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Review

Factors Affecting Lung Function: A Review of the Literature☆

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ABSTRACT

Lung function reference values are traditionally based on anthropometric factors, such as weight, height, sex, and age. FVC and FEV_1 decline with age, while volumes and capacities, such as RV and FRC, increase. TLC, VC, RV, FVC and FEV_1 are affected by height, since they are proportional to body size. This means that a tall individual will experience greater decrease in lung volumes as they get older. Some variables, such as FRC and ERV, decline exponentially with an increase in weight, to the extent that tidal volume in morbidly obese patients can be close to that of RV. Men have longer airways than women, causing greater specific resistance in the respiratory tract. The increased work of breathing to increase ventilation among women means that their consumption of oxygen is higher than men under similar conditions of physical intensity. Lung volumes are higher when the subject is standing than in other positions. DLCO is significantly higher in supine positions than in sitting or standing positions, but the difference between sitting and standing positions is not significant. Anthropometric characteristics are insufficient to explain differences in lung function between different ethnic groups, underlining the importance of considering other factors in addition to the conventional anthropometric measurements.

Factores que afectan a la función pulmonar: una revisión bibliográfica

Palabras clave:
Función pulmonar
Pruebas funcionales respiratorias

RESUMEN

Los valores de referencia de las pruebas de función pulmonar están basados históricamente en factores antropométricos como el peso, la altura, el género y la edad. La FVC y el FEV_1 disminuyen con la edad y, en contraposición, volúmenes y capacidades como el RV y la FRC se incrementan. La TLC, CV, RV, FVC y FEV_1 se ven afectados por la altura, puesto que son proporcionales al tamaño corporal. Esto significa que un individuo alto sufrirá un mayor decremento de sus volúmenes pulmonares a medida que aumente su edad. Algunas variables decrecen exponencialmente con el incremento del peso, como la FRC y el ERV, de tal forma que los sujetos con obesidad mórbida pueden llegar a alcanzar un volumen corriente cercano al RV. Los hombres poseen vías aéreas de conducción más largas que las mujeres, dando lugar a una mayor resistencia específica de las vías respiratorias. El mayor trabajo respiratorio en mujeres para aumentar la ventilación provoca que, en condiciones con la misma intensidad física, el consumo de oxígeno sea más alto que en hombres. En posición vertical los volúmenes pulmonares son más altos que en el resto de las posturas. La DLCO es significativamente mayor en posiciones supinas que en posición sentada y vertical, no existiendo diferencias significativas en posición sentada y de pie. Las características antropométricas no son suficientes para explicar las diferencias existentes en la función pulmonar entre diferentes etnias y ponen de manifiesto la importancia de considerar otros factores adicionales a los clásicos antropométricos para su medición.

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Introduction

Lung function tests (LFTs) are a combination of studies conducted in clinical practice to determine lung capacity and possible deterioration of the mechanical function of the lungs, respiratory muscles, and chest wall. These tests are useful for confirming the possible existence and severity of lung diseases, and also for evaluating respiratory response to possible therapeutic interventions.[1]

Reference values for LFTs in clinical practice are often difficult to estimate. In clinical guidelines, the interpretation of lung function has historically been based on the most important anthropometric factors, including weight, height, sex, and age.[2] However, as knowledge in this area has grown, other factors have gained particular relevance. The most important of these are physical parameters (circadian rhythms,[3] menstrual cycle,[4] chest diameter,[5] trachea size),[6] social and healthcare considerations (educational level,[7] socioeconomic status,[8] workplace exposures),[9] environmental factors (air pollution,[10] climatic conditions,[11] natural disasters,[12] altitude),[13] race or ethnic group,[14] lifestyle (nutrition,[15] level of physical activity,[16] smoking),[17] diseases (diabetes,[18] muscle or hormone disorders),[19] physical position,[20] genetic factors,[21] war situations (military conflicts,[22] terrorist attacks),[23] and even influencing factors occurring during childhood[24] or pregnancy.[25]

Although a more or less extensive bibliography is available on how each of the factors mentioned above affects lung morphology and function, to the best of our knowledge, there are no recent reviews that discuss and integrate all these elements into a single comprehensive source. This review aims to focus on anthropometric factors, physical position, and race and ethnic groups, to give an overview of how these factors affect lung function (Fig. 1).

Materials and Methods

This study was based primarily on a systematic review of the existing literature on factors affecting lung function. To this end, we have used several free-access search engines, including PubMed, Lilacs, SciELO, GoPEDro, Google Scholar, and Scopus databases. Reviews, observational studies, clinical trials, and mathematical models particularly from the last five years were selected, although some older publications that were of particular relevance to the topic were also considered.

The literature search was based on various key words used independently or in combination with the use of OR and AND operators. The search terms included: “lung function testing”, “pulmonary function tests”, “pulmonary function”, “pulmonary impairment”, “spirometry”, “plethysmograph”, “lung volumes”, “diffusing capacity”, “arterial blood gases”, “chronic obstructive pulmonary disease” and “lung function values”, as well as all and each of the spirometric variables analyzed in this study and the correlations between these, and ethnic groups (primarily Caucasian, African American, and Asian) and each factor affecting lung function.

Results

Each of the factors that have the most effect on lung function and those of most interest for this study will be examined in detail in this section.

Age

Age has historically been one of the major factors in the evaluation of lung function. Pulmonary maturity is reached at about 20–25 years of age,[26] after which lung function progressively begins to decline.[27]

The variables most affected are forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1); these decline with age[28] due to decreased compliance of the chest wall, loss of expiratory muscle strength, and the growing tendency of the smaller airways to close during forced expiration.[29] Specifically, FEV_1 declines by around 20 ml/year between the ages of 25 and 39 years, a rate which gradually increases until it reaches 35 ml/year after the age of 65.[30] The FEV_1/FVC ratio also decreases with age, with the steepest decline occurring between the ages of 3 and 10 years, due to the marked increase of FVC compared to FEV_1 that occurs during that period. This trend is temporarily reversed during childhood, when the FEV_1/FVC ratio rises slightly until the age of 16, after which the decline is continuous. This decline is presumably due to the gradual loss of lung elasticity. In contrast, volumes and capacities, such as residual volume (RV) and functional residual capacity (FRC) increase, while vital capacity (VC) and inspiratory capacity (IC) fall as a result of airway closure, progressive hardening of lung tissue, and loss of elastic recoil pressure.[31] Finally, total lung capacity (TLC) generally remains constant in the absence of disease.[30,32]

Gas exchange tends to decrease with age due to the loss of alveolar surface and reduced blood volume.[33] During childhood, PAO_2 and $PACO_2$ do not change significantly, but PaO_2 increases gradually during adolescence. Ventilatory response to hypercapnia and hypoxia is highest in early childhood and fall gradually until adulthood.[34] Specifically, the decline in carbon monoxide diffusion in the lung (DLCO) is around 0.2 mlCO/min/mmHg/year.[30,35] This also causes a progressive decrease in PaO_2 from 95 mmHg at the

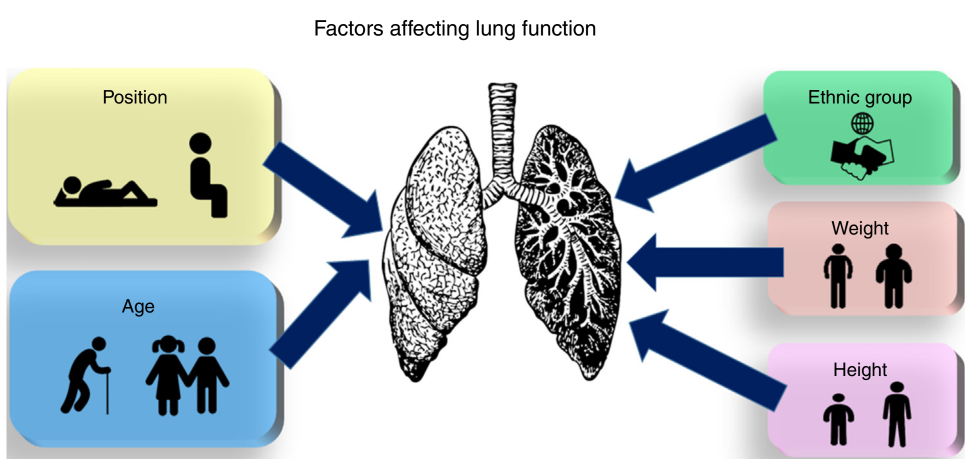

Fig. 1. Factors affecting lung function.