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Real-Time Scapular Dyskinesia Detection using Computer Vision and Machine Learning: A Survey

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***Abstract*— Scapular Dyskinesia which is also known as the scapular dysfunction is a condition in which shoulder blade function abnormally. Traditional methodologies require a human expertise to know if a person has this malfunctioning or not. There is system which have capacity to detect if a person has this disease or not. But they require very large dataset as well as a system with high computation power. In this survey, we are thinking of the much cheaper solution on the same i.e. using computer vision along with some machine learning algorithm to detect the Scapular Dyskinesia. Here we also highlight the challenges to be faced, dataset availability and future scope.**

***Keywords*— Scapula Dyskinesia, OpenCV, Machine Learning.**

I. INTRODUCTION

Scapular dyskinesia is defined as an alteration in the normal motion or positioning of the scapula during shoulder movements [1]. It is frequently linked to shoulder pain and dysfunction, influencing the biomechanics of the upper limb [21]. This condition is commonly observed in individuals with shoulder injuries, particularly those suffering from rotator cuff tears, impingement syndrome, and labral injuries [3]. The abnormal scapular kinematics can lead to compromised shoulder function, reduced range of motion, and increased susceptibility to further musculoskeletal injuries [4].

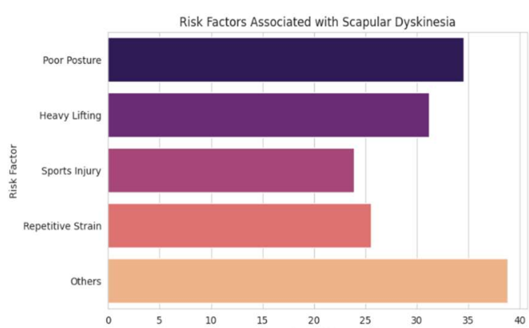

Figure 1 - Risk Factors that could cause scapular dyskinesia

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Scapular dyskinesia is not only a cause of discomfort but can also predispose individuals to long-term shoulder dysfunction [5]. The scapula plays a critical role in force transmission and shoulder stability, with approximately one-third of shoulder movement originating from the scapulothoracic joint [26]. Any alteration in scapular mechanics can disrupt the kinetic chain, leading to compensatory movement patterns and an increased risk of secondary injuries [7]. Understanding scapular dyskinesia is essential for clinicians, as its presence can influence treatment outcomes in various shoulder conditions, including adhesive capsulitis, instability, and post-surgical recovery [8]. They are not only introduced by birth but also with time could be developed. There are various constraint from which this disease would be introduced in the body. Some of them are poor posture, heavy lifting, sports injury and repetitive strain.

II. Types of Scapula Dyskinesia

A. Type I (Inferior Angle Dysfunction)

This condition is marked by an exaggerated prominence of the inferior angle of the scapula[31], typically caused by weakness in the lower trapezius and serratus anterior muscles [2]. It is commonly seen in patients with rotator cuff injuries [3].

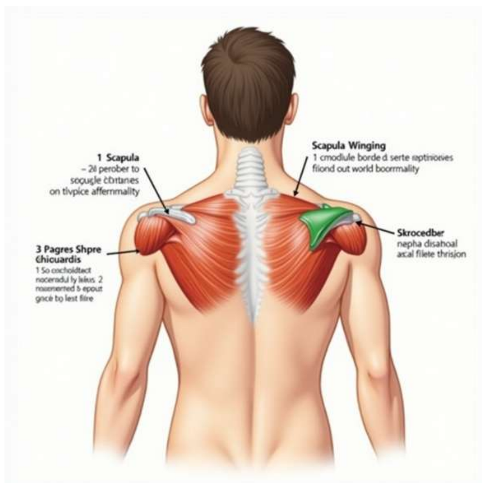

Figure 2 - Type I (Scapular Winging) [22]

B. Type II (Medial Border Dysfunction)

Excessive prominence of the medial border of the scapula is often a sign of weakness or dysfunction in the serratus anterior muscle [4]. This condition may contribute to scapular winging and lead to changes in glenohumeral movement patterns[38], which can increase the risk of impingement syndrome [5].

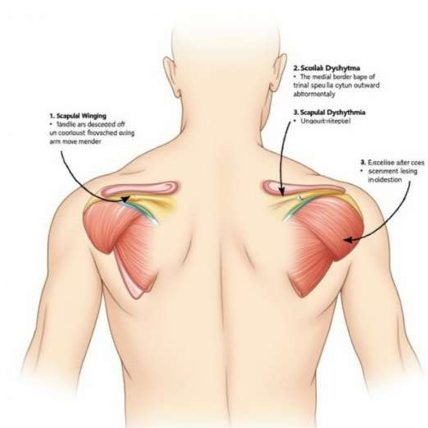

Figure 3 - Type II (Scapular Dysrhythmia) [23]

C. Type III (Superior Dysfunction)

Marked by excessive elevation of the superior border of the scapula, often linked to overactivity of the upper trapezius muscle[27]. This type is commonly seen in individuals who compensate for shoulder instability by increasing activation of the upper trapezius and levator scapulae muscles [8].

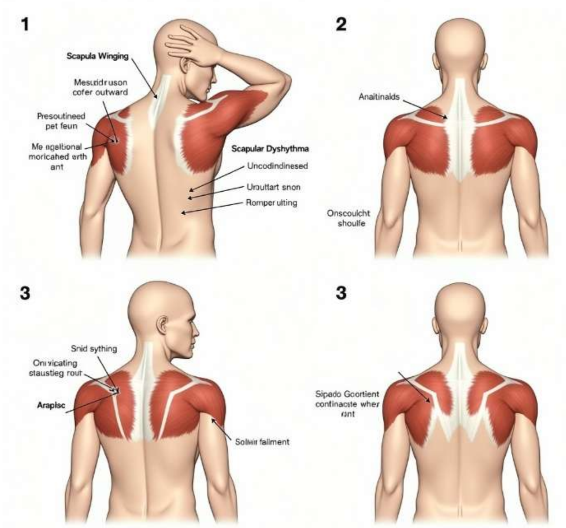

Figure 4 - Type III (Scapular Shrugging) [24]

D. Type VI (Sysmetric Dysfunction)

A fourth category has also been proposed in some studies, referring to bilateral alterations [32] in scapular mechanics that may result from systemic conditions or generalized neuromuscular deficiencies [10].

III. LITERATURE REVIEW

TABLE I

Title	Year	Author(s)	Used Methods	Dataset	Key Findings	Performance Metrics	Limitations
Evaluating the Precision of Scapular Position and Motion Measurement Using a New Motion Capture System	2023	Mantovani, M., Sciascia, A., Varini, A., Muraccini, M., Nardini, F., Tonino, P., Kibler, B. W.	Motion capture system, accuracy analysis, biomechanical evaluation	Captured motion data, motion capture datasets	Validated the accuracy of novel motion capture methods for scapular motion analysis.	High accuracy in capturing scapular motion using advanced motion capture techniques.	Requires specialized equipment; limited by the resolution of the motion capture system.
Impact of Scapular Dyskinesis on Rotator Cuff Injuries	2022	Not listed (as this is from a journal) European Orthopaedics & Traumatology	Clinical study, observational analysis, imaging (MRI, X-ray)	Patient data, MRI/X-ray imaging data	Scapular dyskinesis is a significant factor in the development of rotator cuff tears.	High accuracy in capturing scapular motion using advanced motion capture techniques.	Observational; does not establish a direct causal relationship.
Wearable technology in shoulder biomechanics	2021	Boye, M., Frasi, A., Bouyer, L., Roy, J.-S., Poitras, I., Campeau-Lecours, A.	Wearable sensors, data fusion algorithm, motion analysis	Wearable sensor data, motion tracking data	Wearable technology can effectively monitor scapular motion and shoulder biomechanics.	High accuracy and feasibility of wearable sensors for real-time monitoring.	Limited by sensor wearability and comfort; may not capture all movement nuances.

Neuromuscular fatigue and scapular dyskinesis	2020	Not listed (as this is from a journal) Journal of Musculoskeletal Science and Practice	Fatigue analysis, neuromuscular testing, clinical evaluation	Patient data, neuromuscular testing data	Neuromuscular fatigue exacerbates scapular dyskinesis and contributes to shoulder dysfunction.	Measured fatigue levels and scapular motion; correlation found between fatigue and dyskinesis.	Cross-sectional study; no cause-and-effect conclusions.
Influence of scapular motion on shoulder rehabilitation	2019	Not listed (as this is from a journal) Sports Medicine Journal	Clinical rehabilitation, kinematic analysis, observational study	Clinical data, kinematic movement data	Proper scapular motion is crucial for effective shoulder rehabilitation.	Improved rehabilitation outcomes in patients with normal scapular motion compared to those with dyskinesis.	May not account for other factors affecting rehabilitation (e.g., age, comorbidities).
Applying Conformal Mapping to the Human Scapula for Dense Landmark Feature Generation	2018	Fouefack, J.-R., Douglas, T., Mutsvangwa, T., Narra, N.	Computational modelling, image processing, 3D scanning	3D scapula scans, image data	Developed a method to create dense landmark features on the scapula, aiding in better biomechanical modelling.	Successful use of computational techniques to map scapula, improving biomechanic AI models.	Requires high-quality scans; may be limited by resolution of scanning equipment.
Application of Machine Learning Techniques for Scapular Kinematics Prediction	2017	Nicholson, K. F., Richardson, R. T., Rapp van Roden, E. A., Quinton, R. G., Anzilotti, K. F., Richards, J. G.	Machine learning, algorithm development, data analysis	Kinematic motion data, motion capture datasets	Machine learning can predict scapular kinematics with high accuracy, assisting in rehabilitation.	High prediction accuracy (measured by correlation or error rate) using machine learning techniques.	Requires large and diverse datasets for training; may have limitations in real-world application.

IV. Processing Methods and Steps

A. Image and Video Processing

By making the video recording from cameras, to capture the movements of shoulders and scapula in real-time which is useful for doctors and therapists to analysis how the shoulders and scapula of patients moves in real-time. Is it normal or abnormal [16]

Image Segmentation: In this part there are various machine learning algorithms that are used to process the captured video or image and then to detect the part of scapula and keep it seperates from the remaining body parts for better analysis.

Pose: Again in this part there are some machine learning algorithms that takes the position of scapula body part when it is in motion and then it checks whether it is in correct posture or not. This will help doctors or therapist to detect whether it is normal or abnormal [19].

Tracking: The ML model should repeat this process to find out the difference between normal and abnormal behaviour of scapula over the time period [14].

B. Feature Extraction

Motion Features: ML model is going to extract (finding out) the most important, related and responsible Features for detection of Scapula body part, means whether it is normal or abnormal.

Features like speed (means how much speed can patient move his hand so that he/she does not experience a pain in his/her scapula body part), range of motion (means how much patient can stretch the hands in any direction), and at any specific angles of scapular movements.

Symmetry and Asymmetry: it is much more crucial part as it identifies the difference between the left and right scapula whether it is Symmetric or Asymmetric. If it is Symmetric then there is no issue in scapula of the patient if it is Asymmetric then there is some issue in scapula of patient, it can become a serious injury in future that would cause a lot of pain to patient.

Scapular kinematics: Identifies the characteristics of motion of Scapula like rotating it upward, downward, forward and backward. it is useful for analysis because during rotation of arm in this position patient may feel pain [17].

Joint Angles: Analyzing the angles formed by the Scapula with respect to other body parts [15].

C. Machine Learning Algorithms

Supervised Learning: In this approach, we work with datasets that are already labelled, meaning the scapula movements are marked as either "normal" or "abnormal." Different machine learning techniques, like Support Vector Machines (SVM), Random Forest, or Neural Networks, can then be used to help spot patterns and make sense of the data.
Deep Learning: With deep learning, we use models like Convolutional Neural Networks (CNN) to automatically find the most important features needed for classification from images or videos. This helps the system identify patterns without requiring a lot of manual input.
Time Series Analysis: When we collect data over time, methods like Recurrent Neural Networks (RNN) or Long Short-Term Memory (LSTM) networks are useful for recognizing patterns in scapula movement that change over time. These models help us understand how movements evolve and predict future trends.

D. Biomechanical Modeling

Inverse kinematics: Use of different machine learning computational models will help us to analyze the motion of scapula based on the previously recorded body movements. This process can help us to easily understand the biomechanical reasons for dyskinesia.
Muscles for estimation: The system will identify the force applied by Muscles that control the scapula and analyze how this force makes contribution to detect abnormal scapular motion.

E. Clinical Assessment

Manual scoring: Here a clinical expert like doctor or therapist will judge the scapular motion using observation techniques that we are mentioned in introduction or there are some other physical methods also. These methods can be used with technological tools for comparing and validating the results.
Diagnostic Tools: We are doing the Integration with clinical diagnostic tools, like EMG (electromyography), which can help us to judge the muscle activity happening in scapular body part or any motion analysis systems, which is required to capture the detailed motion of the scapula body part.[21]

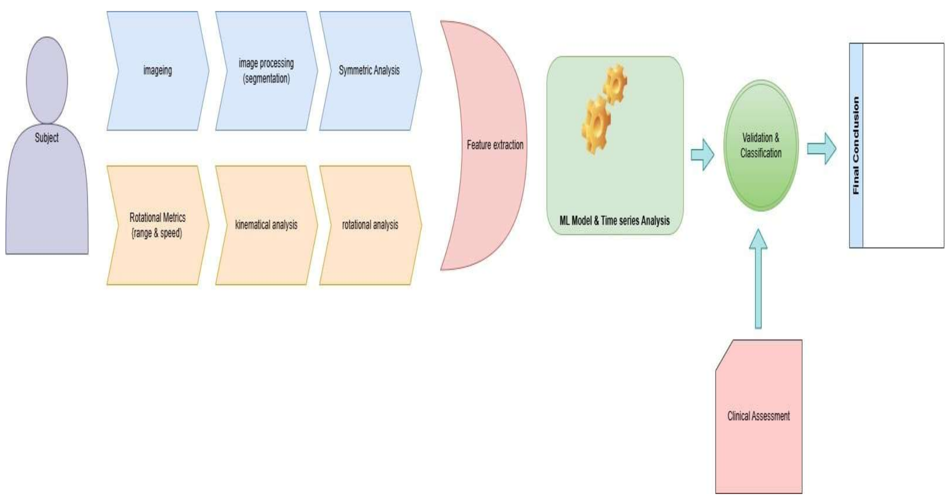

Fig 5

F. Data Fusion

Multimodal Data Integration: As this system takes the data from user in the form of images, videos and clinical observations and then combining these data to improve the accuracy of scapula dyskinesia detection.
Cross-Validation: By using different methods of cross-validation for cross-check the findings, such as combining manual judgement with machine learning. [20]

G. Data Visulaization

By using graphs, charts and many more which helps the doctors or physical therapists for better analysis of the scapula's movement.

V. CONCLUSION

Overcoming the bridge of high computational cost and very large dataset, we can come with best approach with low cost and better efficiency. Although we need to use CNN and deep learning for improvement but the initial cost for the training can be reduced. After the having enough data, we can shift with reinforcement learning and training our model with better efficiency.

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