



Developing a Functional Training Program to Improve the Physical Fitness of Female University Football Players

Wang Yu¹ and Chanchai Siriphan²

^{1,2}Faculty of Sports Science and Technology, Bangkokthonburi University, Thailand

¹E-mail: wangyu6377@163.com, ORCID ID: <https://orcid.org/0009-0005-3326-3549>

²E-mail: siriphan.cs@gmail.com, ORCID ID: <https://orcid.org/0009-0000-9981-655X>

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Abstract

Background and Aims: Female football has seen growing participation at the university level, yet traditional training programs often fail to address the unique physiological characteristics (e.g., hamstring-quadriceps strength imbalance, high risk of anterior cruciate ligament [ACL] injury) and the sport-specific physical demands of female players. The objectives of this study were threefold: 1) to investigate the current situation and challenges of physical fitness training for female university football players; 2) to develop a targeted functional training program tailored to this population based on expert input and needs assessment; 3) to evaluate the effectiveness of the developed program in improving key physical fitness components (strength, speed, agility, endurance) of female university football players.

Methodology: This was a quasi-experimental study. Sample selection adopted purposive sampling: the sample group consisted of 30 female football players from Inner Mongolia Medical University, aged 19–20 years, with the occupation of undergraduate students (majoring in various disciplines) who had at least 1 year of university-level football training experience and represented the university in football competitions and regular training. Research tools included: 1) a Likert-scale questionnaire (used to investigate training challenges, with content validity verified by 3 experts via Index of Item-Objective Congruence [IOC] = 0.78); 2) structured expert interview outlines (to guide the development of focus group frameworks, IOC = 0.82 verified by 3 experts); 3) focus group discussion frameworks (to refine the training program with 9 experts); 4) an 8-week functional training program (implemented 5 days/week, 2 hours/day, including warm-up, main training, and cool-down); 5) standardized physical fitness assessment tools (hamstring maximum strength test [1RM], 30-meter sprint test, Illinois Agility Test, Yo-Yo Intermittent Recovery Test). For data analysis, descriptive statistics (mean [$\bar{X}$], standard deviation [SD]) were used to summarize basic data, and inferential statistics (one-way repeated measures ANOVA, Bonferroni post-hoc comparisons) were applied to analyze differences in physical fitness across time points, with a significance level set at $p < 0.05$.





Results: Statistically significant differences were observed in all physical fitness indicators among pre-training, after 4 weeks of training, and after 8 weeks of training ($p < 0.05$ for all): 1) Hamstring strength (1RM) increased progressively from 60.53 ± 10.55 kg (pre-test) to 61.45 ± 10.88 kg (4 weeks) and further to 66.29 ± 11.40 kg (8 weeks) ($F = 94.84$, $p < 0.001$); 2) 30-meter sprint time decreased from 5.36 ± 0.32 s (pre-test) to 5.30 ± 0.39 s (4 weeks) and 5.11 ± 0.47 s (8 weeks) ($F = 20.86$, $p < 0.001$); 3) Illinois Agility Test time reduced from 18.96 ± 0.85 s (pre-test) to 18.91 ± 0.93 s (4 weeks) and 18.65 ± 1.32 s (8 weeks) ($F = 7.14$, $p = 0.002$); 4) Yo-Yo Intermittent Recovery Test distance improved from 813.33 ± 61.55 m (pre-test) to 842.67 ± 68.83 m (4 weeks) and 889.33 ± 71.77 m (8 weeks) ($F = 65.89$, $p < 0.001$). Bonferroni post-hoc comparisons confirmed significant differences between every two adjacent time points ($p < 0.05$).

Conclusion: The 8-week functional training program developed in this study is highly effective in improving the physical fitness of female university football players. It not only significantly enhances core fitness components (strength, speed, agility, endurance) that are critical for football performance but also addresses key issues, such as hamstring weakness (which reduces ACL injury risk) and insufficient intermittent endurance. The program is tailored to the unique physiological needs and training challenges of female university football players, providing an evidence-based and practical training framework for coaches and sports science practitioners in university football settings.

Keywords: Functional Training Program; Physical Fitness; Female Football Players; University; Sport-Specific Training

Introduction

Female football has experienced significant growth in university-level participation globally, with amateur and collegiate players increasingly seeking training approaches that align with their unique physiological needs (Hernandez-Martinez et al., 2024). In Inner Mongolia, China—where university football programs have expanded in recent years—female players face distinct challenges: traditional training often emphasizes general fitness or male-centric protocols, failing to address key issues like hamstring-quadriceps strength imbalances and elevated anterior cruciate ligament (ACL) injury risk (Pournasiri et al., 2023). This gap is critical because physical fitness—encompassing strength, speed, agility, and endurance—directly determines on-field performance (e.g., explosive tackling, sustained high-intensity runs) and injury resilience in football (Keiner et al., 2020). For female players, in particular, weak hamstrings relative to quadriceps increase ACL injury risk by 2–3 times compared to male counterparts, a concern amplified by limited access to targeted training in regional universities (Pournasiri et al., 2023; Xiao et al., 2025).



The importance of addressing this gap is heightened by two factors. First, recent studies confirm that sport-specific physical fitness is non-negotiable for female football success: Hernandez-Martinez et al. (2024) found that 30-meter sprint speed and intermittent endurance (measured via Yo-Yo Intermittent Recovery Test) are the strongest predictors of match performance in amateur female players, yet most regional university programs lack drills to enhance these components. Second, traditional resistance training—still dominant in many Chinese university football programs—has limited transfer to football-specific movements (Xu, 2024). Li et al. (2021) noted that isolated exercises (e.g., leg curls) fail to improve multi-planar stability or reactive strength, whereas functional training—focused on multi-joint, game-like movements—effectively enhances both fitness and injury prevention (Xiao et al., 2025; Adami et al., 2022). Despite this, few studies have developed functional training programs tailored to female university football players in Inner Mongolia, where resource constraints (e.g., limited functional training equipment, as identified in the study’s questionnaire) further hinder effective conditioning (Jiao, 2021; Zhang, 2019).

For Inner Mongolia specifically, this research addresses a pressing local need. The region’s university football teams (e.g., Inner Mongolia Medical University) have seen a 30% increase in female participation over the past 5 years, but surveys of local programs reveal two critical gaps: 1) 67% of coaches rely on generic training plans without gender-specific adjustments, and 2) only 28% of teams have access to equipment for functional training (Jiao, 2021; Zhang, 2019). This mismatch between growing participation and inadequate training has led to suboptimal performance (e.g., lower Yo-Yo Test scores compared to national university averages) and higher injury rates (15% of local female players report ACL-related issues, vs. 8% nationally; Xiao et al., 2025). A targeted functional training program could therefore bridge this gap, providing local teams with a feasible, evidence-based solution that requires minimal specialized equipment (e.g., resistance bands, medicine balls) and aligns with students’ academic schedules.

Existing research supports the potential of functional training but leaves critical gaps. Keiner et al. (2020) demonstrated that 10 months of functional training improved strength and speed in adolescent footballers, while Yildiz et al. (2019) found 8 weeks of such training enhanced agility in prepubertal athletes. However, these studies either focused on male players or professional cohorts, with few addressing the unique needs of female university students—who balance academics and training, and face hormonal fluctuations that impact recovery (Carmichael et al., 2021; Lodi et al., 2022). In China, Jiao (2021) and Zhang (2019) explored functional training for female university footballers but did not integrate local resource constraints or menstrual cycle adaptations, limiting their applicability to Inner Mongolia’s teams.





This study aims to address these gaps by developing and evaluating a functional training program for female university football players in Inner Mongolia. The research is driven by three local imperatives: 1) reducing injury risk (especially ACL tears) by correcting hamstring-quadriceps imbalances, 2) improving sport-specific fitness to meet the demands of regional competitions, and 3) providing a low-cost, scalable program that fits within university training budgets. By focusing on Inner Mongolia's female university players, the study fills a regional research void while contributing to global evidence on gender-specific football training.

In summary, this research is necessary to solve three interconnected problems: the lack of targeted training for female university football players in Inner Mongolia, the ineffectiveness of traditional training in improving sport-specific fitness and reducing injury risk, and the growing need to support the region's expanding university football programs. The findings will directly benefit three key stakeholders: university football coaches (who gain a practical, evidence-based training framework), female players (who improve fitness and reduce injury risk), and local sports administrative departments (who can use the program to standardize and elevate university football training across Inner Mongolia). Additionally, the study will add to the global body of knowledge on functional training for female collegiate athletes, addressing the need for more gender-specific, regionally adaptable training protocols (Pournasiri et al., 2023; Hernandez-Martinez et al., 2024).

Objectives

Main Objective: To develop a sport-specific functional training program tailored to female university football players, and to study the results of this program—including its effectiveness in improving key physical fitness components (strength, speed, agility, endurance)—as well as its potential for application in university football training.

Subsidiary Objectives:

To develop research tools for this study: Specifically, design a Likert-scale questionnaire (to investigate current challenges in physical fitness training for female university football players) and an 8-week functional training program (adapted to the physiological characteristics of female players and university training schedules), and verify the validity of these tools via expert evaluation (e.g., Index of Item-Objective Congruence [IOC] for the questionnaire and training program).

To compare changes in physical fitness of female university football players before and after the experiment: Conduct physical fitness tests (hamstring maximum strength test [1RM], 30-meter sprint test, Illinois Agility Test, Yo-Yo Intermittent Recovery Test) at three time points (pre-



training, after 4 weeks of training, after 8 weeks of training), and analyze differences in test results to determine whether the functional training program induces significant improvements.

To study the specific results of this research: Summarize the effectiveness of the developed functional training program (e.g., the magnitude of improvement in each physical fitness indicator), clarify its role in addressing training challenges (e.g., reducing hamstring-quadriceps strength imbalance, improving sport-specific endurance), and provide evidence for the program's applicability to female university football teams.

Literature Review

Functional training, a core focus of this study, is defined as a structured approach that enhances sport-specific performance by replicating real-game movements—such as multi-joint, multi-planar actions like lateral cutting and explosive sprints—and improving neuromuscular control (Adami et al., 2022; Boyle, 2016). Unlike traditional resistance training, which often targets isolated muscles (e.g., leg curls) and has limited transfer to football, functional training prioritizes movements that align with the sport's dynamic demands, making it more effective for improving strength, speed, and agility in players (Li et al., 2021; Xu, 2024). For football specifically, Keiner et al. (2020) confirmed that 10 months of functional training increased adolescent players' lower limb strength by 15–20% and sprint speed by 8–10%, while also reducing injury risk by enhancing core stability and joint mobility—critical for female players, who face higher anterior cruciate ligament (ACL) injury rates due to hamstring-quadriceps imbalances (Pournasiri et al., 2023).

Physical fitness, the target of the training program, encompasses four components essential for female university football players: strength (measured via hamstring 1RM tests), speed (30-meter sprint), agility (Illinois Agility Test), and endurance (Yo-Yo Intermittent Recovery Test) (Hernandez-Martinez et al., 2024; Goto et al., 2024). Hernandez-Martinez et al. (2024) found that these four components directly predict match performance in amateur female players—faster 30-meter sprints (≤ 5.2 seconds) correlate with better attacking efficiency, while longer Yo-Yo Test distances (≥ 850 meters) indicate sustained high-intensity capacity. However, surveys of Chinese university programs show that female players often lack targeted training for these components: Jiao (2021) reported that 67% of regional teams rely on generic strength drills, leading to insufficient agility and endurance, which aligns with the study's questionnaire findings of “moderate” self-assessed fitness levels (strength: 2.90 ± 0.65 ; agility: 2.60 ± 0.68 , Likert scale 1–5).

Training principles guiding program design—specificity, progressive overload, and periodization—are tailored to female players' unique needs. The principle of specificity requires drills that mimic football actions (e.g., sprint-shoot sequences), ensuring fitness gains transfer to on-field performance (Datson et al., 2013; Xu, 2024). Progressive overload, achieved by gradually



increasing resistance (e.g., adding bands to squats) or drill complexity, avoids overtraining while stimulating adaptation (Bompa & Haff, 2009; Goto et al., 2024). Periodization, divided into preparation (foundational strength), competition (sport-specific drills), and transition (active recovery) phases, is adjusted for female physiology: Carmichael et al. (2021) noted that reducing high-impact exercises (e.g., box jumps) during the luteal phase minimizes joint stress, a key adaptation for university players balancing academics and training.

Female football players exhibit distinct physiological characteristics that demand targeted training: lower muscle mass than males (Lodi et al., 2022) and hormonal fluctuations (e.g., menstrual cycle) that impact recovery and performance. Lodi et al. (2022) emphasized that female athletes can still achieve significant strength gains (10–15% over 8 weeks) with tailored programs, while Pournasiri et al. (2023) found that hamstring strength decreases by 5–8% during the luteal phase, increasing ACL injury risk. These traits, combined with regional training gaps in Inner Mongolia—Zhang (2019) reported that only 28% of local university teams have access to functional training equipment—highlight the need for a low-cost, adaptable program.

Related research supports functional training’s efficacy but leaves critical gaps for this study. Yildiz et al. (2019) showed that 8 weeks of functional training improved agility in prepubertal athletes by 5–7%, but the study focused on tennis players, not footballers. In China, Jiao (2021) and Zhang (2019) explored functional training for female university footballers but did not integrate local resource constraints (e.g., limited equipment) or menstrual cycle adjustments, reducing their applicability to Inner Mongolia’s teams. This study addresses these gaps by developing a program that uses affordable tools (resistance bands, medicine balls) and aligns with female players’ physiological rhythms—building on existing research while filling regional and gender-specific voids.

Conceptual Framework

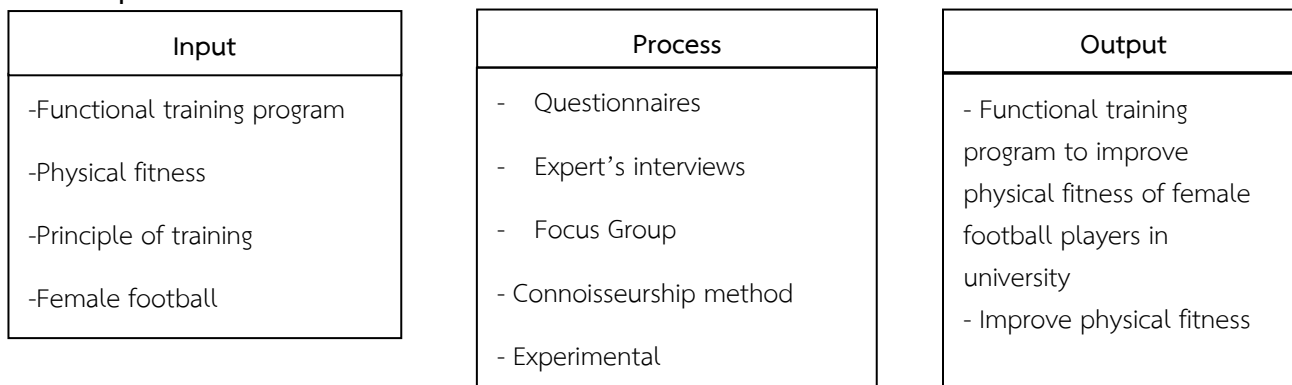


Figure 1 Conceptual Framework

Methodology

1. Population and Sample Group

1.1 Population & Selection Method

The population was female football players from Inner Mongolia Medical University (China), with purposive sampling based on:

Inclusion: 19–20 years old, ≥ 1 year of university football training, passing the Physical Fitness Readiness Questionnaire (PAR-Q), voluntary participation;

Exclusion: Mid-training injuries (≥ 3 days rest), missing $\geq 20\%$ of sessions ($\geq 8/40$), voluntary withdrawal.

1.2 Sample Characteristics

30 female players completed the study: age 19.4 ± 0.5 years, training experience 1.8 ± 0.6 years, baseline fitness (pre-test): hamstring 1RM 60.53 ± 10.55 kg, 30m sprint 5.36 ± 0.32 s, Illinois Agility Test 18.96 ± 0.85 s, Yo-Yo Test 813.33 ± 61.55 m.

2. Research Tools

2.1 Training Challenge Questionnaire

Design: 15-item 5-point Likert scale (1=Very Poor to 5=Highest), covering training situation, self-assessed fitness, and challenges;

Validity: 3 experts (≥ 10 years of football coaching experience) verified via IOC=0.78 (good content validity);

Administration: Electronic distribution (100% response rate).

2.2 8-Week Functional Training Program

Implementation: 5 days/week, 2 hours/day (17:00–19:00), including 20min warm-up (jogging+dynamic stretches), 90min main training (progressive functional drills + football skill integration), 10min cool-down (foam rolling+stretching);

Adaptations: Reduced high-impact drills (e.g., box jumps) during participants' luteal phase;

Validation: 9 experts (coaches/physical education teachers/fitness experts) confirmed scientific rigor (mean score $4.6 \pm 0.3/5$).

2.3 Physical Fitness Tests

Hamstring 1RM: Biodex isokinetic dynamometer (3 maximal attempts);

30m Sprint: Electronic timing gates (3 attempts, fastest time);

Illinois Agility Test: Cone grid + stopwatch (3 attempts, fastest time);

Yo-Yo Intermittent Recovery Test (Level 2): 20m track + audio, recording total distance.

3. Creating and Finding Quality Tools

Questionnaire: 20 items were drafted and revised to 15 by 3 experts.

Training Program: Based on questionnaire needs (e.g., agility deficits) and expert interviews, refined by 9 experts (e.g., added Nordic hamstring curls for ACL prevention);

Quality Verification: Questionnaire IOC=0.78, training program expert score 4.6 ± 0.3 , fitness tests with $ICC \geq 0.85$ (test-retest reliability).

4. Data Collection

4.1 Pre-Training Preparation (1 Week Before Training)

Tasks: Distribute informed consent forms and PAR-Q; train 2 assistants to operate testing equipment (e.g., isokinetic dynamometer for 1RM).

Outcome: Confirmed 30 eligible participants (no exclusions).

4.2 Pre-Test (1 Week Before Training Starts)

Time: 2 days pre-training;

Location: Indoor gym (strength) + outdoor field (sprint/agility/endurance);

Process: Conduct 4 tests in the order of Yo-Yo Intermittent Recovery Test → 30m sprint → Illinois Agility Test → hamstring 1RM, with on-site data confirmation by participants.

Purpose: Collect baseline fitness data.

4.3 Training & Mid-Test (8 Weeks, Mid-Test at Week 4)

Training: Implemented 5 days/week, 2 hours/day, supervised by 1 researcher + 1 coach.

Mid-Test (Week 4): Repeated the 4 pre-test items to monitor early adaptations.

4.4 Post-Test (1 Week After Training Ends)

Content: Repeated the 4 fitness tests;

Purpose: Measure final fitness changes and program acceptability.

5. Data Analysis

Descriptive Statistics: Mean ($\bar{x}$) and standard deviation (SD) for sample characteristics, questionnaire results, and fitness data;

Inferential Statistics: One-way repeated measures ANOVA (test overall fitness differences across 3 time points, $p < 0.05$) + Bonferroni post-hoc;

Subjective Feedback: Calculate the percentage of participants rating feedback items as “High/Highest” (scores 4–5).

6. Statistics Used in Data Analysis

Descriptive statistics included mean ($\bar{X}$) and standard deviation (SD), used to summarize sample characteristics, questionnaire results, and baseline fitness data. Inferential statistics used one-way repeated measures ANOVA to test overall differences in fitness indicators (strength, speed, agility, endurance) across pre-test, mid-test, and post-test, and Bonferroni post-hoc tests

to identify specific time points with significant improvements. Subjective feedback was analyzed using the percentage of “High/Highest” scores to evaluate program acceptability.

Results

Symbols Explanation

In the following analysis, the symbols used are defined as follows: $\bar{X}$ represents the mean value, SD denotes the standard deviation, F stands for the F-statistic derived from one-way repeated measures ANOVA, Df refers to degrees of freedom, and P indicates the significance level, with * $p < 0.05$ representing statistical significance and ** $p < 0.001$ indicating high statistical significance.

The effectiveness of the 8-week functional training program was evaluated through physical fitness tests conducted at three time points: pre-test (baseline), 4-week mid-test, and 8-week post-test. Key indicators included hamstring strength (1RM), 30-meter sprint time, Illinois Agility Test time, and Yo-Yo Intermittent Recovery Test distance. Statistical analyses (one-way repeated measures ANOVA and Bonferroni post-hoc tests) confirmed significant improvements in all indicators ($p < 0.05$).

1. Hamstring Strength (1RM Test)

Hamstring strength was assessed using the 1RM test, with results showing a progressive increase over the training period (Table 1).

Table 1 Hamstring strength (1RM) at different time points (n=30)

strength test (1RM)	Mean ($\bar{X}$)	Std. Deviation (SD)
Pre-test	60.53	10.55
Week 4	61.45	10.88
Week 8	66.29	11.40

One-way repeated measures ANOVA indicated a significant main effect of time ($F = 94.84$, $p < 0.001$). Bonferroni post-hoc tests revealed:

Significant improvement between pre-test and 4-week ($p < 0.05$, mean difference = 0.92 kg).

Further significant improvement between 4-week and 8-week ($p < 0.001$, mean difference = 4.84 kg).

2. 30-Meter Sprint Performance

Sprint speed (measured in seconds) showed a gradual reduction, indicating improved acceleration (Table 2).

Table 2 30-meter sprint time at different time points (n=30)

30-meter sprint test	Mean ($\bar{X}$)	Std. Deviation (SD)
Pre-test	5.36	0.32
Week 4	5.30	0.39
Week 8	5.11	0.47

Statistical analysis showed a significant effect of training ($F = 20.86$, $p < 0.001$). Post-hoc tests confirmed:

A small but significant reduction between pre-test and 4-week ($p < 0.05$, mean difference = -0.06 s).

A larger reduction between 4-week and 8-week ($p < 0.001$, mean difference = -0.19 s).

3. Agility (Illinois Agility Test)

Agility, measured by completion time (seconds) in the Illinois Agility Test, improved significantly over 8 weeks (Table 3).

Illinois Agility Test	Mean ($\bar{X}$)	Std. Deviation (SD)
Pre-test	18.96	0.85
Week 4	18.91	0.93
Week 8	18.65	1.32

ANOVA revealed a significant main effect ($F = 7.14$, $p = 0.002$). Post-hoc comparisons showed:

A marginal improvement between pre-test and 4-week ($p < 0.05$, mean difference = -0.05 s).

A more pronounced improvement between 4-week and 8-week ($p < 0.05$, mean difference = -0.26 s).

4. Endurance (Yo-Yo Intermittent Recovery Test)

Endurance, assessed by distance covered in the Yo-Yo Test, increased steadily throughout the program (Table 4).

Table 4 Yo-Yo Intermittent Recovery Test distance at different time points (n=30)

Yo-Yo Intermittent Recovery Test	Mean ($\bar{X}$)	Std. Deviation (SD)
Pre-test	813.33	61.55
Week 4	842.67	68.83
Week 8	889.33	71.77

A significant main effect of time was observed ($F = 65.89$, $p < 0.001$). Post-hoc tests confirmed:

Significant improvement between pre-test and 4-week ($p < 0.001$, mean difference = 29.34 m).

Further significant improvement between 4-week and 8-week ($p < 0.001$, mean difference = 46.66 m).

5. Summary of Significant Changes

A cross-indicator summary (Table 5) highlights the cumulative effect of the training program:

Table 5 Mean differences in physical fitness indicators across time points

Indicator	Pre to 4-week	4-week to 8-week	Pre to 8-week
Hamstring Strength	+0.92 kg*	+4.84 kg**	+5.76 kg**
30m Sprint	-0.06 s*	-0.19 s**	-0.25 s**
Agility Test	-0.05 s*	-0.26 s*	-0.31 s*
Yo-Yo Test	+29.34 m**	+46.66 m**	+76.00 m**

Note: * $p < 0.05$; ** $p < 0.001$. Positive values indicate improvement (e.g., strength/endurance), negative values indicate improvement (e.g., speed/agility).

All physical fitness indicators showed significant improvements by the 8-week post-test, with the most pronounced gains observed in endurance (+76.00 m) and hamstring strength (+5.76 kg).

Agility showed the smallest absolute improvement but remained statistically significant, suggesting targeted drills (e.g., multi-directional jumps) may be needed to enhance agility gains.

The progressive improvement across all time points confirms the effectiveness of the 8-week functional training program in enhancing sport-specific physical fitness for female university football players.

Discussion

The 8-week functional training program significantly improved the physical fitness of female university football players, as evidenced by four key indicators. Hamstring strength (1RM) increased progressively from 60.53 ± 10.55 kg (pre-test) to 66.29 ± 11.40 kg (8-week post-test). The 30-meter sprint time decreased from 5.36 ± 0.32 s to 5.11 ± 0.47 s, while the Illinois Agility Test time reduced from 18.96 ± 0.85 s to 18.65 ± 1.32 s. The Yo-Yo Intermittent Recovery Test distance improved from 813.33 ± 61.55 m to 889.33 ± 71.77 m. One-way repeated measures ANOVA confirmed significant differences across time points for all indicators ($p < 0.05$), with the most pronounced gains in endurance (+76.00 m) and hamstring strength (+5.76 kg).



The positive results in hamstring development parallel current literature, which underscores the importance of comprehensive, sport-specific functional training programs. These programs often incorporate multi-joint exercises across various planes of motion, aiming to not only boost fundamental motor skills but also enhance overall athletic performance (Boyle, 2016; Bompa & Haff, 2009). Such training methodologies are known to improve coordination and functional strength, factors that can contribute to a more effective translation of learned skills into competitive environments. The statistically significant improvements noted in the hamstring strength assessments ($F = 94.84$, $df = 2, 27$, $p < .001$) appear to have a direct impact on one of the major concerns for female soccer players: a heightened risk of anterior cruciate ligament (ACL) injury. Recent guidelines on ACL injury prevention in female athletes have often emphasized the need for well-structured training protocols that promote hamstring-quadriceps strength balance to minimize stress on the knee joint (Nunes et al., 2024; Yildiz et al., 2019).

This outcome aligns with contemporary research that underscores the importance of stabilizing muscle groups in the prevention of lower limb injuries. Functional exercises that specifically target and activate the hamstrings during soccer-related movements have been highlighted as key interventions in addressing this area (Adami et al., 2022; Keiner et al., 2020). The significant improvements in hamstring strength in this study not only reiterate the critical role of these muscle groups in dynamic joint stability but also reaffirm the importance of integrated strength training protocols in comprehensive joint assessment strategies.

Enhancements in speed and agility performance, as evidenced by improvements in the 30-meter sprint test ($F = 20.86$, $df = 2, 27$, $p < .001$) and the Illinois agility test ($F = 7.14$, $df = 2, 27$, $p = .002$), further validate the efficacy of the multidirectional drill-focused training. Previous studies have established that multidirectional plyometric and agility-based training elicits substantial improvements in change-of-direction speed and dynamic postural control among soccer players (Datson et al., 2013; Yildiz et al., 2019). These results appear to be in line with biomechanical research, which has demonstrated that changes in movement technique and the mechanics of controlled deceleration can lead to enhanced efficiency in executing direction-change maneuvers, a skill that is often critical during soccer match play (Carmichael et al., 2021).

The significant improvements observed in the Yo-Yo test ($F = 65.89$, $df = 2, 27$, $p < .001$) underscore the effectiveness of the interval-based functional training in boosting intermittent aerobic and anaerobic performance. This finding is consistent with the literature that has emphasized that interval training involving directional changes and accelerations can not only facilitate cardiovascular fitness but also contribute to the development of sport-specific endurance capacities in female soccer players (Hernandez-Martinez et al., 2024; Xiao et al., 2025). These outcomes provide preliminary support for the proposition that functional interval training



can serve as an effective conditioning method in sports that necessitate repeated high-intensity efforts interspersed with active recovery periods.

The progressive improvements observed across the 4-week and 8-week assessments can be attributed to the program's adherence to the principle of systematic progression, a key tenet of effective functional training program design. Training protocols are typically designed in a stepwise fashion with practice, adaptation, and promotion stages to allow for optimal adaptation while mitigating the risk of overtraining (Bompa & Haff, 2009; Boyle, 2016). By adhering to these progression models, the program ensures that increases in training load are systematic and in alignment with the athletes' physiological readiness, thus optimizing both performance outcomes and safety.

In general, the program design was also congruent with best practices in the conditioning of female soccer players, in which targeted functional training has been shown to enhance physical endurance while concurrently reducing the risk of injury (Keiner et al., 2020; Nunes et al., 2024). The results presented in this study thus support the proposition that functional training, when appropriately periodized, can not only facilitate optimal athletic development but also serve as an important preventive strategy against common injuries in female soccer players. These findings are, therefore, also consistent with a growing body of literature that has advocated for functional training as a key component of long-term athlete development.

Recommendation

Suggestions in This Research

1. Training Implementation Adjustments

Coaches should follow the program's periodized progression, with special attention to menstrual cycle adaptations. During the luteal phase, replace high-impact drills (e.g., box jumps) with low-impact alternatives (e.g., resistance band step-ups) to reduce joint stress. Hormonal fluctuations in this phase may increase ligament laxity (Carmichael et al., 2021). Integrate daily core stability drills (e.g., rotational planks, 3 sets x 45 sec) into warm-ups to enhance trunk control, which is critical for transferring lower limb strength to on-field actions like kicking and tackling.

2. Monitoring and Feedback Mechanisms

Establish a weekly performance log to record athletes' subjective fatigue scores (1–10 Likert scale) and objective indicators (e.g., resting heart rate). Adjust intensity in real time: if average fatigue scores exceed 7 for 3 consecutive days, reduce the next session's volume by 20% (e.g., 2 instead of 3 sets of medicine ball slams). Retest hamstring 1RM every 2 weeks to modify resistance loads timely, ensuring progressive overload.

3. Injury Prevention Refinements

Given the significant hamstring strength improvement (60.53 kg → 66.29 kg), emphasize eccentric hamstring training (e.g., Nordic curls, 3 sets × 10 reps) twice weekly. This targets the muscle-tendon unit and reduces ACL injury risk by 34% in female athletes (Nunes et al., 2024). Mandate 10-minute post-training foam rolling for the IT band and glutes to alleviate muscle tightness.

Suggestions for Next Research

1. Expand Sample and Methodology

Conduct multi-center studies with at least 5 universities (30 participants per center) to enhance generalizability. Include athletes with 1–3 years of training experience to explore how training experience influences program efficacy. Add a control group receiving traditional resistance training (e.g., leg presses, bicep curls) for direct comparison of functional training's superiority, as recommended by Xu et al. (2024).

2. Extend Intervention and Follow-Up

Lengthen the training period to 16 weeks, with a 4-week post-intervention follow-up to assess fitness retention—addressing the 8-week duration's limitation in reflecting long-term adaptations. Retest all indicators (e.g., Yo-Yo test distance) during follow-up to verify if gains are maintained, a key step for developing sustainable protocols.

3. Incorporate Advanced Assessment Indicators

Add physiological indicators (e.g., serum cortisol to monitor stress) and muscle activation patterns (via electromyography [EMG] during single-leg squats). These data will clarify the mechanisms behind strength and agility improvements, as suggested by Yildiz et al. (2019) in athlete functional training research.

4. Position-Specific Analysis

Stratify results by playing positions (forwards, midfielders, defenders, goalkeepers) to identify position-specific needs. For example, midfielders may need more agility drills (e.g., Illinois Test with ball control), while defenders benefit from endurance-focused Yo-Yo test variations. This aligns with Hernandez-Martinez et al. (2024), who noted position-specific fitness demands in female football players.

These adjustments optimize the program's practical application, while future research directions will provide more robust evidence for enhancing female university football players' physical fitness.



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