Modelling and Prediction of Athletic Readiness based on Sleep and Recovery Patterns

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Problem Statement

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Predicting Athletic Readiness Using Sleep & Recovery Data

In collegiate basketball, athletes experience fatigue due to frequent games, travel, training, academics, and social commitments. Fatigue negatively affects sleep patterns and recovery, which in turn affects your athletic performance. The goal of this project is to analyze sleep and recovery data and predict RSImod (Readiness Measure), a key indicator of an athlete's readiness for competition.

- Frequent games, travel, and academic stress contribute to poor sleep and slower recovery, affecting athletic performance
- Sleep patterns and recovery metrics are examined to identify trends influencing readiness
- Insights from the data help optimize training and rest schedules for improved competition readiness

Literature Survey

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Paper Title	Author	Methodology	Key Findings
Impact of Sleep and Training on Game Performance and Injury in Division-1 Womens Basketball Amidst the Pandemic	Samah Senbel *et al.* [4]	Machine learning (ensemble classifiers, MICE)	Predicted injury risk (F1-score: 0.94). Poor sleep increases injury risk.
How Much Sleep Does an Elite Athlete Need?	Charli Sargent *et al.* [3]	Wrist monitors, sleep logs, statistical modeling	Elite athletes sleep less than needed, causing fatigue and lower readiness.
The Effects of Sleep Extension on the Athletic Performance of Collegiate Basketball Players	Cheri D. Mah *et al.* [2]	Sleep extension (10+ hrs), actigraphy	More sleep improved sprint and shooting, reinforcing sleep's importance.
Examination of Sleep and Injury Among College Football Athletes	Tina M. Burke *et al.* [1]	Sleep surveys, actigraphy, logistic regression	No strong link between sleep duration and injury. Quality over quantity matters.

Dataset Discussion

- The dataset consists of 3,111 rows and 28 features, with RSI (Athlete Readiness Score) as the target variable.

Key Features:

- **Recovery Metrics:** RHR, HRV, Recovery Score
- **Sleep Metrics:** Sleep Score, Hours in Bed, REM Sleep, Deep Sleep, Sleep Consistency
- **Other Factors:** Sleep Latency, Wake Periods, Sleep Debt

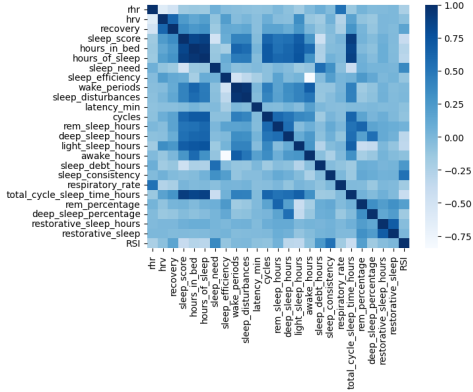

Figure 1: Correlation Map

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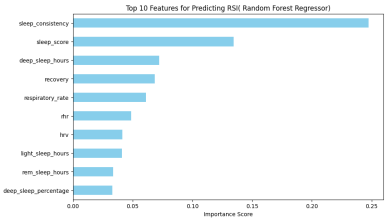
Missing Values & Imputation:

- **36% Missing Values** (1,130 rows)
- **Imputation Methods:** Mean, Median, Mode, KNN, Interpolation, MICE, & EM

Feature	Observed Mean	MICE Mean	EM Mean	Observed SD	MICE SD	EM SD	MICE Error % (Mean)	EM Error % (Mean)	MICE Error % (SD)	EM Error % (SD)
rhr	57.169355	57.174449	57.188839	8.607731	7.018834	7.023708	**0.008911**	0.034081	18.458955	**18.402337**
hrv	91.596774	91.574298	91.562197	37.213932	30.344657	30.347624	**0.024538**	0.037749	18.458880	**18.450908**
recovery	63.895161	63.881556	63.888889	21.246451	17.324644	17.324407	0.021293	**0.009817**	**18.458647**	18.459760
sleep_score	77.701613	77.688525	77.671578	18.603252	15.169424	15.174481	**0.016844**	0.038654	18.458211	**18.431030**
hours_in_bed	7.371210	7.371205	7.370142	1.818986	1.483187	1.483259	**0.000058**	0.014481	18.460754	**18.456826**
hours_of_sleep	6.562500	6.562501	6.563721	1.579239	1.287700	1.287807	**0.000011**	0.018612	18.460754	**18.453932**
sleep_need	8.262742	8.263579	8.268343	1.324386	1.079921	1.082592	**0.010131**	0.067782	18.458701	**18.257040**
sleep_efficiency	89.298387	89.296819	89.323562	5.472741	4.462455	4.475620	**0.001755**	0.028191	18.460332	**18.219771**
wake_periods	14.617647	14.111328	14.570633	7.416925	5.744448	5.889027	3.463752	**0.321623**	22.549460	**20.600148**
sleep_disturbances	11.750000	11.752221	11.737557	6.196494	5.051800	5.054609	**0.018902**	0.105901	18.460094	**18.414758**
latency_min	3.247742	3.249224	3.241676	5.042155	4.111357	4.112167	**0.045635**	0.186776	18.460310	**18.444248**
cycles	4.951613	4.952130	4.956037	1.958325	1.596811	1.597943	**0.010445**	0.089342	18.460396	**18.402571**
rem_sleep_hours	1.989919	1.989919	1.994558	0.776209	0.632915	0.636068	**0.000035**	0.233094	18.460754	**18.054488**
deep_sleep_hours	1.315323	1.315323	1.316723	0.472990	0.385672	0.386145	**0.000038**	0.106495	18.460754	**18.360785**

(a) Imputation Comparison



(b) Feature Importance

Our Approach

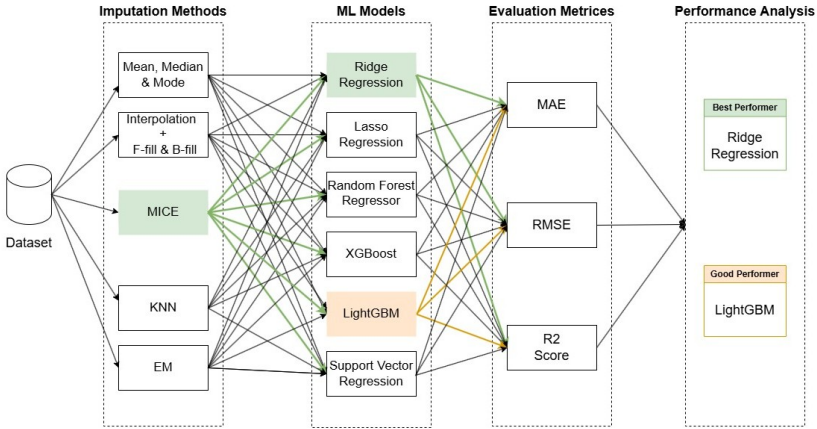
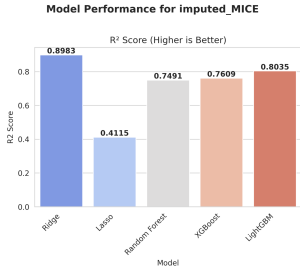


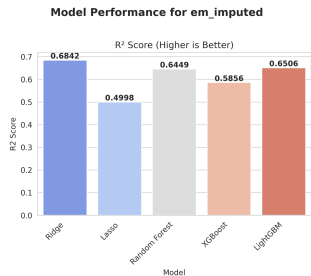
Figure 2: Overview of the Modeling Approach

Results

Model	MAE	RMSE	R^2 Score
Ridge	0.002780	0.000159	0.898314
Lasso	0.019029	0.000919	0.411488
Random Forest	0.010224	0.000373	0.749090
LightGBM	0.008216	0.000307	0.803460
XGBoost	0.010022	0.000737	0.760890

Table 1: Results for MICE Imputed Dataset





Model	MAE	RMSE	R^2 Score
Ridge	0.003854	0.000289	0.684196
Lasso	0.011201	0.000457	0.499777
Random Forest	0.005965	0.000325	0.644861
LightGBM	0.006435	0.000319	0.650644
XGBoost	0.007474	0.000379	0.585643

Table 2: Results for EM Imputed Dataset

Future Work

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- **Dataset Augmentation:** Expand dataset size by employing data generation methods to improve model performance and generalizability.
- **Model Optimization:** Perform extensive testing and optimization to enhance robustness and accuracy.
- **Comparative Analysis:** Evaluate performance enhancements by comparing models trained on original and augmented datasets.
- **Deep Learning Exploration:** Explore deep learning architectures after the dataset is adequately sized.

References

[1] Tina M Burke et al. "Examination of sleep and injury among college football athletes". In: *The Journal of Strength & Conditioning Research* 34.3 (2020), pp. 609–616.

[2] Cheri D Mah et al. "The effects of sleep extension on the athletic performance of collegiate basketball players". In: *Sleep* 34.7 (2011), pp. 943–950.

[3] Charli Sargent et al. "How much sleep does an elite athlete need?" In: *International journal of sports physiology and performance* 16.12 (2021), pp. 1746–1757.

[4] Samah Senbel et al. "Impact of sleep and training on game performance and injury in division-1 women's basketball amidst the pandemic". In: *IEEE Access* 10 (2022), pp. 15516–15527.