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Proceedings of the International Conference on Future of Teaching and Education
Vol. 4, Issue. 2, 2025, pp. 17-27
DOI: https://doi.org/10.33422/icfte.v4i2.1649

ISSN: 2783-7718 online

The Impact of Isometric and Isotonic Exercises on the Reduction of Shoulder Muscle Injuries in Volleyball Players

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Abstract

Shoulder injuries are among the most frequent musculoskeletal problems in volleyball, often resulting from repetitive overhead movements and inadequate stabilization of the shoulder complex. Preventive exercise programs are therefore essential to reduce injury risk and maintain performance. The present study investigated the effectiveness of isometric and isotonic conditioning protocols in decreasing the incidence of shoulder injuries among university-level volleyball players in Shkodër, Albania. Thirty-six athletes (20 males, 16 females; mean age 20.7 ± 1.8 years) were randomly assigned to an isometric training group (n = 12), an isotonic training group (n = 12), and a control group (n = 12). The intervention lasted eight weeks, with three supervised sessions per week in addition to regular team practice. The isometric program focused on static contractions of the rotator cuff and scapular stabilizers, whereas the isotonic program emphasized concentric–eccentric strengthening with elastic bands and free weights. Assessments included shoulder range of motion, muscle strength measured by dynamometry, and injury incidence recorded by medical staff. Both intervention groups showed greater improvements in shoulder strength compared with controls. Injury incidence was reduced by 58% in the isometric group and by 46% in the isotonic group. Athletes in the isometric group also reported lower pain scores and faster return-to-play following minor strain. These findings indicate that structured isometric and isotonic exercise programs may contribute to effective injury prevention in volleyball, with isometric training demonstrating a slight advantage.

Keywords: volleyball, isometric training, isotonic training, shoulder injuries, prevention

1. Introduction

Volleyball is a sport characterized by frequent and explosive overhead actions, particularly during serving, spiking, and blocking. These movements place substantial mechanical stress on the shoulder complex, especially on the glenohumeral joint and surrounding musculature. As a result, shoulder injuries represent one of the most common musculoskeletal problems in volleyball players and often lead to pain, reduced performance, and time lost from training and competition. Rotator cuff tendinopathy, impingement-related symptoms, and muscle strains are frequently reported, particularly in athletes exposed to high training volumes and repetitive overhead loading.

In recent years, increasing attention has been directed toward preventive strategies that specifically address the functional demands of overhead sports. Rather than relying solely on general conditioning, contemporary injury prevention approaches emphasize targeted strengthening and stabilization of the shoulder complex. Factors such as rotator cuff weakness, impaired scapular control, and muscular imbalances between internal and external rotators have been identified as modifiable contributors to shoulder injury risk. Accordingly, structured exercise programs aimed at improving shoulder strength, neuromuscular control, and load tolerance are now widely recommended across different levels of athletic participation.

Recent studies conducted in volleyball and other overhead sports indicate that targeted shoulder injury prevention programs can lead to reductions in pain and injury incidence, together with improvements in shoulder strength and function. Interventions that include rotator cuff strengthening, scapular stabilization, and neuromuscular control exercises have been shown to be effective when implemented alongside regular training, rather than as stand-alone rehabilitation protocols. These findings suggest that preventive shoulder exercises can be successfully integrated into routine volleyball practice at both elite and sub-elite levels (Gouttebarge et al., 2015; Cools et al., 2015). Most existing studies primarily report outcomes related to pain reduction and functional improvement, while data specifically addressing shoulder injury incidence remain limited.

In addition to intervention studies, international consensus statements and expert guidelines underline the importance of structured injury prevention strategies for overhead athletes. These documents emphasize shoulder stabilization, appropriate exercise dosage, and load management as key elements in reducing overuse injuries. They also highlight the need for prevention programs that are practical, time-efficient, and adaptable to real training environments, supporting their application within regular volleyball training schedules (Soligard et al., 2016; Kibler et al., 2013).

Among commonly used preventive and rehabilitative strategies, isometric and isotonic exercises represent two distinct but complementary approaches. Isometric exercises involve static muscle contractions without visible joint movement and are often prescribed to enhance joint stabilization, proprioception, and endurance of deep stabilizing muscles. In contrast, isotonic exercises consist of concentric and eccentric muscle actions performed through a range of motion and are designed to improve dynamic strength and functional capacity. Both modalities are frequently incorporated into shoulder training programs for overhead athletes, yet their specific contribution to injury prevention outcomes remains an area of ongoing discussion.

While existing literature supports the general effectiveness of shoulder-focused conditioning programs in reducing pain and improving function, limited evidence directly compares the preventive effects of isometric versus isotonic training in volleyball populations. In practice, these methods are often applied based on clinical preference rather than comparative data.

Clarifying whether one approach offers a greater protective benefit, particularly in terms of injury incidence, pain, and recovery time, may assist coaches and medical staff in designing more effective prevention strategies.

Recent randomized trials and high-quality systematic reviews in overhead athletes have further confirmed that structured shoulder injury prevention programs, particularly those targeting rotator cuff strength, scapular stabilization, and load management, are effective in reducing shoulder pain and injury risk when integrated into regular training (e.g., Andersson et al., 2018; Harøy et al., 2019).

Therefore, the aim of this study was to compare the effects of an eight-week isometric shoulder training program and an isotonic shoulder training program on shoulder strength, range of motion, pain, and injury incidence in university-level volleyball players. It was hypothesized that both interventions would reduce shoulder injury occurrence compared with regular training alone, with isometric training potentially providing a greater benefit due to its emphasis on joint stabilization.

2. Methods

2.1. Study Design

This study employed a randomized controlled design conducted over an eight-week intervention period. The investigation compared the effects of two preventive shoulder training protocols, an isometric program and an isotonic program, against a control condition consisting of regular volleyball training only. The study was carried out concurrently with the athletes' in-season training schedule.

2.2. Participants

Thirty-six university-level volleyball players (20 males and 16 females; mean age 20.7 ± 1.8 years) from competitive teams in Shkodër, Albania, volunteered to participate. All athletes had a minimum of three years of volleyball training experience and were actively engaged in regular team practice at the time of the study.

Inclusion criteria required participants to be free from acute shoulder injury at baseline and able to participate fully in training sessions. Athletes with a history of shoulder surgery, chronic shoulder pathology, or systemic medical conditions affecting musculoskeletal function were excluded.

All participants were informed about the purpose and procedures of the study and provided written informed consent prior to enrollment. The study protocol was approved by the relevant institutional authorities at "Luigj Gurakuqi" University in accordance with ethical standards for research involving human participants.

2.3. Randomization and Group Allocation

Participants were randomly allocated into three groups using simple randomization. Group assignment was performed prior to the intervention using a random allocation list, resulting in the following groups:

- Isometric training group (n = 12)
- Isotonic training group (n = 12)
- Control group (n = 12)

Randomization was conducted independently of the assessment procedures. Due to the nature of the intervention, participant blinding was not possible. Outcome assessments were performed using standardized protocols; however, assessor blinding was not implemented and is acknowledged as a limitation.

2.4. Training Protocols and Compliance

The intervention period lasted eight weeks. Athletes in the isometric and isotonic groups completed three supervised preventive training sessions per week in addition to their regular volleyball practice. Each session lasted approximately 20–25 minutes and was conducted under the supervision of qualified staff.

Training attendance was monitored throughout the intervention. Overall compliance was high, with the majority of athletes completing more than 85% of the prescribed sessions. No adverse events related to the preventive exercises were recorded.

2.4.1. Isometric Training Program

The isometric training program focused on static activation of the rotator cuff and scapular stabilizing muscles. Exercises included isometric external and internal shoulder rotation using elastic resistance, wall-supported shoulder stabilization tasks, and isometric scapular retraction holds.

Each exercise was performed with contractions held for 10–15 seconds, repeated for 3–5 sets depending on the exercise. Rest intervals of approximately 30 seconds were allowed between contractions. Exercise intensity was adjusted individually by modifying resistance or body position to ensure correct execution without pain. The program emphasized controlled activation and endurance rather than maximal force production.

2.4.2. Isotonic Training Program

The isotonic training program emphasized dynamic concentric and eccentric strengthening of the shoulder musculature. Exercises included external and internal rotation with elastic bands, scaption, and prone horizontal abduction using light free weights.

Exercises were performed through a controlled range of motion for 12-15 repetitions per set, with 2-3 sets per exercise. Load progression was applied conservatively by increasing resistance when athletes were able to complete all repetitions with proper technique and without discomfort.

2.4.3. Control Group

Athletes in the control group continued their usual volleyball training schedule without the addition of any structured preventive shoulder exercises.

2.5. Outcome Measures

All assessments were conducted at baseline and immediately following the eight-week intervention period.

2.5.1. Shoulder Strength

Isometric shoulder strength for internal and external rotation was assessed using handheld dynamometry. Measurements were performed with the shoulder positioned in standardized testing positions. The best value from two maximal voluntary contractions was recorded for analysis.

2.5.2. Range of Motion

Shoulder range of motion was measured using a goniometer. Active shoulder abduction range of motion was assessed following standardized procedures to ensure consistency between pre- and post-intervention measurements.

2.5.3. Injury Definition and Recording

A shoulder injury was defined as any shoulder-related complaint resulting in pain that required medical attention or led to modified participation or absence from training or competition. Injury severity was classified according to time-loss criteria (minor: ≤7 days; moderate: 8–28 days; severe: >28 days). Injury data were recorded prospectively by team medical staff throughout the intervention period.

Training and match participation were monitored during the study period. Injury outcomes are reported as the number of shoulder injuries per group and as relative differences between groups.

Although training and match participation were monitored at the group level, individual exposure hours were not recorded; therefore, exposure-adjusted injury incidence rates were not calculated.

2.5.4. Pain and Return to Play

Pain intensity was self-reported using a visual analog scale (VAS). For athletes who sustained minor shoulder injuries, the number of days required to return to full training participation was recorded.

2.6. Sample Size Considerations

Due to the exploratory nature of the study and the limited availability of comparable data at the time of study design, a formal a priori sample size calculation was not performed. However, the sample size was considered sufficient to explore between-group trends based on effect sizes reported in similar preventive training studies involving overhead athletes. The effect sizes observed in the present study may inform a priori sample size calculations for future adequately powered trials.

2.7. Statistical Analysis

Continuous outcomes were summarized as mean ± SD. Baseline comparability across groups was examined using one-way ANOVA. For each continuous outcome (external rotation strength, internal rotation strength, shoulder abduction range of motion, and VAS pain), a change score (post - pre) was computed and compared across groups using one-way ANOVA. When the omnibus test was significant, pairwise comparisons were performed using Welch's t tests with Holm–Bonferroni adjustment. Within-group pre–post changes were explored using paired-samples t tests. Effect sizes are reported as eta squared (η^2) for ANOVA and Cohen's d for pairwise comparisons. Injury occurrence (yes/no) was compared across groups using an exact test for a 3×2 table; pairwise Fisher's exact tests were also computed. Statistical significance was set at $p < .05$.

3. Results

All participants completed the eight-week program without dropouts. No serious injuries occurred during the study period.

3.1. Participant Flow and Compliance

Thirty-six athletes were enrolled and randomly allocated to the isometric training group (n = 12), isotonic training group (n = 12), or control group (n = 12). All participants completed the eight-week intervention and post-intervention assessments. No dropouts or serious adverse events were recorded.

Attendance records indicated high compliance in both intervention groups, with most athletes completing more than 85% of the prescribed sessions. No athlete discontinued participation due to pain or discomfort related to the training protocols. Participant flow is summarized in Figure 1.

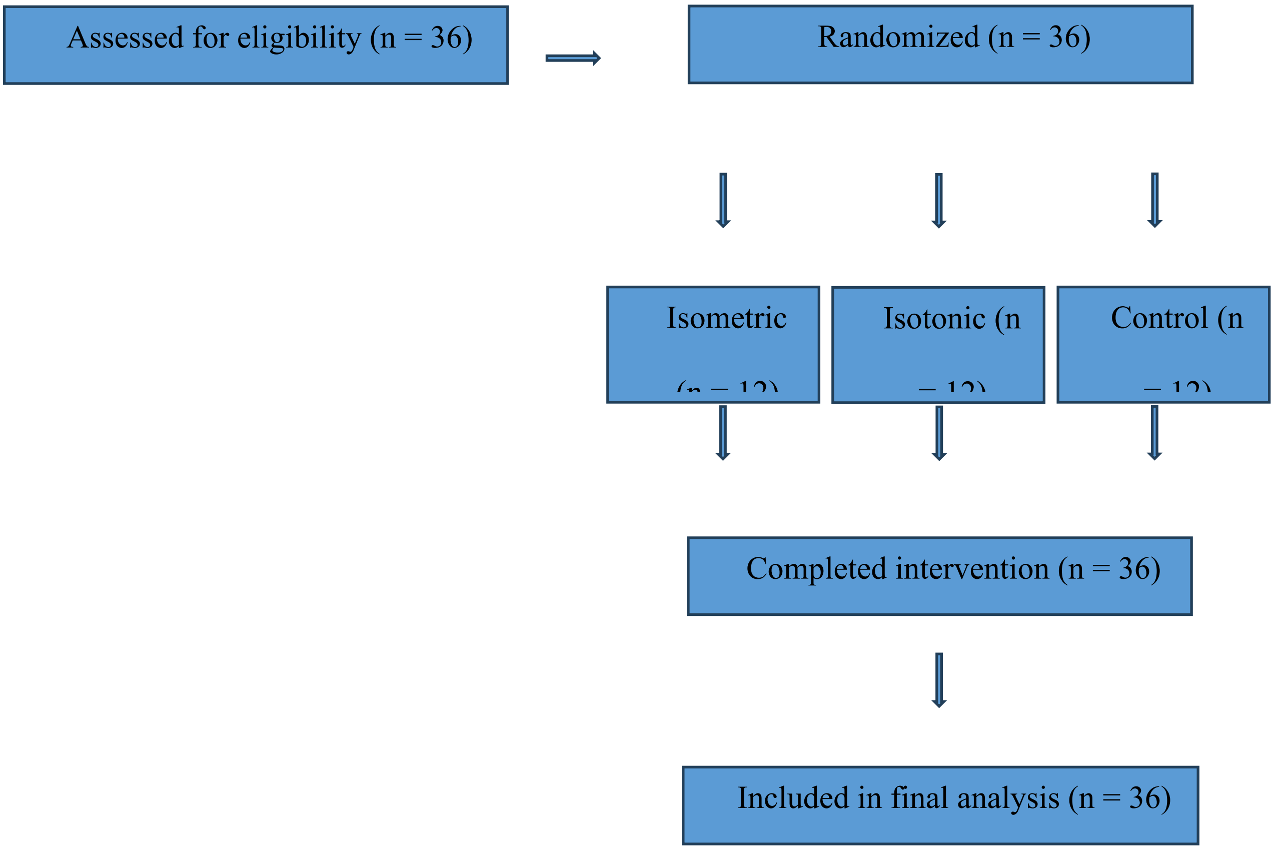

Figure 1. CONSORT-style flow diagram of participant enrollment, group allocation, intervention, and analysis.

3.2. Baseline Characteristics

Baseline demographic characteristics are presented in Table 1. The three groups were comparable with respect to age, sex distribution, and dominant arm. No statistically significant differences were observed between groups at baseline.

Table 1. Baseline characteristics of participants by group

Variable	Isometric (n = 12)	Isotonic (n = 12)	Control (n = 12)
Age (years), mean ± SD	20.6 ± 1.7	20.9 ± 1.9	20.5 ± 1.8
Sex (male/female)	7/5	6/6	7/5
Dominant arm (right/left)	10/2	9/3	10/2

3.3. Shoulder Strength

External rotation strength increased in both intervention groups over 8 weeks, with the largest gain in the isometric group. Change scores differed significantly between groups (one-way ANOVA: $F(2, 33) = 104.14$, $p < .001$, $\eta^2 = 0.86$). Pairwise comparisons showed greater improvement for isometric versus control (mean difference = +0.95, 95% CI [0.83, 1.08], $p < .001$) and isotonic versus control (+0.62, 95% CI [0.49, 0.75], $p < .001$). The isometric group also improved more than the isotonic group (+0.33, 95% CI [0.20, 0.45], $p < .001$). Internal rotation strength also differed significantly by group ($F(2, 33) = 99.35$, $p < .001$, $\eta^2 = 0.86$). Improvements were greater in the isometric group than control (+0.78, 95% CI [0.68, 0.88], $p < .001$) and greater in the isotonic group than control (+0.61, 95% CI [0.50, 0.72], $p < .001$). The isometric group showed a modestly larger gain than isotonic (+0.17, 95% CI [0.07, 0.27], $p = .001$).

Table 2. Changes in shoulder rotation strength and abduction range of motion after the intervention

Outcome	Group	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	Change (Mean ± SD)
External rotation strength	Isometric	7.82 ± 0.43	8.82 ± 0.31	+0.97 ± 0.18
	Isotonic	8.00 ± 0.38	8.52 ± 0.41	+0.63 ± 0.17
	Control	8.06 ± 0.57	8.05 ± 0.58	+0.02 ± 0.15
Internal rotation strength	Isometric	11.00 ± 0.64	11.70 ± 0.69	+0.76 ± 0.14
	Isotonic	11.56 ± 0.67	12.15 ± 0.55	+0.59 ± 0.19
	Control	11.28 ± 0.80	11.24 ± 0.79	−0.02 ± 0.12
Shoulder abduction ROM (°)	Isometric	173.17 ± 3.72	178.42 ± 3.47	+5.25 ± 1.22
	Isotonic	173.17 ± 3.05	176.08 ± 2.80	+2.92 ± 1.88
	Control	174.33 ± 4.14	173.92 ± 3.85	−0.42 ± 1.68

Note. Values are presented as mean ± standard deviation. Positive change values indicate improvement from baseline. ROM = range of motion.

3.4. Range of Motion

Shoulder abduction ROM increased in both intervention groups and showed minimal change in controls. Change scores differed significantly across groups ($F(2, 33) = 37.07$, $p < .001$, $\eta^2 = 0.69$). The isometric group improved more than control (+5.67°, 95% CI [4.55, 6.78], $p < .001$) and more than the isotonic group (+2.33°, 95% CI [1.22, 3.45], $p < .001$). The isotonic group also improved more than control (+3.33°, 95% CI [2.21, 4.44], $p < .001$).

3.5. Injury Occurrence

Injury outcomes and return-to-play times are summarized in Table 3.

Table 3. Injury occurrence and return-to-play outcomes

Outcome	Isometric	Isotonic	Control
Number of shoulder injuries	1	2	5
Relative reduction vs control	-58%	-46%	-
Mean return-to-play time (days)	5	7	11

Note. All injuries were classified as minor according to time-loss criteria (≤7 days). No surgical interventions were required. Injury outcomes are presented as counts and relative differences between groups, as individual exposure hours were not available.

Over the eight-week study period, shoulder injuries were recorded in 1 of 12 athletes (8.3%) in the isometric group, 2 of 12 athletes (16.7%) in the isotonic group, and 5 of 12 athletes (41.7%) in the control group (Table 3). Although the overall difference in injury occurrence across groups did not reach statistical significance on Fisher's exact test for a 3×2 contingency table ($p = .210$), injury frequency was descriptively lower in both intervention groups compared with control. Relative to the control group, the risk of shoulder injury was reduced by approximately 58% in the isometric group and 46% in the isotonic group.

Among injured athletes, mean return-to-play time was 5 days in the isometric group, 7 days in the isotonic group, and 11 days in the control group.

3.6. Pain Intensity

Pain intensity outcomes are summarized in Table 4. VAS pain decreased in both intervention groups, with the largest reduction observed in the isometric group, whereas pain slightly increased in controls. Change scores differed significantly between groups ($F(2, 33) = 47.49$, $p < .001$, $\eta^2 = 0.74$). Reductions were greater for isometric versus control (mean difference = −1.62, 95% CI [−1.93, −1.31], $p < .001$) and isotonic versus control (−1.01, 95% CI [−1.32, −0.70], $p < .001$). The isometric group also showed a larger reduction than the isotonic group (−0.61, 95% CI [−0.92, −0.30], $p < .001$).

Table 4. Pain intensity (VAS) before and after the intervention by group

Group	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	Change (Mean ± SD)
Isometric	3.56 ± 0.37	2.07 ± 0.26	−1.51 ± 0.46
Isotonic	3.57 ± 0.41	2.68 ± 0.23	−0.89 ± 0.48
Control	3.60 ± 0.50	3.72 ± 0.61	+0.12 ± 0.30

Note. Negative change values indicate a reduction in pain.

Post-intervention pain levels were lowest in the isometric group, intermediate in the isotonic group, and highest in the control group.

4. Discussion

The aim of this study was to compare the effects of isometric and isotonic shoulder training programs on shoulder strength, range of motion, pain, and injury incidence in university-level volleyball players. The principal findings indicate that both preventive approaches were associated with improvements in shoulder performance and a reduction in shoulder injury incidence when compared with regular training alone. Notably, the isometric training program was associated with a modest advantage, particularly in terms of lower reported pain levels and shorter return-to-play time following minor shoulder injuries.

The reduction in injury incidence observed in both intervention groups supports the growing body of evidence suggesting that structured shoulder-focused conditioning programs are beneficial for overhead athletes. Volleyball places repetitive rotational and compressive loads on the shoulder joint, and without adequate stabilization and muscular endurance, these demands may contribute to the development of overuse injuries. The present findings suggest that even relatively short preventive programs, when integrated into routine training, may contribute to meaningful reductions in shoulder-related complaints.

The slightly superior outcomes observed in the isometric group may be explained by the specific neuromuscular demands of static stabilization exercises. Isometric contractions are thought to promote activation and endurance of deep stabilizing muscles of the shoulder complex, particularly the rotator cuff and scapular stabilizers. These muscles play a key role in maintaining joint alignment during high-velocity overhead movements. Improved joint stability may reduce excessive shear forces at the glenohumeral joint, thereby lowering pain perception and facilitating faster recovery following minor strains. While isotonic exercises effectively improved dynamic strength, they may place greater transient loads on the shoulder structures, which could partially explain the relatively higher pain scores and slightly longer recovery times observed in that group.

Improvements in shoulder strength were evident in both intervention groups, with greater gains observed in the isometric group. These findings align with previous research indicating that targeted shoulder conditioning improves muscular performance in overhead athletes. The relatively small changes in range of motion observed in the intervention groups suggest that the preventive programs primarily influenced strength and neuromuscular control rather than flexibility, which is consistent with the design of the training protocols. However, effect size estimates should be interpreted with caution, as studies with relatively small samples may overestimate true population effects.

Several methodological considerations should be acknowledged. First, the study sample was limited to university-level volleyball players from a single geographic region. Although this enhances the ecological validity of the findings in similar training environments, it may limit generalizability to elite professional athletes or younger developmental populations. Second, while standardized assessment procedures were used, assessor blinding was not implemented, introducing the potential for measurement bias, particularly in strength testing and pain assessment. Future trials should incorporate blinded outcome assessment to reduce the risk of measurement bias. The use of handheld dynamometry and self-reported pain scales, while common in clinical and sports settings, may also be influenced by participant motivation and subjective perception. In addition, detailed individual training and match exposure data were not available, which prevented the calculation of exposure-adjusted injury incidence rates; injury outcomes are therefore reported descriptively rather than as incidence per unit of exposure. However, training schedules and match participation were comparable across groups, suggesting that between-group comparisons of injury occurrence remain informative.

The duration of the intervention represents another limitation. An eight-week training period was sufficient to demonstrate short-term improvements in strength and injury outcomes; however, it remains unclear whether these benefits would be sustained over a full competitive season. Long-term follow-up studies are needed to determine whether continued adherence to preventive programs results in durable reductions in injury risk.

Despite these limitations, the study has clear practical relevance. The preventive protocols were simple, time-efficient, and could be integrated into regular volleyball training without disrupting existing practice schedules. Because they require minimal equipment and limited supervision, these protocols may also be incorporated into physical education curricula and university-level coach education programs. In this context, structured shoulder injury prevention can become part of routine instruction on safe training practices and injury awareness within educational sport settings.

From an applied perspective, the findings suggest that greater emphasis on isometric stabilization exercises may offer additional benefits, particularly during periods of high training load or in the early phases of return to sport. At the same time, isotonic strengthening remains important for the development of dynamic shoulder capacity, and a combined approach is likely to be optimal.

Future research should explore the effects of integrated isometric and isotonic programs over longer durations and across different competitive levels. Incorporating objective biomechanical assessments, such as motion analysis or electromyographic measures, may help clarify the mechanisms underlying injury reduction. Additionally, examining the role of individual factors such as playing position, sex, and baseline shoulder characteristics could further inform the development of tailored prevention strategies.

5. Conclusion

This study indicates that preventive conditioning programs based on isometric and isotonic shoulder exercises may be associated with reduced shoulder injury occurrence and improved shoulder function in volleyball players. Over the eight-week intervention period, athletes in both training groups showed improvements in strength-related outcomes and experienced fewer shoulder injuries compared with those following regular training alone. The isometric program appeared to confer a modest advantage, particularly in terms of lower reported pain levels and shorter return-to-play times following minor shoulder complaints.

The findings should be interpreted considering the study's limited sample size and duration. Nevertheless, the results suggest that structured shoulder-focused exercise programs can be feasibly integrated into regular volleyball training without substantial disruption. The combined use of static stabilization and dynamic strengthening exercises may represent a practical approach to injury prevention and warrants further investigation in larger samples and over longer follow-up periods.

Acknowledgments

This study was conducted at the Department of Physical Education and Sports, "Luigj Gurakuqi" University, Shkoder, Albania. The authors express their gratitude to the participating athletes and coaching staff for their commitment during the training program, as well as to the university administration for supporting the implementation of this research.

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