

# Restoring Dynamic Shoulder Stability: Insights from the MoveUS Program

Laura Ramírez-Pérez<sup>a, b\*</sup>, María del Carmen Martín-Molina<sup>b, c</sup>, Antonio Ignacio Cuesta-Vargas<sup>a, b, d</sup>

<sup>a</sup> Department of Physiotherapy, University of Málaga, Málaga 29071, Spain

<sup>b</sup> The Institute of Biomedical Research and Nanomedicine Platform in Málaga (IBIMA Plataforma BIONAND), Clinimetric Group F-14, Málaga 29010, Spain

<sup>c</sup> Traumatology, Rehabilitation and Physiotherapy Unit, Axarquía Hospital, Málaga 29700, Spain

<sup>d</sup> ARC Centre for Joint Biomechanics, Queensland University of Technology, Brisbane, QLD 4059, Australia

\* Corresponding author: lrp@uma.es

Received date: 19/11/2025

Accepted date: 16/03/2026

Publication date: 02/06/2026

**Keywords:** shoulder, joint instability, exercise, physical endurance, functional status

© 2026 The Authors

Licence CC-BY 4.0

Published by Société de Biomécanique

## 1. Introduction

Glenohumeral instability affects approximately 1-2% of the general population and 11% of the overhead athletes, generating a wide variety of symptoms, high-lighting pain, loss of functionality, mobility limitations, loss of strength, alterations in movement patterns, and multivariable fatigue.

Management of glenohumeral instability includes both conservative and surgical approaches. Surgical interventions, such as Bankart or Latarjet, are indicated for recurrent instability or when conservative treatment fails, but the risk of recurrence is between 7% and 20%. Regarding the conservative approach, physiotherapy programs try to restore function through shoulder strengthening, but existing protocols are not fully satisfactory. Moreover, there is no consensus about the best approach (Kavaja et al., 2018).

For these reasons, the main aim of this study was to evaluate the effect of an original multicomponent exercise protocol, the MoveUS Program, on the improvement of symptoms in patients with glenohumeral instability.

## 2. Methods

### 2.1 Study design

A phase I prospective cohort study was designed, enrolling 25 patients. Patients were included if they were 18 to 64 years old, had a clinical diagnosis radiographically

confirmed of shoulder instability, and had suffered at least one episode of shoulder instability during the last year.

They underwent a 12-week exercise-based intervention, the MoveUS Program, which was divided into four stages of equal duration with three weekly days of training. The approximation phase focused on regaining motor control, the structural phase was based on strengthening the periarticular muscles, the neural stage emphasized the improvement of motor unit recruitment, and the functional readaptation phase was based on returning to sports and daily life activities. As for supervision, 1 weekly session was developed face-to-face with continuous monitoring by the physiotherapist, and 2 weekly sessions were performed at the hospital without presential monitoring but using the dosage prescription provided by the physiotherapist (Ramírez-Pérez & Cuesta-Vargas, 2024).

### 2.2 Procedure

The patients were followed for 24 weeks, and the improvements were measured using validated questionnaires such as the Western Ontario Shoulder Instability Index (WOSI) for pain, functionality, and quality of life, the Quick-Piper Scale-revised (Quick-Piper) for psychological fatigue, the Questionnaire on the self-perception of the athlete for the return to standardized training after an injury (Return to Play) for the capacity

of a safely return to daily life activities and sports, the modified T-Fast Test for endurance, the MoveUS Test for dynamic stability, a handheld dynamometer for force peak, an electromyography for physiological fatigue, and inertial sensors for kinematic fatigue.

### 2.3. Statistical analysis

Descriptive statistics were performed. Moreover, pre- and post-intervention changes were analyzed using paired t-tests for within-group comparisons, with mean differences, corresponding p-values, and effect sizes. No corrections for multiple comparisons were applied. Subgroup analyses were not performed due imbalance in traumatic and atraumatic instability.

### 2.4. Ethical approval

The study had ethics approval from the Malaga Clinical Research Ethics Committee (PEIBA: 1311-M1-23).

## 3. Results and discussion

The sample consisted of 17 males and 8 females, with a mean age of  $34.3 \pm 12.4$  years. Regarding the instability profile, 17 patients (68%) were atraumatic.

After the MoveUS Program, patients showed a significant improvement in WOSI (mean difference =  $703 \pm 89.1$  points;  $p < 0.001$ ; Cohen's  $d = 1.81$ ), Quick-Piper (mean difference =  $2.6 \pm 0.45$  points;  $p < 0.001$ ; Cohen's  $d = 1.32$ ), and Return to Play (mean difference =  $11.21 \pm 2.04$  points;  $p < 0.001$ ; Cohen's  $d = 1.26$ ). These differences regarding the self-reported outcomes were greater than those found by previous authors (Warby et al., 2018), a fact that could be explained by the specificity of the original exercise program in terms of dosage, load, and progression.

Likewise, the MoveUS Program had a significant effect on endurance, including repetitions in the T-Fast Test 30" (mean difference =  $11.78 \pm 1.87$ ,  $p < 0.01$ ; Cohen's  $d = 1.48$ ) and the T-Fast Test 120" (mean difference =  $37.06 \pm 5.72$ ,  $p < 0.01$ ; Cohen's  $d = 1.53$ ). This finding is consistent with previous studies that reinforced the effect of endurance training through repetitive tasks on shoulder resistance to fatigue (Reinold et al., 2018).

These changes were also observed in the delay of the fatigue appearance measured by inertial sensors, both in the T-Fast Test 30" (mean difference =  $4.9 \pm 1.6$  seconds,  $p = 0.03$ ; Cohen's  $d = 1.24$ ) and 120" (mean difference =  $33.44 \pm 4.1$  seconds,  $p < 0.001$ ; Cohen's  $d = 3.3$ ). Furthermore, trends in physiological fatigue measured with

electromyography were noted, especially in the middle deltoid muscle in elevation in the scapular plane (mean difference =  $7.9 \pm 3.6$  % of mean frequency change in Hz,  $p = 0.04$ ; Cohen's  $d = 0.51$ ). These results indicate that this intervention can improve neuromuscular efficiency, thus agreeing with previous researchers who highlighted the great relationship between force and endurance training on fatigue reduction (Rønnestad & Mujika, 2014).

Moreover, the MoveUS Program had a significant effect on isometric force peak (mean difference =  $42.65 \pm 4.9$  Newtons,  $p < 0.001$ ; Cohen's  $d = 1.1$ ) and on dynamic stability measured with the MoveUS Test adjusted (mean difference =  $1160.8 \pm 289.6$  number of repetitions x pressure in Newtons,  $p < 0.001$ ; Cohen's  $d = 0.95$ ). These gains in isometric force and unilateral wall-push-up stability indicate that the exercise program effectively enhances both shoulder force production and neuromuscular control, aligning with evidence that targeted strengthening and stability training can promote better periarticular shoulder muscles function and dynamic scapular control, helping to explain the functional changes observed.

All these results are summarized in Fig. 1.

## 4. Conclusions

The MoveUS Program was associated with increased endurance, reduced multivariable fatigue, improved stability, and enhanced quality of life and safety in returning to sports. Nonetheless, further research is needed to optimize the implementation of the intervention.

## Acknowledgements

The authors thank the University of Málaga for providing the necessary material to develop this study and the Axarquia Hospital for providing the space to carry out the evaluations and treatments.

## Conflict of Interest Statement

The authors, their immediate families, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

## Contributor Roles

LRP: Conceptualization, Data Curation, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing; MCMM: Data curation, Investigation,

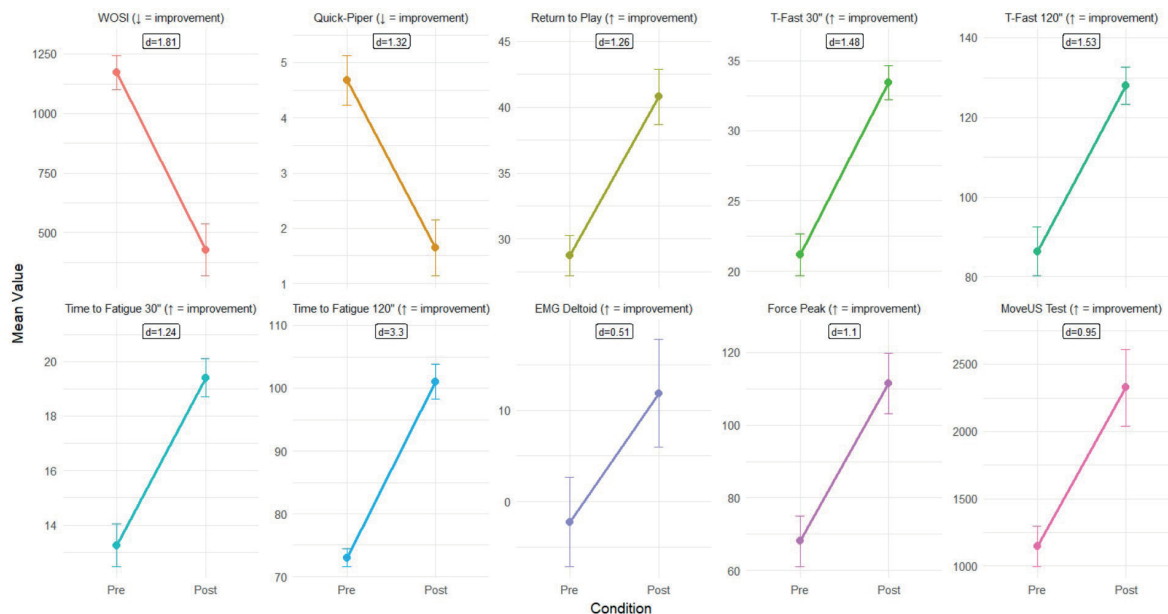


Figure 1. Pre-Post Evolution by Test (± SE) with Cohen's d.

Credit: Laura Ramírez-Pérez.

Resources, Visualization, Writing – review & editing; AICV: Conceptualization, Methodology, Project administration, Supervision, Validation, Visualization, Writing – review & editing.

### Funding

This work is part of a government-funded project supported by the University Teaching Training Programme (FPU) of the Ministry of Universities of Spain. Grant number: FPU21/06296.

This work has been co-financed with FEDER funds through the “Financing for applied research projects and/or technological development projects, interdisciplinary and intersectoral for Research Groups, within the framework of the II Own Plan for Research, Transfer and Scientific Dissemination of the University of Málaga”. Grant number: CTS-631.

### Data, software, code availability

Data are available upon reasonable request to the corresponding author.

### References

Kavaja, L., Lähdeoja, T., Malmivaara, A., & Paavola, M. (2018). Treatment after traumatic shoulder dislocation: A systematic review with a network meta-analysis. *British Journal of Sports Medicine*, 52(23), 1498–1506. <https://doi.org/10.1136/bjsports-2017-098539>

Ramírez-Pérez, L., & Cuesta-Vargas, A. I. (2024). Effect of a multicomponent exercise program focused on multivariable fatigue improvement versus standard care for glenohumeral instability: MoveUS study protocol. *BMC Musculoskeletal Disorders*, 25(1), 1013. <https://doi.org/10.1186/s12891-024-08193-4>

Reinold, M. M., Macrina, L. C., Fleisig, G. S., Aune, K., & Andrews, J. R. (2018). Effect of a 6-week weighted baseball throwing program on pitch velocity, pitching arm biomechanics, passive range of motion, and injury rates. *Sports Health: A Multidisciplinary Approach*, 10(4), 327–333. <https://doi.org/10.1177/1941738118779909>

Rønnestad, B. R., & Mujika, I. (2014). Optimizing strength training for running and cycling endurance performance: A review. *Scandinavian Journal of Medicine & Science in Sports*, 24(4), 603–612. <https://doi.org/10.1111/sms.12104>

Warby, S. A., Ford, J. J., Hahne, A. J., Watson, L., Balster, S., Lenssen, R., & Pizzari, T. (2018). Comparison of 2 exercise rehabilitation programs for multidirectional instability of the glenohumeral joint: A randomized controlled trial. *The American Journal of Sports Medicine*, 46(1), 87–97. <https://doi.org/10.1177/0363546517734508>