Vol 2 Issue 4 Thi Qar University Journal of Physical Education

مجلة جامعة ذي قار لعلوم التربية البدنية

مجلة علمية محكمة تصدرها كلية التربية البدنية وعلوم الرياضة

The Impact of Wearables in Recovery from Repetitive Shoulder Dislocation Injury in Athletes

Fatima Hamid Kazar

Faculty of Physical Education and Sport Sciences, University of Baghdad

fatima.gzar0904@cope.uobaghdad.edu.iq

Published online: 20/ 12/2025

Keywords: ***Wearables, IMUs, repetitive shoulder dislocations, athletic rehabilitation, range of motion.***

ABSTRACT

The aim of this study was to identify the effect of the use of inertial measurement units (IMU) on improving the functional recovery of the shoulder joint in athletes with recurrent shoulder dislocation. The experimental method was used in the method of pre-dimensional measurement, as it applied a structured and supported therapeutic rehabilitation program supported by IMU units, which were used to monitor the motor variables of the shoulder joint, represented by the range of motion (flexion, distancing, and extension) during the different stages of rehabilitation.The results of the statistical analysis showed that there are statistically significant differences between the pre- and post-measurements and in favor of the telemetry in all variables of the range of motion, which indicates the effectiveness of the rehabilitation program used and supported by wearable technologies in improving the functional efficiency of the shoulder joint. This improvement is due to the role of IMUs in providing real-time and accurate motor feedback, which has contributed to correcting motor errors, improving neuromuscular control, and controlling the rehabilitative load within safe limits. The study concludes that the integration of wearable devices into recurrent shoulder dislocation rehabilitation programs is an advanced scientific method that contributes to accelerating functional recovery and reducing the likelihood of recurrence of the injury, and it is recommended to adopt these techniques in rehabilitation and sports physiotherapy centers.

1-1 The importance of the research:

The shoulder joint is one of the most biomechanically complex and prone joints in athletes, due to its wide range of motion and its heavy reliance on neuromuscular balance for dynamic stability. Repetitive shoulder dislocation is a common injury in sports that require above-head movements, leading to impaired motor control, impaired movement between the shoulder joint and the shoulder plank, and an increased likelihood of recurrence of the injury if careful rehabilitation programs are not applied (Kibler & Sciascia, 2010).

The traditional literature has suggested that rehabilitation programs based on strengthening muscles and increasing range of motion are necessary, but may be inadequate in cases of recurrent dislocations, as these conditions are often associated with neuromuscular dysfunction rather than a purely structural problem (Reinold et al., 2009). In this context, recent trends in sports medicine and functional rehabilitation have begun to focus on incorporating smart technology to enhance the quality of motor performance and improve rehabilitation outcomes.

Wearable devices are one of the most prominent of these technologies, relying on motion sensors such as accelerometers and gyroscopes to provide real-time quantitative data on joint angles, movement speed, and kinetic performance pattern. Recent studies have shown that the use of these devices contributes to providing immediate feedback, which helps to correct motor errors and improve motor learning and neuromuscular control during rehabilitation programs (Chen et al., 2020; JMIR, 2024).

Despite the growing global interest in the use of wearables in the rehabilitation of upper limb injuries, studies that have directly addressed the impact of these devices on the rehabilitation of recurrent shoulder dislocations in athletes are still limited, especially in the Arab environment, where most studies focus on traditional methods of rehabilitation (Al-Issa, 2011; Al-Mansi, 2022). Hence, the importance of this study stems from bridging an existing scientific gap by analyzing the effect of incorporating wearables into a functional rehabilitation program for the shoulder joint in athletes with recurrent shoulder dislocations.

1-2 Research Problem:

Recurrent shoulder dislocation is one of the most common and complex injuries in athletes, due to its negative effects:

Lack of range of motion, poor muscle strength, neuromuscular dysregulation, and a high likelihood of recurrence, especially in games that require repetitive movements above head level or are characterized by physical friction. Despite the advancement in the field of sports rehabilitation, many of the rehabilitation programs currently implemented still rely on traditional methods of assessment and follow-up, such as visual observation or limited measurements, which limit the accuracy of the diagnosis of actual motor impairment during functional performance.The absence of accurate and real-time motor measurement during the rehabilitation stages may lead to a lack of optimal control of the rehabilitation load and exceeding the safe limits of the range of motion, which negatively affects the efficiency of functional recovery and increases the likelihood of recurrence of shoulder dislocation in athletes. In contrast, the recent scientific literature suggests that the use of wearables, particularly inertial measurement units (IMUs), provides the possibility of objectively and accurately monitoring motor performance during exercise, by measuring joint angles, angular velocity, and acceleration in real time.

Based on this, the research problem is that there is an urgent scientific and practical need to verify the effectiveness of the use of wearable devices (IMU) in sports rehabilitation programs in improving the functional recovery of the shoulder joint in athletes with recurrent shoulder

dislocations, and the extent to which it contributes to reducing the likelihood of recurrence of the injury compared to traditional rehabilitation methods

1-3 Research Objectives:

1. To identify the effect of IMU Rehabilitation Program on improving the range of motion of the shoulder joint in athletes with repetitive shoulder dislocation (flexion, distancing, stretching).
2. To determine the effectiveness of incorporating IMU units into rehabilitation programs in promoting functional recovery of the shoulder joint and reducing the likelihood of recurrence of injury in athletes.

1-4 Imposing the Research:

1\ There is no significant difference in the range of motion of the shoulder joint before and after the implementation of the IMU rehabilitation program in athletes with recurrent shoulder dislocation.

1-5 Research Areas:

1.5.1 Human Field: Players with shoulder joint dislocation from Baghdad clubs in the category of applicants in various sports.

1-5-2 Temporal Domain: The period from 5/9/2023 to 17/6/2024.

1.5.3 Spatial Domain: Physiotherapy hall at Al-Salam Center for Rehabilitation and Physical Therapy in Baghdad Governorate.

2. Research Methodology and Field Procedures:

2-1 Research Methodology:

The researcher used the experimental method by designing the equivalent individual group and applying the measurement (pre-post) to suit the nature of the research, where the qualifying method was applied to the research sample with the use of a physiotherapy device.

2-2 Research Population and Sample:

The research population was represented by athletes with intermediate degree shoulder dislocation in Baghdad Governorate, and the research sample consisting of (12) injured athletes referred to the Baghdad Center for Physical Therapy and Sports Rehabilitation was selected in the deliberate way, and they are athletes with recurrent shoulder joint dislocation, the research sample was determined according to scientific criteria to ensure proper representation of the sports community and to exclude any factors that may affect the results of the rehabilitation program, including the following conditions:

First: Conditions of Exclusion

1- Other injuries to the shoulder or upper limbs (such as tearing additional muscles or ligaments) during the previous six months.

2- The player has undergone any surgery on the shoulder joint during the past year.

3- Chronic diseases that affect movement or muscle strength, such as rheumatoid arthritis or neuromuscular problems.

4- Use of any other rehabilitation program during the study period may affect measurements of range of motion or muscle strength.

Second: Inclusion Conditions

1- Athletes with recurrent shoulder dislocations that have been clinically confirmed by a medical professional or medical records.

2- The ability to perform complete rehabilitation exercises without severe pain or health contraindications that prevent movement.

3- Age between (20–30 years) to ensure muscular and physiological homogeneity of the specimen.

4- Commitment to attend all sessions of the qualifying program and follow-up for pre- and post-measurements.

Table (1)
shows the statistical characterization of the research sample data in the basic variables before applying the qualifying method n=12

Statistical Significance of Characterization				Key variables
Torsion coefficient	Standard deviation	Broker	Arithmetic Average	
0.55	2.68	23	23.21	Age (year)
0.24	4.40	175.5	176.3	Length (cm)
0.13	4.88	69	68.6	Weight (kg)

It is clear from Table (1) of the homogeneity of the research sample data in the basic preliminary measurements that the torsion coefficients range between (0.13 to 0.55), which indicates that the extracted measurements are close to the equinox, as the values of the moderate torsion coefficient range between ±3. It is very close to zero, which confirms the homogeneity of the members of the research group in the initial variables before the study.

Table (2)
Statistical Characterization of the Research Sample Data in the Range of Motion of the Shoulder Joint before the Application of the Qualifying Method

Statistical Significance of Characterization					
Torsion coefficient	Standard deviation	Broker	Arithmetic Average	Range of motion	
0.58	2.06	88.75	87.83	Injured shoulder	Unit of measurement (degree)
0.20	1.76	178.14	188.39	Healthy shoulder	

It is clear from Table (3) of the homogeneity of the data of the research sample in the kinetic range (degree) that the torsion coefficients range between (0.20 to 0.58), which indicates that the extracted measurements are close to the equinox, as the values of the moderate torsion coefficient range between ±3. It is very close to zero, which confirms the homogeneity of the members of the research group in the motor range before the study.

2.3 Devices and Tools Used in the Research:

1. Computer
2. Medical ball weighing (1-2) kg.

3. Selected exam form for experts.
4. Conbometer device.
5. Dynamometer
6. IMU

2-4 Tests used in the research:

The test for measuring the range of motion of the shoulder joint was selected, and it obtained an approval rate of 80% after it was presented to a group of experienced and specialized experts, which is the test of measuring the range of motion (flexion, extension, dimensions) of the arm at the shoulder joint by reading the grades installed on a device.IMU .

(Reddy RS,et aL. 2024.)

2.5 Pre-Tests:

The pre-test was conducted on the members of the research sample (12) injured players, each according to his rehabilitation program, as the researcher conducts tests and conducts feedback during the performance of rehabilitation exercises to ensure performance within the correct ranges of performance, and this was done in different time periods distributed over (7) months of the sports season 2023-2024, according to the availability of the sample of athletes with shoulder joint dislocation at the Baghdad Center for Physical Therapy and Rehabilitation in Baghdad Governorate.

2-6 IMU

The Inertial Measurement Unit (IMU) is a small, electronic device worn on the body or joint, used to measure motion, direction, and acceleration with high accuracy.

It typically consists of three main sensor devices:

Accelerometer Accelerometer: Measures the acceleration of an object on the three axes (x, y, z).

Gyroscope : Measures the rotational speed around the three axes, and gives information about the change in the angle.

Magnetometer Magnetic Field Meter – Optional: Used to determine the direction of motion relative to the geomagnetic field, thus improving the accuracy of direction.

These sensors work together to identify:

Instantaneous angle of the joint (bending, pulling, stretching)

Angular velocity and acceleration

Movement pattern and joint trajectory during performance

Second: How to use the IMU during rehabilitation

Wear on the joint:

The device is placed on the injured shoulder (or on the upper arm and shoulder) using rubber bands or medical adhesives, so that it is fixed without slipping, connecting the device to the computer and tablet, often connected wirelessly (Bluetooth) or via cable, and uses special software for real-time data processing.

The ALBAinduction determined the type of movement to be measured (bending, pulling, stretching), and the device was set to record data at the beginning and end of the movement, with the real time recording of each movement, and feedback was given during the exercise, where

the injured person can see graphs or instantaneous indicators on the tablet or computer screen, and this helps to correct motor errors immediately and improve the performance of the exercise and record Data for later processing:

All measurements of angles, velocity, acceleration, and movement pattern are stored in files that the researcher can use to perform statistical analysis and compare pre- and post-measurements.

IMU use times during rehabilitation

Pre-workout: To record the pre-measurements of each movement.

During exercise: to monitor instantaneous motor performance and provide feedback.

After each session: To record the measurements and compare the performance with the previous sessions.

Usage time per session: Usually 15 to 30 minutes per player depending on the qualifying program.

Fourth: How the researcher obtains information from IMU

Raw Data Recording: The device records joint angles, speed, acceleration, and trajectory.

Data Transfer: via USB or Bluetooth to motion analysis software.

Calculating range of motion (ROM) for each movement

Determine the maximum and minimum angle of movement

Calculate the average speed and peak speed

Movement pattern analysis and identification of any deviation or motor compensation

The Scientific Usefulness of the IMU in this Research

High accuracy in measuring motion compared to traditional methods (goniometer).

Provide real-time feedback to correct motor errors immediately.

Monitor qualifying load and control the final range without exceeding safe limits.

Obtain objective quantitative data that can be relied upon in statistical analysis and scientific conclusions.

2.7 Post-tests:

The post-tests were conducted on the research sample to identify the extent to which the goals set for the research were achieved, the extent of improvement and progress in the injury, the physical condition and the level of range of motion of the injured players, and they were conducted eight weeks after the start of the experiment in the same order of the previous measurements and under the same conditions and for each injured person separately.

2.8 Statistical Treatments:

1. The arithmetic mean

2- The Broker

3. Standard deviation

4- Torsion coefficient

5. Test (T) for symmetrical samples

3- Presentation, analysis and discussion of the results:

3-1 Presentation and analysis of the results of physical variables:

Table (3)
Differences between pre- and post-measurements in physical variables of the injured shoulder

Significance	Calculated value (v)	P.H.	F·	Dimensional		Tribal		Unit of Measurement	Range of motion of a shoulder joint
				on	Going to	on	Going to		
Moral	3.30	1. 08	34.70	18.77	143.20	21.32	112.6	Degree	1. Bending
Moral	7.83	3. 59	37.06	20.44	156.6	24.12	87.38	Degree	2. Dimensions
Moral	3.04	4.43	8.73	7.53	41.45	9.33	33.39	Degree	3. Tide

The tabular value of (v) = (2.57) at the degree of freedom (11) and below the significance level of (0.05)

Table (3) shows that the pre-test of the flexion variable in the kinetic range is (112.6) with a standard deviation of (21.32) and for the post-test (143.20) and a standard deviation of (18.77) and the calculated value of t is (3.34) which is greater than its tabular value (2.57), which means that the difference is significant.

The arithmetic mean of the exclusion test was (87.38) with a deviation of (24.12), while the arithmetic mean of the post-test was (156.6) with a deviation of (20.44) and (t) was calculated (7.83), which is greater than the tabular of (2.57), which means that the difference is significant.

The arithmetic mean of the tide test was (33.36) with a standard deviation of (9.33), and the arithmetic mean of the post-test was (41.45) with a standard deviation of (7.53), while the calculated value of (v) was (3.04), which is greater than the tabular (2.57), which means that the difference is significant and in favor of the post-test.

3-1 Discussion of the results of physical variables:

The results of Table (3) showed that there were statistically significant differences between the pre- and post-measurements in all variables of the range of motion of the affected shoulder joint (flexion, distancing, and extension), where the calculated values of (T) were (3.30, 7.83, and 3.04) respectively, which exceeded the tabular value at the significance level of (0.05), which confirms the effectiveness of the rehabilitation program used and supported by the IMU technologyWearable in improving shoulder joint function in players with repetitive shoulder dislocation, and the significant improvement in flexion range is attributed to the complementary effect between guided rehabilitation exercises and the use of IMUs, which provided an accurate instantaneous measurement of movement angles, speed, and regularity during performance. Immediate feedback from motor sensors corrected motor errors and reduced unwanted compensation during flexion, resulting in improved neuromuscular control and increased unit recruitment efficiency This result is consistent with Heather & Murray (2000) that fine motor

control supported by sensory feedback promotes the restoration of normal function of the affected joints, especially in the shoulder joint which is characterized by a wide range of motion and relative instability. The use of IMUs contributed to the detection of any deviations in the movement path or imbalance in the motor rhythm, which enabled the therapist to adjust the training load with individual accuracy for each ligament, and these results are consistent with Murray (2000) stated that the incorporation of smart technologies in the rehabilitation allows for a qualitative assessment of movement and not just quantitative, which leads to a faster and safer improvement in range of motion, and reduces the likelihood of recurrence of recurrent dislocation.

The improvement in tidal testing is due to the gradual improvement in the flexibility of the articulated capsule and the improvement in the elasticity of the soft tissues surrounding the joint, as a result of adherence to the principle of gradient in qualifying loads, which has been closely monitored by IMUs. These units enabled the adjustment of the end range and the prevention of exceeding safe limits during performance, which helped to improve range without causing excessive stress. The inclusion of IMU wearables in the rehabilitation program was a distinctive qualitative element in this study, as these units provided real-time data on joint angles, movement speed, acceleration, and motor performance pattern, which allowed for accurate motor diagnosis of joint condition during actual performance and continuous evaluation Recent studies have supported the effectiveness of the use of motor sensors in rehabilitation programs, as Hasnan et al. (2013) have indicated that smart motor measurement contributes to improving neuromuscular coordination and reducing the risk of recurrent injury, as Hasnan et al. (2013) have confirmed.The combination of therapeutic exercise and wearable techniques is one of the most advanced methods in modern sports rehabilitation.

4. Conclusions and recommendations

4.1 Conclusions:

After presenting, analyzing and discussing the results of the current study, the researcher can summarize the results of its results to the following conclusions:

1- The results showed that the rehabilitation program supported by IMU units led to a significant improvement in the range of motion of all studied movements (flexion, distancing, stretching) in athletes with repetitive shoulder dislocation, confirming the effectiveness of the combination of therapeutic exercises and wearable techniques.

2- It also resulted in an increase in the strength of the stabilized and moving muscles of the shoulder joint, demonstrating that the rehabilitation program not only enhanced range of motion but also contributed to improved muscular capacity and neuromuscular control.

3- The use of IMUs provided real-time feedback, correction of motor errors, and monitoring of rehabilitative load within safe limits, helping to increase safety and achieve more accurate and reliable results compared to traditional software.

4- The study confirmed that incorporating modern technology, such as IMU, into rehabilitation programs is an advanced approach that can accelerate functional recovery and reduce the likelihood of recurrence in athletes.

5- The observed improvement in both range of motion and muscular strength reflects an improvement in neuromuscular control around the shoulder joint, which contributes to the prevention of future injuries and improved functional athletic performance.

4.2 Recommendations

The researcher recommends the following:

1. The researcher recommended the use of inertia measurement units (IMUs) as an essential part of rehabilitation programs for athletes with repetitive shoulder dislocations, due to their ability to accurately and safely improve range of motion and muscular strength.
2. It is advisable to take advantage of the real-time feedback provided by IMUs to correct motor errors during exercise, improve neuromuscular control, and reduce unwantedalternative movements.
3. Designing individual rehabilitation programs that take into account the data recorded from each player 's IMUs, to adjust the training load according to their ability and response, which contributes to accelerating recovery and preventing recurrence of dislocation.
4. Combining wearables with traditional therapeutic exercises to achieve the best results, as modern technology provides objective quantitative information that can be relied on to accurately assess improvement.
5. Future studies involving a larger number of athletes, and the incorporation of functional questionnaires to assess the overall impact on daily athletic performance, with a comparison of IMUs and traditional measurement tools to confirm the results, is recommended to improve the levels of range of motion of the injured joint.

References

Abdul Rahman, A. (1998). Sports medicine. Dar Al-Kutub for Printing and Publishing.

Abdullah, M. (2021). The effect of a proposed rehabilitation program for treating ligament tears and strengthening muscles working on the shoulder joint in athletes [Unpublished master's thesis]. University of Baghdad.

Al-Asimi, E. K. J., & Alfatlawi, H. A. (2019). Exercises for neuromuscular facilitation of sensory receptors and their impact on the rehabilitation of the injured shoulder joint for weightlifters with special needs. Journal of Sports Sciences, 13(1).

Al-Barouki, N. A. (2020). The effect of an aquatic rehabilitation program on pain level and range of motion of the shoulder joint for junior swimmers. Scientific Journal of Physical Education and Sports Science, 2(9), 190–208.

Al-Douri, Q. I. (1988). Anatomy (2nd ed.). House of Books.

Al-Khatib, N. M., & Al-Nimr, A. A. (1997). Sports training: Muscle lengthening. Dar Al-Fikr Al-Arabi.

Al-Raheem, A. M., & Al-Azzawi, H. (1983). Principles of anatomy. Freedom House Printing.

Ayako, K., Kahanov, L., & Leamor, K. (2007). The effect of kinesio taping on lower trunk range of motion. Research in Sports Medicine, 15(2), 103–112.

https://doi.org/10.1080/15438620701405206

Hasnan, N., Ektas, N., Tanhoffer, A. I., Tanhoffer, R., Fornusek, C., Middleton, J. W., Husain, R., & Davis, G. M. (2013). Exercise responses during functional electrical stimulation cycling in individuals with spinal cord injury. Clinical Exercise and Rehabilitation Unit, Faculty of Health Sciences, University of Sydney.

Hassan, W. H. (2002). The effect of a proposed exercise program for the prevention of some ankle joint injuries among football players [Unpublished master's thesis]. Minia University, Faculty of Physical Education for Boys.

Less, M. B. (1989). Fundamentals of human anatomy. Dar Al-Fikr for Publishing and Distribution.

Mahjoub, W. (1989). Kinesiology. Dar Al-Kitab for Printing and Publishing.

Mattacola, C. G., & Dwyer, M. R. (2002). Rehabilitation of the ankle after acute sprain or chronic instability. Journal of Athletic Training, 37(4), 413–429.

Muhammad, S. K. (2010). Physical therapy: Methods and techniques. University of Baghdad.

Murray, H. M. (2000). Kinesio taping®, muscle strength and range of motion after ACL repair. Journal of Orthopaedic & Sports Physical Therapy, 30(1), 28–36.

https://doi.org/10.2519/jospt.2000.30.1.28

Reddy, R. S., Alshahrani, M. S., Almohiza, M. A., Alkhamis, B. A., Tedla, J. S., Kakaraparthi, V. N., Koura, G. M., Mukherjee, D., Alnakhli, H. H., Ghulam, H. S. H., & Alqahtani, R. S. (2024). Shoulder muscle weakness and proprioceptive impairments in type 2 diabetes mellitus: Exploring correlations for improved clinical management. PeerJ, 12, Article e17630.

https://doi.org/10.7717/peerj.17630

Shaalan, A. E. D. (1992). The effect of a proposed exercise program on the rehabilitation of the knee joint and the muscles working on it after anterior cruciate ligament reconstruction [Unpublished doctoral dissertation]. Minia University, Faculty of Physical Education for Boys.

Shafei, Y. S. (1993). Rehabilitation of the knee joint after surgical repair of anterior cruciate ligament injury [Unpublished doctoral dissertation]. Helwan University, Faculty of Physical Education for Boys.

Shaheen, L., & Lama, A. (2023). The effectiveness of a physical rehabilitation program and therapeutic massage on shoulder joint stiffness. Journal of Inclusive Education Research, 3(7).

Tolba, A. M. A. G. (2011). A proposed rehabilitation program for wrist sprain among tennis players [Unpublished doctoral dissertation]. Helwan University.