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Reference values and repeatability of inspiratory capacity for men and women aged 65–85

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Summary The inspiratory capacity (IC) has recently gained importance because it may signal the occurrence of dynamic hyperinflation at rest or during exercise by reflecting changes in the end expiratory lung volume (EELV). However, reliable predicted values for IC are not currently available. The aim of the study was to generate predictive equations for reference values of IC in adults aged 65–85 living in Italy and to determine its limits of the within test-session repeatability.

From the control group ($n = 429$) of the SARA study data base, 241 (161 females) never smoked, non-obese (BMI $< 30\,kg/m^2$) healthy subjects aged 65–85 who were able to correctly perform at least two manoeuvres of IC were selected.

A model that incorporated age, height and body mass index as significant predictors in either sexes produced predicting equations for IC with a coefficient of determination of $r^2 = .36$ and .34 for females and males, respectively. Ninety per cent of all the subjects were able to keep the second highest IC within 200 ml (<9%) from the best IC. No significant gender difference was found for IC repeatability.

We provided the equations for deriving reliable IC reference values that can be applied in the elderly people living in southern Europe. In this population IC showed limits of the within-session repeatability similar to those accepted for other spirometric indices such as FEV_1 and FVC.

Introduction

The inspiratory capacity (IC), the maximal amount of air that can be inhaled from the end expiratory lung volume (EELV) that normally corresponds to the static functional residual capacity (FRC), has been neglected as spirometric measurement for a long time. Recently, however, it has been recognized that IC represents the volume reserve of the tidal volume and may specularly reflect the dynamic variations of EELV and FRC when the total

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lung capacity (TLC) is expected to remain unchanged.

Therefore, the IC has been evaluated and found to be useful, mostly in COPD patients exhibiting expiratory flow limitation (EFL), as predictive index of exertional capacity[1,2] and dynamic increase in FRC at rest,[3,4] in different body positions, and during exercise.[5] Furthermore, in flow limited COPD patients the effectiveness of different bronchodilators has also been evaluated also in terms of volume response, looking at the IC increase.[6,7] Today, the IC is increasingly regarded as very important to determine the tolerance of exercise and signal the occurrence or change of dynamic hyperinflation in COPD as well as in other diseases.[8–10] Accordingly, in several studies predicted values of IC were used to select and compare subjects or to assess the results of a given treatment. Actually, the predicted IC can be only calculated by the difference of the theoretical values of TLC and FRC that were obtained with plethysmographic or dilutional method and in subjects aged less than 70 yr several years ago.[11] Because of these reasons, the IC reference values are poorly reliable for research and routine purposes, especially in the elderly. The prediction equations for IC values based on the population studies are surprisingly lacking in the literature. The aim of this study was to obtain appropriate reference values for IC in a sample of never smoker, healthy subjects selected from the general population living in Italy, aged 65–85. The second aim was to assess the within test-session repeatability of this parameter in the same population sample.

Materials and methods

Spirometric data were obtained from the database of the study known as "SAlute Respiratoria nell'Anziano" (SARA), meaning respiratory health in the elderly. SARA was a multi-centre Italian research project designed to analyse several aspects of chronic airway obstruction in the elderly and performed by 24 pulmonary and geriatric institutions distributed throughout the country between January 1996 and December 1997.[12] Subjects with a previous diagnosis of asthma or COPD, or signs and symptoms compatible with either diagnosis were defined as cases ($n = 527$). Subjects not reporting any previous diagnosis nor any sign or symptoms compatible with respiratory diseases were considered as controls ($n = 1084$). Subjects were further excluded if they had one of the following conditions: severe hepatic failure (B and C grade of the Child index), renal failure (plasma creatinine level >2 mg/ml), heart failure (NYHA >2), diabetes and arterial hypertension, severe cognitive or sensory impairment, hospitalization for any reason in the previous 6 month, or acute events in the last 2 weeks. After these exclusion criteria had been satisfied, the control group amounted to 429 subjects.[13] From this group we selected for the analysis lifetime non-smoker subjects with body mass index $<30\,kg/m^2$, without evidence of obstructive (FEV_1/FVC $>70\%$ for individuals aged <70 yr, $\geqslant 65\%$ for individuals aged 70–80 yr and $\geqslant 60\%$ for those aged >80 yr)[14,15] or restrictive ventilatory defect (VC $>80\%$ predicted)[11] and with at least two IC manoeuvres performed correctly. The final data set consisted of 241 subjects.

Spirometry

The technical characteristics of the instruments and the results of the quality control for spirometry during the SARA study have been previously described.[16] Shortly, a computerized water-sealed light-bell Stead-Wells spirometer (Biomedin, Padova, Italy) was used with an incorporated software program that assisted the operator during the test to verify on-line both acceptability and reproducibility of the spirometric manoeuvres. All the spirometric tests employed in the study fulfilled the ATS recommendations.[16] The IC measurements were obtained, while the subjects wearing a noseclip were in the seated position, during a continuous inspiratory manoeuvre starting from FRC and computed as change in lung volume from the EELV, calculated by averaging the baseline signal of at least 3 regular tidal volumes, to TLC identified as the maximal volume signal, unchanged for at least 1 s (Fig. 1). We chose the greatest IC of at least two acceptable inspiratory manoeuvres to obtain reference values and the nearest to the maximum to determine the limits of repeatability for this parameter. The IC repeatability was assessed for males, females and both combined by computing the difference between the highest and second-highest IC, either in absolute (ml) or percentage (%) terms, within the spirometry test session. Spirometry was performed by specifically trained either physicians or technicians with considerable pulmonary function testing experience who were instructed to vigorously coach the subjects during the test execution.

Statistical analysis

Descriptive analysis was performed by computing means, medians and standard deviations (SD) in men