



EDITORIAL

Ageing and changes in lung mechanics

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Due to increasing life expectancy and low fertility, the European Union (EU) is an ageing society. Currently, 16% of its population is aged >65 yrs compared with an estimated 7% for the entire world. Further ageing of the EU population is projected over the next two decades, as shown in figure 1 for the UK, whose current population aged >65 yrs is identical to the EU average. By 2021, nearly 10% of the UK population is projected to be aged >75 yrs, with increased male survival reducing the current striking preponderance of females in the aged population. These demographic trends are important for the future patterns of healthcare and disease. Therefore, it is encouraging that three papers in the current issue of the *European Respiratory Journal* [1–3] address “normal” ageing of different aspects of airway function and study older subjects compared with many earlier studies.

Changes in pulmonary elastic and resistive properties, and in maximum expiratory flow with increasing age, were first described 40 yrs ago, admittedly by small cross-sectional studies of young adults *versus* elderly subjects. These studies established that the maximum size of the lungs (total lung capacity) did not change with age, but functional residual capacity (FRC) and residual volume (RV) both increased so that inspiratory capacity and vital capacity (VC) both declined [4]. The increase in FRC was due to an increase in relaxation volume of the respiratory system, which arose from changes in the static recoil pressure of both the chest wall and the lungs. Static recoil pressure of the lungs (P_L) fell at all lung volumes with increasing age [5, 6]. The fall in P_L contributed to the increase in RV, but this was usually overshadowed by an increased tendency to airway closure at small volume [7], itself reflecting a reduced airway transmural pressure. Changes in the shape of the expiratory P_L /lung volume (V_L) curve increased static lung compliance. All these changes are a minor version of the changes found in advanced emphysema.

Ageing changes in resistive properties were first studied soon after the development of the body plethysmograph technique to measure airway resistance (R_{aw}) by BRISCOE and DUBOIS [8]. They observed that specific airway resistance ($sR_{aw}=R_{aw}\times V_L$) measured at low flow close to FRC was, on average, similar in childhood and old age; one of the few pulmonary function measurements not to change with age. This suggested that the major factor determining R_{aw} in normal subjects was lung size, which was confirmed later by a much larger study [9]. Nevertheless, adequate reference values for resistance have only been developed recently, based on increasing use of the

simple forced oscillation technique, which measures the resistance of the total respiratory system (R_{rs}), including flow resistance of lung tissue and the chest wall, as well as the resistance of the extra- and intra-thoracic airways measured by R_{aw} [10]. Some reference values for R_{rs} have been developed for healthy children and for adults aged up to 70 yrs [10]. In the present issue of the *European Respiratory Journal*, GUO *et al.* [1] report values of R_{rs} in a large group of 223 healthy, nonsmoking subjects aged 65–100 yrs (mean age 83 yrs). They found that: 1) R_{rs} was slightly lower in aged subjects than previously reported in younger adults; 2) R_{rs} was higher in females (the majority of subjects) than males; and 3) R_{rs} was inversely related to height. Although FRC was not measured, R_{rs} was probably measured at a slightly greater V_L than in previous studies of younger adults. Therefore, lower values of R_{rs} do not challenge the findings of BRISCOE and DUBOIS [8], that sR_{aw} remains similar over the full age range. Perhaps an unchanging sR_{aw} is itself unexpected, because BUTLER *et al.* [11] also proposed that reductions in R_{aw} with lung inflation were driven by the accompanying change in P_L , which they regarded as a surrogate for the distending pressure of the intrathoracic airways. The most obvious explanation for retaining a normal or even reduced R_{rs} in old age is that changes in airway elasticity occurred in parallel with those in alveolar elasticity, so that aged airways have a bigger circumference at a standard distending pressure than the airways of younger adults [6].

The decline with increasing age in tests of forced expiration, such as forced expiratory volume in one second (FEV₁), FEV₁/

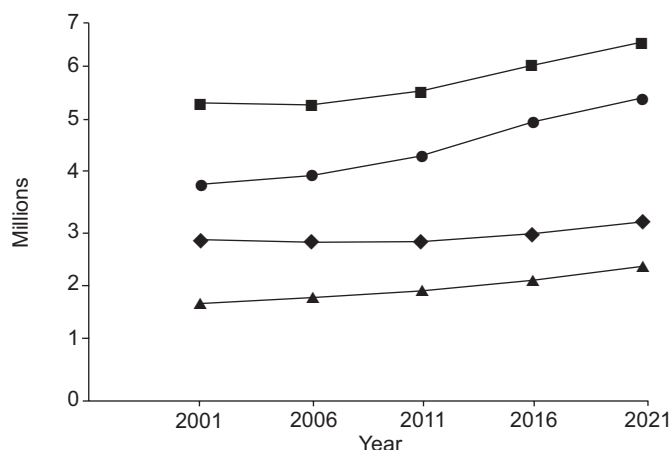


FIGURE 1. UK population projections in millions up to 2021. ■: females ≥ 65 yrs of age; ●: males ≥ 65 yrs of age; ◆: females ≥ 75 yrs of age; ▲: males ≥ 75 yrs of age. Total UK population in 2001 was 60 million.

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VC and maximum flows at different lung volumes is of wider practical importance. These changes are, in part, simply due to the smaller VC, but this is not the whole explanation because FEV₁/VC also declines with age. Although this change is often attributed to "occult" disease of the small airways not detected by resistance measurements, all the changes in maximum expiratory flow with increasing age in healthy subjects can be explained by a direct effect of the loss of PL in reducing the effective driving pressure for maximum expiratory flow, without having to postulate any intrinsic narrowing of the airways [6, 12].

A practical problem in assessing results of spirometry in older subjects is that often reference values have been derived by linear extrapolation of decline rates from studies with few subjects aged >70 yrs [1], thus, ignoring any acceleration in the rate of decline in FEV₁ that occurs with increasing age [13]. Fortunately, in the past 10 yrs several studies have reported reference values from data sets which included reasonable numbers of aged subjects up to 80–85 yrs of age [14–18]. This obviously assists investigators trying to detect mild obstructive disease in the elderly. So far, these newer cross-sectional studies do not provide conclusive evidence of acceleration of decline in FEV₁ with increasing age. The problems in actually acquiring "normal" data in an elderly population are well illustrated by a second paper in this issue of the *European Respiratory Journal* by DE BISSCHOP *et al.* [2]. From an initial 2,612 elderly subjects aged 66–88 yrs, who were identified as living in their own homes in a suburb of Bordeaux (France), the authors ended up with only 116 subjects in their healthy, never-smoker control group, two-thirds of whom were female.

The novelty in the study by DE BISSCHOP *et al.* [2] was their assessment of expiratory flow limitation (EFL) during resting tidal breathing, using the negative expiratory pressure technique. They found EFL at rest was common in old age, and was found in some elderly subjects with dyspnoea in the absence of overt cardiopulmonary disease. Tidal EFL at rest might further reduce the available ventilatory reserve during exercise by preventing any of the increased tidal volume being developed by reducing end-expired lung volume (EELV), an important change consistently found in younger subjects. Studies that have examined tidal and maximum flow-volume curves during progressive exercise in elderly subjects all agree that EFL is observed over a much larger part of the exercise tidal volume than in younger subjects, but in exceptionally fit old subjects, EELV still usually falls on exercise [19, 20]. In untrained subjects achieving much lower levels of ventilation, DELOREY and BABB [21] confirmed that EELV usually falls in "senior" subjects (mean age 70 yrs), but not in "elderly" subjects (mean age 88 yrs!). While a reduced ventilatory reserve potentially contributes to the decreased exercise ability and increased dyspnoea on exertion found with increasing age, other common important changes include reduced habitual activity and physical deconditioning, an impaired cardiac response, and loss of quadriceps mass and strength [22].

While accurate reference values for established lung function tests in old age are clearly needed, studies of the effects of ageing are required on many other less studied aspects of lung biology. A third paper in this issue of the *European Respiratory Journal* [3], which describes an age-related slowing of clearance

of inhaled 6 µm particles from the peripheral airways, is interesting because of the epidemiological evidence that short-term morbidity and mortality related to particulate exposure is concentrated in elderly subjects.

Overall, current knowledge of the basic mechanisms altering pulmonary structure and function with increasing age is very limited. One thing that is known is that the extent of the ageing process in the lungs shows great inter-individual variation at all levels from microscopic structure [23] up to the maximum exercise performance [19–21]. If we understood how such ageing changes could be minimised, it might be possible to improve the quality of the "added years" of survivors into old age.

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