Original Article

Anthropometric thoracic measurements and smoking habits in patients with primary spontaneous pneumothorax: A case-control study

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ABSTRACT

BACKGROUND: Primary spontaneous pneumothorax (PSP) is the spontaneous accumulation of air in the pleural space without any obvious reason. Although PSP typically occurs in young, thin, healthy males, the chest anthropometrics in PSP remain insufficiently explored. We aim to evaluate the chest anthropometrics and smoking habits of patients with PSP compared to healthy volunteers.

METHODS: Fifty-eight adult male participants (38 PSP patients and 20 healthy volunteers) aged between 18 and 30 years were included. The study focused on thoracic anthropometric measurements, including body mass index (BMI), height, weight, circumference, sagittal, transverse diameters, and chest height. Smoking habits and place of residence were also assessed.

RESULTS: Significant differences were observed between PSP patients and healthy controls in terms of weight (70.1 ± 9.7 kg vs. 78.1 ± 12.4 kg, $P = 0.009$) and BMI (20.9 ± 2.0 vs. 23.5 ± 3.9, $P = 0.010$). In addition, significant differences in thoracic sagittal diameter during inhalation (22.3 ± 2.1 cm vs. 24.0 ± 2.5 cm, $P = 0.007$) and exhalation (19.9 ± 2.0 cm vs. 21.4 ± 2.5 cm, $P = 0.016$) and transverse diameter during inhalation (30.7 ± 2.0 cm vs. 32.0 ± 2.5 cm, $P = 0.037$) were noted. Multivariable logistic regression analysis revealed that height, weight, and chest circumference on exhalation significantly influence PSP.

CONCLUSION: PSP patients exhibit distinct thoracic anthropometric characteristics compared to healthy individuals. Although no statistically significant relationship between smoking and PSP incidence was established, a notable trend suggests that smoking may increase the risk, highlighting the need for further research on this potential association.

KEYWORDS

Body mass index, chest anthropometry, primary spontaneous pneumothorax, spontaneous pneumothorax, thoracic measurements

Background

Primary spontaneous pneumothorax (PSP) refers to the accumulation of air in the pleural space without any apparent trauma or underlying lung disease.[1] Emphysema-like changes can be discovered in some patients, although individuals with PSP do not have clinically evident lung disease.[2] Nowadays, additional possible reasons for PSP include peripheral airway blockage with air trapping and pleural porosity, which were identified by fluorescein-enhanced thoracoscopy.[3] It usually occurs in otherwise healthy individuals and is most common among young, tall, thin males, especially

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those between 10 and 30 years.[2] That may raise a hypothesis that their chests could be longer and thinner compared to healthy ones. Previous studies indicate that weight-to-height indices (body mass index [BMI]) and height differ between people with PSP and healthy controls.[4] However, BMI can tell very little about the chest size and shape, which may be associated with a higher risk of developing PSP. There is a lack of studies that have explicitly investigated thoracic, especially anthropometric, measurements in PSP patients. Some of them use specific thoracic measurements to prognose possible recurrence of PSP or talk about specific body shape characteristics in PSP patients; however, all these measurements are usually based on radiological (computed tomography scan) data.[5,6] There is some evidence that anthropometric thoracic measurements could be used as radiological ones.[7] Cigarette smoking history, genetics (PSP-associated conditions such as Marfan syndrome and genetic association between height and PSP), or previous coronavirus disease-2019 disease can be found among other risk factors of spontaneous pneumothorax.[3,4,8-10]

This study aims to compare the thoracic index, chest height, some other thoracic anthropometric measurements, and smoking habits of patients with PSP to those of a healthy volunteer group and looks for possible influencing factors on PSP.

Materials and Methods

In this pilot study, data from 100 potential participants were initially considered. After applying the inclusion criteria, which required participants to be male and between 18 and 30 years old, 42 individuals were excluded. The study focused exclusively on male participants; female participants were excluded due to their low representation in the sample. Consequently, the final sample consisted of 58 adult male participants who met the specified criteria. The study was conducted in a predominantly monoethnic population; thus, all enrolled participants were Caucasian. A total of 20 healthy volunteers and 38 individuals who experienced the first episode of PSP and were treated with a chest tube insertion were included in the analysis. The anonymized data included the participant's age, gender, place of residence (urban/rural), smoking status, height, weight, BMI, and key thoracic anthropometric measurements [Figure 1]. Weight was measured using scales, and height was measured using a standard stadiometer. (a) Sagittal (anterior–posterior) dimension: Measured with calipers (horizontally from the sternum at the level of the 4th rib attachment to the spine) during inhalation and exhalation. (b) Lateral dimension: Measured with calipers at the widest point (usually at the level of the 4th rib attachment to the sternum) during inhalation and exhalation. (c) Height: Measured with a tape measure from the upper edge of the middle of the clavicle (standing upright with arms relaxed) to the costal arch along the anterior axillary line on both the left and right sides. (d) Circumference: measured with a tape measure at the xiphoid process level during inhalation and exhalation.[11] Ratios between different measurements were calculated afterward. In the PSP group, chest measurements were performed the next day after removing the chest tube and having an expanded lung on the chest X-ray.

Smoking history was recorded for every participant and categorized as never or current smoker. Controls were recruited without regard to smoking status and, therefore, were not formally matched to cases on this variable; notably, neither cohort included any former smokers.

Statistical analysis was performed using R software. The normality of quantitative variables was assessed using the Shapiro–Wilk test. Homogeneity of variances between groups was evaluated with the *F*-test. For normally distributed variables, group comparisons were performed using the independent samples *t*-test. In cases where the assumptions of normality or equal variance were violated, the Wilcoxon rank-sum test (Mann–Whitney *U*-test) was applied as a nonparametric alternative. Categorical variables were analyzed using Pearson's Chi-squared test, while Fisher's exact test was employed when expected cell counts were below five. To identify factors possibly influencing PSP, a multivariable logistic regression analysis (both direction stepwise

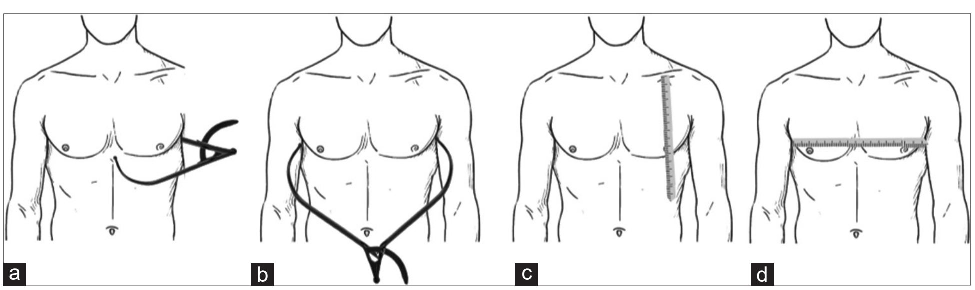

Figure 1: Thoracic anthropometric measurements. (a) sagittal dimension of the chest, (b) lateral dimension of the chest, (c) height of the chest, (d) circumference of the chest

regression model) was performed. Six factors were included in the model with a sample size of 58 ($v = 51$ and $u = 6$) and assuming Cohen's effect size $f^2 = 0.4458$).

The power analysis result is 96.8% to detect a statistically significant effect at $\alpha = 0.05$. This means there is a 3.2% chance of a type II error (failing to detect a true effect). A confidence level of 0.95 was applied, considering $P < 0.05$ as statistically significant.[12]

Results

The study analyzed data from 58 males, of whom 20 (34.5%) were healthy volunteers and 38 (65.5%) were cases of the first episode of PSP. A statistically significant difference in mean weight and BMI scores was observed between PSP patients and the healthy group (70.1 ± 9.7 kg vs. 78.1 ± 12.4 kg, $P = 0.009$, and 20.9 ± 2.0 vs. 23.5 ± 3.9, $P = 0.01$, respectively). The thoracic index (ratio of transverse and sagittal chest diameters) on inhalation and exhalation was higher in the PSP group, however, not significantly. The ratio of BMI and chest height was significantly lower in PSP patients compared to the healthy group (0.57 ± 0.05 vs. 0.63 ± 0.11 on the right and 0.56 ± 0.05 vs. 0.63 ± 0.11 on the left, respectively). The mean values of thoracic sagittal diameters during inhalation and exhalation were significantly smaller in the PSP group. The transverse diameter on inhalation in the PSP group was also smaller (30.7 ± 2.0 cm vs. 32.0 ± 2.5 cm, $P = 0.037$) [Table 1]. Although there was no statistically significant association between smoking and morbidity in the analyzed data (P 0.071), the result suggests a clear trend that may indicate a potential relationship between smoking and PSP, which could become significant in a larger sample [Table 2]. Multivariable logistic regression analysis showed that height, weight, and chest circumference on exhalation had a significant influence on PSP. Other factors, including smoking, had no significant influence on PSP [Table 3].

Discussion

This study found significant differences in BMI, weight, the ratio of BMI and chest height on both sides, sagittal thoracic diameters, and transverse diameters when inhaled between PSP patients and healthy controls. These findings are consistent with earlier research that indicates a typical ectomorphic body habitus – a tall, thin physique – as a characteristic shared by people with PSP.[13] While chest wall proportions and thoracic framework are primarily determined by skeletal anatomy and thus expected to remain relatively stable, functional respiratory movement (i.e., thoracic expansion) in our study may be affected in PSP patients. Specifically, the amplitude of chest movement between inhalation and exhalation could be somewhat reduced due to pain, restricted mobility, or residual effects from a chest drain wound. However, these influences are transient and unlikely to alter the structural thoracic dimensions measured in this study significantly.

Even more specifically, the Ankara Numune Risk Index was created by Akkas *et al*. to evaluate the risk of PSP by dividing BMI by radiological chest height measurements.[14] This index showed high accuracy in predicting PSP risk but was insufficient in determining the likelihood of recurrence.[14] Although the Ankara Numune Risk Index may help assess PSP risk, it is also important to consider genetic predisposition, smoking, and lifestyle factors. In addition, while providing precise data, imaging-based

Table 1: Comparison of the groups.

Factors	Mean values		*P*
	Individuals with PSP (*n*=38)	Healthy volunteers (*n*=20)	
Age (years)	24.2±4.0	24.9±1.9	0.129
Height (cm)	182.6±6.9	182.3±6.7	0.859
Weight (kg)	70.1±9.7	78.1±12.4	0.009*
BMI (kg/m^2)	20.9±2.0	23.5±3.9	0.010*
Chest circumference on inhalation (cm)	91.8±5.7	94.3±7.5	0.169
Chest circumference on exhalation (cm)	86.7±5.7	88.1±9.0	0.537
Difference in chest circumference (cm)	5.1±1.7	6.2±2.7	0.118
Chest height (right) (cm)	37.0±1.7	37.8±2.8	0.282
Chest height (left) (cm)	37.3±1.8	37.8±2.5	0.427
Ratio of BMI and chest height (on the right)	0.57±0.05	0.63±0.11	0.030*
Ratio of BMI and chest height (on the left)	0.56±0.05	0.63±0.11	0.021*
Sagittal diameter on inhalation (cm)	22.3±2.1	24.0±2.5	0.007*
Sagittal diameter exhalation (cm)	19.9±2.0	21.4±2.5	0.016*
Transverse diameter on inhalation (cm)	30.7±2.0	32.0±2.5	0.038*
Transverse diameter on exhalation (cm)	28.9±1.9	29.9±2.5	0.084
Ratio of transverse and sagittal diameters on inhalation (thoracic index)	1.38±0.13	1.34±0.13	0.291
Ratio of transverse and sagittal diameters on exhalation (thoracic index)	1.46±0.13	1.41±0.13	0.140

*Statistically significant (p<0.05). PSP=Primary spontaneous pneumothorax, BMI=Body mass index

Table 2: Association analysis of smoking and place of residence with morbidity.

Factors	Individuals with PSP (*n*=38)	Healthy volunteers (*n*=20)	*P*
Smoking	Smokers 73.7%	Smokers 50%	0.071
Place of residence (urban/rural)	Urban 79%	Urban 75%	0.750

PSP=Primary spontaneous pneumothorax

Table 3: Influence of anthropometric measurements on primary spontaneous pneumothorax (multivariable logistic regression analysis).

Variables	OR (95% CI)	*P*
Smoking	1.42 (0.28–6.96)	0.666
Height (cm)	1.27 (1.09–1.53)	0.005
Weight (kg)	0.69 (0.53–0.84)	0.002
Age (years)	0.96 (0.76–1.20)	0.722
Chest circumference on inhalation (cm)	0.79 (0.47–1.25)	0.334
Chest circumference on exhalation (cm)	1.86 (1.23–3.22)	0.010

OR=Odds ratio, CI=Confidence interval

indices may not always be practical for routine clinical use. Our study attempted to calculate a similar ratio by dividing BMI by anthropometric chest height measurements. We found that the ratio of BMI to chest height was significantly lower in PSP patients compared to healthy controls on both the right (0.57 ± 0.05 vs. 0.63 ± 0.11, P = 0.0297) and the left sides (0.56 ± 0.05 vs. 0.63 ± 0.11, P = 0.0211). Further research is needed to compare radiological and anthropometric chest height measurements to refine PSP risk assessment tools. Regarding the impact of BMI on PSP, some studies suggest that low BMI has been linked to a higher likelihood of PSP recurrence.[15]

Several studies showed a link between PSP and faster height growth throughout adolescence, including a comprehensive Japanese examination of 5604 pneumothorax cases.[13,16] Moreover, research suggests that early childhood may be the period when ectomorphism in patients with spontaneous pneumothorax first becomes apparent.[17] As Chang *et al*. note, the increased chest height in adolescents becomes a characteristic feature of patients with PSP, which could provide insight into the early development of the disease.[18] Accelerated height growth and delayed weight gain (sharp rise in the thoracic cavity's vertical dimension compared to its horizontal dimension) during adolescence could enhance the gradient of negative pleural pressure, potentially contributing to the development of PSP.[19,20] This, compounded by the fact that the reduced sagittal thoracic dimensions were observed in our study, may indicate altered thoracic mechanics, as taller people are thought to have higher distension pressures at the lung apex, which may make them more susceptible to the production of blebs and bullae. However, this notion has not been confirmed.[21,22] It should also be noted that the observed differences in sagittal and transverse measurements could also be influenced by the greater chest wall thickness (greater BMI) and overall larger body habitus of the healthy volunteer group. Nevertheless, the thoracic index was found to be slightly higher in the PSP groups, which suggests that the ratio of transverse and sagittal diameters of the chest could also be important as vertical measurements in assessing the risk of PSP. Further studies on PSP pathophysiology have investigated the involvement of chest wall shape to suggest the possible biomechanical causes of the disease,[23,24] and it may be associated with lung development.[25] These results support the idea that development patterns and body morphology are important factors in the pathophysiology of PSP.

Whereas our study found no statistically significant relationship between smoking and PSP incidence, the observed trends align with previous large-scale studies, such as those conducted in Sweden, which have consistently demonstrated a strong correlation with smoking.[9] It was found that it increases the risk of a first spontaneous pneumothorax episode, making women about nine times and men about twenty-two times more likely to develop the condition compared to nonsmokers, with a clear dose–response relationship.[9] Differences in sample size and participant characteristics (e.g., young age, possibly less established lifestyle habits, and declining traditional cigarette smoking) could explain discrepancies between studies. There is currently insufficient data to determine whether e-cigarette use affects the risk and recurrence rates of PSP despite the growing popularity of e-cigarettes, especially among younger populations.

Artificial intelligence tools could also help with PSP: a simple algorithm with chest measurements and triage data could flag tall, thin patients who arrive with sudden chest pain and prompt doctors.[26] Furthermore, AI technology could be helpful in the future to determine the riskiest PSP patients for recurrence, for whom surgery could be offered as a treatment of choice during the first PSP episode.

Conclusion

The group with PSP had significant differences in BMI, weight, the ratio between BMI and chest height, thoracic sagittal diameter, and transverse diameter on inhalation compared with healthy volunteers. Weight, height, and chest circumference have a significant influence on PSP. The incidence of PSP was independent of the place of residence. At the same time, smokers tend to have a higher incidence of PSP.

Study limitations

Our study analyzed smoking and anthropometric parameters. Factors such as dietary habits, physical activity levels, or even environmental factors were not considered. Detailed data on smoking intensity were missing for a substantial proportion of participants, so cumulative exposure in pack-years was not calculated. The relatively small sample size may affect the robustness and statistical power of the findings and could decrease the accuracy of the regression model. That does not allow for the establishment of definitive cutoffs or a robust clinical algorithm. Furthermore, the results could not be generalized to a larger population because female subjects were excluded from the study. Larger and more diverse cohorts are needed to confirm and extend these results. The excursions of the chest during inhalation and exhalation in the PSP group could be influenced and possibly decreased because of the healing chest tube wound. However, that should not influence the height of the chest and the calculated ratios.

Acknowledgments

None.

Authors' contributions

ZJ conceptualized the study design, conducted data collection and analysis, and contributed to manuscript editing; GK performed statistical analysis, conducted the literature review, and drafted the initial manuscript; AS interpreted the data, reviewed the manuscript, and contributed to its finalization. All authors approved the final draft of the manuscript and take full responsibility for its content and integrity.

Ethical statement

The procedures followed were by the ethical standards of the Helsinki Declaration of 1975, as revised in 2000. This study was also approved by the Vilnius Regional Biomedical Research Ethics Committee at Vilnius University (2021.04.27) and the Lithuanian Bioethics Committee (2021.04.28). All participants provided informed consent before their inclusion in the study.

Participation consent

Participation consent is in native (Lithuanian) language and is available upon reasonable request from the corresponding author.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Data availability statement

Data available upon reasonable request from the corresponding author.

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