

Predicting CPAP Pressure in Taiwanese Patients with Obstructive Sleep Apnea: A Two-Variable Linear Regression Formula versus the Hoffstein Equation and a Neuro-Fuzzy Model

Objective: Manual in-laboratory CPAP titration is resource-intensive, and a reliable pre-titration pressure estimate could guide the starting pressure. The Hoffstein equation, derived in Western patients, reportedly underestimates pressure in Korean and Brazilian cohorts, and Taiwanese formulas were validated in small samples. Machine-learning models have not always been compared with simple regression, and accuracy within ± 2 cmH₂O may appear favorable even without prediction. We aimed to evaluate the Hoffstein equation against a no-information baseline, derive a local linear regression formula, and test whether an adaptive neuro-fuzzy inference system (ANFIS) adds predictive value.

Methods: We retrospectively analyzed 479 OSA patients with successful in-laboratory manual CPAP titration (residual AHI ≤ 5 events/h) at Hualien Tzu Chi Hospital between March 2007 and March 2026. Predictors were selected from nine candidate variables by stepwise regression within nested cross-validation. A two-variable linear regression formula and ANFIS, with hyperparameters tuned only within training folds, were compared by 10-fold cross-validation using Nadeau–Bengio-corrected paired t-tests. The Hoffstein equation and a null model assigning the training-fold mean pressure served as benchmarks.

Results: Patients were aged 51.0 ± 13.4 years (76.8% male), with BMI 28.6 ± 5.2 kg/m², median AHI 38.7 (IQR 25.3–58.5) events/h, and titrated pressure 7.5 ± 2.3 cmH₂O. Across 100 stepwise selections, BMI was selected every time, AHI in 81, and the collinear oxygen desaturation index in 19; other variables in $\leq 6\%$. The null model alone placed 70.2% of patients within ± 2 cmH₂O. Applied without recalibration, the Hoffstein equation underestimated pressure by a mean of 1.25 cmH₂O and was no better than the null model (RMSE 2.34 vs 2.29 cmH₂O; 69.3% within ± 2 cmH₂O). The formula pressure = $1.65 + 0.033 \times \text{AHI} + 0.153 \times \text{BMI}$ achieved an RMSE of 1.91 cmH₂O, MAE of 1.42 cmH₂O, R² of 0.29, and 74.7% within ± 2 cmH₂O, versus 1.95 cmH₂O, 1.47 cmH₂O, 0.26, and 72.2% for ANFIS; no metric differed significantly after correction ($p = 0.19\text{--}0.27$; RMSE difference 0.04 cmH₂O [95% CI -0.03 to 0.11]).

Conclusion: Without local recalibration, the Hoffstein equation underestimated pressure in Taiwanese patients and was no more accurate than assigning the mean. A two-variable AHI–BMI formula modestly improved on this baseline, and ANFIS added nothing further. Because ± 2 cmH₂O accuracy is high even without prediction, it should be interpreted against a no-information baseline. Such formulas suit setting a starting pressure rather than replacing titration.

中文題目：台灣阻塞型睡眠呼吸中止症患者之 CPAP 壓力預測：兩變數線性迴歸公式、Hoffstein 公式與模糊神經模型之比較

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