Assess Rugby Player Knee Joint Via Probability Density Function and Deep Learning

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INTRODUCTION: Quantitative data obtained from Magnetic Resonance Imaging (MRI) provides significant potential for improving medical diagnostics, advancing research activates, and prompting the longitudinal assessment of disease trajectories. However, the practical application of state-of-the-art methodologies is often impeded by their inherent complexity and requirements. The objective of this study is to establish a quantitative approach for assessing knee joint MRIs of rugby players. This approach involves measuring the shape of the probability density function (PDF) through an analysis of the skewness and kurtosis of the PDF of T2-weighted image. Notably, this method does not require additional devices or the presence of highly experienced researchers.

METHODS: This researched experiment has received approval of local institutional review board. The analysis of PDF was performed to assess 600 MRI T2-weighted frames from 44 rugby players (women, 22; men 22; mean age ± standard deviation [SD], 20.5±1.7;) and 660 frames from 40 healthy subjects (women, 21; men 19; mean ag mean age ± standard deviation [SD], 21.5±2;). Particularly, these image frames were preprocessed to separate the region of interest (ROI) from the background to eliminate the implication of the background for PDF analysis (a). Fisher linear discriminant analysis (FLDA) was applied to assess the discrimination power of PDF (d). Subsequently, PDF is extracted from the ROIs (b), and a One-way ANOVA model was employed to compare healthy controls and rugby player groups to verify if statistical significance in both skewness and kurtosis parameters, and only 95% confidence intervals (CIs) and $p \leq .05$ can be viewed as significance (c). Finally, PDFs from ROIs were input into a four-layer fully connected neural network to distinguish rugby players from the healthy group (e). The ensuing outcomes will be compared with those obtained through convolutional neural networks (CNN), assessing factors based on convergence rate, training duration, and accuracy.

RESULTS SECTION: Skewness and kurtosis were statistically analyzed from PDF of ROIs, revealing statistical significance with 95% confidence intervals (CIs) and $p \leq .0001$. FLDA was employed for the discrimination power of PDF analysis which yielded 63% area under the ROC curve (AUC) score for skewness, and 60% AUC for kurtosis, respectively. Furthermore, the PDFs from ROIs were input into four-layer full connected neural networks achieved 99.96% accuracy in distinguish control from rugby player with knee joint issues with 8 seconds convergence and 3 mins training time. However, the CNN attained a 95% accuracy but with lower convergence rate, 30 mins, and longer training time,7 hours.

DISCUSSION: This study does have limitations. Our evaluation evaluated the entire MRI image rather than just focusing on the cartilage region. This approach could introduce extraneous information into the analysis, potentially leading to inaccuracies. Additionally, it's worth noting that distinct images could yield identical PDF, further contributing to potential inaccuracies. However, it is important to highlight our method relies exclusively on statistics, therefore, it reduces the complexity such as relaxing the necessity to mask the ROI, which enhances its applicability in real-world scenarios. Leveraging the statistical significance of skewness and kurtosis, the PDFs extracted from ROIs can be interpreted as distinctive features derived from the MRI image. Subsequently, there may be exist a potential opportunity to combine PDF with deep learning to achieve higher accuracy.

SIGNIFICANCE/CLINICAL RELEVANCE: Combine PDF of T2-weihghed image and deep learning had achieved a higher accuracy for assess player knee, and with less manual intervention, and without extra devices. Our method can be a useful screening tool for assessing player's knee status.

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