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Relationships between vital capacity, height and nasal airway resistance in asymptomatic volunteers

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SUMMARY

Nasal airway resistance (NAR), vital capacity and height were measured in 76 asymptomatic volunteers aged between 18 and 71, mean age 28 ± 1.4 years. Total NAR ranged from 0.15-0.39 Pa/cm^3/s, with a mean total NAR of 0.23 ± 0.006 Pa/cm^3/s. Despite a good correlation between vital capacity and height in these subjects (r = 0.76) no relationships were found between either total NAR and vital capacity or total NAR and height. Physiological NAR is not related to vital capacity or height in normal healthy individuals.

INTRODUCTION

Vital capacity is a parameter of pulmonary function that provides a measure of lung volume. Lung volume is determined by the volume of the thorax, with reflex mechanisms, strength of respiratory muscles and lung elasticity also contributing. In normal individuals it is well known that vital capacity correlates positively with height (Biersteker and Biersteker, 1985).

The size of the upper respiratory tract may well correlate with that of the lower respiratory tract. A tall individual with large vital capacity may have a correspondingly large nasal airway. As nasal airway resistance (NAR) is related to the cross-sectional area of the airway, this study set out to investigate whether NAR was inversely related to vital capacity and height in asymptomatic subjects.

METHOD

Subjects for the study were 76 healthy volunteers, i.e. 47 males and 29 females (aged 18-71, mean 28 ± 1.4 years) from Cardiff University's student and staff population who came forward in response to advertisements. A questionnaire was completed to obtain a brief history and establish subject suitability. All were free from perennial rhinitis, acute seasonal rhinitis, upper respiratory-tract infection, asthma, chronic bronchitis or sinusitis, and had not taken any medication in the 24 hours prior to the study.

Subjects sat quietly for approximately 10 min to acclimatize to the laboratory environment before any measurements were taken. NAR ($Pa/cm^3/s$) was measured using a NR6D Rhinomanometer (Mercury Electronics, Glasgow) by active anterior rhinomanometry at a sample pressure of 150 Pa. Only inspiratory NAR was recorded as it has been previously shown that there is no difference in inspiratory and expiratory NAR in asymptomatic individuals (Eccles et al., 1987). NAR of 4 consecutive breaths was recorded along with the mean NAR. Three consecutive measurements of mean NAR were made. If the coefficient of variation of the overall mean (12 breaths) was less than 20%, then measurements were accepted; if not, measurements were continued until the criteria had been fulfilled. The overall mean NAR of each nasal passage was then used to calculate total NAR from the following equation (Kern, 1977):

$$\frac{1}{R_{left}} + \frac{1}{R_{right}} = \frac{1}{R_{total}}$$

Subjects' age and height was recorded. In order to measure vital capacity, a slow vital capacity test was performed with subjects in a standing position, using a Vitalograph compact spirometer. Subjects were given the following instructions: "Take in a deep breath and completely fill your lungs with air, now put the mouthpiece into your mouth and seal your lips tightly around it, then breathe out into the instrument slowly and smoothly until no more air can be exhaled". As the performance of lung function tests often improves with practise, subjects performed 2 to 4 slow vital capacity manoeuvres with 1-min rests between each. This ensured that all individuals obtained at least 75% of the Vitalograph's predicted value for their sex, age and height. The greatest volume achieved was recorded in litres.

Statistical analysis was carried out using simple regression and unpaired t-tests.

RESULTS

The results showed that total NAR in these asymptomatic subjects ranged from 0.15 to 0.39 $Pa/cm^3/s$ with mean value of 0.23 ± 0.006 $Pa/cm^3/s$. The distribution of total NAR shown in Figure 1 was skewed around the mean and tailed off towards the higher values. Vital capacity in these subjects ranged from 2.36 to 6.59 l and height from 154 to 195 cm.

When total NAR was plotted against vital capacity, no relationship was found between them. Figure 2 shows the lack of correlation between total NAR and vital capacity in these asymptomatic subjects ($r = 0.17$). A similar result was

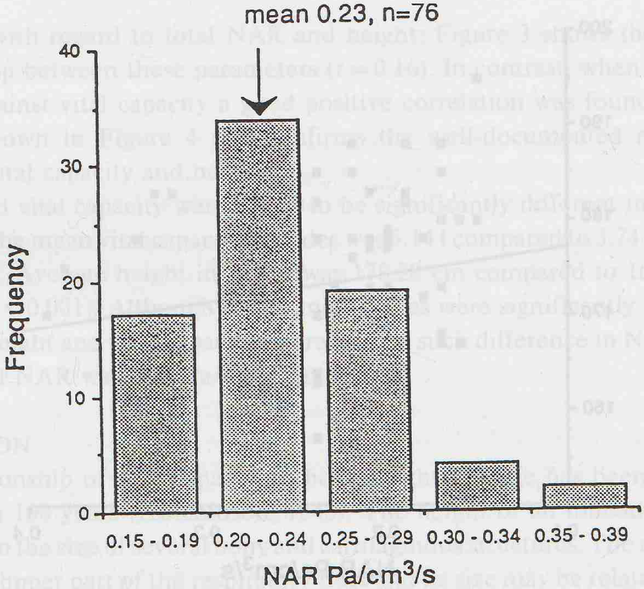

Figure 1. Frequency distribution of total NAR in asymptomatic subjects. The distribution is skewed to the left around the mean of 0.23 Pa/cm^3/s and tails off towards the higher values.

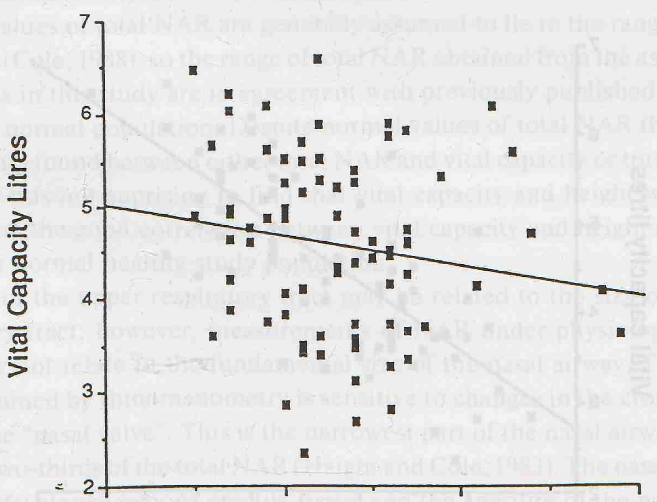

Figure 2. Regression of total NAR and vital capacity in 76 asymptomatic subjects. No relationship was found between total NAR and vital capacity (r = 0.17).

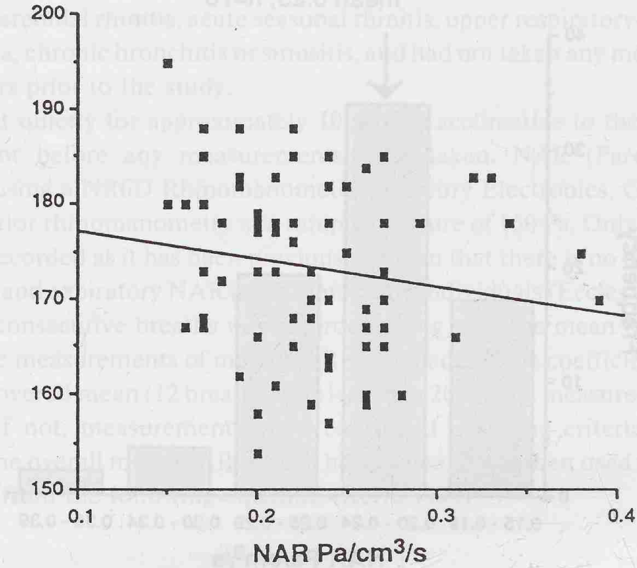

Figure 3. Regression of total NAR and height in 76 asymptomatic subjects. No relationship was found between total NAR and height (r = 0.16).

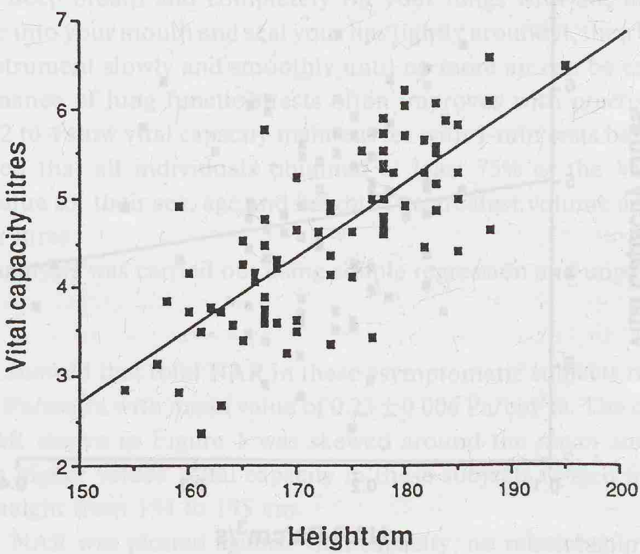

Figure 4. Regression of vital capacity and height in 76 asymptomatic subjects. Vital capacity was directly related to height (r = 0.76).

obtained with regard to total NAR and height: Figure 3 shows there was no relationship between these parameters ($r = 0.16$). In contrast, when height was plotted against vital capacity a good positive correlation was found ($r = 0.76$). This is shown in Figure 4 and confirms the well-documented relationship between vital capacity and height.

Height and vital capacity were found to be significantly different in males and females. The mean vital capacity in males was 5.14 l compared to 3.74 l in females ($p < 0.001$). Average height in males was 178.28 cm compared to 165.21 cm in females ($p < 0.001$). Although males and females were significantly different in terms of height and vital capacity, there was no such difference in NAR and the mean total NAR was 0.23 $Pa/cm^3/s$ in both.

DISCUSSION

The relationship of vital capacity to body height and age has been known for more than 100 years (Hutchinson, 1846). The height of an individual may be reflected in the size of several bony and cartilaginous structures. The nasal airway forms the upper part of the respiratory tract and its size may be related to that of the lower respiratory tract. According to Poiseuille's law, resistance to airflow is inversely related to the cross-sectional area of the airway (Cole, 1989); thus, a tall person with large airways may have lower NAR than a shorter one. This study set out to investigate whether NAR was inversely related to vital capacity and height in asymptomatic subjects.

Normal values of total NAR are generally assumed to lie in the range 0.15–0.30 $Pa/cm^3/s$ (Cole, 1988), so the range of total NAR obtained from the asymptomatic subjects in this study are in agreement with previously published values and suggest a normal population. Despite normal values of total NAR there was no relationship found between either total NAR and vital capacity or total NAR and height. It was not suprising to find that vital capacity and height were closely related and the good correlation between vital capacity and height also helped confirm a normal healthy study population.

The size of the upper respiratory tract may be related to the size of the lower respiratory tract; however, measurements of NAR under physiological conditions may not relate to the fundamental size of the nasal airway. The value of NAR obtained by rhinomanometry is sensitive to changes in the cross-sectional area of the "nasal valve". This is the narrowest part of the nasal airway and contributes two-thirds of the total NAR (Haight and Cole, 1983). The nasal valve area has well-developed venous erectile tissue and the aperture of the nasal valve is largely dependent on the state of engorgement of this tissue which is controlled by the sympathetic activity of the autonomic nervous system. Nasal blood vessels are extremely sensitive to circulating adrenaline and changes in the level of sympathetic tone can alter NAR significantly. One of the best examples is exercise which can reduce NAR by half (Dallimore and Eccles, 1977).

Vital capacity is a fairly stable parameter which changes primarily with age and disease as lung elasticity and muscle strength deteriorate. Such alterations in vital capacity course months or years (Berglund, 1963). In contrast, NAR is continuously changing to some degree. Physiological NAR is likely to be too unstable a parameter to compare directly with vital capacity. Administration of a topical nasal decongestant prior to measuring NAR would shrink the venous erectile tissue and reduce the highly variable mucosal contribution of NAR. This may then enable one to measure the "anatomical" NAR which is more likely to be related to vital capacity than the physiological NAR measured in this study.

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