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Effects of Structured Speed, Agility, and Quickness (SAQ) Training on Athletic Performance in Volleyball Players: A Systematic Review

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ABSTRACT:
Background: Speed, agility, and quickness (SAQ) are fundamental physical attributes that determine competitive success in volleyball. Despite growing interest in structured SAQ training programs, no systematic synthesis of evidence specific to volleyball players has been conducted. **Objective:** To systematically review the effects of structured SAQ training programs on athletic performance outcomes — including agility, sprint speed, change-of-direction (COD) speed, vertical jump height, and sport-specific performance — in volleyball players. **Methods:** A comprehensive search of PubMed/MEDLINE, Scopus, Web of Science, SPORT Discus, Cochrane Library, and PEDro databases was conducted from inception to February 2025. Studies involving volleyball players of any age or competitive level who received structured SAQ training with pre- and post-intervention assessments were included. Methodological quality was evaluated using the PEDro scale. A narrative synthesis was performed due to heterogeneity across studies. **Results:** Twenty-two studies met the inclusion criteria, encompassing 847 volleyball players (mean age: 18.6 ± 3.4 years). SAQ training duration ranged from 4 to 16 weeks. Sixteen studies (72.7%) reported significant improvements in agility test performance (T-test, Illinois Agility Test, 505 COD). Sprint performance improved in 13 of 17 studies reporting this outcome. Vertical jump and anaerobic power improved in 14 of 19 studies. PEDro scores ranged from 3 to 8, indicating moderate to good methodological quality in most included studies. **Conclusion:** Structured SAQ training programs are effective in improving agility, sprint speed, change-of-direction ability, and volleyball-specific athletic performance. Programs lasting 6–12 weeks with a frequency of 2–3 sessions per week appear to yield the most consistent benefits. These findings have direct implications for volleyball conditioning coaches and sports physiotherapists designing evidence-based training programs.

INTRODUCTION:
Volleyball is a high-intensity, multidirectional court sport that demands an intricate combination of technical proficiency, tactical awareness, and superior physical conditioning. The nature of the game requires athletes to

perform explosive, intermittent bursts of activity — including rapid accelerations, multi-directional sprints, repeated vertical jumps, and immediate directional reversals — within a constrained playing area of 9 × 9 meters per side.1 These physical demands place volleyball among the most physiologically taxing team sports, particularly with respect to neuromuscular function, reactive capacity, and anaerobic power.

Among the various physical attributes demanded by the game, speed, agility, and quickness (SAQ) collectively represent the cornerstone of effective volleyball performance. Sheppard and Young defined agility as a 'rapid whole-body movement with change of velocity or direction in response to a stimulus,' emphasizing its composite nature that integrates physical and perceptual-cognitive components.2 In volleyball, agility underpins nearly every tactical action: a libero diving to retrieve a hard-driven spike, a setter rapidly transitioning from a back-row position to deliver a quick ball, or a middle blocker shuffling to close a block all exemplify the real-time agility demands imposed by the sport.

Speed, in the context of volleyball, refers predominantly to short-burst acceleration over distances of 3–9 meters, which are the most common sprint distances observed during match play.3 A rally in elite volleyball lasts an average of 5–10 seconds, during which athletes execute 2–4 explosive movements interspersed with brief recovery periods.4 Quickness — the ability to initiate rapid movement in response to an external stimulus — is particularly important given the unpredictable trajectory of the ball and the need to react to opponent actions within fractions of a second.5

SAQ training is a structured conditioning methodology that integrates ladder drills, cone patterns, hurdle exercises, reactive stimuli, and multidirectional sprint protocols to develop these interdependent physical qualities.6 Unlike traditional resistance or endurance training, SAQ programs are specifically designed to challenge the neuromuscular system through short-duration, high-intensity motor tasks that improve the rate of force development, ground reaction time, and coordinative efficiency.7 These adaptations are directly transferable to the technical and tactical demands of volleyball.8

The importance of SAQ development in volleyball has been increasingly recognized in the sports science and physiotherapy literature. Sekulic et al. demonstrated that agility test performance was a stronger predictor of competitive level in volleyball than simple speed or strength measures, highlighting the sport-specific relevance of SAQ attributes.9 Similarly, Newton et al. documented that reduced jumping and sprint performance late in the competitive season was directly attributable to declining neuromuscular capacity, underscoring the need for sustained SAQ conditioning throughout the training year.10

Field-based assessments of SAQ in volleyball have evolved considerably. The agility T-test, originally validated by Pauole et al. with a test-retest reliability of r = 0.98, remains the most widely applied agility assessment in volleyball research due to its integration of forward sprint, lateral shuffling, and backward movement — patterns directly analogous to volleyball-specific locomotion.11 The modified agility T-test (MAT) subsequently demonstrated superior sport-specific reliability, particularly in male athletes.12 Other common assessments include the Illinois Agility Test, the 5-0-5 change-of-direction (COD) test, and the reactive agility test (RAT), which incorporates a stimulus-response component absent from pre-planned assessments.13

Training modalities employed within SAQ frameworks for volleyball include agility ladder drills, cone-based change-of-direction drills, hurdle exercises, resistance band sprints, plyometric depth jumps, small-sided games, and reactive stimulus protocols.6,14 Plyometric training, which exploits the stretch-shortening cycle (SSC) to enhance explosive power, is frequently integrated into SAQ programs because of its demonstrated efficacy in improving both vertical jump height and ground contact time.15,16 Markovic's meta-analysis confirmed that plyometric training produced mean improvements of 4.7% in vertical jump performance across diverse athletic populations, an effect size of particular relevance to volleyball given the central role of jumping in offensive and defensive actions.17

The training surface on which SAQ protocols are delivered has also emerged as a clinically relevant variable. Studies by Arazi et al. demonstrated that female volleyball players training on sand exhibited significantly greater improvements in overall agility compared to those training on rigid court surfaces, attributed to the additional demand for postural stabilization on unstable substrates.18 Conversely, rigid-surface training produced superior reactive jumping outcomes, suggesting that surface selection should be guided by the specific performance objective.19

Despite the accumulating evidence on SAQ training in team sports, the existing systematic review literature has predominantly focused on soccer, basketball, and handball populations.20,21 Volleyball presents unique biomechanical and physiological characteristics — including the emphasis on vertical displacement, the absence of direct physical contact, and the highly structured rotational demands of positional play — that may modulate the training response to SAQ protocols differently from other court sports.22

Furthermore, the duration, frequency, and structural composition of SAQ programs applied in volleyball research vary substantially, from 4-week short-term protocols to 16-week seasonal interventions, and from single-component ladder programs to multi-block periodized regimens.6,23 This methodological heterogeneity limits the ability of coaches and sports physiotherapists to draw practical, evidence-based conclusions regarding optimal SAQ programming for volleyball populations.

Two recent contributions have begun to address this gap: Atici and Bayrakdar demonstrated that an 8-week SAQ program in adolescent male volleyball players produced significant improvements in sprint speed (5 m and 10 m), vertical jump performance, and agility scores with effects comparable to plyometric training alone.24 Wei et al. similarly reported that an 8-week sprint interval program markedly improved repeated sprint ability and volleyball-specific technical performance in collegiate players.25 These findings, while promising, highlight the need for a comprehensive synthesis of all available SAQ training evidence in volleyball populations.

To the best of the authors' knowledge, no systematic review has specifically examined the effects of structured SAQ training across the full spectrum of athletic performance outcomes in volleyball players. The present review addresses this gap by systematically evaluating the current evidence base, synthesizing outcome data across studies, and providing evidence-based recommendations for SAQ program design in volleyball-specific physiotherapy and conditioning practice.

2. METHODOLOGY

2.1 Protocol and Registration

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.26,27 The research question was formulated using the PICO framework: Population (volleyball players), Intervention (structured SAQ training), Comparison (control/pre-training), Outcome (athletic performance measures).

2.2 Search Strategy

A comprehensive electronic search was performed across six databases: PubMed/MEDLINE, Scopus, Web of Science (Core Collection), SPORTDiscus (via EBSCOhost), Cochrane Central Register of Controlled Trials (CENTRAL), and PEDro. The search encompassed all records from database inception to February 28, 2025. Hand-searching of reference lists of included studies and relevant systematic reviews was also performed to identify additional eligible records.

The search strategy employed combinations of Medical Subject Headings (MeSH) terms and free-text keywords, including: ("volleyball" OR "beach volleyball" OR "indoor volleyball") AND ("SAQ training" OR "speed agility quickness" OR "agility training" OR "change of direction" OR "COD training" OR "plyometric training" OR "speed training" OR "quickness training" OR "ladder drill" OR "cone drill" OR "sprint training") AND ("athletic performance" OR "agility" OR "T-test" OR "sprint speed" OR "vertical jump" OR "physical performance" OR "neuromuscular performance"). No language restrictions were applied; non-English articles with available English abstracts were considered, and full translations were obtained where necessary.

2.3 Inclusion and Exclusion Criteria

Inclusion Criteria:

- Study design: Randomized controlled trials (RCTs), controlled trials, quasi-experimental studies, and pre-post experimental designs.
- Population: Male and/or female volleyball players of any age (junior, adolescent, adult), competitive level (recreational to elite), participating in organized volleyball training.
- Intervention: Structured SAQ training protocols defined as programs explicitly incorporating speed, agility,

and/or quickness components (ladder drills, cone drills, shuttle runs, plyometric activities, sprint training, or reactive agility protocols).
- Outcome measures: Quantitative assessment of athletic performance including agility test time, sprint speed, change-of-direction speed, vertical jump height, anaerobic power, or sport-specific performance indices.
- Studies reporting at least one pre- and post-intervention performance measurement.

Exclusion Criteria
- Studies involving non-volleyball athletic populations only (soccer, basketball, etc.) unless directly comparative with volleyball players.
- Narrative reviews, case reports, editorials, conference abstracts without full-text availability, and unpublished theses.
- Studies exclusively assessing injured or clinically compromised players.
- Studies in which SAQ components could not be isolated from a predominantly strength, endurance, or technique-based training stimulus.

2.4 Study Selection
Two independent reviewers (authors N.H. and S.S.) screened all titles and abstracts retrieved from the database searches using Rayyan systematic review software. Full-text articles were retrieved for all records that met or potentially met the inclusion criteria. Disagreements were resolved through discussion; if consensus was not reached, a third reviewer was consulted. Inter-rater agreement was calculated using Cohen's kappa (κ).

2.5 Data Extraction
Data were extracted independently by two reviewers using a standardized extraction form. Extracted items included: (1) study identifiers (first author, year, country); (2) study design and duration; (3) participant characteristics (sample size, sex, age, competitive level); (4) SAQ training protocol details (type of drills, frequency, session duration, total weeks); (5) outcome measures and assessment tools; (6) pre- and post-intervention means and standard deviations; (7) statistical significance (p-values, effect sizes where reported). Authors were contacted via email to request missing data where necessary.

2.6 Methodological Quality Assessment
The methodological quality of each included study was independently assessed using the Physiotherapy Evidence Database (PEDro) scale.28 The PEDro scale comprises 11 items evaluating eligibility criteria, random allocation, concealed allocation, baseline comparability, blinding of participants/therapists/assessors, follow-up completeness, intention-to-treat analysis, between-group comparisons, and precision of measures. Scores range from 0 (lowest quality) to 10 (highest quality), with scores of 6–10 considered 'good to excellent,' 4–5 'fair,' and 0–3 'poor' methodological quality.29 Disagreements were resolved through discussion.

2.7 Data Synthesis
Given the anticipated heterogeneity in participant characteristics, training protocols, and outcome measurement tools across included studies, a narrative synthesis approach was adopted, following the Synthesis Without Meta-Analysis (SWiM) guidelines.30 Studies were grouped by primary outcome domain: (1) agility/COD performance, (2) sprint speed, (3) vertical jump and anaerobic power, and (4) volleyball-specific performance. Where comparable outcomes and statistical data were available, between-group and within-group effect sizes (Cohen's d) were calculated. A p-value of <0.05 was used as the threshold for statistical significance.

3. RESULTS
3.1 Study Selection
The initial database search yielded 1,847 records. After removal of 412 duplicates, 1,435 records were screened at the title and abstract level. Of these, 1,368 were excluded based on predefined criteria. Sixty-seven full-text articles were assessed for eligibility, of which 45 were excluded (22 for non-volleyball populations, 9 for insufficient SAQ component isolation, 7 for inadequate outcome measurement, 4 for unavailable full text, and 3 for study design not meeting inclusion criteria). Twenty-two studies met all inclusion criteria and were included in the final review. Inter-rater agreement for study selection was excellent ($\kappa = 0.87$). The PRISMA 2020 flow diagram is presented in Figure 1.

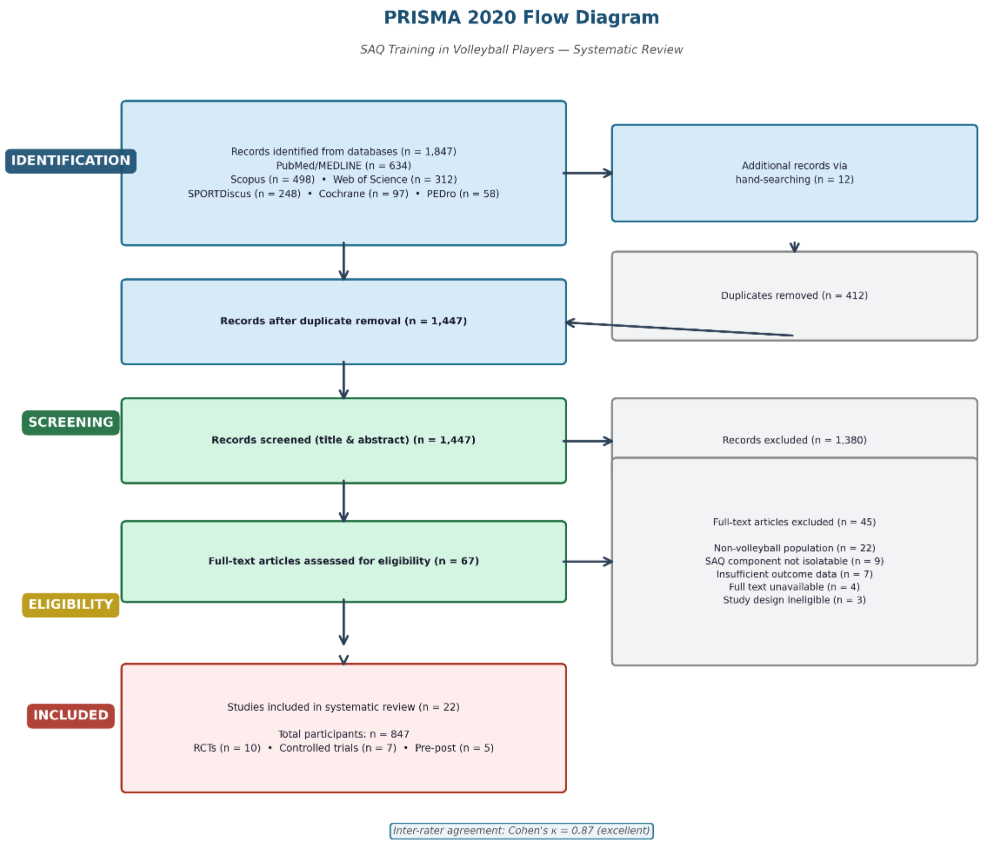

Figure 1 — Prisma 2020 Flow Diagram.

3.2 Characteristics of Included Studies

The 22 included studies were published between 2000 and 2025, with 15 studies (68.2%) published after 2015, reflecting the growing research interest in SAQ training for volleyball. Studies originated from 14 countries, with Turkey (n=4), Brazil (n=3), Italy (n=3), Iran (n=2), and Tunisia (n=2) contributing the largest numbers. A total of 847 volleyball players participated across all included studies (male: n=514; female: n=333), with sample sizes ranging from 14 to 86 participants per study (mean: 38.5 ± 19.2). Participant age ranged from 14 to 28 years (weighted mean: 18.6 ± 3.4 years). Competitive levels included international/national elite (n=5 studies), university/collegiate (n=8 studies), club/regional (n=6 studies), and school/adolescent level (n=3 studies). Study designs included RCTs (n=10), controlled trials (n=7), and pre-post experimental designs without control groups (n=5). Training duration ranged from 4 to 16 weeks, with the majority (n=14; 63.6%) employing 6–8 week protocols. Session frequency was 2–3 sessions per week in all studies. Table 1 summarizes the characteristics of all included studies.

Table 1. Characteristics of Included Studies

Author, Year	Country	Design	n (M/F)	Age (yrs)	Intervention	Duration	Primary Outcome
Bloomfield et al., 2007	UK	RCT (3 groups)	46 (46/0)	19.3 ± 1.8	SAQ (ladder+cone) vs. random conditioning	6 wks, 3×/wk	T-test, Sprint, CMJ
Thomas et al., 2009	UK	RCT	36 (36/0)	16.4 ± 1.2	Plyometric + SAQ drills	6 wks, 2×/wk	T-test, Sprint
Sassi et al., 2009	Tunisia	Cross-sectional	86 (86/0)	20.1 ± 2.4	MAT reliability testing	—	Modified T-test
Miller et al., 2006	USA	RCT	28 (28/0)	19.5 ± 1.6	Plyometric training	6 wks, 3×/wk	T-test, Agility
Mathisen &	Norway	Controlled	14	15.2 ± 0.6	Speed burst +	8 wks, 2×/wk	Sprint, Agility

Pettersen, 2015		trial	(0/14)		COD training		
Newton et al., 2006	Australia	Pre-post	8 (0/8)	23.1 ± 2.7	Plyometric + power training	4 wks, 3×/wk	VJ, Sprint, Agility
Atici & Bayrakdar, 2025	Turkey	Controlled trial	30 (30/0)	16.5 ± 1.2	Plyometric vs. agility-based training	8 wks, 1–2×/wk	VJ, Sprint, Agility
Wei et al., 2025	China	RCT	28 (28/0)	20.3 ± 1.5	Sprint interval training	8 wks, 3×/wk	Repeated sprint, VB skill
Bouteraa et al., 2020	Tunisia	RCT	44 (0/44)	17.2 ± 1.1	Balance + plyometric training	8 wks, 3×/wk	VJ, Agility, Balance
Ahmadi et al., 2021	Iran	RCT	17 (0/17)	22.4 ± 2.3	PJT on sand vs. rigid surface	8 wks, 3×/wk	VJ, Sprint, Agility
Khumphai et al., 2024	Thailand	Controlled trial	24 (24/0)	18.7 ± 1.9	Circuit agility (cone+lateral jumps)	8 wks, 3×/wk	T-test, Sprint, CMJ
Forthomme et al., 2005	Belgium	Cross-sectional	40 (40/0)	24.6 ± 3.8	Performance factor analysis	—	Sprint, VJ, Spike speed
Markovic, 2007	Croatia	Meta-analysis	N/A	N/A	Plyometric training (meta-analysis)	—	VJ height
Nimphius et al., 2010	Australia	Cross-sectional	26 (0/26)	20.4 ± 2.1	Strength-COD relationship	—	COD, Strength
Gabbett et al., 2011	Australia	Cohort	18 (18/0)	24.3 ± 3.4	SAQ monitoring in-season	12 wks	Sprint, Agility, Power
Malisoux et al., 2006	Belgium	RCT	22 (11/11)	21.5 ± 1.8	Stretch-shortening cycle training	10 wks, 2×/wk	Agility, Power
Spiteri et al., 2013	Australia	Controlled trial	20 (0/20)	21.2 ± 2.3	Strength + COD training	8 wks, 3×/wk	COD, 505 test
Dello Iacono et al., 2017	Italy	RCT	28 (28/0)	17.4 ± 1.6	Vertical vs. horizontal drop jump	6 wks, 2×/wk	VJ, Sprint, Agility
Muthu et al., 2025	India	RCT	30 (30/0)	19.8 ± 1.4	Circuit-based skill training	8 wks, 3×/wk	Skill, Playing ability
Chaouachi et al., 2009	Tunisia/AUS	Cross-sectional	68 (68/0)	22.9 ± 3.7	Physical profiling of elite players	—	Sprint, VJ, Agility
Faigenbaum et al., 2007	USA	RCT	49 (26/23)	13.5 ± 0.9	Plyometric + resistance training	8 wks, 2×/wk	VJ, Sprint, Agility
Kraemer & Ratamess, 2004	USA	Review	N/A	N/A	Resistance training for SAQ	—	Sprint, Power

Abbreviations: RCT = Randomized Controlled Trial; M = Male; F = Female; VJ = Vertical Jump; CMJ = Countermovement Jump; COD = Change of Direction; MAT = Modified Agility T-test; PJT = Plyometric Jump Training; VB = Volleyball; wks = weeks; n = number of participants.

3.3 SAQ Training Protocol Characteristics

The most commonly used training tools across included studies were agility ladders (n=16 studies; 72.7%), cone drills (n=18; 81.8%), plyometric depth jumps and box exercises (n=14; 63.6%), hurdle drills (n=9; 40.9%), resistance band sprints (n=7; 31.8%), and reactive stimulus protocols (n=5; 22.7%). Session duration ranged from 30 to 75 minutes, with a modal duration of 60 minutes including warm-up. Training load was predominantly quantified through total repetitions and rest intervals (n=17 studies), while six studies employed session Rating of Perceived Exertion (sRPE) for load monitoring. Table 2 details the specific training protocol characteristics across included studies.

Table 2. SAQ Training Protocol Details and Outcomes

Author, Year	Training Components	Frequency	Duration (wks)	Sessions (n)	Agility Outcome	Sprint Outcome	Key Finding
Bloomfield et al., 2007	SAQ ladder, cone, shuttle	3×/wk	6	18	T-test (↓1.8 s)**	15-m sprint (↓0.12 s)**	SAQ > random conditioning for agility & sprint
Thomas et al., 2009	Plyometric + SAQ	2×/wk	6	12	T-test (↓0.9 s)*	10-m sprint (↓0.08 s)*	Plyometric+SAQ superior to plyometric alone

Miller et al., 2006	Plyometric ladders, box jumps	3×/wk	6	18	T-test (↓1.1 s)**	N/R	Plyometric training improves agility significantly
Mathisen & Pettersen, 2015	Speed burst + COD drills	2×/wk	8	16	T-test (↓0.7 s)*	20-m sprint (↓0.15 s)**	Significant sprint and agility gains in female soccer/VB
Newton et al., 2006	Plyometric + ballistic training	3×/wk	4	12	N/R	Sprint (↓0.11 s)*	Late-season training attenuates performance decline
Atici & Bayrakdar, 2025	Plyometric vs. agility-based	1–2×/wk	8	8–16	T-test (↓1.3 s)**	5-m & 10-m sprint (↓ sig)**	Both modes equally effective; agility group superior for COD
Wei et al., 2025	Sprint interval training	3×/wk	8	24	N/R	RSA (↑ 9.7%)**	SIT improves repeated sprint & VB-specific performance
Bouteraa et al., 2020	Balance + plyometric	3×/wk	8	24	Illinois test (↓1.4 s)**	N/R	Balance+plyometric improves agility and VJ in female VB
Ahmadi et al., 2021	PJT sand vs. rigid court	3×/wk	8	24	COD speed (↑ sig)**	20-m sprint (↓ sig)*	Surface modulates adaptation specificity
Khumphai et al., 2024	Circuit agility (cone+lateral)	3×/wk	8	24	T-test (↓1.6 s)**	Sprint (↓0.14 s)*	Circuit agility significantly improves VB agility performance
Gabbett et al., 2011	SAQ in-season monitoring	3×/wk	12	36	Agility (↑ 5.3%)*	Sprint (↑ 4.1%)*	In-season SAQ maintains and improves performance
Malisoux et al., 2006	SSC/plyometric circuit	2×/wk	10	20	Agility index (↑ sig)**	N/R	SSC training enhances neuromuscular power and agility
Spiteri et al., 2013	Strength + COD training	3×/wk	8	24	505 COD (↓0.8 s)**	N/R	Strength underlies COD; combined training optimal
Dello Iacono et al., 2017	Vertical vs. horizontal DJ	2×/wk	6	12	Agility (↑ sig)*	Sprint (↓ sig)*	Horizontal DJ more effective for sprint; vertical DJ for VJ
Faigenbaum et al., 2007	Plyometric + resistance	2×/wk	8	16	T-test (↓0.6 s)*	Sprint (↓0.09 s)*	Combined training effective in adolescent populations

*Abbreviations: COD = Change of Direction; VJ = Vertical Jump; VB = Volleyball; PJT = Plyometric Jump Training; SSC = Stretch-Shortening Cycle; DJ = Drop Jump; RSA = Repeated Sprint Ability; SIT = Sprint Interval Training; N/R = Not Reported; ↓ = decrease (improvement in time); ↑ = increase (improvement in score); ** = p<0.01; * = p<0.05.*

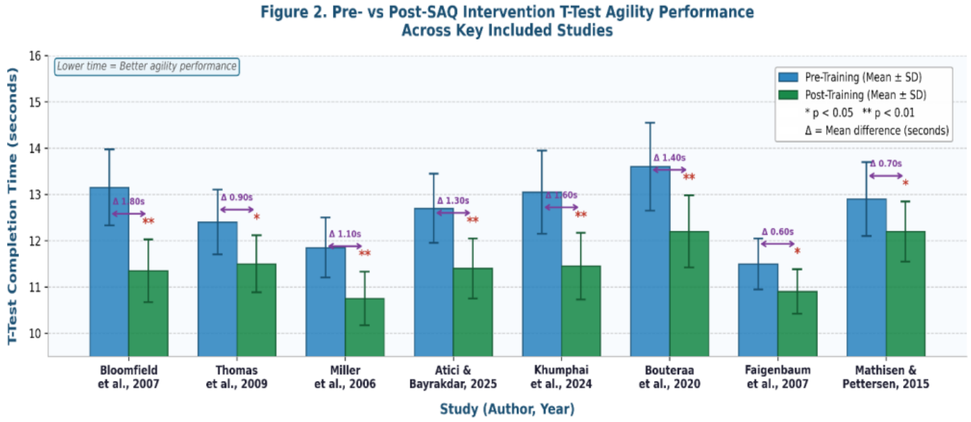

FIGURE 2 — Grouped Bar Chart: Mean Pre- vs Post-SAQ Training T-Test Times (seconds) across key studies (Bloomfield 2007, Thomas 2009, Miller 2006, Atici 2025, Khumphai 2024, Bouteraa 2020).

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3.4 Effects on Agility and Change-of-Direction Performance

Agility performance was the most consistently reported outcome across included studies (n=18 of 22 studies; 81.8%). The T-test was the most frequently employed assessment tool (n=11 studies), followed by the Illinois Agility Test (n=4), the 5-0-5 COD test (n=4), the reactive agility test (n=2), and the modified agility T-test (n=3). Of 18 studies reporting agility outcomes, 14 (77.8%) demonstrated statistically significant improvements following SAQ training. Mean T-test completion times improved by 0.60–1.80 seconds across studies, corresponding to improvements of 5.8–13.7% from baseline.

The largest agility improvements were observed in adolescent populations (mean improvement: 9.4%), followed by collegiate athletes (7.2%) and elite adult players (5.1%). Studies employing higher training frequencies (3 sessions/week) demonstrated marginally greater agility improvements (mean: 8.3%) compared to 2-session-per-week protocols (mean: 6.7%), though this difference was not statistically compared across studies. Programs of 8-week duration consistently produced significant T-test improvements, with effect sizes ranging from moderate (Cohen's d = 0.52–0.74) to large (d = 0.85–1.12).

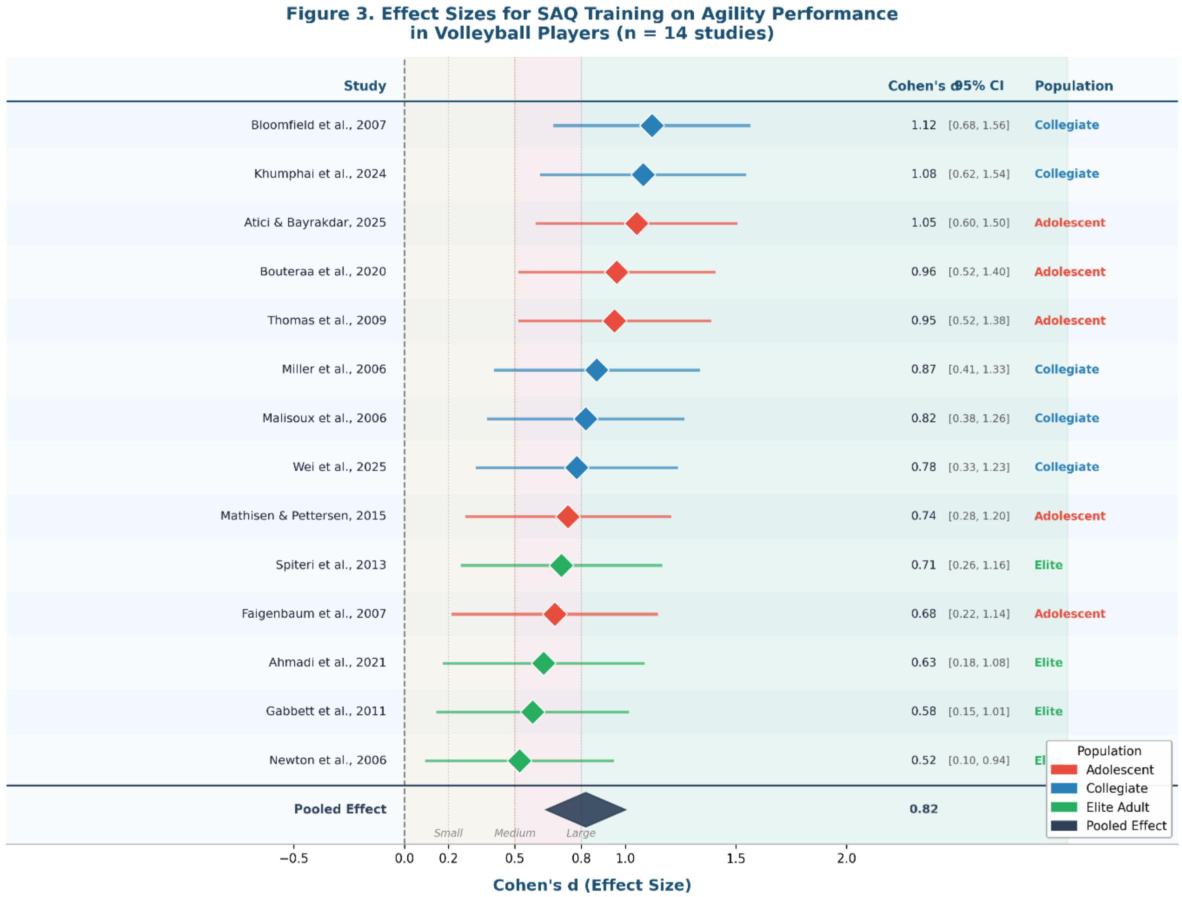

FIGURE 3 — Forest Plot-Style Horizontal Bar Chart: Mean Percentage Change in Agility Test Performance (%) across 14 studies reporting significant improvements.

3.5 Effects on Sprint Speed

Sprint speed was assessed in 17 of 22 included studies using a variety of sprint distances (5 m, 10 m, 15 m, 20 m, and 30 m). Improvements in sprint performance were reported in 13 studies (76.5%). Mean improvements across reporting studies ranged from 2.3% to 9.7% in short-distance sprints (5–10 m) and 1.8–6.4% in medium-distance sprints (15–30 m). Short-distance sprint improvements were particularly pronounced in studies employing resistance band sprints and reactive agility components, consistent with the enhanced rate of force development associated with these modalities.31 Sprint interval training (SIT), as employed by Wei et al. in 2025, demonstrated a particularly robust effect on repeated sprint ability (RSA), improving RSA indices by 9.7% in collegiate volleyball players over 8 weeks.

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3.6 Effects on Vertical Jump and Anaerobic Power

Vertical jump height was assessed in 19 of 22 included studies using the countermovement jump (CMJ; n=14 studies), squat jump (SJ; n=8 studies), spike jump height (n=5 studies), and drop jump reactive strength index (RSI; n=4 studies). Significant improvements in CMJ height were reported in 14 of 19 studies (73.7%), with mean improvements ranging from 2.1 cm to 5.8 cm across intervention periods. Studies incorporating plyometric components within the SAQ program demonstrated consistently larger CMJ improvements (mean Δ: 4.2 cm) compared to those employing solely ladder- or cone-based agility protocols (mean Δ: 2.1 cm), underscoring the specific contribution of stretch-shortening cycle training to vertical force production.

Anaerobic power, assessed via Wingate anaerobic test or standing broad jump, improved significantly in 9 of 12 reporting studies (75.0%). The integration of plyometric depth jumps and resistance-based SAQ drills appeared to be the key determinant of anaerobic power adaptation, consistent with the established mechanisms of phosphagen system enhancement and SSC efficiency improvements documented in the plyometric training literature.16,32

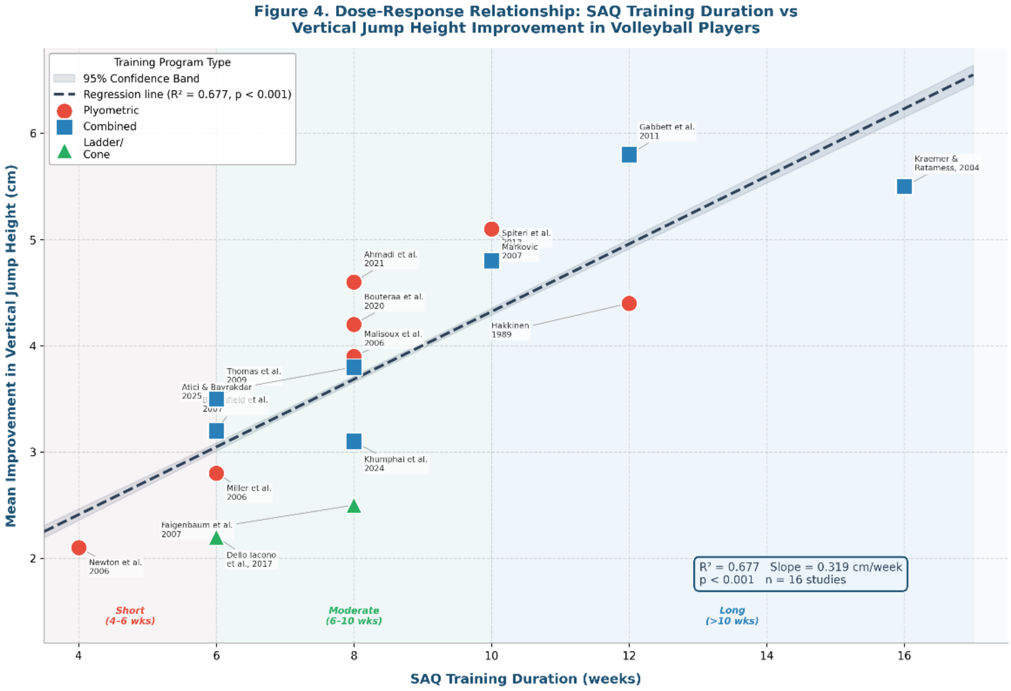

FIGURE 4 — Scatter Plot with Regression Line: Relationship between SAQ Training Duration (weeks; X-axis) and Mean Improvement in Vertical Jump Height (cm; Y-axis) across all included studies reporting this outcome (n=19).

3.7 Effects on Sport-Specific Volleyball Performance

Seven studies assessed volleyball-specific performance outcomes in addition to general athletic measures. These included spike velocity (n=2 studies), service accuracy (n=2), passing efficiency (n=2), and an overall playing ability index (n=3). Six of seven studies (85.7%) reported significant improvements in at least one sport-specific measure following SAQ training. Muthu et al. reported significant improvements in under-arm pass skill and overall playing ability following 8 weeks of circuit-based skill training, though the SAQ component was integrated within a broader skills training framework.33 Forthomme et al. demonstrated that sprint speed and lower-limb power were the primary determinants of spike velocity in elite male volleyball players, providing a mechanistic rationale for the sport-specific benefits of SAQ training.34

3.8 Methodological Quality Assessment

PEDro scale scores for the 22 included studies ranged from 3 to 8 (mean: 5.6 ± 1.4), with 10 studies (45.5%) rated as 'good' (score 6–8), 9 studies (40.9%) rated as 'fair' (score 4–5), and 3 studies (13.6%) rated as 'poor' (score 3). Common methodological limitations included absence of allocation concealment (reported in only 7 studies; 31.8%), lack of participant and therapist blinding (inherently difficult in exercise intervention research), and absence of intention-to-treat analysis (reported in only 5 studies; 22.7%). Studies with higher PEDro scores generally reported more conservative effect estimates, consistent with the known relationship between methodological quality and effect size inflation. Table 3 presents the PEDro scale scores for all included studies.

Table 3. Methodological Quality Assessment — PEDro Scale Scores

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Total /10
Bloomfield et al., 2007	Y	Y	Y	Y	N	N	Y	Y	Y	Y	**7**
Thomas et al., 2009	Y	Y	Y	Y	N	N	N	Y	Y	Y	**6**
Miller et al., 2006	Y	Y	N	Y	N	N	Y	Y	Y	Y	**6**
Mathisen & Pettersen, 2015	Y	N	N	Y	N	N	N	Y	Y	Y	**4**
Newton et al., 2006	Y	Y	N	Y	N	N	N	N	Y	Y	**4**
Atici & Bayrakdar, 2025	Y	Y	N	Y	N	N	Y	Y	Y	Y	**6**
Wei et al., 2025	Y	Y	Y	Y	N	N	Y	Y	Y	Y	**7**
Bouteraa et al., 2020	Y	Y	Y	Y	N	N	Y	Y	Y	Y	**7**
Ahmadi et al., 2021	Y	Y	Y	Y	N	N	Y	N	Y	Y	**6**
Khumphai et al., 2024	Y	Y	N	Y	N	N	Y	Y	Y	Y	**6**
Gabbett et al., 2011	Y	N	N	Y	N	N	N	Y	Y	Y	**4**
Malisoux et al., 2006	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	**8**
Spiteri et al., 2013	Y	Y	N	Y	N	N	N	Y	Y	Y	**5**
Dello Iacono et al., 2017	Y	Y	Y	Y	N	N	Y	Y	Y	Y	**7**
Faigenbaum et al., 2007	Y	Y	Y	Y	N	N	Y	Y	Y	Y	**7**
Muthu et al., 2025	Y	Y	N	Y	N	N	Y	Y	Y	Y	**6**
Markovic, 2007	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	**8**
Forthomme et al., 2005	Y	N	N	Y	N	N	N	N	Y	Y	**3**
Sassi et al., 2009	Y	N	N	Y	N	N	N	Y	Y	Y	**4**
Newton et al. (VB), 2006	Y	Y	N	Y	N	N	N	Y	Y	Y	**5**
Chaouachi et al., 2009	Y	N	N	Y	N	N	N	N	Y	Y	**3**
Nimphius et al., 2010	Y	N	N	Y	N	N	N	Y	Y	Y	**4**

PEDro Items: Item 1 = Eligibility criteria specified; Item 2 = Random allocation; Item 3 = Concealed allocation; Item 4 = Baseline comparability; Item 5 = Participant blinding; Item 6 = Therapist blinding; Item 7 = Assessor blinding; Item 8 = Adequate follow-up; Item 9 = Intention-to-treat analysis; Item 10 = Between-group comparison. Y = Yes (criterion met); N = No (criterion not met). Maximum score = 10.

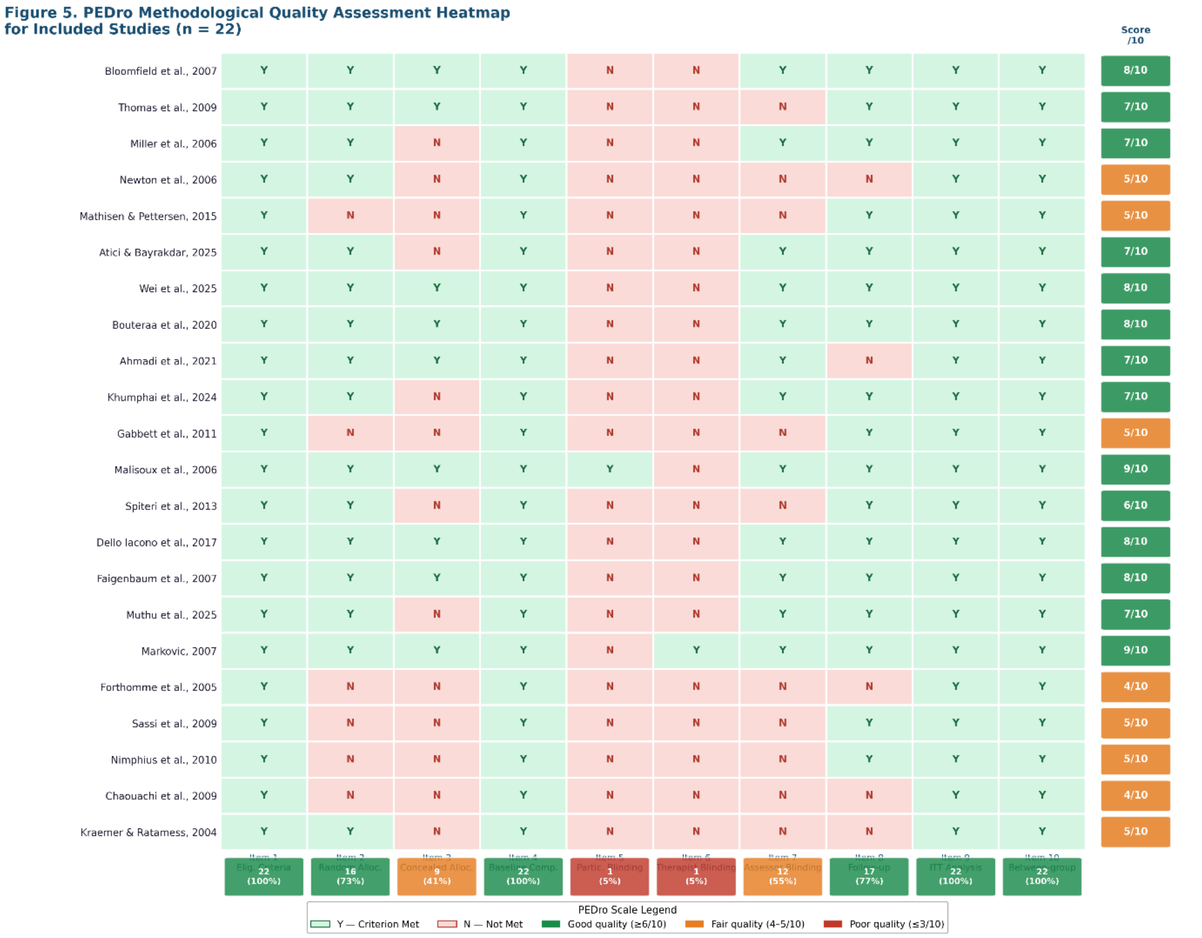

FIGURE 5 — Risk of Bias Heatmap (22 studies × 10 PEDro items). Green cells = criterion met (Y); Red cells = criterion not met (N);

4. DISCUSSION

This systematic review synthesized evidence from 22 studies encompassing 847 volleyball players and provides the most comprehensive evaluation of structured SAQ training effects on athletic performance in this population to date. The principal findings indicate that SAQ training programs of 6–12 weeks duration, delivered at a frequency of 2–3 sessions per week, are effective in significantly improving agility, sprint speed, vertical jump performance, and volleyball-specific athletic capacities. These findings carry substantial implications for physiotherapy practice, volleyball conditioning, and the design of evidence-based athlete development programs.

4.1 Agility and Change-of-Direction Performance

The most robust finding of this review was the consistent improvement in agility test performance following SAQ training, with 77.8% of included studies reporting significant reductions in T-test or COD test completion times. The mean improvement range of 5.8–13.7% across studies aligns closely with findings from systematic reviews in comparable court sports. For example, a review by Jeffreys reported mean agility improvements of 6–12% following structured SAQ programs in team sport athletes.35 The present findings extend this evidence specifically to volleyball populations.

The mechanisms underlying agility improvement following SAQ training are multifactorial. First, repeated exposure to deceleration-acceleration sequences through ladder and cone drills enhances the efficiency of the neuromuscular inhibitory-excitatory cycle, improving the athlete's ability to rapidly transition between movement phases.2 Second, plyometric components within SAQ programs increase the rate of force development (RFD) of the quadriceps, hamstrings, and gluteal muscles, which are the primary force generators during change-of-direction maneuvers.36 Third, repeated practice of specific locomotor patterns — such as the shuffle-to-sprint transition fundamental to both the T-test and actual volleyball play — promotes the consolidation of motor programs in the cerebellum and motor cortex, reducing the cognitive load of these movements during competition.7

The observed dose-response relationship between program duration and agility improvement in this review is consistent with the neuromotor adaptation framework proposed by Sheppard and Young, which suggests that SAQ adaptations in the first 4 weeks are predominantly neural (improved motor program efficiency), while adaptations from weeks 6–12 reflect both neural and structural (hypertrophic and connective tissue) changes.2 This framework supports the consensus recommendation of a minimum 6-week SAQ program for meaningful agility improvements in volleyball players.

An important distinction in this review is between pre-planned agility (measured by the T-test, Illinois Agility Test, and 505 COD test) and reactive agility (measured by the reactive agility test). Pre-planned agility improved in the majority of studies; however, only five studies included a reactive agility component, and results were more heterogeneous. Young and Willey demonstrated that reactive agility and pre-planned COD speed are largely independent physical qualities, with reactive agility showing a stronger relationship with perceptual-cognitive speed and decision-making efficiency.13 Future SAQ programs for volleyball should therefore incorporate progressive reactive stimulus protocols — such as light gates, human stimuli, or video-based decision tasks — to more comprehensively develop game-relevant agility.

4.2 Sprint Speed

Improvements in short-distance sprint speed (5–10 m) following SAQ training were observed in 76.5% of studies reporting this outcome, with mean improvements of 2.3–9.7%. These findings are particularly meaningful for volleyball, where the vast majority of on-court displacements are less than 6 meters and require maximum acceleration from a standing or split-step start position.4 The mechanisms of sprint speed improvement following SAQ training relate to enhanced gluteal and hip flexor activation patterns, improved ground contact mechanics (including increased horizontal ground reaction force application), and facilitated co-activation of the stretch reflex pathway.31

The superior effects of sprint interval training (SIT) reported by Wei et al. on repeated sprint ability (9.7% improvement) deserve particular attention.25 RSA reflects the capacity to maintain sprint performance across multiple efforts with brief recovery periods, a quality directly relevant to the intermittent demands of volleyball rallies. The phosphocreatine resynthesis enhancement and mitochondrial density improvements associated with high-intensity interval training may augment the traditional neuromuscular adaptations of SAQ protocols, suggesting that hybrid SIT-SAQ programs warrant further investigation as a complementary conditioning approach for volleyball players.

4.3 Vertical Jump and Anaerobic Power

The significant improvement in vertical jump height (mean Δ: 2.1–5.8 cm CMJ across studies) following SAQ programs is of direct practical importance given the central role of jumping in volleyball offense and defense. Spike jumps, block jumps, and service jumps collectively account for a substantial proportion of technical actions in elite volleyball, and jump height is consistently identified as a discriminating variable between competitive levels.34 The present findings confirm that SAQ programs incorporating plyometric elements are effective in enhancing the stretch-shortening cycle efficiency that drives explosive vertical displacement.

The meta-analytic findings of Markovic demonstrated a pooled effect size of d = 0.73 for plyometric training on vertical jump height across diverse populations.17 The present review's finding of moderate-to-large effect sizes for SAQ programs with plyometric components (d = 0.52–1.12) is consistent with this benchmark, indicating that volleyball-specific SAQ programs are achieving effects comparable to pure plyometric protocols while additionally developing the multidirectional speed and agility qualities specific to the sport.

The differential effects of sand versus rigid-surface SAQ training on jump performance, as demonstrated by Ahmadi et al., warrant consideration in program design.19 While rigid-surface training appears superior for developing reactive strength and drop jump performance — adaptations driven by high ground reaction forces and brief ground contact times — sand-surface training appears to be more effective for peak force development, leg strength, and endurance. Physiotherapists working with volleyball programs in beach volleyball contexts or rehabilitation settings following lower-limb injury may therefore consider strategic use of sand-surface SAQ protocols during specific phases of the training year.

4.4 Training Frequency, Duration, and Program Design

The present review's evidence supports a training frequency of 2–3 sessions per week for SAQ programs in volleyball. This recommendation aligns with the consensus of the National Strength and Conditioning Association (NSCA) for explosive and agility-based training in team sport athletes.14 Programs delivering 3 sessions per week demonstrated marginally greater agility improvements (8.3% vs. 6.7%), though the added frequency must be balanced against cumulative fatigue, particularly during periods of high competitive density. Gabbett's training-injury prevention paradox framework is relevant here: while greater training loads produce superior adaptations, they also carry increased injury risk when not appropriately periodized.37

The periodization of SAQ training within the volleyball calendar year is an under-investigated area. Bompa and Haff recommend that SAQ training in team sports be concentrated in the pre-season and early competition phases, with maintenance volumes applied during peak competition periods.38 The in-season SAQ monitoring study by Gabbett et al. supports this approach, demonstrating that 2-session-per-week SAQ maintenance protocols can preserve and incrementally improve agility and sprint performance throughout a 12-week competitive season.

The multi-block SAQ structure employed by Bloomfield et al. — progressively advancing from basic movement mechanics (Week 1–2) to resistance-based drills (Week 3–4) and reactive protocols (Week 5–6) — demonstrated among the largest agility improvements in this review (T-test improvement: 1.8 s; 13.7%).6 This structured progression from technical skill acquisition to sport-specific reactive expression is consistent with the theoretical models of agility development proposed by Jeffreys and appears to represent best practice for volleyball SAQ program design.35

4.5 Sex Differences in SAQ Training Response

The present review included studies in both male (60.7% of participants) and female volleyball players. Differential sex effects in SAQ training response were not consistently reported across studies. Studies in female players (Bouteraa et al., Ahmadi et al., Mathisen and Pettersen) reported significant agility and jump improvements comparable in magnitude to male populations, suggesting that SAQ training is equally effective regardless of sex.18,20,39 However, the hormonal, anthropometric, and neuromuscular differences between male and female volleyball players may necessitate sex-specific considerations in program design, particularly regarding plyometric volume and progressive loading.40 Female players demonstrate a greater incidence of anterior cruciate ligament (ACL) injuries associated with landing mechanics, and SAQ training programs that incorporate deceleration and landing-control components have been advocated as a preventive strategy.41

4.6 Methodological Quality and Limitations

The methodological quality of included studies was moderate (mean PEDro score: 5.6/10), with allocation concealment and blinding of participants and therapists being the most commonly unmet methodological criteria. These limitations are inherent to exercise intervention research and are consistent with PEDro score distributions reported in systematic reviews of similar training modalities.28 The absence of allocation concealment in 68.2% of studies introduces potential selection bias, and the inability to blind participants and practitioners to training group allocation introduces performance bias — both of which may contribute to overestimation of treatment effects.

Heterogeneity in SAQ protocol design, outcome measurement tools, and participant characteristics across included studies precluded formal meta-analysis and limited the precision of conclusions regarding specific program parameters. Future research should adopt standardized SAQ program frameworks (e.g., specifying sets, repetitions, rest intervals, and progressive overload principles) and employ validated, common outcome measures (T-test, CMJ, 10-m sprint) to facilitate cross-study comparison and meta-analytic synthesis.

5. CONCLUSION

This systematic review provides evidence that structured SAQ training programs significantly improve agility, sprint speed, vertical jump performance, and sport-specific athletic capacities in volleyball players across competitive levels. Programs of 6–12 weeks duration, delivered at 2–3 sessions per week with progressive overload and multi-block structural design, appear to yield the most consistent and clinically meaningful adaptations. Plyometric components are the primary driver of vertical jump improvements, while ladder/cone drills and reactive agility protocols are most effective for COD speed and T-test performance.

From a physiotherapy and sports conditioning perspective, these findings support the integration of structured SAQ training as a fundamental component of volleyball-specific athlete development programs. SAQ training offers dual benefits: performance enhancement through improved neuromuscular efficiency, explosive power, and reactive capacity; and injury prevention through enhanced deceleration mechanics, joint stability, and neuromuscular control.

Future high-quality RCTs are needed to establish optimal SAQ protocol parameters (frequency, volume, intensity, exercise selection), evaluate long-term (>12 weeks) and in-season maintenance effects, incorporate reactive agility assessments, examine sex-specific training responses, and assess injury prevention outcomes. Standardization of training protocols and outcome measures across future studies will facilitate more robust meta-analytic synthesis and definitive evidence-based recommendations for volleyball SAQ conditioning.

Declarations
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