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Title: The Effect of an Injury Prevention Warm-Up Program on Injury Incidence and the VFMS in Premier League Volleyball Players

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To appear in: ***Physical Treatments***

Received date: 2026/06/10

Revised date: 2026/08/23

Accepted date: 2026/09/7

First Online Published: 2026/11/08

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Please cite this article as:

Ghafouri M, Shamsi Majelan A, Daneshmandi H. The Effect of an Injury Prevention Warm-Up Program on Injury Incidence and the VFMS in Premier League Volleyball Players. ***Physical Treatments.*** Forthcoming 2027. DOI: http://dx.doi.org/10.22034/ptj.2027.778.2

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Abstract

Purpose: Volleyball is a high-demand sport characterized by repetitive jumping, rapid changes of direction, overhead actions, and frequent landing tasks, which expose athletes to a considerable risk of injury. Therefore, this study aimed to examine whether a structured volleyball-specific injury-prevention warm-up program could reduce injury incidence and improve Volleyball Functional Movement Screen (VFMS) performance in male players competing in the Iranian Premier Volleyball League.

Methods: This quasi-experimental pretest–posttest study was conducted on 72 male volleyball players competing in the Iranian Premier Volleyball League. Participants were allocated to an intervention group, which completed a 9-week progressive injury-prevention warm-up program, or a control group, which continued their regular warm-up routine. Injury occurrence was recorded using the FIVB Medical Injury Report Form, and functional movement was assessed using the VFMS before and after the intervention. Data were analyzed using mixed-model ANOVA and related statistical tests, with statistical significance set at $p < 0.05$.

Results: Both groups showed significant improvements over time in total VFMS scores and in upper-extremity, trunk, and lower-extremity domains; however, no significant group-by-time interactions were observed. Likewise, the intervention did not result in significant between-group differences in injury incidence, injury distribution, injury mechanism, injury severity, or injured body region. The ankle and knee were the most frequently injured body regions in both groups.

Conclusion: Among male Iranian Premier Volleyball League players, the 9-week volleyball-specific warm-up program did not demonstrate a statistically significant advantage over routine warm-up practices in reducing injuries or improving functional movement performance. Although both groups showed improvements over time, these changes were not significantly different between groups and therefore cannot be attributed to the intervention. Accordingly, the present findings do not support the effectiveness of this warm-up program as a standalone injury-prevention strategy in this specific population and should not be generalized to other athlete populations.

Keywords: neuromuscular training; movement screening; injury epidemiology; ankle injuries.

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Highlights:

- VFMS scores improved significantly in both intervention and control groups.
- No significant group-by-time interaction was observed for VFMS outcomes.
- The injury-prevention warm-up program did not significantly reduce injuries.
- Ankle and knee injuries were the most frequently reported injuries.
- Functional improvements appeared to reflect general training adaptations.

Plain Language Summary:

Volleyball is a physically demanding sport that involves frequent jumping, rapid changes of direction, overhead movements, and repeated landings. Because of these demands, volleyball players are at risk of various injuries, particularly to the ankle, knee, and shoulder. Coaches and sports medicine professionals often use warm-up programs designed to reduce injury risk and improve movement quality. However, the effectiveness of such programs in elite volleyball players remains unclear. This study investigated whether a structured volleyball-specific injury-prevention warm-up program could reduce injuries and improve functional movement performance in male athletes competing in the Iranian Premier Volleyball League. Seventy-two elite volleyball players participated in the study and were assigned either to an intervention group that completed a nine-week injury-prevention warm-up program or to a control group that continued their usual warm-up routine.The results showed that both groups improved significantly in functional movement performance over time. However, the improvements were similar in both groups, indicating that the specialized warm-up program did not provide additional benefits beyond regular volleyball training. Likewise, injury rates and injury characteristics were not significantly different between the intervention and control groups. Although the intervention group experienced slightly fewer injuries, these differences were not statistically significant. These findings suggest that a short-term injury-prevention warm-up program alone may not be sufficient to substantially reduce injuries or improve movement quality in highly trained volleyball athletes. Coaches and practitioners should consider integrating warm-up exercises with broader injury-prevention strategies, including neuromuscular training, workload monitoring, recovery management, and sport-specific conditioning programs.

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Introduction

Volleyball is a globally popular team sport played by millions of athletes across more than 200 countries (1).The sport involves frequent jumping, rapid changes of direction, explosive actions, repetitive landings, and overhead movements, all of which impose substantial mechanical and neuromuscular loads on the musculoskeletal system(2) . High-level performance in volleyball depends on a combination of physical and neuromuscular attributes, including strength, power, agility, balance, coordination, and motor control(3). While these attributes are essential for performance enhancement, they simultaneously increase the risk of both acute and overuse injuries(4). As a result, injury prevention has become a key priority for coaches, clinicians, and sports scientists working in elite volleyball environments(5). Epidemiological evidence indicates that volleyball players are particularly susceptible to injuries involving the ankle, knee, shoulder, and fingers. Among these, ankle injuries are the most frequently reported, accounting for a substantial proportion of total injury cases. Reported injury incidence rates in competitive volleyball range from approximately 1.7 to 4.2 injuries per 1,000 hours of exposure(6). Such injuries can negatively affect athletic performance, increase medical burden, reduce training availability, and in severe cases shorten athletic careers. Therefore, identifying modifiable risk factors and implementing effective preventive strategies remains essential in volleyball performance and sports medicine research(7). In recent years, the focus of injury prevention has shifted from post-injury rehabilitation toward the early identification of modifiable neuromuscular and movement-related risk factors (8). Within this context, movement screening tools have been widely adopted to assess functional movement quality and identify deficits that may increase the risk of sports injuries. Among these, the Functional Movement Screen (FMS) is one of the most commonly used instruments, evaluating fundamental movement patterns through a standardized battery of tests assessing mobility, stability, balance, and motor control (9). Although the FMS has demonstrated acceptable reliability, evidence regarding its validity and ability to predict injuries remains inconsistent, particularly in highly trained athletic populations (10). Moreover, because the FMS was developed as a general movement screening tool, it may not adequately capture the sport-specific biomechanical demands of volleyball, such as repetitive jumping, high-impact landings, rapid changes of direction, and overhead movements (11). To overcome these limitations, the Volleyball Functional Movement Screen (VFMS) was developed specifically for volleyball athletes. Compared with the FMS, the VFMS incorporates volleyball-specific movement tasks that more closely reflect the neuromuscular and biomechanical demands encountered during training and competition, including jumping, landing, multidirectional movement, and upper-extremity functional actions (11). Consequently, it may provide greater sensitivity for identifying movement deficits and functional adaptations that are directly relevant to volleyball performance and injury prevention (10). Because the present study involved elite male volleyball players, the VFMS was selected in preference to the general FMS, as it was considered more appropriate for evaluating sport-specific movement quality in this population. Nevertheless, despite its theoretical advantages and greater ecological validity, evidence regarding the responsiveness of the VFMS to training interventions and its association with injury outcomes remains limited. Therefore, further research is needed to establish its practical value in both performance enhancement and injury prevention. In parallel with advances in movement screening, structured injury-prevention warm-up programs have been widely investigated as effective strategies for reducing injury risk and improving neuromuscular performance (12). Multicomponent injury-prevention warm-up programs typically

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incorporate strength, balance, plyometric, agility, and core stability exercises and have demonstrated beneficial effects across a range of athletic populations (13). Among these, the FIFA 11+ program has consistently been shown to reduce injury incidence while improving neuromuscular performance in football players, serving as the foundation for the development of similar preventive strategies in other team sports (14). Collectively, these findings suggest that structured neuromuscular warm-up programs may also be effective in volleyball. However, high-quality sport-specific evidence in elite volleyball players remains limited. Despite the growing body of research on injury prevention and movement screening, several important knowledge gaps remain. First, few studies have investigated whether structured injury-prevention warm-up programs can produce measurable improvements in volleyball-specific movement quality as assessed by the Volleyball Functional Movement Screen (VFMS). Second, the relationship between changes in VFMS performance and subsequent injury incidence following preventive training has not been clearly established. Third, existing studies have rarely examined both injury outcomes and sport-specific functional movement adaptations within the same intervention in elite volleyball athletes. Consequently, the combined effects of structured injury-prevention warm-up programs on injury occurrence and volleyball-specific movement quality remain insufficiently understood.The present study was designed to address these gaps by simultaneously evaluating the effects of a structured injury-prevention warm-up program on both injury incidence and volleyball-specific functional movement quality in elite male volleyball players. By integrating clinical injury outcomes with a sport-specific movement assessment using the VFMS, this study extends the current literature by providing evidence on the responsiveness of volleyball-specific movement quality to preventive training while further clarifying the potential role of the VFMS as a practical tool for monitoring functional adaptations associated with injury prevention. Addressing these knowledge gaps is of considerable practical importance because injuries in elite volleyball adversely affect not only athletes' health and long-term development but also team performance, player availability, and competitive success. Therefore, identifying evidence-based preventive strategies capable of simultaneously enhancing functional movement quality and reducing injury risk is of substantial value for clinicians, coaches, strength and conditioning specialists, and sports medicine researchers. Accordingly, the present study aimed to investigate the effects of a structured injury-prevention warm-up program on injury incidence and volleyball-specific functional movement, as assessed by the Volleyball Functional Movement Screen (VFMS), in elite male volleyball players. Specifically, the study examined whether participation in a systematic neuromuscular warm-up program could reduce injury incidence while improving volleyball-specific functional movement characteristics of the upper extremity, trunk, and lower extremity compared with a routine warm-up program. It was hypothesized that players who completed the structured injury-prevention warm-up program would demonstrate lower injury incidence and better volleyball-specific functional movement, as assessed by the VFMS, than those performing their routine warm-up.

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Methods

Study Design

This study employed a quasi-experimental pretest–posttest controlled design to investigate the effects of a structured injury-prevention warm-up program on sports injury incidence and VFMS performance among elite male volleyball players during the competitive season of the Iranian

Premier Volleyball League. Because players trained and competed within established team environments, individual randomization was not feasible and could have resulted in contamination between participants. Therefore, group assignment was performed at the team (cluster) level, whereby entire teams were allocated to either the intervention or control group. To minimize selection bias and potential confounding, teams were matched before group assignment based on competitive level, training load, and baseline anthropometric and performance characteristics. This matching procedure was intended to improve baseline comparability between groups while preserving the ecological validity of the study within a real-world elite volleyball setting. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all participants before enrolment.

Sample Size

Because this study was conducted in a limited population of elite male volleyball players competing in the Iranian Premier Volleyball League, all eligible athletes who met the inclusion criteria during the study period were invited to participate. Therefore, an a priori sample size calculation was not performed. Instead, a post hoc power analysis was conducted to evaluate the statistical power of the primary outcomes.

Participants

A total of 72 elite male volleyball players competing in the Iranian Premier Volleyball League participated voluntarily in this study. Participants were recruited using a convenience sampling strategy from eligible teams that met the inclusion criteria. Following recruitment, allocation to study conditions was performed at the **team (cluster) level**, resulting in an intervention group (n = 36) and a control group (n = 36). Cluster allocation was adopted to eliminate contamination effects between players training within the same team environment. Eligibility criteria included: age between 18 and 30 years, participation in at least two structured volleyball training sessions per week, elite competitive playing experience, and body mass index (BMI) between 18.5 and 25 kg/m^2. Participants were excluded if they voluntarily withdrew, missed more than two consecutive or three non-consecutive training sessions during the intervention period, or failed to complete post-intervention assessments within one week after completion of the intervention. Baseline demographic, anthropometric, and injury history variables were assessed prior to the intervention, and statistical comparison confirmed no significant differences between groups, ensuring baseline equivalence.

Intervention

The intervention consisted of a structured volleyball-specific injury-prevention warm-up program developed based on current scientific evidence and expert consensus in volleyball injury prevention. The program was implemented before each regular training session over a 9-week period, with a frequency of three sessions per week and a duration of approximately 15 minutes per session. The intervention was divided into three progressive phases, each lasting three weeks, to ensure gradual adaptation and progressive overload.Each session consisted of two components. The first component included 4–5 minutes of general cardiovascular activation (e.g., running variations, dynamic locomotor drills) aimed at increasing body temperature and preparing the neuromuscular system for subsequent activity. The second component comprised 10–11 minutes of structured neuromuscular injury-prevention exercises targeting the shoulder, knee, ankle, and trunk. These exercises were designed to enhance dynamic balance, trunk stability, neuromuscular control, landing mechanics, and joint stabilization specific to volleyball demands. Exercise

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complexity, intensity, and task specificity were progressively increased across the three phases to ensure continued adaptation. To ensure intervention fidelity and reduce implementation bias, all sessions were supervised by trained strength and conditioning coaches. Attendance and adherence were systematically recorded throughout the intervention period.

Outcome Measures

The primary outcome measures of this study were sports injury incidence and functional movement performance as assessed by the Volleyball Functional Movement Screen (VFMS). Secondary descriptive outcomes included injury characteristics such as type, location, mechanism, severity, and time-loss. All outcome assessments were conducted under standardized conditions. Data collection followed a pretest–posttest framework, with baseline measurements completed prior to intervention initiation and follow-up assessments conducted within one week after the 9-week intervention period using identical procedures and equipment.

Injury Surveillance

Sports injuries were prospectively recorded throughout the competitive season using the Fédération Internationale de Volleyball (FIVB) Medical Injury Report Form (M-10). Prior to data collection, standardized training sessions were conducted for team physicians and medical staff to ensure uniform injury reporting across all teams. Injuries were defined according to consensus volleyball injury surveillance guidelines and included any musculoskeletal complaint resulting from training or competition that required medical attention or led to time-loss. Exposure was recorded in terms of total player-hours, including both training and official match participation for each group. Injury incidence was calculated as the number of injuries per 1,000 player-hours of exposure. In addition, detailed injury-related variables including anatomical location, injury type, mechanism, severity, playing position, and timing of occurrence were systematically documented for each case.

Volleyball Functional Movement Screen (VFMS)

Functional movement pattern assessment in the present study was conducted using the Volleyball Functional Movement Screen (VFMS), a sport-specific screening tool developed and localized by Tabatabaei et al. (2018) in Iran based on the original Functional Movement Screen (FMS) proposed by Cook et al. (2006). This instrument was designed to enhance diagnostic sensitivity in volleyball athletes and address the limitations of the general FMS by identifying sport-specific deficits in movement patterns, core stability, balance, explosive power, and neuromuscular control relevant to volleyball performance. The VFMS consists of 12 functional components, including the Deep Squat, Three-Hop Test, Hexagon Test, In-line Lunge, Trunk Stability Push-Up, Rotary Stability, Lateral Lunge, Shoulder Mobility, Triple Jump for Distance, Medicine Ball Side Throw, Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), and Squat Jump, each assessing different dimensions of motor control, explosive strength, core stability, and neuromuscular coordination. Scoring was based on a four-point ordinal scale ranging from 0 to 3, where a score of 3 indicated correct movement execution without compensation, 2 indicated successful performance with compensatory movement patterns, 1 indicated inability to perform the movement correctly, and 0 indicated the presence of pain during execution. The total score was calculated as an overall indicator of functional movement performance for each athlete. All assessments were administered by a trained evaluator under standardized environmental and temporal conditions to minimize measurement error.Regarding psychometric properties, the VFMS demonstrated acceptable content validity in its initial development study, as confirmed by experts in sports injury and physical fitness (CVI > 0.80). Additionally, the test showed good reliability, with satisfactory inter-rater and intra-rater reliability (ICC > 0.85), and its construct

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validity in predicting injury risk among elite volleyball players was reported as significant. Accordingly, compared with the general FMS, the VFMS offers advantages such as greater sensitivity in detecting volleyball-specific movement dysfunctions, inclusion of explosive and jumping movement patterns, and a closer association with common injury mechanisms in volleyball. All assessments were performed during familiarization sessions and on rest days to minimize the potential effect of fatigue on performance outcomes.

Data Collection Procedures

Baseline assessments were conducted prior to the intervention and included demographic variables (age, height, body mass, BMI), competitive experience, and previous injury history. Additionally, VFMS performance was assessed at baseline under standardized conditions. Post-intervention assessments were conducted within one week following completion of the 9-week program using identical testing protocols, equipment, environmental conditions, and the same blinded evaluator. This standardization was implemented to minimize measurement variability and ensure internal validity.

Table 1. Volleyball-Specific Injury-Prevention Warm-Up Program

Phase	Week	Exercise	Sets	Repetitions / Duration
General Warm-Up	1–9	Forward and backward running, carioca, short shuttle/lateral shuffles, running with shoulder rotation, high knees, butt kickers, high skipping, multidirectional jumps (forward, backward, lateral)	—	8–10 min
Phase 1	Week 1	Dynamic shoulder stretch	2	10 reps
		Half squat	2	10 reps
		Good morning	2	10 reps
		Single-leg Romanian deadlift (without hip extension)	2	5 reps
		Standing W position	2	10 reps
		Lateral lunge	2	10 reps
		Plank	2	20 s
		Cross-leg movement in prone position	1	10 reps
		Quarter-squat jump with bilateral landing	2	5 reps
		Partner ball passing with two hands, then one hand	1	1 min
Phase 1	Week 2	Dynamic shoulder stretch in single-leg stance	2	10 reps
		Half squat	3	10 reps
		Good morning	2	10 reps
		Single-leg Romanian deadlift (without hip extension)	2	5 reps
		Shoulder external rotation	2	15 s
		Forward lunge	3	10 reps
		Side plank (knees on floor)	2	15 s
		Cross-leg movement in supine position	1	10 reps
		Quarter-squat jump with bilateral landing	2	5 reps
		Partner ball passing with two hands, then one hand	1	1 min
Phase 1	Week 3	Dynamic shoulder stretch	2	10 reps
		Half squat	3	10 reps
		Single-leg Romanian deadlift	2	7 reps
		Shoulder external rotation	2	15 s
		Backward lunge	3	10 reps

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		Plank	2	20 s
		Cross-leg movement in prone position	1	10 reps
		Forward squat jump	2	9 m
		Partner ball passing with two hands, then one hand	1	60 s
		Blocking drill at the net	2	5 reps
Phase 2	Week 1	Dynamic shoulder stretch	2	10 reps
		Single-leg half squat	3	5 reps
		Single-leg Romanian deadlift	2	10 reps
		T exercise in bent-over position	2	10 reps
		Split squat	2	10 reps
		Plank	2	30 s
		Cross-leg movement in prone position	1	10 reps
		Shoulder-touch jumps	2	5 reps
		Partner ball passing with two hands, then one hand	1	60 s
		Blocking drill at the net	2	5 reps
Phase 2	Week 2	Dynamic shoulder stretch in single-leg stance	2	10 reps
		Single-leg squat	3	5 reps
		Good morning	2	10 reps
		T exercise in prone position	2	10 reps
		Side plank	2	15 s
		Diagonal lunge	2	10 reps
		Burpee	2	10 reps
		Partner balance perturbation on one leg	2	10 s
		Partner ball passing with two hands, then one hand	2	60 s
		Ball return with lateral stepping	2	10 reps
Phase 2	Week 3	Dynamic shoulder stretch in single-leg stance	1	10 reps
		Squat	3	15 reps
		Windmill	2	10 reps
		T exercise in bent-over position	2	10 reps
		Split squat	2	10 reps
		Plank	2	30 s
		Cross-leg movement in prone position	1	10 reps
		Lateral jump with single-leg landing	2	10 reps
		Partner ball passing with two hands, then one hand	1	60 s
		Ball return with lateral stepping	2	10 reps
Phase 3	Week 1	Dynamic shoulder stretch in single-leg stance with eyes closed	2	10 reps
		Squat	3	15 reps
		Single-leg Romanian deadlift	2	10 reps
		W exercise in bent-over position	2	10 reps
		Backward lunge	2	10 reps
		Plank with alternate leg raise	2	20 s
		Shoulder external rotation	1	10 reps
		Blocking drill with safe single-leg landing	2	10 reps
		Partner ball passing with two hands, then one hand on one leg	1	10 reps
		Ball return with lateral stepping	2	10 reps
Phase 3	Week 2	Dynamic shoulder stretch in single-leg squat with eyes closed	2	10 reps
		Single-leg squat with eyes closed	3	5 reps
		Single-leg Romanian deadlift	3	5 reps
		Diagonal lunge (right and left)	2	10 reps

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		W exercise in prone position	2	10 reps
		Side plank with upper-leg raise	2	5 reps
		Cross-leg movement in supine position	1	10 reps
		Blocking drill with lateral movement	1	10 reps
		Partner ball passing with two hands, then one hand on one leg	1	30 s each leg
Phase 3	Week 3	Dynamic shoulder stretch in single-leg stance	1	10 reps
		Single-leg squat with eyes closed	3	5 reps
		Single-leg Romanian deadlift	2	10 reps
		W exercise in bent-over position	2	10 reps
		Split squat	2	15 s
		Plank with alternate leg raise	3	10 reps
		Cross-leg movement in prone position	3	30 s
		Blocking drill with safe single-leg landing and lateral movement	1	10 reps
		Partner ball passing with two hands, then one hand on one leg	1	60 s

Statistical Analysis

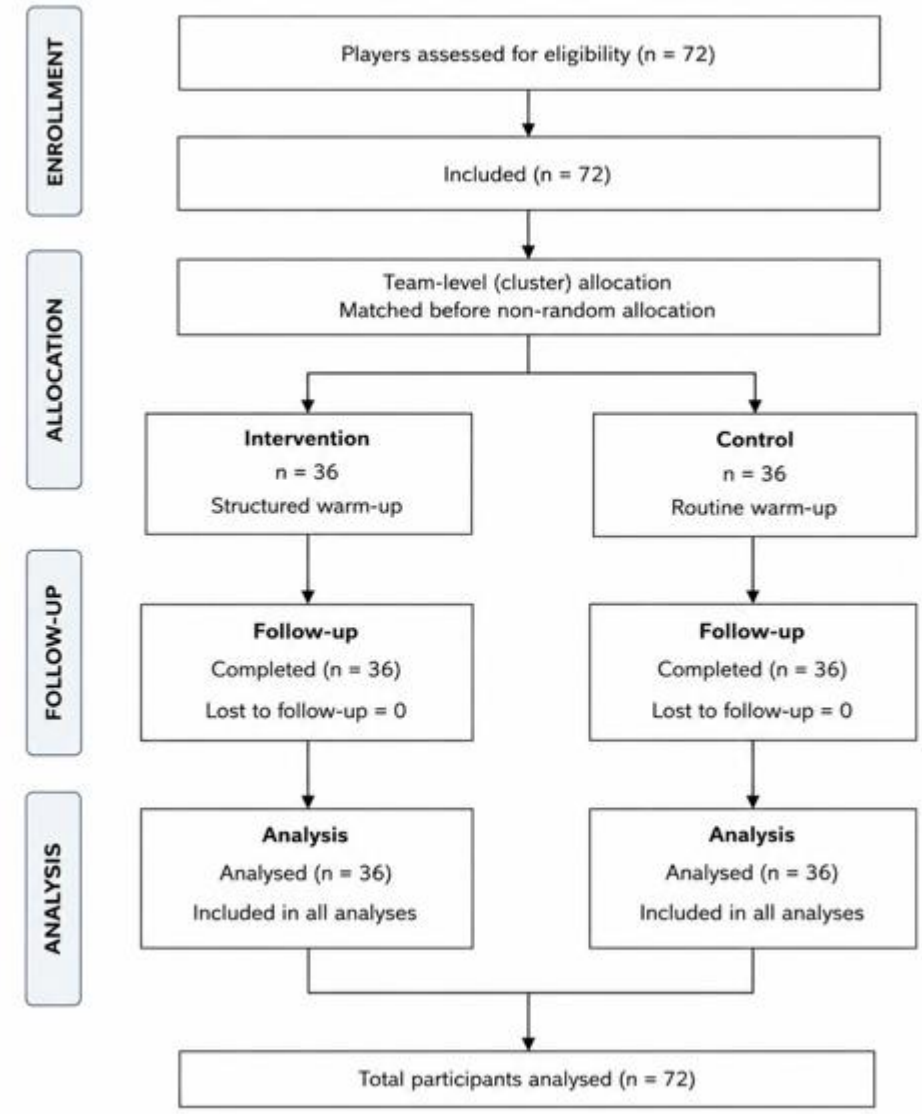
All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as mean ± standard deviation (SD) for continuous variables and frequency (percentage) for categorical variables. Normality of data distribution was assessed using the Shapiro–Wilk test. Between-group and within-group differences in VFMS scores were analyzed using a two-way mixed-model analysis of variance (ANOVA) with group (intervention vs. control) as the between-subject factor and time (pre-test vs. post-test) as the within-subject factor. Post hoc comparisons were adjusted using Bonferroni correction.Injury incidence was analyzed using exposure-adjusted models, and incidence rate ratios (IRR) with 95% confidence intervals (CI) were calculated based on injuries per 1,000 player-hours. Group comparisons of injury rates were performed using Poisson regression-based methods.Categorical injury variables were analyzed using Pearson's chi-square test or Fisher's exact test when appropriate. Effect sizes (Cohen's d, partial eta squared, and IRR) were reported to determine practical significance. Statistical significance was set at $p < 0.05$.

Ethical Considerations

The study protocol was approved by the Ethics Committee of the University of Guilan (IR.GUILAN.REC.1404.126). All participants provided written informed consent prior to participation. Participation was voluntary, and athletes were informed of their right to withdraw at any stage without penalty. The study was conducted in accordance with the Declaration of Helsinki for human research. Confidentiality and anonymity were strictly maintained, and all collected data were used exclusively for scientific purposes.

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Figure 1. Flow diagram of participant recruitment, allocation, follow-up, and analysis.



Abbreviation: VFMS, Volleyball Functional Movement Screen.

Results

Table 2. Baseline characteristics of participants with between-group comparison

Variable	Intervention (n = 36) Mean ± SD	Control (n = 36) Mean ± SD	Mean Difference	95% CI	*p* value
Age (years)	23.47 ± 4.71	25.16 ± 4.89	−1.69	−3.84 to 0.46	0.138
Weight (kg)	84.11 ± 9.37	86.24 ± 7.23	−2.13	−5.41 to 1.15	0.280
Height (m)	1.93 ± 0.08	1.94 ± 0.07	−0.01	−0.04 to 0.02	0.749
BMI (kg/m²)	22.36 ± 2.03	22.77 ± 1.20	−0.41	−1.32 to 0.50	0.308

Table 2 shows that there were No statistically significant between-group differences were observed in any baseline demographic or anthropometric characteristic (all $p > 0.05$). Furthermore, the 95% confidence intervals for the mean differences included zero for all variables, supporting baseline comparability between the intervention and control groups.**hours (training + match).**

Table 3. Distribution of Sports Injuries According to Injury Characteristics

Variable	Intervention n (%)	Control n (%)	Statistical test	*p* value	Cramer's V
Playing position	Outside hitter (37.0)	Outside hitter (31.6)	χ^2	0.759	0.137
Match set	Fourth (39.1)	Third (29.8)	Fisher's exact	0.793	0.127
Injured body part	Ankle (21.7)	Ankle (24.6)	Fisher's exact	0.878	0.294
Injury type	Cramp (23.9)	Dislocation/Subluxation (15.8)	Fisher's exact	0.572	0.308
Injury mechanism	Contact with fixed object (23.9)	Contact with fixed object (22.8)	Fisher's exact	0.141	0.324
Return to play	Yes (71.7)	Yes (70.2)	χ^2	1.000	0.017
Time-loss	2 days (52.2)	2 days (56.4)	Fisher's exact	0.911	0.172

Table 3 summarizes the distribution of injury characteristics in the intervention and control groups. No statistically significant between-group differences were observed for playing position, match set of injury, injured body part, injury type, injury mechanism, return to play, or time-loss (all $p > 0.05$). Effect sizes (Cramer's V) were uniformly small, indicating minimal practical differences between groups. Given the multiple comparisons performed, these findings should be interpreted cautiously because of the increased risk of type I error.

Table 4. Injury incidence rates per 1,000 player-hours, incidence rate ratios (IRRs), 95% confidence intervals (CIs), and between-group comparisons by body region

Body region	Intervention injuries (n)	Control injuries (n)	Intervention IR (per 1,000 h)	Control IR (per 1,000 h)	IRR (95% CI)	*p* value
Lower back	5	2	0.92	0.37	2.50 (0.49–12.90)	0.27
Shoulder/Clavicle	4	7	0.74	1.29	0.57 (0.17–1.95)	0.37
Elbow	5	4	0.92	0.74	1.25 (0.34–4.62)	0.74
Finger	7	9	1.29	1.66	0.78 (0.30–2.01)	0.61
Knee	8	13	1.48	2.40	0.62 (0.26–1.45)	0.27
Ankle	10	14	1.85	2.59	0.71 (0.33–1.57)	0.39

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Others	7	8	1.31	1.48	0.88 (0.33–2.36)	0.80
Total	**46**	**57**	**8.51**	**10.55**	**0.81 (0.55–1.19)**	**0.28**

Table 4 presents injury incidence rates per 1,000 player-hours, incidence rate ratios (IRRs), and corresponding 95% confidence intervals for each anatomical region. Overall injury incidence was lower in the intervention group than in the control group (IRR = 0.81, 95% CI: 0.55–1.19); however, this difference did not reach statistical significance (***p*** = 0.28). Across both groups, the ankle and knee were the most frequently injured body regions. No statistically significant between-group differences were observed for injury incidence in any anatomical region.

Table 5. Mixed ANOVA for Functional Volleyball Movement Scores

Outcome	Time effect F	*p*	Partial η²	Group × Time interaction F	*p*	Partial η²
Total VFMS score	732.241	<0.001	0.912	0.890	0.349	0.012
Upper extremity	56.569	<0.001	0.443	0.435	0.512	0.006
Trunk	317.783	<0.001	0.817	0.377	0.541	0.005
Lower extremity	426.828	<0.001	0.857	2.976	0.089	0.040

Table 5 presents the results of the two-way mixed ANOVA for VFMS outcomes. Significant main effects of time were observed for all outcomes (all **p** < 0.001), indicating improvements in functional movement performance over time irrespective of group allocation. No statistically significant group × time interaction effects were found for the total VFMS score, upper extremity, trunk, or lower extremity (all **p** > 0.05), indicating that the magnitude of improvement did not differ significantly between the intervention and control groups. The main effects of time were associated with large effect sizes, whereas interaction effects were uniformly small.

Table 6. Bonferroni-adjusted pre–post comparisons of functional movement scores

Outcome	Group	Mean Difference	p	Effect Size (Cohen's d)	% Change	95% CI
Total score	Experimental	-6.361	<0.001	0.912	29.61	NR
Total score	Control	-5.932	<0.001	0.912	28.41	NR
Upper extremity	Experimental	-0.402	<0.001	0.497	23.58	NR
Upper extremity	Control	-0.337	<0.001	0.388	19.53	NR
Trunk	Experimental	-0.494	<0.001	0.803	28.21	NR
Trunk	Control	-0.529	<0.001	0.831	32.83	NR
Lower extremity	Experimental	-0.616	<0.001	0.883	33.13	NR
Lower extremity	Control	-0.521	<0.001	0.826	27.89	NR

Table 6 presents Bonferroni-adjusted within-group pre–post comparisons for functional movement scores. Both experimental and control groups showed statistically significant improvements across all outcomes (p < 0.001). However, these results reflect within-group changes over time and do not represent direct between-group differences. Therefore, while both groups improved, the magnitude of improvement should not be interpreted as evidence of superiority of one group over the other in the absence of significant interaction effects.

Table 7. Between-group comparison of change scores for individual functional performance tests

Test	Experimental (% Change)	Control (% Change)	Between-group difference (Δ%)	p (between)	Effect size (Cohen's d)	95% CI of Δ
Shoulder Mobility	29.31	20.97	8.34	0.284	0.29	−6.42 to 23.10

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Closed Kinetic Chain UET	18.46	18.18	0.28	0.931	0.01	−10.87 to 11.43
Deep Squat	26.76	33.33	−6.57	0.371	0.24	−21.08 to 7.94
Inline Lunge	22.30	38.58	−16.28	0.081	0.48	−34.52 to 1.96
Push-up Stability	27.54	17.74	9.80	0.214	0.34	−5.74 to 25.34
Rotary Stability	36.08	39.81	−3.73	0.602	0.13	−17.79 to 10.33
Side Medicine Ball Throw	32.08	36.19	−4.11	0.547	0.15	−17.45 to 9.23
Hexagon	31.94	22.79	9.15	0.176	0.37	−4.29 to 22.59
Squat Jump	69.81	41.94	27.87	0.061	0.56	−1.18 to 56.92
Triple Hop	18.31	15.49	2.82	0.684	0.09	−10.81 to 16.45
Triple Crossover Hop	41.44	41.35	0.09	0.989	0.00	−13.74 to 13.92
Lateral Lunge	17.96	24.39	−6.43	0.402	0.21	−21.43 to 8.57

Table 7 presents the between-group comparison of change scores for individual functional performance tests. The change scores (post-test minus pre-test) were compared between the intervention and control groups, and the corresponding p-values, Cohen's d effect sizes, and 95% confidence intervals are reported. No statistically significant between-group differences were observed for any of the functional performance tests (all $p > 0.05$). The estimated effect sizes ranged from trivial to moderate, and the 95% confidence intervals included zero for all comparisons, indicating that the improvements observed following the intervention were comparable between the two groups.

Discussion

The present study investigated the effects of a structured warm-up program on injury characteristics and functional movement performance among male Iranian Premier League volleyball players. Overall**,** the findings indicated that the structured warm-up program did not result in statistically significant between-group differences in injury distribution across playing position, timing of injury occurrence, injured body region, injury type, injury severity, injury-related absence, or Functional Movement Screening (FMS) outcomes. Although both groups demonstrated significant within-group changes over time in several variables, these changes were not significantly different between groups, suggesting that the observed improvements may be attributable to general training exposure and seasonal adaptation rather than to the specific effect of the intervention. Regarding playing position, outside hitters demonstrated the highest injury frequency, whereas opposite hitters showed the lowest injury frequency. These findings are broadly consistent with previous volleyball epidemiological studies, which have reported that attacking positions are exposed to a higher injury risk because of repeated jumping, landing, and overhead actions. However, the discrepancy between the present findings and earlier reports suggesting a higher injury prevalence among liberos may reflect contextual factors, such as tactical variations, training load distribution, and league-specific characteristics **(15)**. Importantly,

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although within-group variability across playing positions was observed in the experimental group, no statistically significant between-group differences were detected, indicating that the structured warm-up program did not appear to meaningfully modify the positional injury profile **(16)**. With respect to injury type, the results showed that the distribution of injury categories did not differ significantly between groups (17)**.** Muscle cramps and sprains were among the most frequently reported injury types, which is consistent with the biomechanical demands of volleyball (18)**.** Although descriptive differences were observed in some rare injury categories, such as a lower frequency of fractures and meniscal injuries in the intervention group, these findings were not statistically supported and should therefore be interpreted cautiously. Previous literature has suggested that warm-up programs may reduce overall injury risk; however, the evidence regarding their ability to alter the distribution of specific injury types remains limited and inconsistent (19)**.** In terms of injury timing, injury occurrence varied across match sets within both groups, suggesting that injury risk may fluctuate during competition **(7)**. This pattern is consistent with previous evidence suggesting that accumulated fatigue and repeated high-intensity actions may influence injury susceptibility during the later stages of matches (20)**.** However, no significant interaction effect was observed between groups, indicating that the structured warm-up program did not appear to influence the temporal pattern of injuries across match sets (21)**.** Regarding the injured body region, the ankle was the most frequently affected anatomical site in both groups. This finding is consistent with the existing epidemiological literature on volleyball, which has consistently identified the ankle as the most vulnerable anatomical region because of the repetitive landing and jumping demands of the sport **(22)**. Other anatomical regions exhibited lower injury frequencies. Although some within-group variation was observed, no statistically significant between-group differences were detected, indicating that the intervention did not appear to substantially alter the anatomical distribution of injuries (23)**.**The analysis of injury mechanisms and causation revealed no statistically significant differences between groups. While recurrent injuries and overuse-related patterns were descriptively less frequent in the experimental group, these observations were not supported by inferential statistics (2)**.** Therefore, they should not be interpreted as evidence supporting the effectiveness of the intervention**.** The absence of statistically significant between-group differences may be related to the multifactorial nature of sports injuries, in which multiple interacting factors contribute to injury occurrence. With respect to injury severity and injury-related absence, no statistically significant differences were found between groups **(7)**. Although both groups showed reductions in severity indicators over time, these changes were not significantly different between groups**.** This finding suggests that factors other than the structured warm-up program, such as general training adaptation, medical support, or injury monitoring practices, may have contributed to these improvements. Similarly, Volleyball Functional Movement Screening (VFMS) outcomes improved significantly over time in both groups; however, no statistically significant between-group differences were observed. These findings suggest that the structured warm-up program did not provide additional improvements in functional movement performance beyond those achieved through regular elite-level volleyball training. The improvements observed in both groups may reflect normal training adaptations, repeated exposure to volleyball-specific movement patterns, and motor learning effects associated with participation in a competitive season. Furthermore, given the high baseline functional capacity of elite athletes, a ceiling effect may have limited the potential for detecting additional improvements attributable to the intervention. This finding suggests that the structured warm-up program did not provide additional benefits beyond those achieved through regular elite-level training. The observed improvements in both groups may reflect general training adaptations and

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motor learning effects commonly observed in elite athletes. Furthermore, given the high baseline functional level of the participants, a ceiling effect may also have limited the ability to detect further improvements attributable to the intervention. From a practical perspective, the findings suggest that structured warm-up programs implemented as standalone interventions are unlikely to produce substantial independent effects on injury reduction or functional movement enhancement in male Iranian Premier League volleyball players. Instead, injury prevention should be considered a multifactorial process requiring the integration of multiple strategies, including workload management, neuromuscular training, recovery optimization, and sport-specific conditioning. Several limitations should be considered when interpreting these findings. First, the sample size calculation was performed post hoc rather than a priori, which should be acknowledged as a methodological limitation because the study may have been underpowered to detect small between-group differences. Additionally, the study population was restricted to male Iranian Premier League volleyball players**,** which limits the generalizability of the findings to female athletes, younger players, or athletes competing at other performance levels. Potential confounding factors, such as training load variability, recovery status, psychological stress, sleep, and nutrition, were not fully controlled. Finally, the intervention duration may not have been sufficient to produce measurable neuromuscular adaptations. In conclusion, the structured warm-up program did not demonstrate statistically significant effects on injury patterns or functional movement outcomes compared with the control condition. Although both groups showed improvements over time, these changes were not significantly different between groups and therefore cannot be attributed to the intervention**.** Consequently**,** the present findings do not support the effectiveness of the structured warm-up program as a standalone injury-prevention strategy in male Iranian Premier League volleyball players. Future research should focus on adequately powered studies using a priori sample size calculations and should investigate multifactorial, individualized injury-prevention strategies that integrate structured warm-up programs with complementary evidence-based approaches.

Conclusion

In conclusion, the structured warm-up program did not result in statistically significant differences in injury distribution, injury characteristics, or functional movement performance compared with the control condition in male Iranian Premier League volleyball players. Although both groups demonstrated improvements over time in functional movement outcomes and some descriptive differences were observed in injury patterns, these changes were not significantly different between groups and therefore cannot be attributed to the intervention**.** Accordingly, the present findings do not support the effectiveness of the structured warm-up program as a standalone injury-prevention strategy in this specific population. These results highlight the importance of interpreting injury-prevention strategies within a multifactorial framework, as warm-up routines alone are unlikely to produce substantial independent effects in highly trained athletes. Consequently, future injury-prevention approaches should integrate structured warm-up programs with broader strategies, such as workload management, neuromuscular conditioning, recovery optimization, and sport-specific preventive exercises, to more effectively reduce injury burden in male Iranian Premier League volleyball players and should be evaluated in larger, adequately powered studies before being generalized to other athletic populations.

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Authors' contribution

Conceptualization and Methodology: Mohammad Ghaffouri, Ali Shamsi; Data Collection, Formal Analysis, and Writing – Original Draft: Mohammad Ghaffouri; Supervision, Review & Editing: Ali Shamsi, Hassan Daneshmandi. All authors approved the final version of the manuscript.

ETHICAL CONSIDERATIONS

Ethical Approval: The study protocol was approved by the Ethics Committee of the University of Guilan (Ethics Code: IR.GUILAN.REC.1404.126). All participants were informed about the objectives, procedures, potential benefits, and possible risks of the study and provided written informed consent prior to participation. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human participants. Confidentiality and anonymity of all participants were maintained throughout the research process.

Funding Statement

This research was conducted as part of the doctoral dissertation of Mohammad Ghafouri in the Department of Sports Injury and Corrective Exercises, Faculty of Sport Sciences, University of Guilan, Rasht, Iran. The authors received no specific financial support or external funding for this research.

Conflicts of interest:

The authors declared no conflict of interest regarding the publication of this article.

AI-Assisted Technology Disclosure

No artificial intelligence (AI)-assisted technologies were used in the preparation, writing, analysis, or editing of this manuscript.

Acknowledgments

The authors would like to express their sincere gratitude to all volleyball players, coaches, team physicians, and club officials who participated in and supported this study. We also appreciate the cooperation of the Iranian Premier Volleyball League teams and the Department of Sports Injury and Corrective Exercises, University of Guilan, for facilitating the implementation of this research.

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Reference

1. Smith L. Difference in Participation in Club Volleyball Prior to College and Receiving Collegiate Volleyball Athletic Scholarships in the Midwest. Undergrad Res J [Internet]. 2019 Jul 1;23(1). Available from: https://openspaces.unk.edu/undergraduate-research-journal/vol23/iss1/7
2. Kilic O, Maas M, Verhagen E, Zwerver J, Gouttebarge V. Incidence, aetiology and prevention of musculoskeletal injuries in volleyball: A systematic review of the literature. Eur J Sport Sci. 2017 Jul;17(6):765–93. doi:10.1080/17461391.2017.1306114 PubMed PMID: 28391750.
3. Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement screening: the use of fundamental movements as an assessment of function - part 1. Int J Sports Phys Ther. 2014 May;9(3):396–409. PubMed PMID: 24944860; PubMed Central PMCID: PMC4060319.
4. Daneshjoo A, Mokhtar AH, Rahnama N, Yusof A. Effects of the 11+ and Harmoknee Warm-up Programs on Physical Performance Measures in Professional Soccer Players. J Sports Sci Med. 2013 Sep 1;12(3):489–96. PubMed PMID: 24149156; PubMed Central PMCID: PMC3772593.
5. Zarei M, Abbasi H, Daneshjoo A, Gheitasi M, Johari K, Faude O, et al. The Effect of the '11+ Kids' Program on the Isokinetic Strength of Young Football Players. Int J Sports Physiol Perform. 2020 Jan 1;15(1):25–30. doi:10.1123/ijspp.2018-0827 PubMed PMID: 30958052.
6. Hartley EM, Hoch MC, Boling MC. Y-balance test performance and BMI are associated with ankle sprain injury in collegiate male athletes. J Sci Med Sport. 2018 Jul;21(7):676–80. doi:10.1016/j.jsams.2017.10.014 PubMed PMID: 29102301.
7. Fattahi A, Sadeghi H, Rezaei M, Einanloo M. Effects of Two Warm up Protocol on Vertical Jump Performance in Mini-volleyball Players | Advances in Research [Internet]. [cited 2026 Jul 2]. Available from: https://journalair.com/index.php/AIR/article/view/471?__cf_chl_f_tk=_cAfKus1VWWf97nnwZWzVTJlgYA8.w7gqmgRcURejEE-1782983312-1.0.1.1-iypLbZXb92v5EQ.DcLIgC_Pv3j99uQDvpxOH.2wLn9I
8. Steffen K, Nilstad A, Krosshaug T, Pasanen K, Killingmo A, Bahr R. No association between static and dynamic postural control and ACL injury risk among female elite handball and football players: a prospective study of 838 players. Br J Sports Med. 2017 Feb;51(4):253–9. doi:10.1136/bjsports-2016-097068 PubMed PMID: 28148513.
9. Bouteraa I, Negra Y, Shephard RJ, Chelly MS. Effects of Combined Balance and Plyometric Training on Athletic Performance in Female Basketball Players. J Strength Cond Res. 2020 Jul;34(7):1967–73. doi:10.1519/JSC.0000000000002546 PubMed PMID: 29489714.
10. Wang H. PREVENTION OF SPORTS INJURIES DURING PHYSICAL TRAINING OF VOLLEYBALL PLAYERS. Rev Bras Med Esporte. 2023;29:e2022_0801. doi:https://doi.org/10.1590/1517-8692202329012022_0801
11. Soligard T, Myklebust G, Steffen K, Holme I, Silvers H, Bizzini M, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. BMJ. 2008 Dec 9;337:a2469. doi:10.1136/bmj.a2469 PubMed PMID: 19066253; PubMed Central PMCID: PMC2600961.
12. Schons P, Fischer G, Rosa RG da, Berriel GP, Peyré-Tartaruga LA. CORRELATIONS BETWEEN THE STRENGTH OF KNEE EXTENSOR AND FLEXOR MUSCLES AND JUMP PERFORMANCE IN VOLLEYBALL PLAYERS: A REVIEW. J Phys Educ. 2018;29:e2926. doi:https://doi.org/10.4025/jphyseduc.v29i1.2926
13. Cole CL, Vasalos K, Nicandri G, Apt C, Osterling E, Ferrara Z, et al. Use of PROMIS and Functional Movement System (FMS) Testing to Evaluate the Effects of Athletic Performance

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and Injury Prevention Training in Female High School Athletes. Orthop Sports Med Open Access J. 2019;3(2):255–8. doi:10.32474/osmoaj.2019.03.000160 PubMed PMID: 32039407; PubMed Central PMCID: PMC7007986.
14. Al-Kaabi A. The motor response and its relationship to the accuracy of the performance of the high preparation skill in volleyball for juniors. Mustansiriyah J Sports Sci. 2024 Feb 11;599–607. doi:10.62540/mjss.Conf.4th.2023.28
15. Gürses V, Akgül M. FUTBOLCULARIN ISINMADA UYGULADIKLARI FARKLI GERME YÖNTEMLERİNİN DİKEY SIÇRAMA, SÜRAT VE ÇEVİKLİK PERFORMANSINA AKUT ETKİSİ. SPORMETRE Beden Eğitimi Ve Spor Bilim Derg. 2019 Mar 31;17(1):178–86. doi:10.33689/spormetre.520033
16. Fradkin AJ, Zazryn TR, Smoliga JM. Effects of warming-up on physical performance: a systematic review with meta-analysis. J Strength Cond Res. 2010 Jan;24(1):140–8. doi:10.1519/JSC.0b013e3181c643a0 PubMed PMID: 19996770.
17. Banković V, Živković A, Trunić N. Enhancing Athletic Performance Through Wearable Technology Integration in Volleyball: A Pilot Study. Sint 2024 - Int Sci Conf Inf Technol Comput Sci Data Sci. 2024;358–63. doi:10.15308/Sinteza-2024-358-363
18. Nemati J, Hemmatinafar M, Niknam A, Nikahd M, Zeighami N, Imanian B, et al. Effects of Different Doses of Caffeine Supplementation on Collegiate Male Volleyball Players' Specific Performance and Skills: A Randomized, Double-Blind, Placebo-Controlled, Crossover Study. Nutrients. 2023 Sep 19;15(18):4049. doi:10.3390/nu15184049 PubMed PMID: 37764832; PubMed Central PMCID: PMC10536286.
19. Zhu S. REDUCING THE SPORTS INJURY THROUGH FUNCTION MOVEMENT BIOLOGICAL IMAGE DATA SCREENING. Rev Bras Med Esporte. 2021;27:286–90. doi:https://doi.org/10.1590/1517-8692202127032021_0108
20. (PDF) The Effect of 12 Weeks of Wrestling+ Specific Warm-Up Program on Dynamic Balance in Cadet Wrestlers [Internet]. [cited 2026 Jul 2]. Available from: https://www.researchgate.net/publication/373471423_The_Effect_of_12_Weeks_of_Wrestling_Specific_Warm-Up_Program_on_Dynamic_Balance_in_Cadet_Wrestlers
21. Baugh CM, Weintraub GS, Gregory AJ, Djoko A, Dompier TP, Kerr ZY. Descriptive Epidemiology of Injuries Sustained in National Collegiate Athletic Association Men's and Women's Volleyball, 2013-2014 to 2014-2015. Sports Health. 2018;10(1):60–9. doi:10.1177/1941738117733685 PubMed PMID: 28985702; PubMed Central PMCID: PMC5753967.
22. Reeser JC, Gregory A, Berg RL, Comstock RD. A Comparison of Women's Collegiate and Girls' High School Volleyball Injury Data Collected Prospectively Over a 4-Year Period. Sports Health. 2015;7(6):504–10. doi:10.1177/1941738115600143 PubMed PMID: 26502443; PubMed Central PMCID: PMC4622377.
23. Augustsson SR, Augustsson J, Thomeé R, Karlsson J, Eriksson BI, Svantesson U. Performance Enhancement following a Strength and Injury Prevention Program: A 26-Week Individualized and Supervised Intervention in Adolescent Female Volleyball Players. Int J Sports Sci Coach. 2011 Sep 1;6(3):399–417. doi:10.1260/1747-9541.6.3.399

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