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Original Research

Improved shoulder stability through plyometric, proprioceptive and strength exercises in rugby players. A randomized clinical trial

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Abstract

Background: The shoulder is one of the most frequently injured joints in rugby. Improving muscle strength can increase glenohumeral joint stability, thus preventing injuries to this joint.

Purpose: Evaluating the effectiveness of a plyometric, proprioceptive and strength exercise program in promoting shoulder stability in rugby players.

Study design: Randomized single blind clinical trial, with follow up. Level of evidence, 2.

Methods: Thirty federated rugby players were included in the study and randomized to the two study groups. The experimental group performed an exercise program including plyometric exercises using a fitness ball, proprioceptive exercises with BodyBlade® and strength training with elastic bands. The intervention lasted four weeks, with two weekly sessions lasting 15 minutes each. The control group continued with their usual routine. The study variable was glenohumeral stability, measured with the *Closed Kinetic Chain Upper Extremity Stability* test and the *Y-Balance* test. Three evaluations (pre-treatment, post-treatment and follow-up) were carried out. Changes were calculated after each evaluation and repeated measures analysis was performed.

Results: Stability improved after the intervention and when comparing pre-treatment and follow-up assessments ($P < 0.05$) in the experimental group. There were differences between the two groups ($P < 0.05$) and between the different study evaluations ($P < 0.001$).

Conclusion: A protocol based on plyometric, proprioceptive and strength exercises improves glenohumeral stability. This improvement can be maintained for four weeks.

Keywords

Shoulder; Stability; Plyometric exercise; Proprioception; Strength

1. Introduction

Rugby is one of the most popular sports worldwide, played in more than 150 countries [1]. The injury rate in this sport is 91 per 1000 player hours, this figure being higher than in sports such as soccer and ice hockey [2].

Shoulder injuries are common in contact sports such as rugby with a high recurrence rate [3]. The pathology of the glenohumeral joint causes the athlete's prolonged absence from competition, mainly due to anterior dislocation of the shoulder and instability [4]. As much as 67% of anterior shoulder dislocations occur in tackling due to poor technique and unsuitable postures adopted in a tackle [5]. The incidence of injury in connection with these two shoulder pathologies is 1.25 per 1000 hours of training and competition, while both pathologies present a high injury recurrence rate. In players under the age of 25 suffering a traumatic anterior shoulder dislocation for the first time, the risk of recurrence is 90-95% when no surgical treatment is carried out [6].

Shoulder stability depends on the relationship between the muscles, which offer dynamic stabilization, and the ligament structures and static stabilization structures [7]. The sensorimotor system plays a mediating role between the muscle structures and the other joint components, thanks to the afferent information from the mechanoreceptors (present in the capsuloligamentous and musculotendinous tissue) that reaches the central nervous system and triggers neuromuscular control. This control enables shoulder stability and coordinated movement patterns [8]. The glenohumeral joint is inherently unstable due to a reduced congruency that enables greater mobility. The stabilizing components maintain the humeral head in position. Such instability may increase due to alterations in the capsule-ligament or soft tissues of the muscles, or as a result of a dysfunctional sensorimotor system [9].

Although the deltoid and pectoralis major muscles are also potential destabilizers of the glenohumeral joint, their stabilizing function depends on the orientation of structures such as the scapula and humerus. Improving the strength of the rotator cuff and the large periarticular muscles of the shoulder can decrease the incidence of shoulder joint injuries in rugby players [10]. Myers and Lephart [11] reported that the deltoid and pectoralis major muscle strength is able to provide stability to the glenohumeral joint. On the other hand, Myers and Oyama [12] verified how the development of closed kinetic chain exercises generates a greater co-contraction of the scapula and rotator cuff stabilizing muscles, this being essential for glenohumeral joint stability.

The Bodyblade® device (Mad Dogg Athletics®, Inc, Venice CA) is an exercise instrument based on oscillatory/vibration motions. It is based on the rapid change of direction, with a low frequency rate of 4.5 Hz (cycles per second). In this way, the body reacts up to 270 times per minute in order to counter the destabilizing forces that can vary depending on the size and the oscillatory speed [13, 14].

The main aim of this study is to evaluate the effectiveness of a physiotherapy intervention in improving shoulder stability in rugby players through an exercise program implementing plyometric exercises using a fitness ball, proprioceptive training with BodyBlade® and strength exercises using elastic bands.

2. Methods

2.1 Study design

Single-blind randomized clinical trial with follow-up, carried out on athletes recruited at the Rugby Club of Majadahonda (Madrid, Spain). The study period was from January to May 2019. The study compared the clinical outcome after applying a plyometric, proprioceptive and strength training program in 30 rugby players randomly allocated to the study groups.

2.2 Study population

A representative sample of the sample under study has been calculated. The magnitude of this difference was considered by calculating the effect size (d = 0.76) [15] in order to measure glenohumeral joint stability in healthy subjects with shoulder pain. With an alpha level (type I error) of 0.05, a statistical power of 80% ($1-\beta = 0.80$), and a non-sphericity correction of 1, a sample size of 46 rugby players was estimated. As a non-multicenter randomized clinical trial, 30 rugby players were recruited. The calculation was performed using G*Power software, version 3.1.9.4.

The inclusion criteria for participating in the study were: males: federated rugby players; over 18 years of age; and participation in regional competitions at the time of the study. By contrast, subjects excluded were those who: had received treatment with anti-inflammatory drugs in the month prior to the study; had glenohumeral injuries; had a diagnosis of cardiovascular or metabolic disease; and failed to sign the Informed Consent Document.

2.3 Randomization

Initially, 32 rugby players were invited to participate in the study. Selection criteria were met by 30 who were included in the study. Subjects were randomly assigned to the two study groups: experimental and control. Randomization was carried out by someone unrelated to the study objectives, who was not involved in data collection or any other phase of the study. Randomization was performed using an opaque envelope system. The subjects included in the experimental group (n = 15) underwent intervention based on a program implementing plyometric exercises with a fitness ball, proprioceptive exercises with BodyBlade® and strength training with elastic bands. Subjects included in the control group (n = 15) received no intervention whatsoever and continued with their usual routine and sports practice.

2.4 Outcome evaluation

The primary study variable was stability. This variable was measured using two measuring instruments: *Closed Kinetic Chain Upper Extremity Stability Test* and *Upper Quarter Y-Balance Test*.

The *Closed Kinetic Chain Upper Extremity Stability Test* (CK-CUEST) was designed by Lee *et al.* [16] and assesses shoulder stability, with scores ranging from 0 to infinite points (where 0 denotes no stability). This test has shown excellent interobserver reliability (ICC: 0.86; 95% CI: 0.11-0.96) [17]. The initial position in the test is a push-up position with arms perpendicular to the floor. Two 3.80-cm strips were taped to the floor with a 91.44-cm separation between strips. Players placed their hands on each strip of tape with their third finger on the strip, moving one hand over the body in the transverse plane until touching the other strip and then returning to the starting position. Players then had to perform the same movement with the other hand. Touches are counted every time either strip is touched in 15 seconds. Each subject performed warm-up movements, followed by 3 attempts with a 45-second rest between attempts.

The *Upper Quarter Y-Balance Test* (YBT-UQ) was validated by Westrick *et al.* [18] for the evaluation of shoulder stability. This test has shown excellent interobserver reliability (ICC: 1.00; 95% CI: 0.80-0.99) [19]. This tool allows the quantitative analysis of an athlete's ability to reach a distance with his free hand while maintaining weight on the contralateral arm. In order to perform the YBT-UQ, the player is asked to reach the maximum range possible with the free hand (medial, inferior lateral and superior lateral range), while maintaining the load on the supporting hand that is placed in a standardized location. This scale consists of three items (medial, superior lateral and inferior lateral range) with scores ranging from 0 to an infinite number of points (0 denotes no stability), obtained by calculating the average of the three items.

At the beginning of the study, the main sociodemographic, anthropometric and clinical variables of the participating subjects were evaluated.

Three evaluations were performed in this study: pre-treatment (T0), post-treatment (T1) and at four weeks follow-up (T2). The physiotherapist who carried out the various study evaluations, with years of experience in musculoskeletal assessment, was blinded to the subjects' allocation to the different study groups. All evaluations were conducted under the same conditions and following the same measurement protocol.

2.5 Intervention

The intervention was carried out over a period of four weeks, with two weekly sessions, lasting 15 minutes each. The exercise program proposed for the intervention in the experimental group consisted of four exercises, each lasting one minute, on both shoulders, and with one-minute rest between exercises. All exercises were performed bilaterally. The exercises were carried out with the aim of improving the stability and control of the shoulder, as well as the stabilizing muscle strength of the glenohumeral joint. All sessions were supervised by a physiotherapist specializing in Sports Physiotherapy.

A fitness ball was used for the first exercise, whereby the player, in two-legged stance with 90° shoulder abduction and 90° elbow flexion, should catch the ball and perform an external rotation movement, returning the ball using internal rotation [20]. For the second exercise, while holding an elastic band in a standing position, the player was asked to stand on the elastic band with one foot and with the contralateral limb to perform shoulder flexion to exercise the flexor muscles of the shoulder [21]. The third exercise required no type of material and rugby players were asked to perform scapular approximation and separation without changing their initial position, from a push-up position with their hands on the floor, while shoulders, elbows and wrists remained aligned [22]. For the last exercise, a Bodyblade device© was used; the athletes, in a standing position with 90° shoulder abduction and 90° elbow flexion, were asked to push in an anteroposterior direction, causing an oscillation effect, in order to work on proprioception by anteroposterior stabilization of glenohumeral joint [23]. The first three exercises were repeated 15 times, while the last exercise was performed over a period of 30 seconds.

During the experimental phase, control group subjects did not receive any type of intervention. All athletes included in the two study groups were asked not to take part in any other interventions or training sessions during the experimental phase and follow-up other than those being carried out prior to the study. In this way, it was possible to control that no other parallel intervention might impair the reliability of the results.

2.6 Statistics

A descriptive analysis was performed using the statistical software SPSS, version 19.0, for Windows. A descriptive analysis was used to calculate the main statistics (mean and standard deviation) of the independent quantitative variables. Sample distribution analysis was carried out using the Kolmogorov-Smirnov test [24].

The difference in means between the various evaluations in each group was calculated using the paired samples *t*-test. The within-subject effect and group interaction were obtained using the repeated measures ANOVA. The error rate of the significance level was controlled using the Bonferroni correction. When Mauchly's sphericity test was significant, the Greenhouse-Geisser correction coefficient was used. The partial Eta-squared value was calculated as an indicator of the effect size (classified as small 0.01, medium 0.06 and large 0.14) [25]. An intent-to-treat analysis has been performed in this study. The significance level of the study was $\alpha < 0.05$.

3. Results

3.1 Patient characteristics

Of the 30 rugby players taking part in the study, one from the control group dropped out prior to the post-treatment assessment due to injury. None of the athletes in the experimental group abandoned the study. Fig. 1 shows the flow diagram of the study.

The mean age of the 30 subjects was 25.13 years (DT: 8.10), with a mean height of 1.79 meters (DT: 13.09), and a mean body mass index of 26.62 kg/m^2 (DT: 3.48). Most of the subjects (63%) trained 3 days a week and 76% of the sample performed gym sessions. With regard to sample distribution at baseline, there were only differences ($P < 0.001$) in the age variable. Table 1 shows the main central trend statistics (mean and standard deviation) of the independent variables measured during the pretreatment assessment.

3.2 Functional clinical outcome

Changes were observed in the experimental group athletes for all measuring instruments. The stability measured with

JOMH
Journal of Men's Health

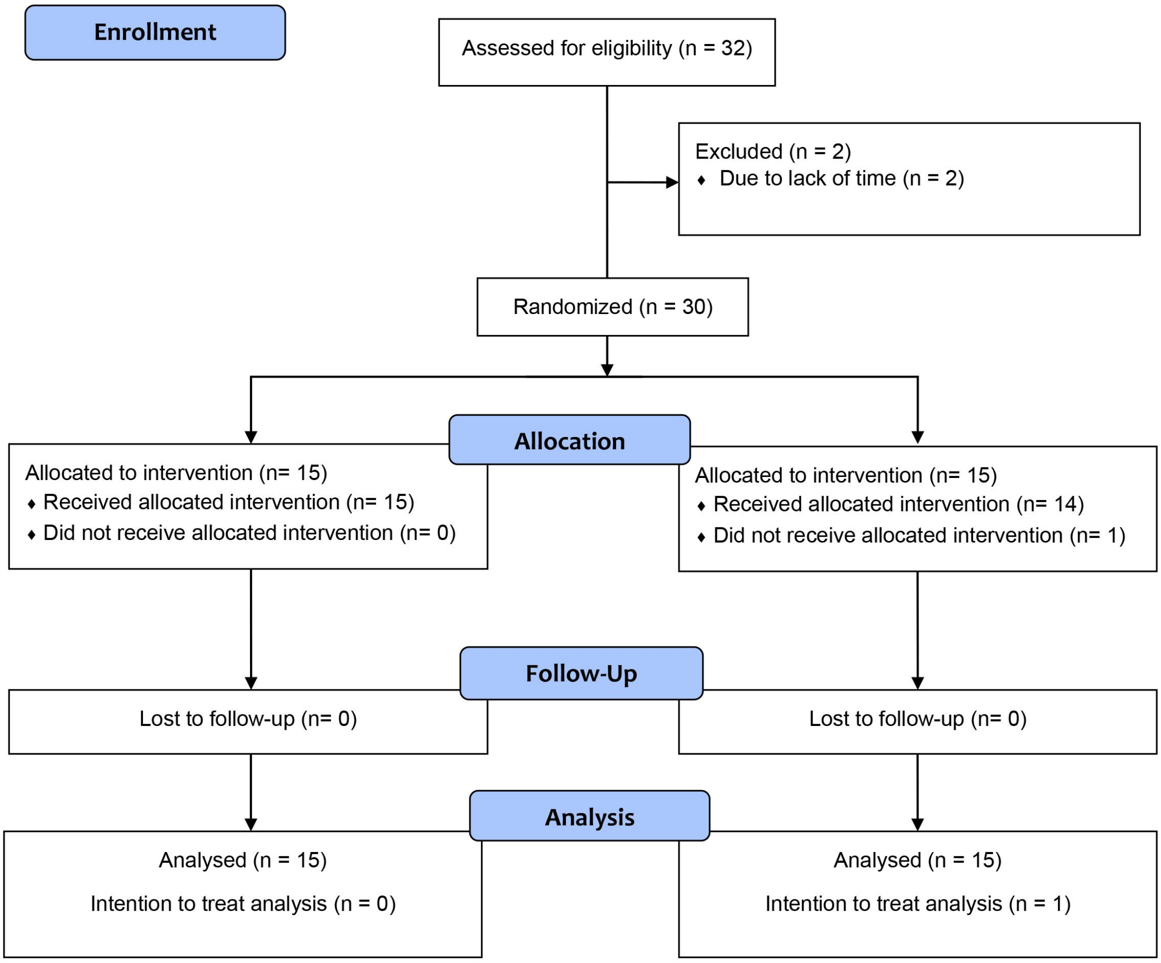

FIG. 1. CONSORT 2010 Flow Diagram.

TABLE 1. Descriptive analysis, median (and standard deviation) of the sample.

Variables	Experimental group		Control group		Sig.
Age (years)*	24.53 (9.51)		25.73 (6.69)		0.00 [a]
Height (cm)	1.80 (0.08)		1.78 (0.04)		0.09 [a]
Weight (kg)	85.60 (13.9)		86.27 (12.71)		0.20 [a]
Body mass index (Kg/m^2)	26.06 (2.73)		27.17 (4.11)		0.12 [a]
Close Kinetic Chain Upper Extremity Stability test	24.23 (3.55)		23.93 (3.59)		0.19 [a]
Y-Balance test (right)	91.74 (12.30)		92.54 (8.63)		0.18 [a]
Y-Balance test (left)	90.74 (10.48)		91.57 (9.31)		0.19 [a]
	n	%	n	%	
Weekly sessions (2 / 3)	5 / 10	33.3 / 66.6	6 / 9	40.0 / 60.0	0.07 [b]
Gym session (Yes / No)	12 / 3	80.0 / 20.0	11 / 4	73.3 / 26.6	0.07 [b]

n, number of subjects; %, percentage; Sig., significance.
[a] Kolmogórov-Smirnov test.
[b] Fisher exact test.
* Significant difference ($P < 0.05$).

the CKCUEST scale showed changes ($P < 0.001$) following the intervention period and when comparing T0-T2 (P = 0.005). Evaluation of stability using the Y-Balance test found differences in the stability of the right arm ($P < 0.001$) and left arm (P = 0.001) subsequent to intervention and at follow-up ($P < 0.01$). The control group exhibited decreased stability of the right upper limb, measured with the Y-Balance test after intervention (P = 0.03) and at follow-up (P = 0.009). Table 2 and 3 show the calculation of the main central trend descriptors and the difference in means between the various assessments, respectively.

3.3 Repeated measures analysis

There were significant differences ($P < 0.001$) in the repeated measures factor and in group interaction for all measure-

TABLE 2. Statistical analysis, median (and standard deviation), of the dependent variables of the study at baseline, posttreatment and follow-up assessment.

Measuring instruments	Experimental group		Control group	
	T1	T2	T1	T2
Close Kinetic Chain Upper Extremity Stability test	29.00 (3.60)	28.00 (3.70)	24.20 (3.78)	23.67 (3.47)
Y-Balance test (right)	103.59 (8.49)	101.68 (9.00)	91.44 (8.61)	90.86 (8.38)
Y-Balance test (left)	104.26 (9.39)	102.44 (9.39)	90.22 (9.97)	89.35 (9.45)

Outcome measures at the baseline (T0), after the four-weeks period of experimental and control interventions (T1) and after further four-weeks as follow-up (T2).

TABLE 3. Means difference [and 95% confidence interval] after posttreatment and follow-up period of the dependent variables of the study.

Measuring instruments	Experimental group		Control group	
	T0-T1	T0-T2	T0-T1	T0-T2
Close Kinetic Chain Upper Extremity Stability test	-5.16**	-4.1*	-0.23	0.5
	[-7.62, -2,71]	[-6.71, -1.48]	[-0.81, 0.34]	[-0.36, 1.36]
Y-Balance test (right)	-13.44**	-10.97*	1.06*	1.91*
	[-18.81, -8.07]	[-16.77, -5.18]	[0.11, 2.01]	[0.56, 3.25]
Y-Balance test (left)	-12.93*	-11.51*	0.76	2.03
	[-19.49, -6.37]	[-18.12, -4.89]	[-1.42, 2.95]	[-0.04, 4.11]

Outcome measures at the baseline (T0), after the four-week period of treatment and control interventions (T1) and after further four-weeks as follow-up (T2).
*Significant difference between improvements of the study groups ($P < 0.01$).
**Significant difference between improvements of the study groups ($P < 0.001$).

TABLE 4. Intra-subject and interaction with group results in each one of the dependent variables of the study, among the study groups.

Variables	Mauchly sphericity test		Intra-subject effect			Interaction		
	W	Sig.	F	Sig.	η_p^2	F	Sig.	η_p^2
Close Kinetic Chain Upper Extremity Stability test [a]	0.46	0.00	13.56	0.00**	0.32	13.63	0.00**	0.32
Y-Balance test (right) [a]	0.12	0.00	16.99	0.00**	0.37	26.15	0.00**	0.48
Y-Balance test (left) [a]	0.05	0.00	11.63	0.00**	0.29	17.61	0.00**	0.38

W, Mauchly Sphericity Test; Sig., significance. $\eta^2{}_p$: partial squared eta.
[a] The df corresponds to Greenhouse-Geisser test.
**Interaction with the group ($P < 0.001$).

ments of glenohumeral stability. When using the CKCUEST test we observed how stability changed depending on the time when evaluated (F (1.3, 36.47) = 13.56; $P < 0.001$; η_p^2 = 0.32), moreover the difference between the two groups was not the same at the three times of assessment (F = 13.63; $P < 0.001$ η_p^2 = 0.32). When measuring shoulder stability with the Y-Balance test on the right shoulder changes were found depending on the time when evaluated (F (1.06, 29.83) = 16.99; $P < 0.001$; η_p^2 = 0.37), and differences between the three times of assessment (f = 26.15; $P < 0.001$; η_p^2 = 0.48). When assessing left shoulder stability with the Y-Balance test, there were differences depending on the time when evaluated (F (1.02, 28.81) = 11.63; $P < 0.001$; η_p^2 = 0.29), and differences between the three times of assessment (F = 17.61; $P < 0.001$; η_p^2 = 0.38). When calculating the partial Eta-squared, we found high effect size values in all measured variables $\eta_p^2 > 0.14$). Table 4 shows the repeated measures analysis and group interaction.

3.4 Pairwise comparison analysis

In the pairwise comparison analysis relative to the glenohumeral stability evaluation based on the CKCUEST test, there were significant differences between the pre-and post-treatment evaluations ($P < 0.001$) and between pre-treatment and follow-up evaluations ($P < 0.02$). When analyzing the stability with the Y-Balance test we found differences in the stability of the right (T0-T1, $P < 0.001$; T0-T2, $P < 0.01$) and left upper limb (T0-T1, $P < 0.01$; T0-T2, $P < 0.01$). Table 5 shows the pairwise comparison analysis.

4. Discussion

The purpose of this study was to evaluate the effectiveness of a plyometric, proprioceptive and strength exercise protocol in improving glenohumeral stability in rugby players. The implementation of this exercise program has shown to improve shoulder stability, measured with two different measuring instruments (Closed Kinetic Chain Upper Extremity

TABLE 5. Pairwise comparison analysis, means difference and (significance), between the three evaluations carried out in each study group.

Variables	T0-T1	T1-T2	T0-T2
Close Kinetic Chain Upper Extremity Stability test	-2.70 (0.00)**	0.90 (0.10)	-1.80 (0.02)*
Y-Balance test (right)	-6.19 (0.00)**	1.65 (0.00)**	-4.53 (0.00)*
Y-Balance test (left)	-6.08 (0.00)*	1.34 (0.00)**	-4.73 (0.02)*

T0-T1: outcome measures between baseline to posttreatment assessments; T1-T2: outcome measures between posttreatment to follow-up assessments: T0-T2: outcome measures between baseline to follow-up assessments (T0).

* Significant difference between improvements of the study groups ($P < 0.05$).

** Significant difference between improvements of the study groups ($P < 0.001$).

Stability Test and Upper Quarter Y-Balance test).

Shoulder injuries in rugby players are common due to the physical demands this sport involves. Horsley *et al.* [26] noted the high incidence of rugby-related shoulder joint pathologies. However, there is little evidence regarding programs addressing the prevention of such pathologies in athletes. Similarly, few studies have evaluated the relationship of improved stability after the development of a strength training focused on the stabilizing muscles of the shoulder.

Cho *et al.* [27] performed an intervention based on strength training using elastic bands and double oscillation exercises in healthy young subjects. After four weeks of intervention, with five weekly sessions, improvements were observed in the strength of the shoulder muscles. Our study applied a protocol of only 8 sessions of plyometric, proprioceptive and strength exercises on the shoulder stabilizing muscles, resulting in an improved glenohumeral stability. This improvement was maintained after a four-week follow-up period.

Our findings coincide with evidence reporting a relationship between increased stabilizing muscle strength and enhanced shoulder stability. This relationship has been noted after applying a scapular muscle strength program, which resulted in increased glenohumeral stability [7].

The application of plyometric exercises to improve neuromuscular adaptations has already been developed. Swanik *et al.* [20] combined strength and plyometric exercises to improve muscle strength by applying 24 sessions over an 8-week period, finding improvements in shoulder stability and strength. Although our results are consistent in terms of improved stability, the protocol developed used a lower frequency, with a total of 8 intervention sessions.

Weakness of the rotator cuff shoulder muscles has been associated with relapsing anterior instability of the glenohumeral joint [9]. An improved shoulder stability observed in athletes who underwent the intervention based on plyometric, proprioceptive and strength exercises, can likewise reduce shoulder injury rates. The training protocol applied over 8 sessions, and whose effects are maintained after a four-week follow-up period, may be an effective preventive tool for rugby players with the aim of avoiding glenohumeral joint injuries.

Plyometric exercises for the upper limbs and strength training have been shown to be effective in reducing risk factors for upper limb injury, improving performance [20]. When comparing the results obtained in the two groups, we found significant differences that show the effectiveness of the protocol used in the study despite the short period of intervention.

Estimates of effect size are useful in determining the practical or theoretical importance of an effect, the relative contributions of the various factors, and the power of an analysis [25]. The most important statistical value of this study is the high effect size recorded for the intra- and intergroup analysis. Regardless of the sample size and significance, the effect size allows us to establish the power of the intervention, eliminating type I errors. Our study produced high values ($\eta_p^2 > 0.14$) for all the variables studied between the various evaluations and based on the group. Accordingly, we are able to report the high power of the results related to the intervention for the improvement of shoulder stability in rugby players.

Future lines of work should include a larger sample size, maintaining the structure of this randomized clinical study. Maintaining all methodological quality characteristics, other variables such as muscle strength (muscle isometric force, kinematics) and shoulder range of motion should be evaluated, together with an analysis of medium-term prevalence of shoulder injury.

One of the main limitations of the study is the small sample size. To compensate for the low sample size the main methodological quality characteristics (e.g. blinding of the evaluator, calculation of the effect size, intent-to-treat analysis, etc.) have been adjusted. Similarly, the evaluation of muscle strength together with stability would have increased the power and size of the study results. Other authors such as Hibberd *et al.* [28] assessed the effectiveness of an intervention using elastic bands on shoulder strength and range of movement using an instrument. Similarly, the use of an objective measuring instrument, such as a dynamometer, would have simplified the study design and the collection and interpretation of the data.

The exercise program described in this study can be put into normal clinical practice for any sports team, with the aim of improving glenohumeral stability in athletes. For sports with high involvement of the shoulder joint, these exercises can become a working tool to improve joint stability. Similarly, this exercise program is easy to apply, economical and is carried out in a short time (5-10 minutes).

5. Conclusions

A plyometric, proprioceptive and strength exercise program improves shoulder stability in rugby players. The effectiveness of this exercise protocol in glenohumeral stability is maintained after a four-week follow-up period. Future research should confirm the findings observed in the present study, comparing stability improvements and strength of the stabilizing muscles of the shoulder.

Author contributions

M.S.-G., P.L.-M., M.N.-M. and R.C.-B. conceived and designed the study, generated random allocation sequence, enrolled participants and assigned participants to interventions. M.S.-G., P.L.-M. and M.N.-M. carried out data collection. M.S.-G., P.L.-M., M.N.-M. and R.C.-B. performed the statistical analyses. M.S.-G., P.L.-M., M.N.-M. and R.C.-B. participated in data interpretation and analysis. R.C.-B. was in charge of the writing process. M.S.-G., P.L.-M., M.N.-M. and R.C.-B. participated in reviewing/editing the manuscript and all authors approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

The study was approved by the Research Committee of the European University of Madrid (CIPI/18/034). All patients signed an informed consent document, after being briefed on study objectives by the principal investigator. Prior to commencing the study, the protocol was registered in an international clinical trials registry (ClinicalTrials.gov ID: NCT04254055).

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Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

References

[1] Quarrie KL, Gianotti SM, Chalmers DJ, Hopkins WG. An evaluation of mouthguard requirements and dental injuries in New Zealand rugby union. British Journal of Sports Medicine. 2005; 39: 650-651.

[2] Brooks JH, Fuller CW, Kemp SP, Reddin DB. Epidemiology of injuries in English professional rugby union: part 1 match injuries. British Journal of Sports Medicine. 2005; 39: 757-766.

[3] Garraway WM, Lee AJ, Hutton SJ, Russell EB, Macleod DA. Impact of professionalism on injuries in rugby union. British Journal of Sports Medicine. 2000; 34: 348-351.

[4] Headey J, Brooks JHM, Kemp SPT. The epidemiology of shoulder injuries in english professional rugby union. American Journal of Sports Medicine. 2007; 35: 1537-1543.

[5] Ogaki R, Takemura M, Shimasaki T, Nariai M, Nagai S, Imoo Y, *et al.* Preseason muscle strength tests in the assessment of shoulder injury risk in collegiate rugby union players. Football Science. 2016; 13: 36-43.

[6] Gibson J, Kerss J, Morgan C, Brownson P. Accelerated rehabilitation after arthroscopic Bankart repair in professional footballers. Shoulder & Elbow. 2016; 8: 279-286.

[7] Dodson CC, Cordasco FA. Anterior glenohumeral joint dislocations. Orthopedic Clinics of North America. 2008; 39: 507-518.

[8] Myers JB, Oyama S. Sensorimotor factors affecting outcome following shoulder injury. Clinics in Sports Medicine. 2008; 27: 481-90.

[9] Edouard P, Degache F, Beguin L, Samozino P, Gresta G, Fayolle-Minon I, *et al.* Rotator cuff strength in recurrent anterior shoulder instability. Journal of Bone and Joint Surgery American Volume. 2011; 93: 759-765.

[10] Maki N, Kawasaki T, Mochizuki T, Ota C, Yoneda T, Urayama S, *et al.* Video analysis of primary shoulder dislocations in rugby tackles. Orthopaedic Journal of Sports Medicine. 2017; 5: 2325967117712951.

[11] Myers JB, Lephart SM. The role of the sensorimotor system in the athletic shoulder. Journal of Athletic Training. 2000; 35: 351-363.

[12] Lin Y-L, Karduna AJHms. Exercises focusing on rotator cuff and scapular muscles do not improve shoulder joint position sense in healthy subjects. Human Movement Science. 2016; 49: 248-257.

[13] Arora S, Button DC, Basset FA, Behm DG. The effect of double versus single oscillating exercise devices on trunk and limb muscle activation. International Journal of Sports Physical Therapy. 2013; 8: 370-380.

[14] Moreside JM, Vera-Garcia FJ, McGill SM. Trunk muscle activation patterns, lumbar compressive forces, and spine stability when using the bodyblade. Physical Therapy. 2007; 87: 153-163.

[15] Jeon N, Chon S. Effect of glenohumeral stabilization exercises combined with scapular stabilization on shoulder function in patients with shoulder pain: a randomized controlled experimenter-blinded study. Journal of Back and Musculoskeletal Rehabilitation. 2018; 31: 259-265.

[16] Lee D-R, Kim LJ. Reliability and validity of the closed kinetic chain upper extremity stability test. Journal of Physical Therapy Science. 2015; 27: 1071-1073.

[17] Sciascia A, Uhl T. Reliability of strength and performance testing measures and their ability to differentiate persons with and without shoulder symptoms. International Journal of Sports Physical Therapy. 2015; 10: 655-666.

[18] Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. International Journal of Sports Physical Therapy. 2012; 7: 139-147.

[19] Gorman PP, Butler RJ, Plisky PJ, Kiesel KB. Upper Quarter Y Balance Test: reliability and performance comparison between genders in active adults. Journal of Strength and Conditioning Research. 2012; 26: 3043-3048.

[20] Swanik KA, Thomas SJ, Struminger AH, Bliven KCH, Kelly JD, Swanik CB. The effect of shoulder plyometric training on amortization time and upper-extremity kinematics. Journal of Sport Rehabilitation. 2016; 25: 315-323.

[21] Watson L, Warby S, Balster S, *et al.* The treatment of multidirectional instability of the shoulder with a rehabilitation: Part 2. Shoulder and Elbow. 2016; 1-8.

[22] Sommervold M, Østerås H. What is the effect of a shoulder-strengthening program to prevent shoulder pain among junior female team handball players? Journal Of Sports Medicine. 2017; 8: 61-70.

[23] Escamilla RF, Yamashiro K, Dunning R, Mikla T, Grover M, Kenniston M, *et al.* An electromyographic analysis of the shoulder complex musculature while performing exercises using the Bodyblade® classic

and Bodyblade® pro. International Journal of Sports Physical Therapy. 2016; 11: 175-189.

[24] Rigby RA, Stasinopoulos MD, Heller GZ, De Bastiani F. Distributions for Modeling Location, Scale, and Shape using GAMLSS in R. ed. Florida: Taylor & Francis. 2020.

[25] Fritz CO, Morris PE, Richler JJ. Effect size estimates: current use, calculations, and interpretation. Journal of Experimental Psychology. 2012; 141: 2-18.

[26] Horsley IG, Fowler EM, Rolf CG. Shoulder injuries in professional rugby: a retrospective analysis. Journal of Orthopaedic Surgery and Research. 2013; 8: 9.

[27] Cho J, Lee K, Kim M, Hahn J, Lee W. The effects of double oscillation exercise combined with elastic band exercise on scapular stabilizing muscle strength and thickness in healthy young individuals: a randomized controlled pilot trial. Journal of Sports Science and Medicine. 2018; 17: 7-16.

[28] Hibberd EE, Oyama S, Spang JT, Prentice W, Myers JB. Effect of a 6-week strengthening program on shoulder and scapular-stabilizer strength and scapular kinematics in division I collegiate swimmers. Journal of Sport Rehabilitation. 2012; 21: 253-265.