Stability of pulmonary function in U.S. Navy Divers.

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Navy divers undergo repeated hyperbaric exposures under many different conditions. One concern is that repeated pulmonary insult may result in persistent or progressive decreases in lung function (1). Indeed, researchers have reported significant reductions in pulmonary function among professional divers over periods of only three to six years (2–4). To investigate whether experimental Navy diving is associated with progressive diminution of pulmonary function, we undertook a retrospective study of forced vital capacity (FVC), forced expired volume in one second (FEV₁), and diffusing capacity for carbon monoxide (DLCO) in 25 U.S. Navy divers for whom we had at least three separate baseline measurements with more than one year between the first and last measurement. Of the 25 measurement sets, 20 spanned more than two years, and eight somewhat more than five years. Divers ranged from 31 to 50 years of age with 6 to 28 years of diving experience.

The age-associated changes in pulmonary function reported from long-term, longitudinal studies vary: One study (10) predicts changes for a never-smoking, 1.8-meter tall man of –11 mL/yr in FVC and –18 mL/year in FEV₁ at age 31, –25 mL/year in FVC and –27 mL/year in FEV₁ at age 40, and –41 mL/year in FVC and –37 mL/year in FEV₁ at age 50. Another study (11) found an average change between ages 25 and 46 of –60 ± 5 mL/yr in FVC for smokers and non-smokers alike, and of –34 mL/year in FEV₁ for never-smokers and of –65 mL/year in FEV₁ for high-tar smokers.

We were unable to demonstrate these previously reported changes in pulmonary function tests in the Navy divers studied. Only two individual regression slopes, both of FVC as a function of time, were significantly less than zero; one subject showed a decline in FVC of 70 mL/year over 4.5 years (p<0.04), and the other, a heavy smoker, a decline in FVC of 140 mL/year over 1.7 years.

Pulmonary function tests are imperfectly reproducible. The American Thoracic Society has reported 95% confidence limits on changes in FVC of 11%, and in FEV₁ of 12% (5), while Knudson et al. (8) set the confidence limits at 23.5% for DLCO. At the Navy Experimental Diving Unit we have found 95% confidence limits of 7.7% for FVC, 8.4% for FEV₁, and 14.2% for DLCO (9), tighter perhaps because of a more homogeneous population and because all DLCO measurements were adjusted for hemoglobin concentration. Even so, a study would need a much larger number of subjects and a much longer time frame to demonstrate real changes.

Controversially, authors of a number of short-term studies have concluded that diving is associated with accelerated decline in pulmonary function. In commercial divers, Skogstad et al.
UHM 2004, Vol. 31, No. 4 – Pulmonary function in US Navy Divers

(2) found FVC to decrease by 0.91%/year, FEV\textsubscript{1} by 0.84%/year, and D\textsubscript{L}CO by 1.3%/year during six years. However, the average differences between first and last measurements lie within the 95% confidence bands of measurement, and the decreases in FVC and FEV\textsubscript{1} are not different from some age-related values (11). Watts (3) found FVC to be reduced by 240 mL during three or four years, a measurement difference that is not significant, and by 400 mL through five or more years, a difference that is marginally significant with a decline somewhat higher than age-related values. Bermon et al. (4) found no significant difference in pulmonary function variables over time except in D\textsubscript{L}CO, which decreased by 3%/year during five years, a measurement difference significant under NEDU criteria (9) but not under criteria applying to the general population (8), and, because the investigators did not adjust for hemoglobin or carboxyhemoglobin concentrations, the inter-test variability was probably high; we see changes in calculated D\textsubscript{L}CO ranging from 0.8% to 5% when a hemoglobin correction is applied.

The uncertainty inherent in pulmonary function measurement means that some published diving-related decreases in pulmonary function with time may not be significant. The small sample of U.S. Navy divers we studied showed no lasting effects of diving exposures on FVC, FEV\textsubscript{1}, or D\textsubscript{L}CO through periods up to 5.9 years. Because the number of subjects studied was small and the time frame short, we cannot rule out long-term deleterious pulmonary effects. However, Navy diving does not appear to have major cumulative damaging effects on lung function.

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