Effect of Physical Activity and Parameters of Body Stature and Body Composition on Respiratory Muscle Strength in Healthy Young Males: An Observational Study

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Abstract

Background and Aim: Obesity and physical inactivity affect respiratory functioning adversely. Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) measure the strength of respiratory muscles. We studied the MIP and MEP in nonathletic young males in relation to adiposity and physical activity. **Methods:** We conducted a cross-sectional study on a consecutive sample of sixty young apparently healthy nonathletic males. Body mass index (BMI) and body composition were measured by Omron Karada Scan by tetra poplar bio-electrical impedance. We measured MIP and MEP by Ultima PFX real-time diffusion (RTD) (Medgraphic diagnostic company, USA), Breezesuite software, flow volume calibration, and guidelines laid by the American Thoracic Society. Results were analyzed further by comparing the actual value against the predicted value among the three patterns of subgrouping based on BMI, visceral fat (VF), and physical activity. Statistical significance was set at $P < 0.05$. **Results:** The study group had a mean age of 21 years, mean BMI of 22.5, and nearly half with BMI <22.5 and half were physically active. Better profile of body composition was present in males with BMI <22.5, VF <10%, and physical activity. MIP and MEP of the study participants were significantly lower than the predicted values, significantly better with physical activity and better without statistical significance with BMI or VF controlled. MIP and MEP correlated negatively but insignificantly with most other test parameters. **Conclusion:** Maximal respiratory pressures of young nonathletic males were less than predicted, more so with physical inactivity than adiposity. This indicates the importance of exercise and moderate physical activity to strengthen the respiratory muscle for optimal maximum respiration.

Keywords: Maximal respiratory pressures, obesity, physical activity, young males

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Introduction

Obesity affects body composition adversely,[1] with increased adiposity and decline in muscle mass. This is very much evident in aged individuals and in obesity aftermaths such as type 2 diabetes.[2] Root of the same is there in the early life in the form of physical inactivity and sedentary life style[3] amidst the stressful challenges of professional life. Knowing body composition beyond body weight and body mass index (BMI)[4] offers distinct self-motivating advantage. Respiratory functions are known to be compromised in young individuals with obesity.[5] However, quantification of respiratory ability by simple spirometry misses the challenge of generating maximum strengths of respiratory muscles.

Maximal inspiratory pressure and maximal expiratory pressure (MIP and MEP) provide an estimate of respiratory muscle strength.[6] Predictive equations are available for maximal respiratory pressures' (MRPs) reference values.[7] Age, gender, and ethnicity are proven determinants of MRPs.[7-11] Decline of MRPs starts after the second and third decades of life.[11] Role of parameters of body stature such as height, weight, BMI, physical activity, and

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qualitative body fat is still studied sparsely as confounder for MRPs.[8]

Obesity and sedentary lifestyle are increasing,[12] more so in young individuals which can compromise MRPs that is not evident during resting tidal breathing. We have set out to study the effects of these parameters on MRPs in nonsmoking, nonathletic, young, apparently healthy males.

Materials and Methods

Study population

We have conducted an observational study from September 15, 2015 to June 5, 2016 in pulmonary function test laboratory of the Department of Physiology of Government Medical College, Bhavnagar, Gujarat, India. Using consecutive sampling, we have recruited sixty apparently healthy, young, asymptomatic male medical students and faculties, leading a sedentary life style, from the institute. The study protocol was approved by the Institutional Review Board of our college. Each participant gave written informed consent for participation in the study.

Inclusion and exclusion criteria

We included asymptomatic, apparently healthy, nonathletic males, aged between 18 and 35 years, who were not smoker or tobacco chewer, not having any other addiction, not using any lifestyle interventions such as yoga, meditation, and ready to give written informed consent. We excluded ex-smokers, occasional smokers, alcoholics, tobacco chewers, hypertensives, diabetics, individuals with current respiratory diseases, individuals having occupational exposure to air pollution, doing yoga or breathing exercises, and those who are unwilling to give informed consent. Three individuals were excluded from the study due to technical difficulties including measurement techniques and cooperation.

Body composition measurement

After instrument calibration, participant details were entered and participants were allowed to stand on the instrument. A digital, portable noninvasive instrument, namely Omron Karada Scan (Body Composition Monitor, Model HBF-510, Omron Healthcare Singapore Pte Limited, China), working on the principle of tetra polar bioelectrical impedance analysis, was used. It passes electric current of 500 µA at a frequency of 5 kHz, scanning the whole body to derive regional body composition.

We used Ultima PFX (Medgraphics Diagnostic Company, Saint Paul, MN, USA) instrument that uses RTD, with the facility of exact flow sensor calibration by 3 l syringe calibration and gas analyzer calibration before each testing. We also followed quality control procedure after installation. The graph displays the pressure versus time tracing for each participant's effort. The graph's lower half is negative pressure (inspiratory maneuver); the top half is positive pressure (expiratory maneuver) [Figure 1]. The Ultima series system uses the BreathPath patient circuit and PreVent flow sensor. Breezesuite is a true multitasking software package that allows digital data acquisition and precise breath by breath analysis. Test participants were physically healthy on the basis of clinical examination, free from symptoms of any acute respiratory illness. Participants were properly explained about the aim, objectives, methodology, expected outcome, and implications prior to the commencement of the study. Written informed consent was obtained from all the participants. Participants were given practice and minimum three attempts. All recordings were accomplished between 8 am and 12 noon in the morning.

Procedure

Maximal inspiratory pressure test

After a minimum of four tidal breaths, the participant exhales slowly to residual volume (RV).When the participant appears to be at RV, the proximal scissor valve is closed and participant inhales as hard as possible to produce maximal negative pressure. The valve reopens in 4 s, ending the test.[6]

Maximal expiratory pressure test

After a minimum of four tidal breaths, the participant inhales slowly to total lung capacity (TLC). When the participant appears to be at TLC, the proximal scissor valve is closed and the participant exhales as hard as possible to produce a maximal positive pressure. The valve reopens in 4 s, ending the test. Pressure measurements were obtained at any lung volume. Measurements did not have to be taken at RV or TLC.[6]

Multiple regression equations for reference values[7] of MIP and MEP are as follows:

- MIP: 278.53 – (1.23 × H) + (1.60 × W) – (3.80 × BMI – (0.27 × age)
- MEP: 566.98 – (2.85 × H) + (3.29 × W) – (7.13 × BMI) – (1.04 × age).

Subgrouping for the study was as follows:

To analyze further, we divided the study group into three subgroups based on the following:

- BMI[13] – cutoff of 22.5 kg/m^2
- Visceral fat (VF)[14] – cut off of 10%

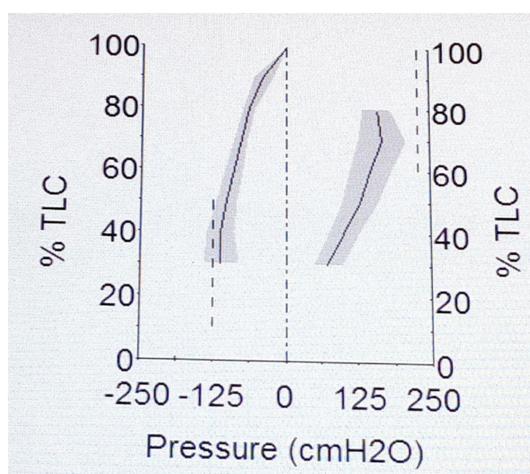

Figure 1: Pressure versus time tracing graph to measure maximal inspiratory pressure and maximal expiratory pressure

- Physical activity (self-reported)[15] – presence or absence (defined as continuous moderate physical exercise for at least 30 min in a day for at least 5 days a week regularly).

Statistical analysis

The data were transferred on Excel spreadsheet, and descriptive analysis was expressed as mean ± standard deviation. All calculations were accomplished using Graph Pad in STAT-3 software (demo version free software of GraphPad Software, Inc. California, USA). We calculated the statistical significance difference in mean distribution of various quantitative parameters among various subgroups by Student's *t*-test or Mann–Whitney test. Normality test was applied to compare difference between groups for qualitative data. Correlation between the study parameters (dependent with independent) was done by Spearman's correlation test using simple linear regression model. Difference was considered statistically significant with $P < 0.05$.

Results

Our study group of male participants ($n = 60$) had a mean age of 21 years, mean BMI of 22.5, with half of the participants having BMI controlled and half having physical activity. Subgroups stratified by BMI cutoff of 22.5 were comparable in age and height, but measures of body fat such as BMI, VF, total body fat (TBF), and subcutaneous fat (SF - whole body and trunk) were significantly higher and skeletal muscle mass (SkM - whole body and trunk) was insignificantly lower in participants with BMI ≥22.5 than those with BMI <22.5. Similarly, participants with VF ≥10% had significantly higher BMI, TBF, VF, SF, and lower SkM as compared to subgroup of equal numbered matched individuals with VF <10%. Physically active participants had lower BMI, VF, TBF, SF, and higher SkM as compared to sedentary participants, but all differences were statistically insignificant [Table 1].

The study group exhibited significantly lesser test values of MIP (mean − 58 vs. −82.59) and MEP (mean 54.17 vs. 115.14) than the predicted values [Table 2]. Actual values of MIP and MEP were higher in subgroup with BMI ≥22.5 than one with BMI <22.5; higher in subgroup with VF ≥10% than the matched subgroup with VF <10%. However, in both instances, differences were small and lacked statistical significance. Physically active participants exhibited significantly higher values of MIP (mean − 76 vs. −39) and MEP (mean 71 vs. 37) than sedentary individuals [Table 3].

Correlation analysis showed no significant correlation of all parameters with MIP and MEP except the positive correlation of age with MIP ($P = 0.001$) [Table 4].

Discussion

Obesity is now officially declared a disease, and physical inactivity is one of its causes that is causative of multiple lifestyle-related morbidities and impairments.[3] Ventilatory pump which drives air for gas exchange is constantly under mechanical load, levied upon the force generators–respiratory muscles.[16] MIP and MEP, together known as MRPs, are most common, noninvasive, volitional tests to assess the same.[17] Males have better MRPs than females, more so at young age.[7,10,11] Physical inactivity, BMI, body fat, smoking, and ethnicity are confounders affecting MRPs which are not yet fully studied,[8] more so in healthy young individuals. MRPs are known to decease after mid-thirties.[18] BMI is a quantitative correlate and body fat is a qualitative correlate of obesity, the latter being superior to the former. Raised BMI and body fat are proven causes for impaired lung functions in normal adults.[19] We studied the effect of physical activity, BMI, and body fat in young Gujarati males aged <40 years.

By instrument calibrated for volume, flow and pressure, we measured MIP and MEP using standard protocol recording the best reading as result. It was compared against reference

Table 1: Study parameters in three subgroups (stratified by body mass index cutoff of 22.5 kg/m^2, visceral fat cutoff of 10%, and physical activity)

Parameter	BMI			VF			PA		
	<22.5 (*n*=33)	≥22.5 (*n*=27)	*P*	<10 (*n*=12)	≥10 (*n*=12)	*P*	Present (*n*=32)	Absent (*n*=28)	*P*
Age (years)	20±2.40	21.56±4.62	0.219	20.41±5.53	20.08±4.41	1.000	21.34±3.84	19.96±3.26	0.032*
Height (cm)	169.91±7.35	168.15±4.62	0.171	167.58±5.52	168.67±5.25	0.627	170.34±5.28	167.71±7.08	0.131
Weight (kg)	56.16±7.72	74.44±8.40	0.000*	59.33±8.15	80.08±9.04	0.000*	64.53±9.65	64.21±14.68	0.921
BMI (kg/m^2)	19.29±1.78	26.34±2.92	0.000*	21.14±2.83	28.19±3.4	0.000*	22.16±3.46	22.80±5.03	0.563
BSA (m^2)	1.65±0.13	1.84±0.11	0.000*	1.67±0.11	1.90±0.11	0.000*	1.75±0.13	1.72±0.18	0.606
PA present (*n*)	20	12	0.299	3	6	0.400	32	0	-
TBF (%)	15.05±4.44	23.54±5.87	0.000*	15.38±5.11	27.38±4.99	0.000*	18.01±6.06	19.86±7.22	0.283
VF (%)	3.06±1.78	8.74±3.57	0.000*	3.83±2.76	11.67±2.96	0.000*	5.13±2.83	6.18±4.90	0.807
SF-WB (%)	11.83±3.53	19.91±6.02	0.000*	13.04±5.57	23.45±6.28	0.000*	14.91±5.74	16.10±6.84	0.467
SkM-WB (%)	33.46±5.26	31.21±5.84	0.036*	33.60±5.30	30.05±7.64	0.128	32.94±5.15	31.88±6.11	0.467
SF-T (%)	10.99±3.95	19.14±7.44	0.000*	11.87±5.99	23.45±7.63	0.000*	13.43±5.43	16.05±8.40	0.411
SkM-T (%)	29.26±4.49	27.5±4.43	0.133	30.43±2.73	25.78±5.67	0.018*	28.45±4.08	28.49±5.05	0.976

*Statistical significance, *P* value represents the statistical comparison of the preceding two groups. Data are represented as mean±SD. BMI: Body mass index, VF: Visceral fat, PA: Physical activity, SD: Standard deviation, BSA: Body surface area, TBF: Total body fat, SF-WB: Subcutaneous fat-whole body, SkM -WB: Skeletal muscle mass-whole body, SF-T: Subcutaneous fat-trunk, SkM-T: Skeletal muscle mass-trunk values[2] and in three subgrouping schemes. Young, apparently healthy, nonsmoking, nonathletic, nonlifestyle modification user males showed significantly lower values of MIP than the expected values of MIP (mean − 59 vs. expected – 83 cmH_2O) and MEP (mean 54 vs. expected 115 cmH_2O). This could be due to ethnicity, mean BMI of 22.5, nonathletic participants, physical inactivity in half, and perhaps lack of motivation during testing. Participants with BMI <22.5 kg/m^2 did not differ from those with BMI ≥22.5 kg/m^2 in body fat or MRPs. This nonsignificant effect of BMI in males aged 20–40 years is in line with previous studies.[7,9,11] BMI itself lacks qualitative inference with disparity in cutoff values.[13] BMI has J- or U-shaped relationship with morbidity.[19] Underweight and obese[20] individuals are supposed to have lesser pulmonary functions than normal weight and overweight individuals. BMI <22.5 group (n = 33) comprised underweight (n = 15) mixed with normal weight (n = 18) individuals and BMI ≥22.5 group comprised obese (n = 6) mixed with overweight (n = 21) individuals, which also explains the insignificant effect of BMI on MRPs. Similarly, BMI ≥30 is known to cause comparatively more adverse effects on MRPs[21] and we had only three such individuals. We used VF measured by bio-electrical impedance method as a measure of central obesity and a qualitative fat measure. We found better MRP values in individuals with VF ≥10% than equal numbered matched individuals with VF <10% (MIP: mean −55 vs. expected −46 cmH_2O, MEP: mean 47 vs. expected 46 cmH_2O). This effect was too small and statistically insignificant. This unexpected result can be due to the fact that all readings were taken in sitting position where abdominal fat exerts minimal effect[22] and mean age of 21 years might have some role as other studies had population more aged than the present study. Recent studies also support this obesity paradox[23] that overweight and obese (not morbidly obese) have better MRPs. Further consolidation is required for this result.

Table 2: Comparison between actual and predicted values (mean±standard deviation) of maximal inspiratory pressure and maximal expiratory pressure in the study group (*n*=60)

Parameter (cmH_2O)	Actual value	Predicted value	*P*
MIP	−58.97±26.80	−82.59±3.59	0.000*
MEP	54.17±24.15	115.14±10.79	0.000*

*Statistical significance. MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, SD: Standard deviation. Data expressed are mean ± SD

Age, height, weight, and SkM correlated positively and BMI, whereas TBF, VF, and SF correlated negatively with MRPs. All results were statistically insignificant, in line with two previous Indian studies.[7,9] Sedentary individuals performed poor than moderately physically active individuals (MIP: mean −39 vs. −76 cmH_2O, MEP: mean 37 vs. 71 cmH_2O). It becomes further significant with the fact that these two subgroups based on physical activity had comparable age, height, weight, BMI, body fat, and working environment. Moderate level, self-reported, regular physical activity is known to have a positive impact on lung functioning[16] and our study revealed the same in reference to MRPs.

Sedentary lifestyle is a curse of modern civilization, India being no different to other countries.[24] Strength of respiratory muscle, the lifetime force generators, affects respiratory function during demanding situations such as exercise and exertion. Reduced MRPs indicate impairment of respiratory pump that compromises ventilation, gas exchange, and tissue respiration.[7] Weak respiratory pump can lead to clinical consequences such as impaired exercise tolerance, ineffective coughing, respiratory insufficiency, and dyspnea.[25] This calls for lifestyle intervention which makes physical activity and exercise tailor made for them. Surgical or nonsurgical weight reduction,[26] though effective, is dependent on physical activity for its maintenance. In chronic lung diseases, MRPs become a limiting factor for the level of individual's physical activity.[27] Reciprocally, in young asymptomatic individuals, physical activity seems a factor limiting MRPs. Physical activity is a positive predictive factor, for not only MRPs and lung functioning but also for multiple body homeostatic systems. It can be targeted as both primordial and primary prevention that will also take care of optimum BMI and body fat.

Limitations of the study

Our study was limited by moderate sample size, limitations of bio-electrical impedance, exclusion of females and elderly, and its observational nature. It calls for further vertical and/or interventional study to support the results obtained.

Conclusion

In young nonathletic males, we found compromised MRPs associated with physical inactivity but not to body adiposity. It suggests the importance of physical activity and exercise to develop the strength of respiratory muscles in young

Table 3: Effect of body mass index (cutoff: 22.5 kg/m²), visceral fat (cutoff: 10%), and physical activity (presence or absence) on actual values (mean±standard deviation) of maximal inspiratory pressure and maximal expiratory pressure

Parameter (cmH_2O)	BMI			VF			PA		
	<22.5 (*n*=33)	≥22.5 (*n*=27)	*P*	<10 (*n*=48)	≥10 (*n*=12)	*P*	Present (*n*=32)	Absent (*n*=28)	*P*
MIP	−53.03±26.77	−63.78±26.55	0.211	−46.33±20.53	−55.00±29.00	0.407	−76.03±22.35	−39.46±16.03	0.000*
MEP	52.12±24.62	58.22±23.58	0.335	46.83±24.80	47.42±24.23	0.954	70.66±15.46	36.82±19.16	0.000*

*Statistical significance, *P* value represents the statistical comparison of the preceding two groups. Data are represented as mean±SD. BMI: Body mass index, VF: Visceral fat, PA: Physical activity, SD: Standard deviation, MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure

Table 4: Correlation between maximal inspiratory pressure and maximal expiratory pressure (dependent variables) with other study parameters (independent variables) in study group (*n*=60) using simple linear regression model

Independent variable	MIP (cmH_2O)		MEP (cmH_2O)	
	r	*P*	*r*	*P*
Age	0.41	0.001*	0.11	0.387
Height	0.20	0.138	0.12	0.367
Weight	0.05	0.687	−0.03	0.828
BMI	−0.01	0.937	−0.09	0.497
BSA	0.10	0.435	0.01	0.919
TBF	−0.10	0.446	−0.14	0.286
VF	−0.09	0.479	−0.12	0.373
SF-WB	−0.05	0.684	−0.03	0.801
SkM-WB	0.04	0.747	0.10	0.438
SF-T	−0.08	0.512	−0.10	0.457
SkM-T	0.06	0.630	0.03	0.806

MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, BMI: Body mass index, VF: Visceral fat, BSA: Body surface area, TBF: Total body fat, SF-WB: Subcutaneous fat-whole body, SkM-WB: Skeletal muscle mass-whole body, SF-T: Subcutaneous fat-trunk, SkM-T: Skeletal muscle mass-trunk. *Indicates statistical significance

individuals for optimum respiratory functioning during maximal physical exertion.

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Conflicts of interest

There are no conflicts of interest.

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