Timing of Changes in Oxyhemoglobin Saturation Resulting from Breath Holding

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Objectives: In the diagnosis of Obstructive Sleep Apnea (OSA), hypopneas are commonly defined as an event lasting 10 seconds or more with at least a 30% reduction in thorocoabdominal movement or airflow, and with at least a 4% oxygen desaturation. In this study, the investigators assessed the effects of anthropomorphic parameters and lung volume influence on the ability to achieve a 4% desaturation.

Materials: 18 male and two female healthy subjects completed three breath hold (BH) trials from supine functional residual capacity. Supine lung volumes were measured using the nitrogen wash-out technique. Arterial blood was sampled at 5-second intervals from a radial artery line during and for 20-seconds after the end of each breath hold. Oxyhemoglobin saturation was measured using a Bayer Model 845 CoOximeter. A cubic spline interpolation was used to predict the time and depth of the oxyhemoglobin nadir and to estimate data points representative of each one-second period during the breath holds. For each trial, SaO2 values were calculated at 5-second intervals from the start of the BH until breathing resumed, and from the oxyhemoglobin nadir at 3-second intervals for 18-seconds. The mean SaO2 values were then computed by subject across trials. FRC thresholds were used to establish three FRC groups; the high and middle group was defined using a threshold of 2.7 liters and the middle and low group were separated using a threshold of 2.0 liters. Correlations between the SaO2, anthropomorphic, and lung volume measures were calculated.

Results: Weight ($r = 0.49$, $p < 0.01$) and Body mass index (BMI) ($r = 0.55$, $p < 0.01$) were positively correlated with the length of time between the start of the breath-hold and the oxyhemoglobin saturation (SaO2) nadir (mean 46 ± 6.3 seconds).

There was a negative correlation between functional residual capacity (FRC) and BMI ($r=-0.58$, $p = < 0.01$) (Table 1). Weight and BMI were negatively correlated with FRC ($r = -0.49$ and -0.58, respectively, $p < 0.01$)(See Figure 1).

FRC was positively correlated with the SaO2 levels at 25, 30, 35 and 40 seconds after the start of the breath hold ($p < 0.05$) and three-seconds subsequent to the nadir ($p < 0.01$). Figure 2 presents the relationship between FRC and SaO2 at the 35 second time point.

A negative correlation was observed between FRC and the maximum depth of desaturation for SaO2 ($r=-0.56$, $p=0.01$). These findings are more apparent when the desaturation profiles are stratified by FRC group (Figure 3), confirming that subjects with larger BMIs have smaller lung volumes resulting in deeper desaturations during apnea and hypopnea like events.

Both BMI ($r=0.55$, $p = 0.01$) and FRC ($r=-0.45$, $p = 0.05$) were correlated with the elapsed time between the resumption of breathing (i.e., airflow) after the breath hold (i.e., apnea/hypopnea) and the nadir of the desaturation.

Conclusions: The percentage change in SaO2 as a result of a 30-second breath hold can be explained in part by FRC and that FRC is related to BMI. This suggests that a 4% desaturation criterion may result in an underestimation of OSA severity in patients with lower BMIs.

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Table 1: Mean ± S.D. of Measures Stratified by FRC Group

FRC Group	BMI	Weight lbs.	FRC liters	Max Desat O2
Overall	26.9 ± 4.4	195 ± 37.3	2.3 ± 0.7	11.8 ± 3.5
High > 2.7 liters	25.4 ± 1.7	185 ± 20.1	3.2 ± 0.3	10.2 ± 2.5
Middle	25.8 ± 4.8	183 ± 36.8	2.4 ± 0.2	10.4 ± 2.1
Low < 2.0 liters	29.2 ± 5.0	216 ± 43.9	1.5 ± 0.3	14.6 ± 4.1

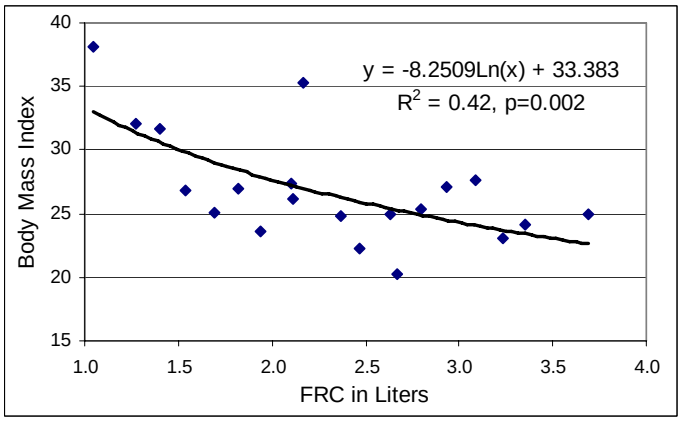

Figure 1: Relationship between FRC and BMI.

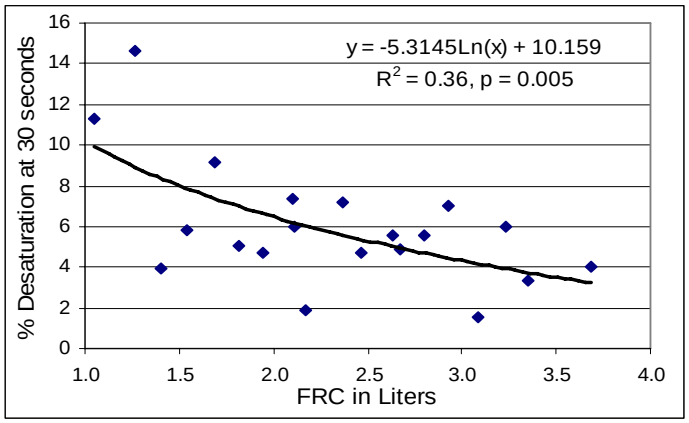

Figure 2: Relationship between FRC and %O2 Desaturation after 30 seconds of a breathhold.

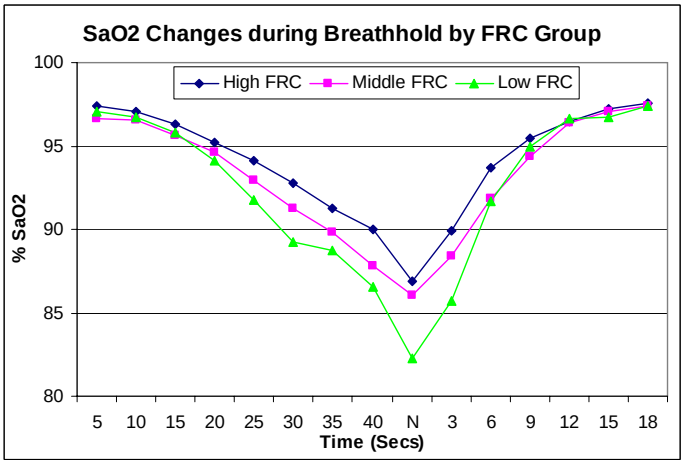

Figure 3: Changes in SaO2 during breathhold, stratified by FRC group.