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Machine-Learning Models For Shoulder Rehabilitation Exercises Classification Using A Wearable System

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Faculty Disclosure Information

Nothing to disclosure

Bakground

- Rehabilitation treatment for shoulder disorders is essential for restoring joint functionality and preventing chronic conditions
- Sensors such as magneto-inertial measurement units (M-IMUs) can be integrated into wearable systems[1]
- M-IMUs for capturing kinematic data and enabling objective analysis of exercise performance during physical therapy

Bakground

- Machine Learning (ML) is revolutionizing the healthcare sector[2]
- The classification of shoulder rehabilitation exercises holds significant potential for improving the patients monitoring and adherence to the prescribed physiotherapy[3]

Aim

The objective of this study was to **train** and **test machine learning models** to automatically **classify shoulder physiotherapy exercises**

Methods

Study population[4]

Characteristics	Healthy subjects	Patients
Sex (male/female, no.)	5/14	9/8
Age (years, mean ± standard deviation)	25.18 ± 1.67	61.76 ± 8.87
Height (cm, mean ± standard deviation)	167.89 ± 8.53	166.76 ± 7.73
Weight (kg, mean ± standard deviation)	61.58 ± 11.95	76.88 ± 14.12
BMI (kg/m^2, mean ± standard deviation)	21.67 ± 2.57	27.63 ± 4.85
Dominant arm (right/left, no.)	19/0	16/1
Pathological side (right/left, no.)	N/A	17/0
Treatment (surgical/conservative, no.)	N.A.	13/4

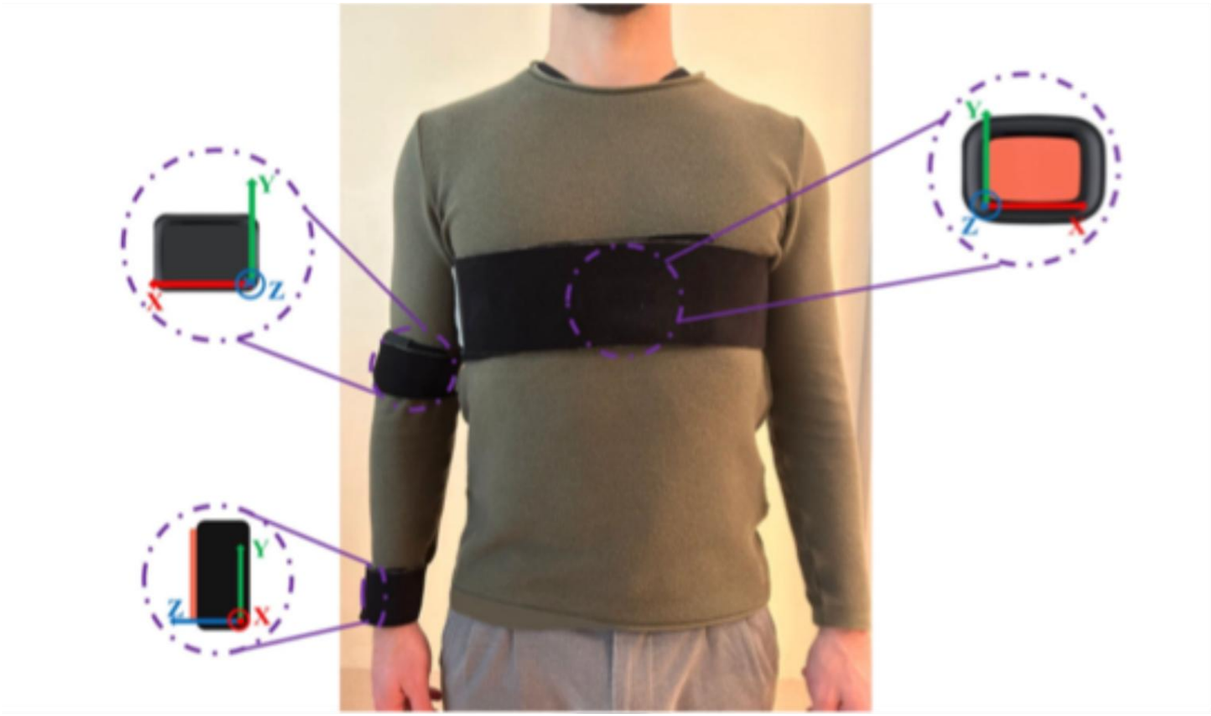
Patients

Diagnosis of rotator cuff tear; Completion of ≥ 6 months of rehabilitation treatment.

Methods

Study protocol[4]

Wearable system equipped with three M-IMUs



Methods

Study protocol[4]

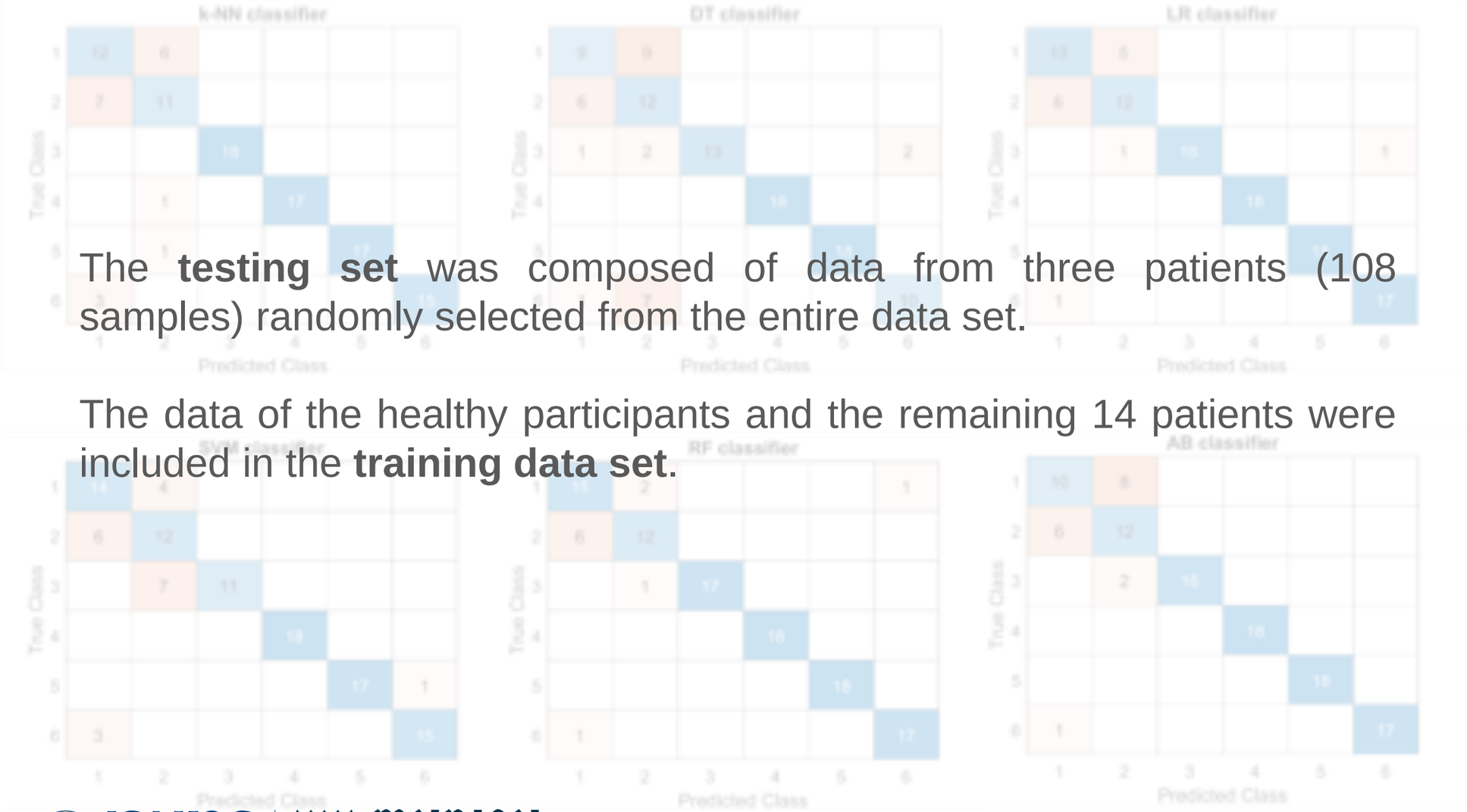
Six shoulder rehabilitation exercises:[5]
(1) upright active flexion/extension without any weight;
(2) upright active flexion/extension using a 2 kg weight;
(3) external rotation with the shoulder at 90° of abduction using a 2 kg weight;
(4) towel slide;
(5) external/internal rotation self-assisted with a stick
(6) abduction/adduction.

Methods

Six supervised ML models were trained to classify shoulder rehabilitation exercises: k-Nearest Neighbours, Support Vector Machine, Decision Tree, Random Forest, Logistic Regression and Adaptive Boosting.

The algorithms' ability to accurately classify rehabilitation exercises was evaluated using the nested cross-validation method, with different combinations of outer and inner folds.

Results



The **testing set** was composed of data from three patients (108 samples) randomly selected from the entire data set.

The data of the healthy participants and the remaining 14 patients were included in the **training data set**.

Results

The RF achieved the highest classification performance, with 89.81% of overall accuracy and sensitivity, 89.89% of F1-score, 97.96% of specificity and 90.44% of precision.

Metrics of performance of all classifiers implementing the nested cross validation method with 10 outer folds and 5 inner folds.

Classifiers	Accuracy	F1 score	Sensitivity	Specificity	Precision
k-NN	0.8333	0.8411	0.8333	0.9667	0.8541
SVM	0.8056	0.8134	0.8056	0.9611	0.8447
DT	0.7407	0.7533	0.7407	0.9481	0.7938
RF	0.8981	0.8989	0.8981	0.9796	0.9044
LR	0.8704	0.8727	0.8704	0.9741	0.8769
AB	0.8426	0.8473	0.8426	0.9685	0.8556

k-NN: k-Nearest Neighbour; SVM: Support Vector Machine; DT: Decision Tree; RF: Random Forest; LR: Logistic Regression; AB: Adaptive Boosting.

Discussion

- Wearable sensors and ML algorithms accurately classify shoulder rehabilitation exercises
- ML effectively learn patterns and features from M-IMUs data
- Remote performance evaluation may provide insights into rehab effectiveness
- Personalized treatment and improved care quality
- Better outcomes for patients with shoulder musculoskeletal diseases

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