Biomechanical Analysis in Lower Limb Alignment to Predicting Running-Related Injuries in Machine Learning

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Background

- Running is a popular physical activity worldwide, and Hong Kong is no exception. Running has numerous health benefits and is easy to get into. Running is a major cause of sports injuries, contributing to almost 43%.

- Common running injuries include patellofemoral pain syndrome and tendinopathies, which affect up to 32% of runners (Andere et al., 2021; Wayner et al., 2023). Motion Metrix uses AI and machine learning to analyse biomechanical data. (Jaén-Carrillo et al., 2023)

Purpose

- This study investigates how biomechanical abnormalities increase injury risk among athletes.

- It also aims to identify factors that would increase susceptibility to injuries related to running by examining the interplay between abnormalities in the foot, ankle, and hip regions.

Method

- Integrating advanced technology and machine learning with empirical data to explore biomechanical factors influencing running injuries and performance.

- This project involves a three-part methodology and predictive analytics using Python to estimate injury risk among experienced runners.

PART 1: QUESTIONAIRE (Hespanhol Junior et al. (2012)

PART 2: CLINICAL TEST

i) Foot posture index (FPI) (Cowley & Marsden, 2013; Pérez-Morcillo et al., 2019)

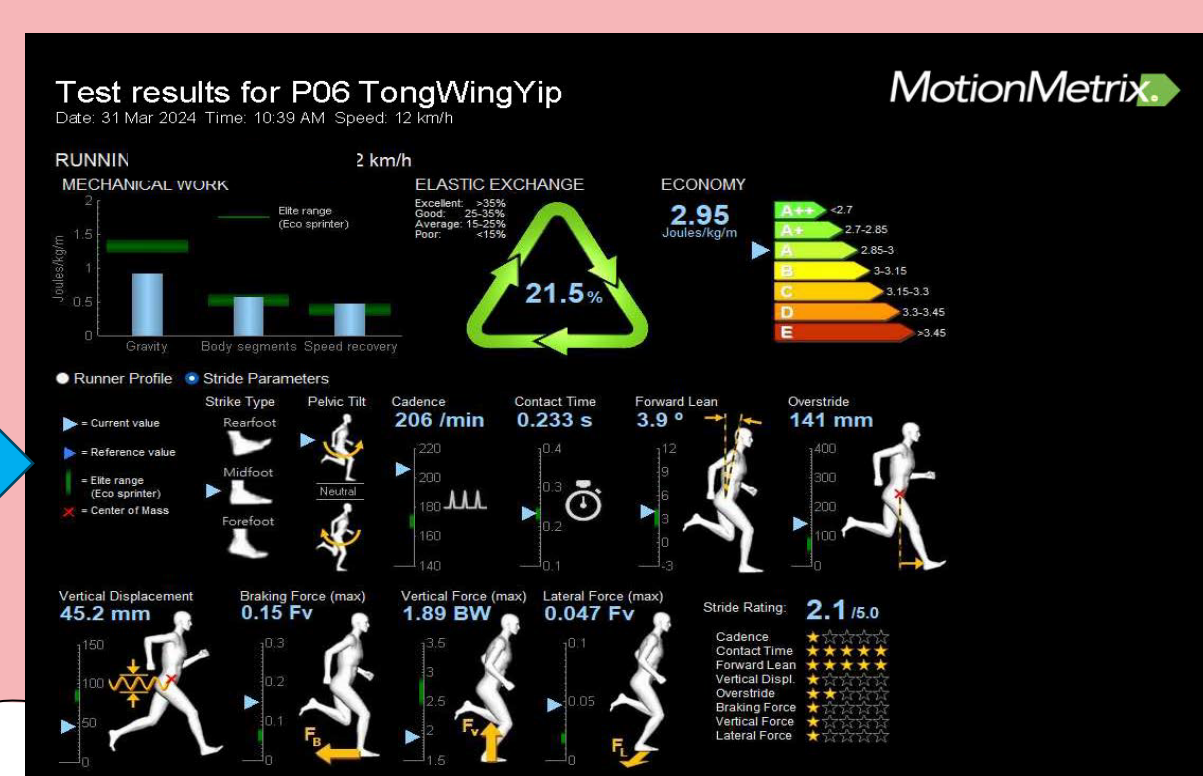**ii) Ankle Dorsiflexion Range of Motion Test** (Konor et al., 2012)

iii) Single Leg Squat Test (SLST) (McGovern et al., 2019)

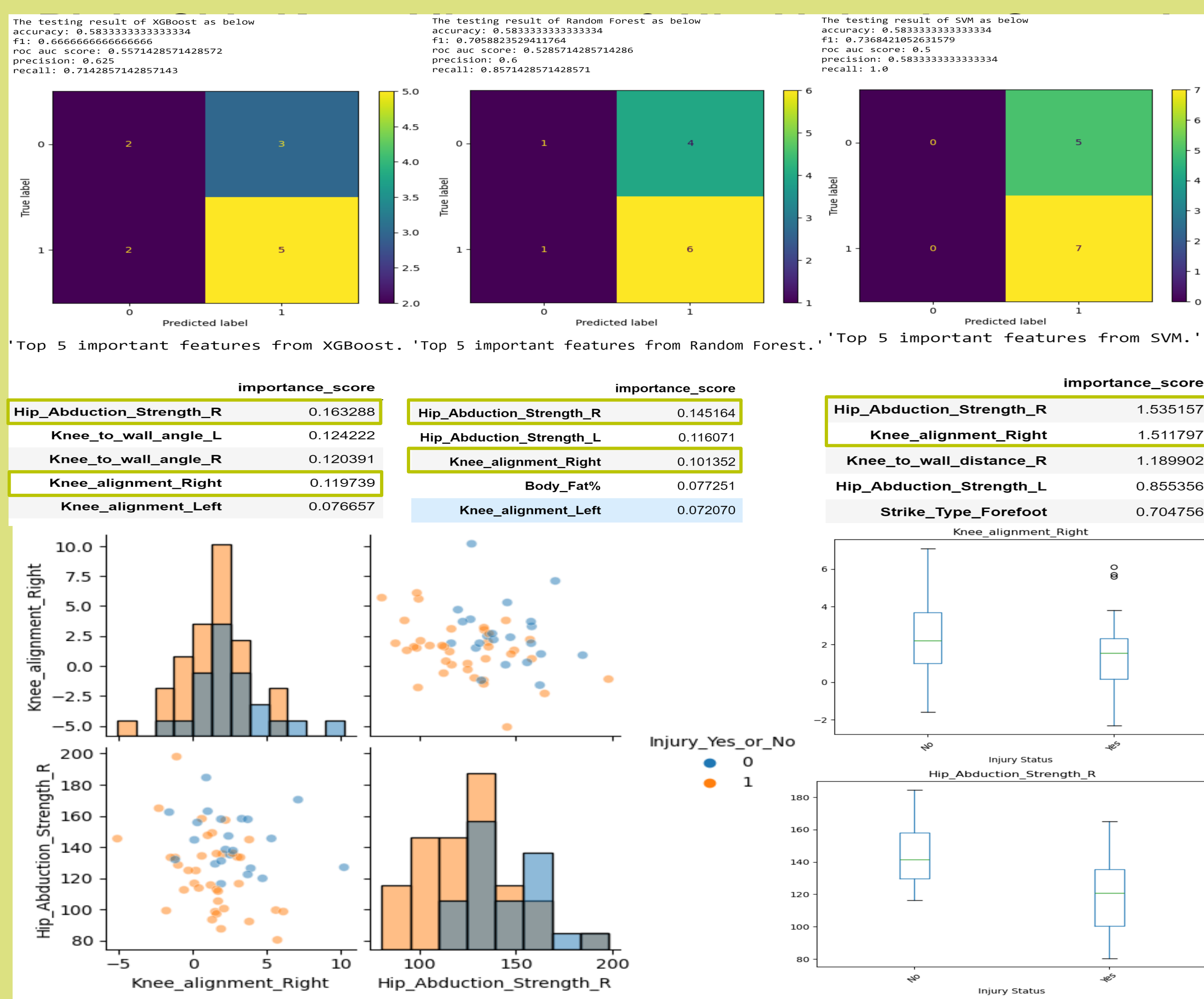**iv) Hip Abduction Measurement (McGovern et al., 2019)**

Part 3: MOTION METRIX RUNNING ASSESSMENT (Jaén-Carrillo et al., 2023)

Result

- The study's 59 participants, 44 males and 15 females aged 27-53, had at least 10km of running experience. Three machine learning methods (Random Forest Classifier, XGBClassifier, and SVM) are used to analyze biomechanical factors and identify injury risks in experienced runners. The three models identified the top 5 features, illustrated in the diagrams below:

The testing result of XGBoost as below
accuracy: 0.5833333333333334
f1: 0.6666666666666666
roc auc score: 0.5571428571428572
precision: 0.625
recall: 0.7142857142857143

The testing result of Random Forest as below
accuracy: 0.5833333333333334
f1: 0.7058823529411764
roc auc score: 0.5285714285714286
precision: 0.6
recall: 0.8571428571428571

The testing result of SVM as below
accuracy: 0.5833333333333334
f1: 0.7368421052631579
roc auc score: 0.5
precision: 0.5833333333333334
recall: 1.0

Top 5 important features from XGBoost.

	importance_score
Hip_Abduction_Strength_R	0.163288
Knee_to_wall_angle_L	0.124222
Knee_to_wall_angle_R	0.120391
Knee_alignment_Right	0.119739
Knee_alignment_Left	0.076657

Top 5 important features from Random Forest.

	importance_score
Hip_Abduction_Strength_R	0.145164
Hip_Abduction_Strength_L	0.116071
Knee_alignment_Right	0.101352
Body_Fat%	0.077251
Knee_alignment_Left	0.072070

Top 5 important features from SVM.

	importance_score
Hip_Abduction_Strength_R	1.535157
Knee_alignment_Right	1.511797
Knee_to_wall_distance_R	1.189902
Hip_Abduction_Strength_L	0.855356
Strike_Type_Forefoot	0.704756

Discussion

- Compared to different algorithms for predicting running-related injuries, the XGBClassifier was the most effective. When selecting a model, it's essential to balance precision and recall depending on the application's requirements.

- A higher recall model may be preferred to identify potential injuries for further examination, reducing the risk of overlooking actual injuries.

- Data bias may exist in data collection or models toward right-side injuries, which can impact the accuracy of injury prediction models. Balanced data collection and feature engineering can be explored to mitigate this bias. Reducing data biases in machine learning applications is important to create fairer injury prediction models.

Practical Application

Create educational programs for athletes and coaches based on machine learning findings with an emphasis on hip and knee biomechanics in injury prevention and proper techniques to improve performance. Signs of potential injuries can be identified which help seeking early medical attention, crucial to maintain athlete health and success.