI) and Chest Expansion Values in Young Adult Females: A Cross Sectional Study

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ABSTRACT

Worldwide, non communicable diseases such as obesity, metabolic syndrome etc. are on the rise. An increased adiposity due to obesity has several systemic adverse effects, including those on the respiratory system. Physiotherapists have an essential role in the management of obesity by means of fitness training and medically supervised exercise programs. The objective of this study was to understand the direct correlation between Body Mass Index (BMI) and chest expansion. The chest expansion was evaluated using cloth tape measurement technique at 3 reference levels- axilla, nipple and xiphisternum. Data from 59 subjects, young adult females (aged 18-24 years) was collected and analysed. A weak negative correlation was obtained, which was not statistically significant. ($p > 0.05$). A direct correlation may thus be difficult to establish between the two variables and other confounding factors must be considered.

Keywords- Body Mass Index (BMI), Chest expansion, Obesity, Correlation, Young adults, cross sectional

INTRODUCTION

In the recent years, due to unhealthy lifestyle habits such as physical inactivity, imbalanced diet, alcohol consumption, stress, smoking, etc., the overall global incidence of non-communicable diseases such as obesity, hypertension, diabetes mellitus, metabolic syndrome, cardiovascular diseases, cancer and stroke is on the rise.[1] Obesity is a chronic metabolic disorder characterized by increased adiposity in the peripheral and visceral regions of the body.[2] It was earlier considered to be a disease of adulthood, but is now on the rise in young adults and children as well.[1-2] The effects of obesity on every system are well known, and it is, in itself, a risk factor for many systemic complications later in adulthood.[2-3] People with obesity may suffer from a wide range of psychosocial issues in addition to their musculoskeletal, respiratory, cardiovascular, digestive and metabolic issues and thus their quality of life may be affected.[4-5] Haomio Jia & Erica I. Lubetkin studied the impact of obesity on health-related quality of life in the general adult US population. It was found that subjects with obesity experienced more unhealthy days, associated with reduced participation in ADLs, and impaired mental health, thus significantly affecting the quality of life. Another study by Katherine M. Morrison et.al. studied the relationship between depression and health related quality of life with body composition in children and youth with obesity. It was found that 36.4% of the population with obesity also had association with depression.

Obesity adversely affects the respiratory system by causing a decrease in both, the lung as well as chest wall compliance. As the adiposity in the lower thoracic and upper abdominal region increases, there is reduction in the normal excursion of diaphragm. This leads to reduced lung volumes leading to increased work of breathing. In the long run, there is reduced lung compliance, and therefore obesity acts as a restrictive lung disorder.[2-3,6] At the same time, due to increased adiposity over the thoracic cage,[6] there is increase in work of breathing. The respiratory muscles are forced to work more in obese subjects as compared to counterparts with normal Body Mass Index (BMI). This leads to reduced chest wall mobility due to reduced muscle efficiency in the long run.[7-8]

The compliance of the respiratory system was studied by Naimark and R.M Cherniack in 24 normal and 12 obese subjects. Using spirometry, the lung volumes and capacities were measured. The results of this study showed that total respiratory compliance was reduced in obese individuals. An increase in the mechanical work of breathing was also shown in obese individuals.

As physiotherapists, we have an important role in management and prevention of the musculoskeletal and cardiorespiratory complications of obesity by means of exercise prescription and training. Safe and optimal training demands an adequate physiological response to the exercise.[9] Altered chest wall mobility and reduced lung volumes due to increased adiposity may compromise respiratory function and subsequent physiological responses to exercise. Both, the resting and exercising energy expenditure rates are increased in obese subjects, indicating higher exertion levels to optimize their responses to demands at rest and exercise.

Although measurement of lung volumes provides more accurate data regarding lung compliance, it requires sophisticated equipment of spirometry, which is not always feasible and is expensive to use. Also, it does not selectively study reduction in chest wall compliance.[7-8]

Measurement of chest expansion by tape method is a simple, reliable, bed side clinical assessment technique to assess the chest wall mobility.[10-12] It can be used as a tool for documentation during fitness evaluation of clients, and serial measurements at regular intervals can be used to evaluate the overall prognosis and improvement in the chest wall mobility of obese subjects following the prescription of comprehensive exercise protocols (that include aerobics, breathing exercises, yoga, resistance exercises, etc.)

Dayla Sgariboldi et. al. carried out a study to evaluate the influence of age, anthropometric characteristics and body fat distribution on women's thoracic mobility. They concluded that thoracic mobility decreases with age and obesity [6]. However, the study included participants over a wide age criteria (25-75 years). Age can be a significant confounding variable while determining the effect of increased Body Mass Index (BMI) on chest expansion, and therefore, we have considered only young adult females (18-24 years) as a part of our study, in order to better evaluate the effect of Body Mass Index (BMI) on the chest expansion. Moreover, very few studies have been carried out in young adult females in order to study the correlation of obesity with chest expansion values using tape measurement.[6] Most studies have used spirometry to study effects of obesity on lung volumes.[8] Therefore, the results of this study will help in better understanding the changes in chest compliance with variation in Body Mass Index (BMI). Including females only will facilitate better comparison of data and will eliminate gender-based bias in the study. [13]

Therefore, the aim and objectives of this study were as follows-

AIM: To find correlation between Body Mass Index (BMI) and chest expansion values in young adult females.

OBJECTIVES:

1. To calculate the Body Mass Index (BMI) of female young adult subjects using height and weight measurements.
2. To measure the chest expansion of subjects by tape method.
3. To find the correlation between Body Mass Index (BMI) and chest expansion values at the level of axilla.
4. To find the correlation between Body Mass Index (BMI) and chest expansion values at the level of the nipple.
5. To find the correlation between Body Mass Index (BMI) and chest expansion values at the level of xiphisternum.

METHODOLOGY

A Cross sectional correlation study was conducted over a period of 6 months (December 2020 to June 2021) in healthy young adult females. Young adult non exercising females (18-24 years of age) were considered for the study. Females with coexisting respiratory disease, with comorbidities (musculoskeletal, neurological, cardiac or endocrine) which may affect respiratory function, who were pregnant or lactating, who were suffering from psychological disorders including eating disorders, who had a history of pathological weight loss in last 6 months, chronic smokers and those actively participating in fitness programs were excluded from the study. Verbal advertisement was done. Subjects in the age group of 18-24 years were recruited from students, staff and clients coming to fitness OPD of KJ Somaiya College of Physiotherapy. They were screened for inclusion and exclusion criteria. The materials used for the study were an analog weighing scale and a cloth tape measure. Upon obtaining written informed consent, firstly the height and weight measurements were done. The Body Mass Index (BMI) was calculated and the class of Body Mass Index (BMI) was determined using WHO classification. [14-15] Next, chest expansion was measured using tape method. [16] Subject was in sitting position, with hands placed on the occiput. The measuring tape was placed on the chest and the subject was instructed to exhale out completely. This reading was noted. Next, the subject was asked to inhale deeply via nostrils. Measurement was made at the same level in a position of full inspiration. The difference between the two readings was noted and compared with normative data. [17]

The above measurements were taken at 3 levels-axilla (2^{nd} intercostal space), nipple (4^{th} intercostal space) and xiphisternum. [15] Three readings were recorded at each level and best of three readings were considered. Body frame type was noted. All necessary precautions were taken during the assessment of subjects, given the backdrop of the Covid-19 pandemic. The data was compiled and analyzed using the appropriate statistical tests. This was followed by interpretation of data and arrival at a conclusion.

The sample size was calculated using OpenEpi software. The level of significance was taken as 5%, confidence level as 95% and power 90%. Expected correlation coefficient between Body Mass Index (BMI) and chest expansion (at axillary level) as per the parent article was taken as – 0.42. The minimum sample size obtained was 55.

STATISTICAL ANALYSIS:

Table 1: Distribution of the subjects across various Body Mass Index (BMI) categories

SR. NO.	CATEGORY OF Body Mass Index (BMI)	NUMBER OF PARTICIPANTS
1.	Underweight (<18.5 kg/m2)	6
2.	Normal (18.5 to 24.9 kg/m2)	33
3.	Overweight (25.0-29.9 kg/m2)	10
4.	Obese grade 1 (30.0-34.9 kg/m2)	10
5.	Obese grade 2 (35.0-39.9 kg/m2).	No subjects

The estimated sample size for the study was 55. However, at the time of analysis, the data collection of a total of 59 participants was complete, and therefore the sample size (N) was considered as 59. All the subjects were females, the mean age being 21.83 years. Table no. 1 shows the distribution of subjects across various Body Mass Index (BMI) categories.

The statistical analysis was done using GraphPad Instat software (version 3.0). Table no.2 shows the mean, standard deviation and normality of the data obtained.

Table 2: Parameters obtained on Statistical analysis

Sr. No.	Parameters	Body Mass Index (BMI) (kg/m2)	Chest expansion values at axilla (cm)	Chest expansion values at nipple (cm)	Chest expansion values at the xiphisternum (cm)
1.	Mean	24.11	4.56	5.44	5.47
2.	Standard deviation (SD)	4.719	1.016	1.223	0.9992
3.	Normality test p value	0.0348	>0.10	>0.10	0.0647
4.	Passed normality test	No	Yes	Yes	Yes

The scatter plots for correlation between Body Mass Index (BMI) and chest expansion at each reference level were plotted subsequently and they are as follows-

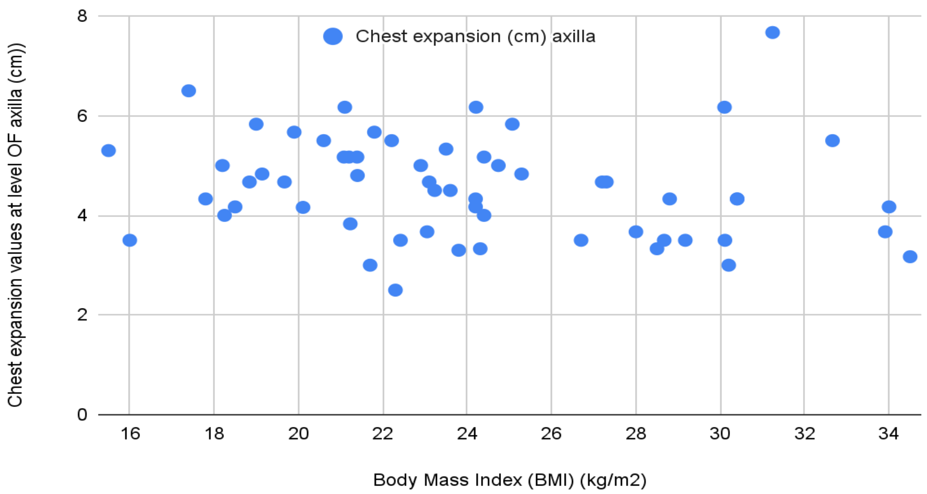

Figure (1). Correlation between Body Mass Index (BMI) and chest expansion values at axilla

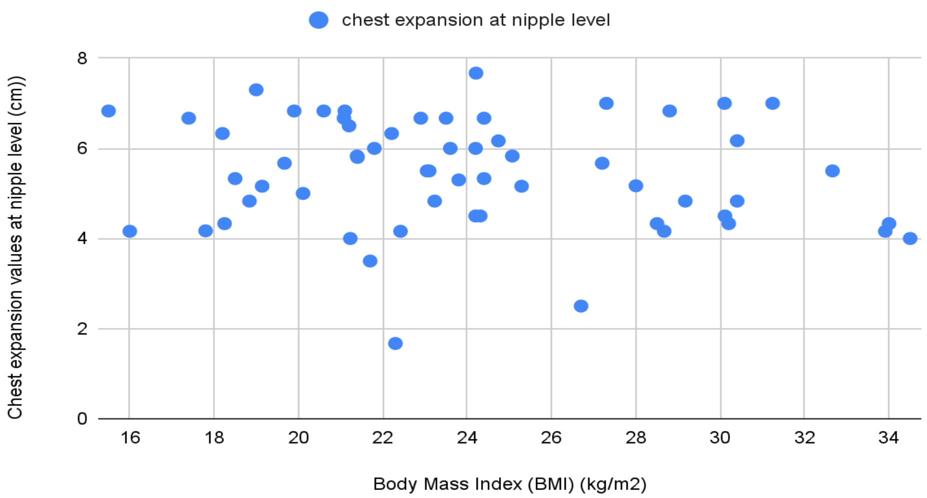

Figure 2. Correlation between Body Mass Index (BMI) and chest expansion values at the level of nipple

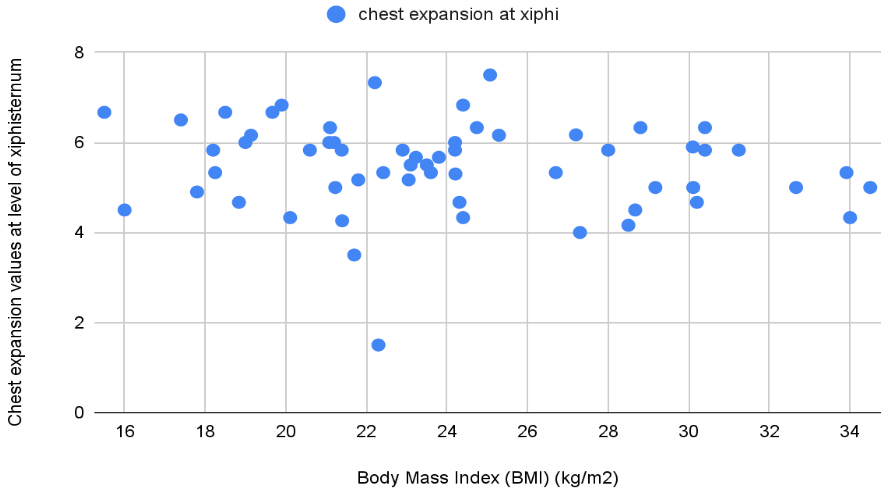

Figure 3. Correlation between Body Mass Index (BMI) and chest expansion values at the level of xiphisternum

The data passed Normality and therefore, Pearson correlation coefficient was used to analyse the correlation between Body Mass Index (BMI) and chest expansion at each reference level.

The statistical parameters namely, Pearson correlation coefficient (r), coefficient of determination (r squared), and p value obtained for each of the reference levels are as follows- (Table no. 3)

Table 3. Statistical parameters for each reference level

Parameters	At the level of axilla	At the level of nipple	At the level of xiphisternum
Pearson Correlation coefficient (r)	-0.1856	-0.1605	-0.1453
Coefficient of determination (r squared)	0.03446	0.02557	0.02113
p value	0.1592	0.2245	0.2720
Statistical significance	Not significant	Not significant	Not significant

RESULT

Table no. 3 shows that for each reference level, a large p value has been obtained (>0.05) at 95% confidence level. This signifies that there is a weak negative correlation between Body Mass Index (BMI) and chest expansion values, and it is not statistically significant.

DISCUSSION

By means of this study, an attempt was made to understand the direct correlation of Body Mass Index (BMI) with chest expansion values in young adult females. Statistical analysis revealed a weak negative correlation between Body Mass Index (BMI) and chest expansion values at all three reference levels and it was statistically not significant. This suggests that a complex relationship exists between the two variables and that there may be several other contributing factors that may affect chest wall mobility in conjunction with Body Mass Index (BMI). The results of this study imply that a true linear relationship may not exist between Body Mass Index (BMI) and chest expansion values in the young adult age group.

The body frame type, i.e. the characteristic pattern of body fat distribution for an individual may affect the chest expansion values. [18] An android body frame which comprises increased adipose tissue in the thoracoabdominal regions substantially increases the risk of non communicable diseases such as Type-2 Diabetes Mellitus, Hypertension, metabolic syndrome, etc [19]. Android obesity has therefore been likened to central obesity, and may affect chest wall mobility more than a gynoid body frame type, which signifies an increase in the adiposity in the gluteal and pelvifemoral regions of the body [18-19] Android obesity is said to be more prevalent in males and gynoid obesity, in females. However, at a higher Body Mass

Index (BMI), the body frames of both males and females resemble those of central obesity. [18-19]

There is a wide physiological variation amongst individuals in the respiratory biomechanics owing to differences in the shape, size and orientation of the costovertebral, chondrosternal and sternocostal articular surfaces. Larger and more mobile articular surfaces at these joints would mean a better excursion of the ribs during inspiration and expiration, overall contributing to better chest wall mobility.[20] Along with individual skeletal variations, several studies have also reported individual variations in the proportion of Type-1 and Type-2 muscle fibres in the respiratory muscles such as diaphragm, the intercostals, and the accessory muscles of respiration, namely, scaleni, sternocleidomastoid, pectoralis major, serratus anterior and so on.[21]

Like for every peripheral skeletal muscle, an optimum length-tension relationship must exist for muscles of respiration, in order to work at their maximum efficiency. A deviation from the optimal muscle length reduces its capacity of maximum force production, thereby affecting the work produced, in this case, being the excursion of the ribs during inspiration and expiration.[20]

Poor postural habits are a well-known cause of musculoskeletal dysfunction [22], with certain muscle groups showing a predilection for shortening (tightness) and the opposing muscle groups for weakness, due to lengthening.[22] A pre-existence of upper-crossed syndrome may cause alterations in respiratory mechanics, thereby affecting the chest expansion. [20-22]

Respiratory muscle strength is an important aspect of respiratory mechanics, especially in activities requiring heavy exertion and forced inspiration and expiration.[23] A study done by Fernanda de Cordoba Lanza et.al. reports that there is a relationship between chest wall mobility, respiratory muscle strength and lung volumes [24] Another study by Sarikaya et.al. confirms similar findings in obese patients and suggests the need to incorporate respiratory muscle strengthening exercises in training programs for obese patients.[23-24]

Kevin Triangto et.al. conducted a study on the biomechanical effects of forward head posture on the respiratory function. They reported that a prolonged forward head posture affects the respiratory mechanics [25]. Another study done by See Yoon Kim et.al. confirms similar findings in young adults. [26] Smartphone usage time can be attributed to cause postural dysfunction [20,22] and a study by Sang In Jung et.al. confirms that prolonged hours of smartphone use adversely affect both, posture as well as respiratory mechanics.[27] This shows that there is a need to address postural deviations in young adults in order to improve respiratory function.

CONCLUSION

A weak negative correlation between Body Mass Index (BMI) and chest expansion was noted and it was not statistically significant.

The results of the study indicate that a direct correlation between Body Mass Index (BMI) and chest expansion values may be difficult to establish, and that a complex, multifactorial relationship exists between the two variables. Further research is needed in this domain to better understand the same.

Research concerning obesity and other non-communicable diseases are ever-evolving. Therefore, it is of utmost importance that clinicians and researchers stay abreast of the latest developments in this field, in order to formulate the best practices and provide the best available treatments and fitness programs to the concerned patients. Evidence based clinical practice must be encouraged.

At this juncture, the authors would like to state certain identified limitations and put forth certain suggestions which may guide future research in this domain.

The above study was carried out in young adult females; young adult males were not included in the study.

A larger sample size may be considered for subsequent studies.

Equal number of subjects across all categories of Body Mass Index (BMI) must be considered.

Factors such as the body fat distribution, the body frame type and their influence on chest expansion were not considered in this study.

Subjects with only gross musculoskeletal postural deviations such as scoliosis and kyphosis were excluded from this study. However, habitual postures such as forward head and rounded shoulders also affect respiratory mechanics and therefore must be considered in subsequent studies.

An individual's baseline respiratory muscle strength, smartphone usage time, posture and physiological variations in respiratory mechanics must be considered and documented during future studies in this area.

The authors duly acknowledge the limitations of this study.

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Conflict Of Interest

There are no conflicts of interest in this study.

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Abbreviations

BMI = Body Mass Index (kg/m^2)

Ethical Approval: Approved

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