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# PREDICTING SLEEP SCORES - MODELING INSIGHTS

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## ABSTRACT

Sleep quality is a fundamental aspect of human health, and recent advancements in wearable technology have enabled non-invasive monitoring through metrics such as the Fitbit Sleep Score. This study presents a machine learning framework to predict sleep scores using a longitudinal dataset collected from a Fitbit device over nearly one year. The dataset includes features such as total sleep minutes, time spent in different sleep stages, awakenings, and resting heart rate. We developed and evaluated four supervised models—Random Forest, Light Gradient Boosting Machine (LightGBM), a sequential LSTM baseline, and the deep learning–based TabNet—with emphasis on predictive performance and interpretability. LightGBM achieved the lowest error (MAE = 1.8480, MSE = 6.1385), while Random Forest performed comparably and attained the highest $R^2$ (0.8002). The LSTM captured short-term temporal structure and was competitive (MAE = 2.1751, MSE = 7.0135, $R^2$ = 0.7702). In contrast, despite tuning, TabNet underperformed on this single-subject dataset (MAE = 3.0748, MSE = 14.5975, $R^2$ = 0.5216). Feature analysis consistently highlighted Minutes Asleep, Minutes Awake, REM Sleep, and Deep Sleep as the most influential factors. These findings reinforce the strength of compact, interpretable ensemble models for wearable sleep-score prediction, while the LSTM provides a fair time-aware baseline. The study also underscores the data-size limitations for deep tabular models such as TabNet, suggesting that robust ensemble methods remain pragmatic choices for real-world wearable health analytics.

**Keywords:** Sleep score prediction, wearable sensors, Fitbit, LightGBM, Random Forest, LSTM

## INTRODUCTION

Sleep is an essential biological function that plays a critical role in maintaining overall health, cognitive performance, emotional regulation, and metabolic processes. Poor sleep quality has been linked to a range of adverse outcomes, including cardiovascular diseases, depression, and reduced productivity. As awareness of sleep health has grown, wearable technologies such as Fitbit devices have emerged as popular tools for individuals to monitor and manage their sleep. These devices offer a composite sleep score, typically ranging from 0 to 100, derived from multiple physiological and behavioral metrics including total sleep time, sleep stages, heart rate variability, and nighttime restlessness.

While Fitbit provides this score as an interpretive guide, the underlying factors contributing to it are not fully transparent to users. Furthermore, there is a lack of predictive modeling frameworks that can estimate sleep score in advance or identify which features most influence its value. Most prior research in this area has focused either on sleep staging using deep learning or clinical-grade datasets (e.g., polysomnography), which limits real-world applicability and personalization.

This paper proposes a machine-learning approach to predict nightly Fitbit Sleep Scores from a year-long, real-world single-participant dataset. We benchmark four models—Random Forest, Light Gradient Boosting Machine (LightGBM), a sequential Long Short-Term Memory (LSTM) baseline that leverages short-term temporal context, and the deep-learning model TabNet. We evaluate the models using to