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Short communication

A Rwandan spirometry and resting ventilation study

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ABSTRACT

To illustrate spirometric population variation and ventilatory adaptation to moderate altitude, we report the spirometric and resting ventilation values observed in a student population in Butare, Rwanda (altitude: 1 768 m; barometric pressure: 629 mm Hg). Spirometry was carried out with a Mijnhardt Volutest VT-3 water-sealed spirometer in students aged between 20 and 30 years. The results (mean ± SD) are as follows: Vital capacity: males: 4 123 ± 537 mL, females: 2 810 ± 393 mL; Vital capacity per m^2 body surface area: males: 2 352 ± 245 mL/m^2, females: 1 771 ± 219 mL/m^2; FEV1: males: 3 576 ± 618 mL, females: 2 347 ± 474 mL; FEV1%: males: 87.8 ± 8.5 %, females: 84.5 ± 7.7 %; tidal volume: males: 540 ± 80 mL, females: 454 ± 66 mL; respiratory frequency: 17 ± 4 both in males and in females; minute volume: males: 9.3 ± 2.7 L/min., females: 7.6 ± 2.0 L/min. The results indicate that t he vital capacity and the FEV1 are lower than classical values from white populations, FEV1% is higher. The tidal volume, respiratory frequency and minute volume are increased relative to sea level. ***(Afr. J. Biomed. Res. 9: 137 - 140, May 2006)***

Keywords : *FEV1, Vital Capacity, high altitude, ventilation*

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INTRODUCTION

Spirometry is important in pulmonary diagnosis; it is often carried out in practice to check the pulmonary function (Crapo, 1994). Spirometric results depend on several influencing factors, notably age, height, weight, body surface area, sex and race (White *et al*., 1994). Significant deviation from normal values can be used as an aid to pulmonary diagnosis. High altitude increases pulmonary ventilation by acclimatization to high altitude hypoxemia (Lenfant and Sullivan, 1971; Schoene, 1997); however there are population differences (Frisancho *et al*., 1999; Moore, 2000). Its effects on lung volumes are negligible at altitudes lower than 1 800 m (Brändli *et al*., 1996; Fiori *et al*., 2000; Gaultier and Crapo, 1997). We recently described blood gas, acid-base and hemoglobin characteristics in Butare, Rwanda (altitude: 1 768 m, barometric pressure: 629 mm Hg); acclimatization to moderate altitude was observed, characterized by a slight chronic respiratory alkalosis with complete metabolic compensation (Gahutu *et al*., 2005).

We report here spirometric values observed in Rwandan university students in Butare, so far the only spirometry study carried out in the Rwandan population.

SUBJECTS AND METHODS

Spirometric measurements were carried out on voluntary non-smoker students of the National University of Rwanda, aged between 20 and 30 years, in apparent good health, without any respiratory disease. Sex and age were recorded for each subject. The weight and height were measured on slightly clothed subjects without shoes. We did not measure the sitting height. We used a Mijnhardt Volutest VT-3 water-sealed spirometer in compliance with the manufacturer's instructions (Mijnhardt, Odijk, Holland). The spirometer has a 9 L bell; its normal speed is 60 mm/min and its speed during FEV1 maneuver is 1 200 mm/min. The spirometer system was leak-proof. Soda lime was used for trapping CO_2 and the spirogram curve was stabilized by an oxygen supply. The smallest unit of the spirogram paper was 50 mL, permitting an acceptable accuracy (Quanjer *et al*., 1993). The test subjects were in resting conditions, 2–5 hours after the meal, in sitting position and with a nose clip. Ambient temperature was around 24 ºC. One maneuver of relaxed vital capacity was performed: after a maximum inspiration, the test subject expired as deeply as possible, and the vital capacity value was determined by measuring the maximum amplitude of the recorded spirogram. One maneuver of forced vital capacity was also performed: after a maximum inspiration, the test subject expired as fast and as deeply as possible; forced vital capacity was determined by measuring the maximum volume forcefully expired. In case of difference between relaxed vital capacity and forced vital capacity, the highest value was retained as vital capacity. The maneuver of forced vital capacity also permitted to determine the FEV1 (forced expiratory volume in 1 second: volume forcefully expired in the first second) and the FEV1% (forced expiratory volume in 1 second in % of the forced vital capacity). Volumes were transformed from ATPS (ambient temperature and pressure, saturated with water vapor) to BTPS (body temperature and pressure, saturated with water vapor) with an appropriate formula (Quanjer *et al*., 1993). The body surface area was calculated according to the formula of DuBois in order to calculate the vital capacity per m^2 of body surface area.

Statistical Analysis

The results were analyzed on the computer with Epi-Info 6.04 software.

RESULTS

The mean age of the subjects was 24 years for males and 23 years for females. The anthropometric data of test subjects (mean ± SD) are as follows: Weight: 64.2 ± 6.5 kg in males and 57.8 ± 8.7 kg in females. Height: 172.4 ± 6.7 cm in males and 160.2 ± 6.0 cm in females. Body surface area: 1.76 ± 0.11 m^2 in males and 1.59 ± 0.11 m^2 in females.

The spirometric and resting ventilation results (mean ± SD) are shown in Fig. 1 1.

DISCUSSIONS

Compared with classical theoretical values obtained from European and American populations, vital capacity is lower in our study, both in males and in females, due to a lower inspiratory reserve volume; the expiratory reserve volume is higher.

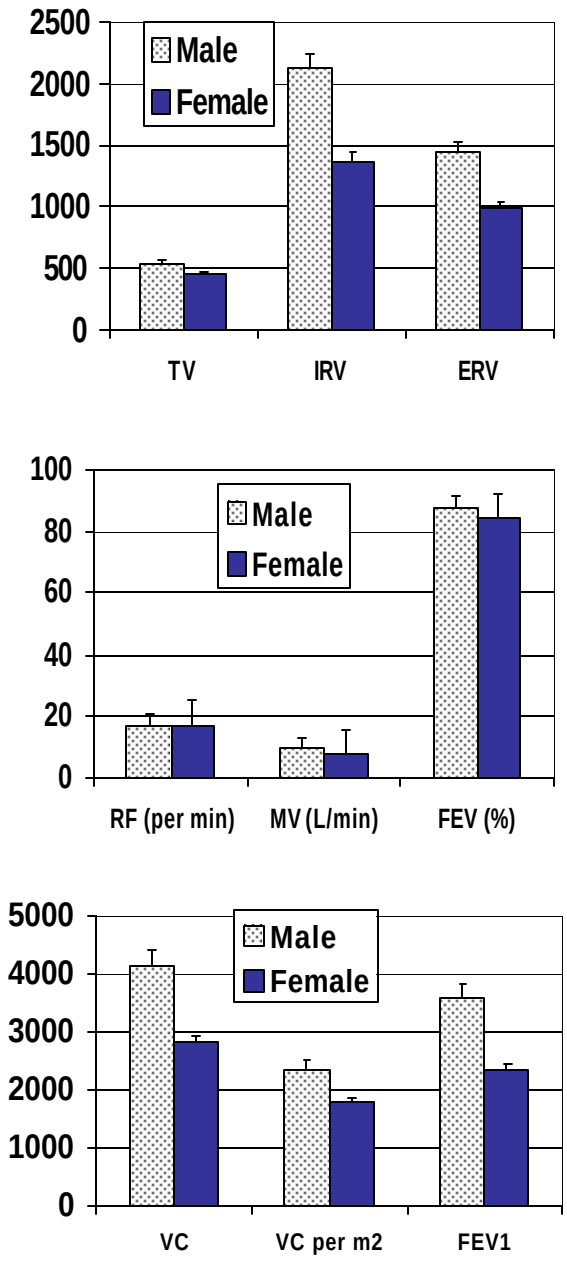

Fig. 1:
Mean values of pulmonary volumes and capacities. Each bar represents the mean value ± SD, in mL unless otherwise indicated. TV = tidal volume; RF =respiratory frequency; MV = minute volume; IRV = inspiratory reserve volume; ERV = expiratory reserve volume; VC = vital capacity; VC per m2 = vital capacity per m2 of body surface area; FEV1 = forced expiratory volume in 1second; FEV1% = forced expiratory volume in 1 second in % of the forced vital capacity. N: males: 73, females: 35.

Variations in vital capacity values in African, American, Asian and European populations are classical (Goldin *et al*., 1996; Louw *et al*., 1996; Quanjer *et al*., 1993). Lower values of vital capacity in African populations have been reported in males and females (Dufetel *et al*., 1989; Goldin *et al*., 1996; Louw *et al*., 1996; Mengesha and Mekonnem, 1985; Mustafa, 1977; Quanjer *et al*., 1993). This is also the finding of our study, in which the decrease in vital capacity is 14 % in males and 12 % in females while the decrease of the vital capacity per m^2 of body surface area is 9 % in males and 15 % in females. Differences in the above mentioned studies are similar. Besides anthropometric differences (Goldin *et al*., 1996; Hankinson *et al*., 1999; Quanjer *et al*., 1993), nutritional and socio-environmental factors may play a role in the lower FVC observed in Africans (Gaultier and Crapo, 1997; Goldin *et al*., 1996; Quanjer *et al*., 1993). Lower values observed in our series are not due to the sitting position, since in young adults it does not lower the vital capacity relative to the standing position (Quanjer *et al*., 1993).

The FEV_1 is also lower than classical values in our series (10 % in males and 8 % in females); lower FEV1 values in Africans have also been found by other authors (Dufetel *et al*., 1989; Hankinson *et al*., 1999; Mengesha and Mekonnem, 1985; Mustafa, 1977). The FEV1% in our series is 5 % higher than the classical mean value, both in males and in females, probably due to a lower vital capacity. In other studies, the ratio is similar in black and white subjects (Dufetel *et al*., 1989; Hankinson *et al*., 1999).

The tidal volume, the respiratory frequency and the minute volume are higher than at sea level both in males and in females. This is due to acclimatization to altitude that we illustrated in a recent study, showing in Butare a P_aO_2 of 83.0 and 84.5 mm Hg, a $PaCO_2$ of 34.7 and 31.8 mm Hg and a hemoglobin oxygen saturation of 97.0 and 94.7 % in males and females respectively (Gahutu *et al*., 2005). This increase in minute volume is a classical altitude respiratory adaptation (Frisancho *et al*., 1999; Lenfant and Sullivan, 1971; Schoene, 1997). The observed minute volume in males and in females is about 55 % higher than at sea level, indicating a slight hyperventilation. This is mainly attributable to altitude acclimatization. However, the subjects were not in basal conditions (not fasting since at least 12 hours). Spirometry was done 2-5 hours after the meal and the resting metabolism determined by indirect calorimetry using the same spirometer showed a mean increase of

14 % in the males and 7 % in the females relative to the predicted theoretical basal metabolic rate for the test subjects. Therefore, part of the increase in ventilation was due to resting metabolism. At a slightly lower altitude of 1 680 m, a comparable ventilation was observed in males: 153 ± 5.7 $mL.min^{-1}.kg^{-1}$; weight: 64.3 ± 1.5 kg (mean ± SD) (Serebrovskaya and Ivashkevich, 1992). At higher altitudes, the increase in ventilation is greater (Frisancho *et al*., 1999; Schoene, 1997; Serebrovskaya and Ivashkevich, 1992).

The difference observed between males and females, with pulmonary volumes and capacities 20 to 25 percent lower in females than in males is classical (Quanjer *et al*., 1993).

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