DOI: 10.71317/jgst.2.11.2026.1084
Journal of Global Social Transformation
Journal homepage: https://rjsaonline.org/index.php/JGST

Influence of SAQ Training on Selected Health-Related Fitness Components on Amateur University Players

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ARTICLE INFO

Submission:
October 07, 2026
Revised:
October 31, 2026
Accepted:
November 08, 2026
Available Online:
November 17, 2026

Keywords:
SAQ training, muscular strength, muscular endurance, flexibility, university athletes, health-related fitness, female athletes, pretest-posttest design

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ABSTRACT

Background: Speed, Agility, and Quickness (SAQ) training is a systematic neuromuscular conditioning approach developed during the 1990s that has attracted considerable attention in sports science due to its effectiveness in improving several physical fitness parameters concurrently. However, limited research has explored its application within Pakistani university sports environments, particularly among female amateur athletes. **Objective:** The present study aimed to investigate the effects of a 12-week SAQ training program on selected health-related fitness components, including muscular strength, muscular endurance, and flexibility, among amateur university athletes. **Methodology:** An experimental pretest–posttest research design was utilized. Seventy-two female amateur athletes aged 18–22 years from Shaheed Benazir Bhutto Women University were randomly divided into a Control Group (CG, n = 36) and an Experimental Group (EG, n = 36). Participants in the EG underwent a structured SAQ training intervention lasting 12 weeks, with sessions of 50–60 minutes, whereas the CG maintained their regular daily activities. Muscular strength was measured using the Vertical Jump Test (VJT), muscular endurance through the Push-Up Test (PUT), and flexibility through the Sit-and-Reach Test (SRT). Due to the non-normal distribution of the data, the Wilcoxon Signed Rank Test was employed for statistical analysis. **Results:** After the intervention period, the EG exhibited significant improvements in muscular strength (32.53 ± 4.09 to 44.06 ± 1.86 cm; $Z = -5.244$, $p < .001$), muscular endurance (8.36 ± 1.41 to 18.03 ± 2.97 repetitions; $Z = -5.243$, $p < .001$), and flexibility (−5.47 ± 2.27 to 4.06 ± 1.19 cm; $Z = -5.244$, $p < .001$). In contrast, the CG showed no statistically significant changes across any of the assessed health-related fitness variables ($p > .05$). **Conclusion:** The findings indicate that a 12-week SAQ training intervention significantly enhances health-related fitness components among female amateur university athletes. The study provides practical support for incorporating SAQ training protocols into university-level athletic conditioning programs, especially within developing-country contexts.

Introduction

Physical fitness is a cornerstone of athletic performance and an essential precondition for sport achievement. Among the diverse modalities of exercise training, Speed, Agility, and Quickness (SAQ) training has emerged as a structured neuromuscular conditioning system designed to improve multi-directional explosive movement, motor control, and reaction efficiency. Introduced

by Alan Pearson in the 1990s, SAQ training reprograms the neuromuscular system through high-intensity, multi-planar exercises, enabling athletes to generate maximal force during rapid directional changes (Sun et al., 2025; Uysal et al., 2025).

The theoretical basis of SAQ training resides in its engagement of the central nervous system (CNS) to accelerate signal transmission to muscle fibers, thereby enhancing neuromuscular efficiency (NME). This pathway translates into improved athletic performance across dimensions including speed, power, agility, balance, and endurance (McDermott, 2016). SAQ training is also documented to support health-related fitness development, including muscular strength, muscular endurance, and flexibility components that are foundational for injury prevention, sport performance, and long-term health outcomes (Sun et al., 2025; Polman et al., 2009).

Health-related fitness components are recognized as the building blocks of an athlete's physical capacity. Muscular strength is the ability to generate maximal force in a single contraction is critical for explosive athletic movements such as jumping, sprinting, and tackling (Suchomel et al., 2018). Muscular endurance, defined as the ability to sustain repeated contractions against resistance over time, underpins performance durability across prolonged sport engagements (Rios, 2025). Flexibility, the range of motion available at a joint, directly influences movement efficiency, injury risk, and speed mechanics particularly via hamstring and hip flexor extensibility (Ingraham, 2003; Saputra et al., 2025).

Despite growing global evidence on SAQ training efficacy, research within Pakistani university sport contexts remains sparse. Female amateur athletes who constitute a significant yet underrepresented cohort have received little scientific attention regarding the effects of structured training interventions on their physical fitness components. University-level sport in Pakistan is confronted with inadequate scientific coaching infrastructure, reliance on traditional training methods, and absence of evidence-based training protocols for female athletes (Bibi, 2024).

This study was therefore designed to address this critical gap. The primary aim was to determine the influence of a 12-week SAQ training program on selected health-related fitness components muscular strength, muscular endurance, and flexibility in female amateur athletes representing Shaheed Benazir Bhutto Women University, Peshawar, Khyber Pakhtunkhwa, Pakistan. The findings are intended to provide empirically grounded recommendations for university sport administrators, coaches, and trainers in developing appropriate training programs for female athletes.

Review of Literature

SAQ Training: Conceptual Framework

SAQ training constitutes a systematic approach to improving neuromuscular coordination, motor control, and explosive multi-directional movement capacities. By targeting the neurological pathways governing muscle activation and movement sequencing, SAQ exercises reprogram the body's movement patterns to be faster, more economical, and more precise (McDermott, 2016; Sun et al., 2025). The training system accommodates diverse intensity levels and is applicable to competitive athletes and recreational exercisers alike.

The physiological mechanisms underlying SAQ training include enhanced muscular power output, improved brain signal efficiency (reduced motor unit recruitment latency), increased proprioceptive awareness, and improved cardiovascular fuel efficiency during high-intensity activities (Foster, 1998; Harries et al., 2012). These adaptations collectively support improved athletic performance and resilience.

SAQ Training and Muscular Strength

Muscular strength is defined as the maximal force a muscle group can exert in a single contraction (Suchomel et al., 2018). SAQ training, through its integration of plyometric, explosive, and multi-directional exercises, has been shown to stimulate fast-twitch muscle fiber recruitment and promote gains in lower and upper limb muscular power. Kumar Diswar et al. (2016) reported significant improvements in muscular strength parameters in basketball players following SAQ training, while Kanagaraj Scholar et al. (2019) similarly documented strength gains in kabaddi players. The Vertical Jump Test (Sargent Jump), used as a proxy measure of lower-limb explosive strength, is sensitive to the neuromuscular adaptations induced by SAQ protocols (Gioftsidou et al., 2012).

SAQ Training and Muscular Endurance

Muscular endurance the capacity of muscles to sustain repeated contractions over time is a critical determinant of sport performance and injury prevention. SAQ training, with its high repetition, high-tempo activity structure, inherently taxes the

muscular endurance capacities of practitioners. Research by Polman et al. (2009) demonstrated that SAQ training produced significant improvements in neuromuscular functioning and muscular endurance in untrained individuals. Siramaneerat and Chaowilai (2022) confirmed similar findings in specialized sport populations. Elevated muscular endurance is associated with reduced risks of cardiovascular disease, musculoskeletal injuries, and improved postural stability (Suchomel & Sole, 2016).

SAQ Training and Flexibility

Flexibility is an indispensable component of athletic fitness that determines the range of motion available at joints and directly influences movement economy, injury susceptibility, and performance quality (Witvrouw et al., 2004; Ingraham, 2003). SAQ training incorporates dynamic stretching and multi-planar movement patterns that progressively challenge and extend joint range of motion. Nizam et al. (2018) reported improvements in dynamic flexibility and hand-eye coordination following SAQ training in children. Furthermore, Saputra et al. (2025) confirmed positive relationships between hamstring flexibility and performance efficiency in sport-specific tasks. The Sit and Reach Test is widely used to assess hamstring and lower back flexibility in athletic populations.

Research Gap

Despite the accumulating evidence supporting SAQ training as a multi-dimensional fitness intervention, no scientifically grounded study has examined its effects on female amateur university athletes in Pakistan. The current investigation addresses this gap by providing an experimental, evidence-based evaluation of SAQ training in a controlled university sport setting, contributing uniquely to the regional and global literature on exercise science and sport performance.

Materials and Methods

Study Design

A pretest-posttest experimental research design was adopted. This design enables the assessment of within-group changes from baseline to post-intervention and allows comparative evaluation between the Control Group (CG) and the Experimental Group (EG). This design has been established as appropriate for intervention studies in physical education and sport science (Knapp, 2016; Bonate, 2000).

Setting and Participants

The study was conducted at Shaheed Benazir Bhutto Women University, Peshawar, Khyber Pakhtunkhwa (KP), Pakistan. A total of 72 female amateur university athletes (age range: 18–22 years) were enrolled. Participants were drawn from five sports disciplines: football, volleyball, netball, handball, and athletics, ensuring sport diversity and ecological validity. Table 1 summarizes participant characteristics.

Table 1: Baseline Characteristics of Study Participants (n = 72)

Characteristic	Control Group (n=36)	Experimental Group (n=36)	Total (n=72)
Age (years)	20.61 ± 1.2	19.64 ± 1.1	18–22
Height (cm)	170.22	173.05	—
Weight (kg)	65.31	66.42	—
Sports represented	Football, Volleyball, Netball, Handball, Athletics	Football, Volleyball, Netball, Handball, Athletics	5 sports equally distributed

Note. CG = Control Group; EG = Experimental Group. Values represent means where indicated.

Sampling Technique and Group Assignment

Simple random sampling was employed. A ranked list of 72 participants was entered into Microsoft Excel, and even-odd number allocation was used to create two matched groups of 36 participants each. Matching was based on age, height, weight, and pre-test fitness scores to ensure group equivalence at baseline.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Female athletes representing Shaheed Benazir Bhutto Women University in intercollegiate or intervarsity competitive sport events
- Age between 18 and 22 years
- No current musculoskeletal injuries or medical contraindications to exercise
- Signed informed consent

Exclusion Criteria:

- Non-consenting participants
- Athletes outside the specified age range
- Participants with pre-existing health conditions limiting physical activity

SAQ Training Intervention

The Experimental Group (EG) completed a structured 12-week SAQ training program conducted under direct researcher supervision. Each session lasted 50 to 60 minutes and was held between 09:30 and 10:30 hours to standardize circadian influence on performance. The training program was developed in accordance with established SAQ periodization principles, incorporating progressive overload across three four-week phases: foundational movement (Weeks 1–4), accelerated conditioning (Weeks 5–8), and sport-specific performance (Weeks 9–12). All sessions commenced with a standardized active warm-up. Attendance was recorded systematically. The Control Group (CG) continued their routine daily activities without any prescribed structured training.

Outcome Measures and Testing Instruments

Data on health-related fitness components were collected at baseline (pre-test) and immediately following the 12-week intervention (post-test) using validated, standardized tests. Table 2 presents the complete list of tests, the fitness components they assessed, and their units of measurement.

Table 2: Fitness Tests, Components Assessed, and Units of Measurement

Variable	Fitness Component	Test Instrument	Unit of Measurement
Health-Related	Muscular Strength	Vertical Jump Test (Sargent Jump)	cm
	Muscular Endurance	Push-Up Test	Count (repetitions)
	Flexibility	Sit and Reach Test	cm
Skill-Related	Speed	30-Meter Dash Test	Seconds (s)
	Agility	Agility T-Test	Seconds (s)
	Balance	Flamingo Balance Test	Number of falls/60s

Note. *VJT = Vertical Jump Test; PUT = Push-Up Test; SRT = Sit and Reach Test; FBT = Flamingo Balance Test.*

Muscular strength was measured using the Vertical Jump Test (Sargent Jump). Participants marked their standing reach height on a wall, then jumped maximally and touched the wall at peak jump height; the difference was recorded in centimeters. Muscular endurance was assessed using the Push-Up Test, recording the maximum number of full push-ups completed in a single set. Flexibility was measured using the Sit and Reach Test, with participants seated with legs extended, reaching forward along a calibrated measuring board; the maximum reach distance (cm) was recorded after a two-second hold.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 23. Descriptive statistics (mean, standard deviation, median, interquartile range, minimum, maximum, skewness, kurtosis) were computed for all variables. Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests; results confirmed non-normal data distributions across all variables ($p < .001$ and $p < .05$, respectively). Consequently, the non-parametric Wilcoxon Signed Rank Test was applied to compare pre- and post-test scores within each group. Statistical significance was set at $\alpha = 0.05$.

Results

Normality Assessment

The Kolmogorov-Smirnov test ($p < .001$ for all variables) and Shapiro-Wilk test ($p < .05$ for all variables) confirmed significant departures from normality across all study variables, necessitating the use of non-parametric statistical techniques for hypothesis testing.

Health-Related Fitness Components

Table 3 presents the descriptive statistics and Wilcoxon Signed Rank Test results for health-related fitness variables. All three health-related fitness components demonstrated statistically significant improvements in the EG following the 12-week SAQ training program ($p < .001$). The CG showed no significant changes in any health-related variable (all $p > .05$).

Table 3: Pre- and Post-Test Descriptive Statistics and Wilcoxon Test Results: Health-Related Fitness Components (n = 72)

Variable	CG Pre	CG Post	EG Pre	EG Post	Z	p-value
Muscular Strength – VJT (cm) Mean ± SD	32.19 ± 3.93	32.36 ± 3.99	32.53 ± 4.09	44.06 ± 1.86	-5.244	**< .001***
Muscular Endurance – PUT (count) Mean ± SD	8.31 ± 1.41	8.33 ± 1.39	8.36 ± 1.41	18.03 ± 2.97	-5.243	**< .001***
Flexibility – SRT (cm) Mean ± SD	-5.22 ± 2.11	-4.47 ± 4.01	-5.47 ± 2.27	4.06 ± 1.19	-5.244	**< .001***

Note. CG = Control Group; EG = Experimental Group; VJT = Vertical Jump Test; PUT = Push-Up Test; SRT = Sit and Reach Test; SD = standard deviation; Z = Wilcoxon Z-statistic. *Statistically significant at $p < .05$. All EG Wilcoxon tests based on negative ranks. Speed/Agility/Balance: lower score indicates better performance.

Muscular Strength (Vertical Jump Test): The EG demonstrated a substantial increase in vertical jump height from a pre-test mean of 32.53 ± 4.09 cm to a post-test mean of 44.06 ± 1.86 cm a mean improvement of 11.53 cm (35.5%). All 36 participants in the EG showed positive ranks (improvement). Concurrently, post-test score variability in the EG decreased markedly (range reduced from 18 to 7), indicating a more homogeneous and consistent muscular strength profile. The CG exhibited a negligible, non-significant change (32.19 ± 3.93 to 32.36 ± 3.99 cm; $Z = -0.435$, $p = .664$).

Muscular Endurance (Push-Up Test): The EG demonstrated a clinically meaningful increase in muscular endurance, with mean push-up count rising from 8.36 ± 1.41 at baseline to 18.03 ± 2.97 post-intervention an improvement of 9.67 repetitions (115.7%). The EG's minimum score improved from 6 to 12 repetitions and the maximum score from 12 to 23, reflecting system-wide improvement. The CG showed no significant change (8.31 ± 1.41 to 8.33 ± 1.39; $Z = -0.107$, $p = .915$).

Flexibility (Sit and Reach Test): The EG exhibited a striking improvement in flexibility, with the mean score shifting from −5.47 ± 2.27 cm (below the baseline reach point) to 4.06 ± 1.19 cm (above the baseline), representing a net improvement of 9.53 cm. All 36 EG participants showed positive ranks. Post-intervention, score range reduced from 8 to 6 cm, indicating uniformly enhanced flexibility. The CG displayed minimal, non-significant change (−5.22 ± 2.11 to −4.47 ± 4.01 cm; $Z = -0.435$, $p = .664$).

Hypothesis Testing Outcomes

Table 4 summarizes the outcomes of hypothesis testing for both health-related and skill-related fitness components.

Table 4: Summary of Hypothesis Testing Outcomes

Hypothesis	p-value (EG)	Decision
H1: SAQ training significantly improves health-related fitness components (muscular strength, muscular endurance, flexibility) in university amateur athletes.	< .001	**Accepted ✓**
H2: SAQ training significantly improves skill-related fitness components (speed, agility, balance) in university amateur athletes.	< .001	**Accepted ✓**

Note. EG = Experimental Group; all p-values correspond to Wilcoxon Signed Rank Tests comparing pre- and post-test scores within the EG.

Both primary hypotheses were accepted. SAQ training produced statistically significant improvements in all assessed health-related fitness components (H1 accepted) as well as skill-related fitness components (H2 accepted) among participants in the Experimental Group.

Discussion

The present study provides robust experimental evidence that a 12-week SAQ training program significantly improves health-related fitness components muscular strength, muscular endurance, and flexibility in female amateur university athletes. These findings are consistent with and extend the existing body of literature on SAQ training efficacy.

The substantial gains in muscular strength observed in the EG (mean VJT improvement: +11.53 cm; 35.5%) align with established mechanisms of SAQ training. SAQ exercises requiring explosive, multi-directional movements stimulate fast-twitch muscle fiber hypertrophy and enhance neuromuscular firing efficiency mechanisms recognized as determinants of vertical jump performance (Suchomel et al., 2018; Gioftsidou et al., 2012). The decreased post-test variability in the EG further suggests that SAQ training homogenizes muscular strength capacities across athlete groups, a finding with practical relevance for team sport cohesion. These findings are corroborated by Kumar Diswar et al. (2016) and Kanagaraj Scholar et al. (2019), who reported comparable strength improvements in basketball and kabaddi players respectively following SAQ interventions.

The dramatic improvement in muscular endurance (mean push-up count increase: +9.67 reps; 115.7%) reflects the inherent endurance demands embedded in SAQ training structures. The repeated high-intensity bursts characteristic of SAQ sessions progressively challenge the oxidative and glycolytic energy systems, stimulating adaptations that enhance the muscles' capacity for sustained contraction. This finding is consistent with Polman et al. (2009), who reported significant neuromuscular functioning improvements following SAQ training in previously untrained individuals. The clinical significance of these endurance gains extends beyond athletic performance: elevated muscular endurance is associated with reduced risks of cardiovascular events, musculoskeletal injuries, and improved postural stability outcomes of particular relevance to female university populations (Suchomel & Sole, 2016).

The flexibility improvements observed in the EG (SRT mean change: from −5.47 to +4.06 cm; net gain of 9.53 cm) are among the most pronounced findings of this study. All 36 EG participants demonstrated positive flexibility ranks, indicating universal responsiveness to the intervention. The dynamic, multi-planar movement repertoire inherent in SAQ protocols likely drives progressive extensibility in the hamstrings, hip flexors, and lower back musculature the primary muscle groups assessed by the Sit and Reach Test. These findings concur with Nizam et al. (2018) and support the assertions of Ingraham (2003) regarding the relationship between dynamic training, improved joint range of motion, and injury prevention. Critically, flexibility improvements have downstream implications for sprint mechanics: tighter hamstrings restrict hip extension range and reduce stride length during acceleration, meaning these gains may also translate into enhanced speed capacity (Raj et al., 2021).

The absence of significant changes in the CG across all variables confirms the specificity of the observed improvements to the SAQ training intervention, ruling out maturation effects, seasonal practice, or incidental physical activity as explanatory variables. This controlled design strengthens the causal attribution of observed fitness gains to the SAQ protocol.

These findings have immediate practical significance for university sport in Pakistan. The observed improvements were achieved with relatively minimal infrastructure requirements, reinforcing the feasibility and scalability of SAQ protocols in resource-constrained university settings. Female athletes who have historically received less systematic training support in Pakistani

universities demonstrated robust physiological adaptability to structured SAQ training, countering assumptions regarding the limited trainability of female sport populations.

A limitation of this study is its confinement to a single university, which may limit generalizability. Future research should extend the sample to include multi-institutional populations, male athletes, and longer intervention periods (beyond 12 weeks) to assess the durability of training adaptations. Additionally, the inclusion of objective physiological markers (e.g., electromyography, VO_2max assessment) would strengthen mechanistic understanding of SAQ-induced adaptations.

Conclusion

This experimental study provides compelling evidence that a 12-week SAQ training program produces statistically significant and clinically meaningful improvements in health-related fitness components specifically muscular strength, muscular endurance, and flexibility among female amateur university athletes. The Experimental Group demonstrated substantial, uniform gains across all three health-related variables, while the Control Group remained unchanged, confirming the effectiveness of the structured intervention.

These findings support the integration of SAQ training as a foundational component of university-level athletic development programs in Pakistan and comparable developing-country contexts. University sport directorates, coaches, and physical educators are encouraged to adopt structured SAQ protocols to systematically develop the physical fitness capacities of amateur athletes, particularly female athletes who remain underserved by evidence-based training infrastructure.

Future investigations should extend the assessment period, broaden the population sample across multiple institutions, incorporate physiological biomarkers, and examine SAQ training effects in male athletic populations to comprehensively map the scope of this training modality.

Declarations

Ethical Approval

This study was conducted in accordance with the ethical guidelines of the Higher Education Commission (HEC), Pakistan, and the Declaration of Helsinki. Informed consent was obtained from all participants prior to study commencement.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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