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Physiology Section

# Assessment of $VO_2$ Max among Female Workers of Cotton Textile Industry at Visnagar, North Gujarat Region: A Cross-sectional Study

SHAH MANSI NILESHKUMAR[1], GNANADESIGAN EKAMBARAM[2], JINAL PANDYA[3], ALKESH VARA[4], RIYA NILESH KHANDHEDIA[5], SIVASUBRAMANIAN NAGOORAN[6]



## ABSTRACT

**Introduction:** Occupational lung illness is a significant problem among textile factory workers. Occupational cotton dust exposure has been linked to lung involvement in many epidemiological studies of cotton industry workers. The maximum oxygen intake is one of the measures used to estimate functional capacity ($VO_2$ max) of cardiopulmonary efficiency. The integration of the ventilatory, cardiovascular and neuromuscular system is necessary for attainment of $VO_2$ max.

**Aim:** To assess the $VO_2$ max among women employees in cotton textile industry and to study the correlation between $VO_2$ max and anthropometric parameters like Body Mass Index (BMI), Body Surface Area (BSA), fat percent (fat %) and Lean Body Mass (LBM).

**Materials and Methods:** This cross-sectional study was conducted from January 2021 to June 2021 at Nootan Medical College and Research Centre/Nootan General Hospital, Visnagar, Dt. Mehsana, North Gujarat, India, which included study and control group which comprised 50 female workers of cotton industry and 50 age matched females, respectively (n=50 each) who had never worked in the cotton industry or been exposed to cotton dust. The labourers of cotton industry were chosen from the Mehsana district's numerous cotton factories. Physical examinations (resting heart rate, resting systolic and diastolic blood pressure) and a standardised proforma were used to gather data. $VO_2$ max and anthropometric measurements such as BMI, BSA, fat % and LBM were measured by standard procedure. The statistical analysis was done by using Student's t-test and Pearson correlation test. The correlation between BMI, BSA, fat percent and LBM with maximal oxygen consumption ($VO_2$ max) was assessed by using Karl-Pearson's correlation with level of significance was considered statistically significant if $p<0.05$.

**Results:** The mean value of $VO_2$ max in study and control group was 35.62±0.34 mL/kg/min and 36.80±0.58 mL/kg/min, respectively. It was decreased significantly ($p<0.001$) in study group. The r-values of BMI, BSA, LBM and body fat % were 0.262, 0.132, 0.236, 0.224, respectively. In the present study correlation between BMI, BSA, LBM, body fat % with $VO_2$ max was reported as weak positive correlation which was not statistically significant.

**Conclusion:** $VO_2$ max was significantly decreased in cotton industry workers compared to non exposed control subjects. More studies on the effects of cotton dust on $VO_2$ max should be conducted in future in both genders.

**Keywords:** Body mass index, Body surface area, Cotton industry workers, Functional capacity, Lean body mass, Maximum oxygen intake

## INTRODUCTION

Cardiorespiratory fitness, also known as cardiovascular fitness or maximal aerobic power, refers to the entire capacity of the circulatory and respiratory systems, as well as the ability to perform extended hard activity [1]. Deterioration of the cardiorespiratory system increases morbidity and is a significant and independent predictor of all-cause mortality [2]. The maximum oxygen intake is one of the measures used to estimate cardiopulmonary functional capacity ($VO_2$ max) [3]. The maximum capacity for oxygen absorption, transportation, and consumption is represented by $VO_2$ max ($O_2$). The integration of the ventilatory, cardiovascular and neuromuscular system is necessary for attainment of $VO_2$ max. People with a low $VO_2$ max have a higher risk of developing chronic diseases, all-cause mortality, and cardiovascular diseases like coronary artery disease, whereas people with a high $VO_2$ max have a lower risk of developing chronic diseases, all-cause mortality, and cardiovascular diseases like coronary artery disease [4]. Studies show the establishment of Queens's College Step Test (QCT) to predict $VO_2$ max indirectly [5]. The QCT is accepted and recommended method for evaluation of cardiorespiratory activity when laboratory testing methods are unavailable.

The direct measurement of $VO_2$ max with Cardiopulmonary Exercise Testing (CPET) is extensively considered as a gold standard method for assessment of fitness level of individual [1]. Nevertheless, this method is expensive, requires trained staff. Tragically, not all countries meet these requirements to conduct $VO_2$ max with CPET. The assessment is impractical in non laboratory and field-tests condition and also, high level of trained staff and proper supervision is required. It is not suitable for those individuals also for whom vigorous exercise is not recommended. These indirect techniques are much simple and less costly and easier to apply in situations like indoor or outdoor, epidemiological studies. Hence, indirect $VO_2$ max prediction needs to be implemented especially in studies of large population. Body composition factors like BSA, BMI, body fat % and LBM have strong link with cardiorespiratory fitness [2]. Researchers have reported conflicting statements in terms of such anthropological parameters in relation to $VO_2$ max [3,4].

Occupational lung illness is a significant problem among textile factory workers. When operating in various departments of the cotton mill, such as opening, picking, combing, weaving, slashing, and spinning, cotton mill workers are exposed to raw cotton dust.

In India, the prevalence rate remains high. Various epidemiologic studies of cotton industry workers have found indications of lung involvement as a result of occupational cotton dust exposure [6,7] The chronic exposure of cotton dust in cotton industries particularly on female workers has not been clarified [6]. The present study was undertaken to assess the $VO_2$ max among women employees in cotton textile industry. The secondary objective of the study was to study the correlation between $VO_2$ max and anthropometric parameters (BMI, BSA, LBM and fat %).

## MATERIALS AND METHODS

The present study was a cross-sectional study conducted from January 2021 to June 2021 at Nootan Medical College and Research Centre/Nootan General hospital, Visnagar, district Mehsana, North Gujarat, India. Study was approved by Institutional Ethics Committee (IEC) (Approval No: IEC/NMCRC/APPROVAL/22/2021), and all subjects gave their informed consent after the study methods and goal were explained in local language (Gujarati). The experiments followed the amended Helsinki Declaration of 1975 that was revised in 2013.

Convenient non random sampling method was followed for selection of participants. The present study included a study group (group A) and a control group (group B) comprising 50 female workers of cotton industry between the ages of 18 and 40, as well as 50 age-matched females. The labourers were chosen from the Mehsana district's numerous cotton factories.

**Inclusion criteria:** Female workers of cotton industries with not less than three years of exposure and healthy females who had never worked in the cotton industry or been exposed to cotton dust were included in study and control groups, respectively. All of the employees volunteered to take part in the present study.

**Exclusion criteria:** Subjects on medication for cardiorespiratory illness, subjects with a history of diabetes mellitus, psychiatric disease, or a history of smoking were excluded from the study.

### Study Procedure

Clinical histories of subjects were obtained in detail, including relevant family history, prior history, drug history, and personal history. All volunteers (subjects) were given a standardised proforma in local language (Gujarati) to collect information about their demographic parameters such as (duration of employment) occupational history, which included past and present respiratory diseases (cough, phlegm, chest tightness and dyspnoea) and lassitude (physical or mental tiredness). Anthropometric measurements such as height, weight, BMI, BSA, LBM, and fat L % were recorded. The subjects were instructed to wear light clothing and to stand erect with their arms relaxed at their side, with both feet close together. By using a portable standard weighing machine, weight in kilograms was recorded to the nearest 0.5 kg. Height was measured on a vertical scale with the heel, buttocks and occiput against the wall and the head in the Frankfurt plane to the nearest 0.5 cm. A stadiometer (Prestige and IS Indo Surgical) was used to measure height to the nearest 0.1 cm. Without shoes, the participant stood on the stadiometer with their scapula, buttocks, and heels in contact with the vertical bar, their head held straight, their inferior orbital border in the same horizontal plane as their external auditory meatus (Frankfurt's plane), and their scapula, buttocks, and heels in contact with one another. BMI was calculated by the formula weight (kg) divided by height squared (metre). The body fat % was calculated by using a formula that converts BMI into an estimate of body fat %: Body fat %=(1.39×BMI)+(0.16×Age)-(10.34×Gender)-9 with gender equal to 1 for men and 0 for the woman [8]. BSA was calculated using the formulas created by Mosteller RD [9]. Formulas by Monsteller [Height (cm)×Weight (kg)/3600)½] and Body [Weight (kg) 0.4838×Height (cm) 0.3×0.017827]. LBM was calculated using Boer formula for males: e LBM=0.407W+0.267H-19.2, for females: e LBM=0.252W+0.473H-48.3 (In this formula, W is the body weight in kilogram and H is the body height in centimetre) [10]. The systolic and diastolic artery pressures (SAP and DAP) were measured in supine position using an aneroid sphygmomanometer (DAP). Reading (SAP and DAP) was taken one time only during resting condition. The QCT method was used to investigate $VO_2$ max indirectly [5]. A tool with a height of 16.25 inches was used for the step test. Subjects were required to step for 3 minutes at a rate of 22 steps per minute, which was determined using a metronome. The carotid pulse rate was measured from the fifth to the twentieth second of the recovery time after the exercise was completed. The 15-second pulse rate was translated to beats per minute, and the $VO_2$ max was calculated using the equation below. The evaluations were carried out at a room temperature ranging from 27 to 29° Celsius. The following equation was used to predict $VO_2$ max [5]. For females: $VO_2$ max=65.81-[0.1847×pulse rate beats/min] [mL/kg/min] [5].

## STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS) was used to conduct the statistical analysis (version 17.0). The Student's t-test was used to examine the results, which are given as mean±standard deviation (SD). A statistically significant p-value of 0.05 was used. The relation between BMI, BSA fat % and LBM with maximal oxygen consumption ($VO_2$ max) was done using 'Karl-Pearson's correlation with level of significance was considered statistically significant if $p<0.05$'.

## RESULTS

The mean age was 28.44±6.83 years, 26.68±7.53 years in study group (cotton industry workers) and control groups, respectively. Anthropometric particulars (BMI, BSA, Fat %, and LBM) of cotton textile industry workers and control subjects were studied thoroughly [Table/Fig-1].

| Anthropometric parameters | Mean value in control group | Mean value in study group |
|---|---|---|
| BMI (kg/m$^2$) | 24.36±3.68 | 24.64±3.33 |
| BSA (m$^2$) | 1.63±0.14 | 1.59±0.12 |
| LBM (kg) | 41.69±4.78 | 40.08±4.72 |
| Body fat % | 31.4±6.64 | 30.74±7.81 |
| Body weight (kg) | 61.38±9.26 | 59.14±8.10 |

**[Table/Fig-1]:** Mean values of anthropometric parameters.

[Table/Fig-2] shows mean value of $VO_2$ max, resting heart rate, systolic blood pressure (resting), diastolic blood pressure (resting). The mean value of $VO_2$ max in study group was decreased significantly ($p<0.001$) when compared with control group [Table/Fig-2]. There were no significant result found in other parameters.

| Variables | Study group (Cotton dust) n=50 Mean±SD | Control group n=50 Mean±SD | p-value |
|---|---|---|---|
| $VO_2$ Max (mL/kg/min) | 35.62±0.34 | 36.80±0.58 | <0.0001 (S) |
| Heart rate (resting) (beats per minute) | 73.1±0.76 | 73.06±0.61 | 0.7722 (NS) |
| SBP (resting) (mmHg) | 120.64±1.53 | 120.36±1.69 | 0.3872 (NS) |
| DBP (resting) (mmHg) | 79.76±1.43 | 79.68±1.77 | 0.8042 (NS) |

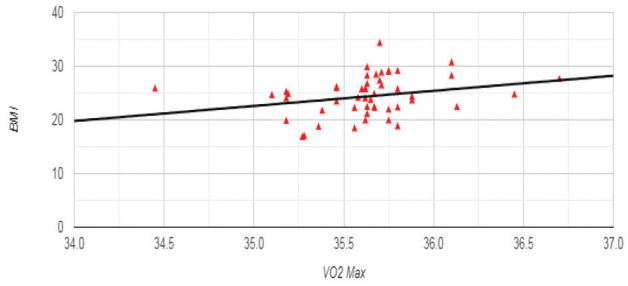
**[Table/Fig-2]:** Comparison of study variables in study group (cotton dust) and control group subjects.
n=Number of sample S: Significant NS: Not significant, Test applied-Student's t-test

Karl Pearson's correlation test was used to assess correlation between $VO_2$ max and BMI, BSA, LBM, and Body fat % among study group subjects. Correlation values between $VO_2$ max and BMI, BSA, LBM, Body fat % is given in [Table/Fig-3]. There was no significant correlation obtained in any of the parameters.

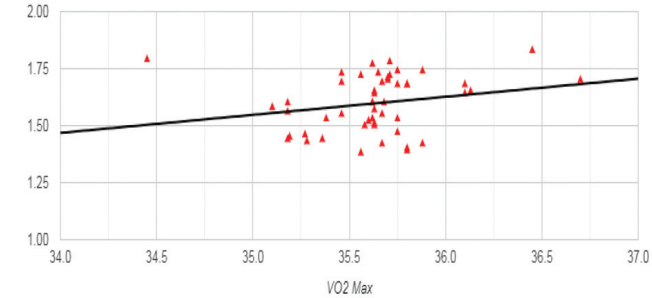
| Parameters | Correlation coefficient (r) | p-value |
|---|---|---|
| BMI | 0.2624 | 0.065 (NS) |
| LBM | 0.132 | 0.361 (NS) |
| Fat % | 0.2362 | 0.098 (NS) |
| BSA | 0.224 | 0.117 (NS) |

**[Table/Fig-3]:** Correlation between BMI, LBM, Fat%,BSA and $VO_2$ max among study group individuals (n=50).
n=Number of sample NS: Not significant, Test applied-Karl Pearson's correlation test

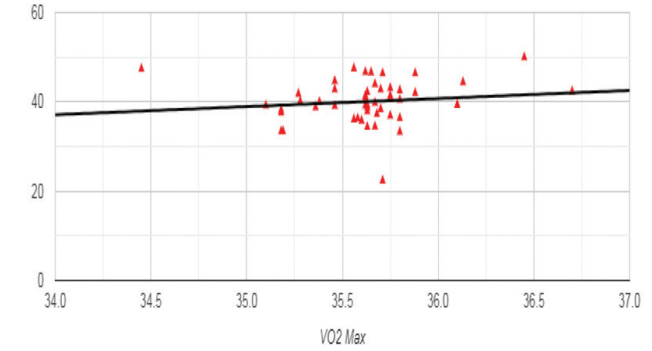
No significant correlation was not obtained between $VO_2$ max and all the parameters as represented in [Table/Fig-4-7]. Correlation between BMI, BSA, LBM, body Fat % with $VO_2$ max was reported as weak positive correlation and was not statistically significant.




**[Table/Fig-4]:** Correlation between BMI and $VO_2$ max among study group participants.
(Test applied-Karl Pearson's Correlation ; Pearson's r-value: 0.2624, p-value: 0.065)

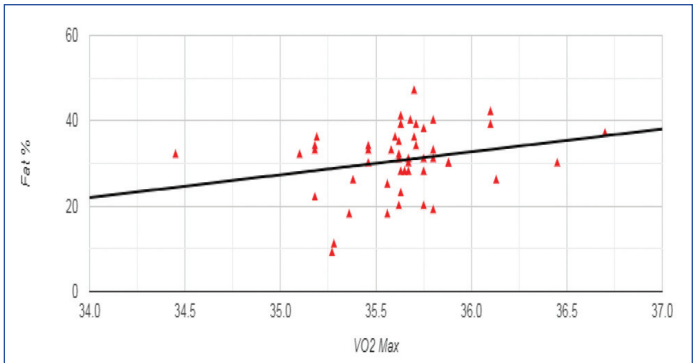



**[Table/Fig-5]:** Correlation between BSA and $VO_2$ max among study group participants.
(Test applied-Karl Pearson's Correlation, Pearson's r-value: 0.224, p-value: 0.1179)




**[Table/Fig-6]:** Correlation between LBM and $VO_2$ max among study group participants.
(Test applied-Karl Pearson's Correlation, Pearson's r-value: 0.132, p-value: 0.361)

The above mentioned anthropometric parameters were not statistically significant when compared with control subjects. The majority of respiratory problems experienced by cotton workers in the previous 12 months were work-related. Cough (20%) and dyspnea (20%) were the symptoms most closely linked to the workplace in cotton spinners in the present study [Table/Fig-8].




**[Table/Fig-7]:** Correlation between fat % and $VO_2$ max among study group participants.
(Test applied-Karl Pearson's Correlation,Pearson's r-value: 0.2362, p-value: 0.098)

| Variables | Cotton industry workers (n=50) |
|---|---|
| Duration of employment ≤10 years | 30 (60%) |
| Duration of employment>10 years | 20 (40%) |
| Family history of COPD | 4 (8%) |
| Exposure to cotton dust ≤4 hours per day | 29 (58%) |
| Exposure to cotton dust >4 hours per day | 21 (42%) |
| Cough | 10 (20%) |
| Phlegm | 7 (14%) |
| Chest tightness | 8 (16%) |
| Dyspnoea | 10 (20%) |
| Headache | 8 (16%) |
| Lassitude | 7 (14%) |

**[Table/Fig-8]:** Demographics and prevalence of respiratory symptoms of study subjects (cotton industry workers) (data are expressed as number and percentage of study subjects).

## DISCUSSION

The association between exposure to cotton dust and the development of a sickness known as byssinosis. The goal of this study was to see how exposure to cotton dust affects $VO_2$ max in cotton textile workers. "$VO_2$ max also known as maximal oxygen consumption, peak oxygen uptake, maximal oxygen uptake, or maximal aerobic capacity is the maximum capacity of an individual's body to transmit through circulatory system and use oxygen in motor muscles." In the textile industry, byssinosis is the most well-known and specific work-related sickness. Fever, malaise, chest tightness, and dyspnoea are the hallmark signs of byssinosis. The maximum quantity of oxygen a person can take in ($VO_2$ max) is reduced in Chronic Obstructive Pulmonary Disease (COPD) patients due to poorer cardiovascular capabilities and weaker peripheral skeletal muscle strength, resulting in a lower $VO_2$ max.

In the present study, $VO_2$ max was significantly reduced in study group participants. Exercise ($VO_2$ max) capacity in COPD was linked to deterioration of both inspiratory (active) and expiratory (passive components) muscles of lungs, according to Loiseau A et al., [11]. Since $VO_2$ max is linked with impaired lung function such as restrictive and obstructive type of lung disease present study findings support the theory that COPD patients' exercise tolerance is limited by weak inspiratory muscles [12,13]. The results of $VO_2$ max among control subjects in present study were consistent with other studies that have examined $VO_2$ max in female subjects in India. It gives a confirmation of $VO_2$ max level among Indian women and used for comparison with study group participants [14].

Many research papers have used heart rate to assess mental workload, physical workload, weariness, rating of perceived exertion and other physiological factors, demonstrating the accuracy of heart rate as a physiological factor and $VO_2$ max is one of the most commonly used parameter in exercise physiology for cardiorespiratory fitness measurement [15-18]. Generally, regular involvement in physical activity beyond certain period can decrease individuals resting heart rate by increasing the contractile strength and the length of time the heart fills with blood. An increase in parasympathetic nervous system activity and possibly a decrease in sympathetic nervous system activity cause a drop in heart rate. In the present study, no significant change was observed in resting heart rate between study and control group. Similarly the present study wasn't able to find any differences in resting systolic and diastolic blood pressure between study and control group members.

Blood pressure appears to be substantially affected by noise exposure, since noise causes larger changes in blood pressure among textile employees working in "high noise areas compared to those working in low noise areas [19]. In the present study, many workers have been working in low noise areas and do not have exposure more than five years in cotton textile industry area. A study from Gupta S et al., and Koskinen HL et al., reported that noise exposure in working atmosphere was positively associated with hypertension and many studies were in support of their statement [20,21]. Kalantary S et al., showed an increase in blood pressure in workers after exposure to noise in industry environment [22]. In the present study, there was no such noise related impact in present study workers. In the present study, an association between BMI, BSA, LBM, Fat % with $VO_2$ max was reported weak positive correlation since the r value was less than 0.3. When fat mass was taken into account, Welch BE et al., found that $VO_2$ max was much lower in overweight people, indicating the changes in cardiorespiratory performance in severely overweight people [23]. Obesity exacerbates exercise intolerance and inadequate aerobic capacity, excessive body fat places an adverse stress on cardiac function, especially during intensive activity, when excessively hyperactive body muscles fails to absorb appropriate amounts of oxygen due to the deposition of proportionately large amounts of fat mass [23]. In the present study, there was no significant change reported on BMI, BSA, LBM and fat % and there is no negative correlation. This suggests the effect of such anthropometric parameters on $VO_2$ max was not statistically significant. Many subjects in present study belonged to younger age group and reported less exposure to cotton dust and other co-morbidities. Since the findings in present study revealed a modest positive association between $VO_2$ max and weak factors such as BMI, BSA, LBM, and body fat %, these anthropometric characteristics must be included when predicting $VO_2$ max in different age groups with various duration of cotton dust exposure in a thorough manner.

The following recommendations are given based on the findings of this research: i. A similar study might be undertaken with male subjects or with populations of varying ages and levels of participation. ii. Additional research can be done utilising additional measurement methods on the above-mentioned physical and physiological factors. iii. A similar study on psychological and sociological aspects could be done. iv. A similar study might be done on a bigger scale with the same or different factors. v. The findings of this study will aid future research in the field of sports physiology.

## Limitation(s)

An important limitation of this study was that male individuals was not included and the study population was limited to those between 18-40 years old and thus may not represent the broader population in slums, but it still gives useful information regarding this age group. The present study doesn't contain any noise interruption in the working environment. Noise pollution is common in majority of factories. Further studies assessing the noise effect can be conducted in future.

# CONCLUSION(S)

The $VO_2$ max was significantly decreased in cotton industry workers compared to non exposure control subjects. All people with decreased $VO_2$ max who have a decreased quality of life and/or physical capabilities should be offered fitness training as part of their rehabilitation. It is, stated that $VO_2$ max is an essential determinant of an individual's ability to work for long periods of time and is the best measure of physical fitness. More studies on the effects of cotton dust on $VO_2$ max are needed to be conducted in future in both genders.

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**PARTICULARS OF CONTRIBUTORS:**
1. Undergraduate Student, Department of Physiology, Nootan Medical College and Research Centre, Sankalchand Patel University, Visnagar, Gujarat, India.
2. Assistant Professor, Department of Physiology, Nootan Medical College and Research Centre, Sankalchand Patel University, Visnagar, Gujarat, India.
3. Assistant Professor, Department of Physiology, Nootan Medical College and Research Centre, Sankalchand Patel University, Visnagar, Gujarat, India.
4. Associate Professor, Department of Physiology, Nootan Medical College and Research Centre, Sankalchand Patel University, Visnagar, Gujarat, India.
5. Undergraduate Student, Department of Physiology, Nootan Medical College and Research Centre, Sankalchand Patel University, Visnagar, Gujarat, India.
6. Professor, Department of Psychiatric Nursing, Nootan College of Nursing, Sankalchand Patel University, Visnagar, Gujarat, India.

**NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:**
Gnanadesigan Ekambaram,
Staff Quarters, E Block, G-2, Sankalchand Patel University,
Visnagar-384315, Gujarat, India.
E-mail: edesigan_phy@nootanmedical.edu.in

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