Movement-based approach in strength training weekly periodization for women's football: linking the gym with the pitch

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Headline

Football combines intermittent efforts like speed changes, direction shifts, agility, and endurance. On-field periodization typically splits high-demand loads into two cycles: intensive and extensive. Intensive sessions use small-to-medium drills to focus on acceleration and deceleration. Extensive sessions utilize large-sized drills to prioritize maximum velocity and high-speed running exposure. This movement-based approach synchronizes field demands with gym-based reinforcement to optimize athletic performance and reduce injury risks for elite female players.

Aim

The primary objective of this research is to develop a specialized, movement-based strength training framework tailored to the high-intensity intermittent demands of elite women's football. While traditional strength programs often focus on isolated muscle hypertrophy, this project aims to enhance the biomechanical efficiency of repetitive, high-demand actions such as acceleration, deceleration, and multidirectional agility (1).

Furthermore, the study seeks to address the "gender gap" in sports science by integrating physiological adaptations specific to female athletes. Given that female players exhibit different neuromuscular control patterns and a higher predisposition to non-contact ACL injuries compared to their male counterparts, a core aim is to implement injury-mitigation strategies through neuromuscular loading and landing stabilization (2), as well as improving the efficiency on change of direction and deceleration mechanics (3,4). By bridging the gap between gym-based force production and on-field tactical execution, this system intends to optimize performance while ensuring long-term athletic durability.

Design of the study

This study utilizes a methodological framework grounded in current sports science literature and expert consensus to design a movement-specific periodization protocol. The design process centers on a "transfer-of-training" model, where gym exercises are selected based on their kinetic and kinematic similarity to football-specific movements. The program prioritizes specific biomechanical patterns, including linear acceleration, curvilinear sprinting, sidesteps and crossover change of direction, deceleration and maximum velocity mechanics.

Special emphasis is placed on the mechanics of deceleration and change-of-direction (COD), incorporating movements such as shuffle side-steps, crossover steps, and backpedals to improve reactive strength and eccentric control (3). To account for the unique anatomical considerations of the female athletes, the protocol includes unilateral landing tasks across multiple planes of motion to enhance joint stability (5). The resulting weekly periodization model synchronizes gym-based loads with the "Intensive" and "Extensive" cycles of pitch-based sessions, creating a unified physiological stimulus that respects the recovery needs of the female athlete.

The design follows a "Movement-Based" philosophy, which prioritizes the mechanical quality of the exercise over mere metabolic load. The framework is built upon the synthesis of current scientific literature regarding:

1. **Force-Velocity Profiling:** Utilizing VBT to ensure relative load precision.
2. **Tissue Resilience:** Implementing heavy isometrics for tendon health.
3. **Specific Periodization:** Aligning gym output with the tactical "Match Day" (MD) cycle.
4. **Movement mechanics training:** optimizing biomechanical models on specific football multiarticular actions

Biomechanical models – Addressing these patterns through strength training

The linear & curvilinear acceleration

The optimization of sprint performance in female football players necessitates a deep understanding of Force-Velocity ($\mathbf{F}-\mathbf{V}$) profiling, particularly during the initial acceleration phase. As illustrated in the figure, female athletes frequently exhibit shorter distances covered during acceleration (ACC), a phase heavily dependent on the prevalence of horizontal force application (6). While data often shows that women possess a high theoretical maximal force $\mathbf{F}_0$ relative to their maximal velocity $\mathbf{V}_0$ they encounter significant difficulties in maintaining this initial force production throughout the transition phase. This is compounded by a lower force-to-time (F/t) contact production ratio, suggesting that while the capacity for force exists, the rate at which that force is applied during the brief ground contact times of a sprint is a primary performance bottleneck (7).

Central to this mechanical characteristic is the challenge of pelvic control. Within the female athlete linear sprint mechanics, a critical need for managing pelvic anteversion (anterior tilt) can be identified; however, achieving the necessary trunk stiffness through retroversor muscle activity is often hindered by quadriceps dominance, a common neuromuscular trait in female athletes (8). This dominance shifts the load away from the gluteal and hamstring complexes, which are vital for horizontal propulsion, and places it on the anterior chain, leading to energy leaks at the core (9). Furthermore, the slide identifies reduced ankle dorsiflexion as a significant "handicap."

Insufficient dorsiflexion range of motion prevents the athlete from achieving the optimal "attack angle" during ground contact, thereby reducing the lower limb's ability to create the stiffness required for explosive power transfer and efficient elastic energy return (6,10). Consequently, strength training must prioritize both eccentric ankle strengthening and stiffness, as well as pelvic stability to transform these biomechanical challenges into functional advantages.

Implementing specialized training for curvilinear running in elite female football is supported by recent biomechanical evidence that highlights the distinct mechanical demands of sprinting on a curve compared to linear sprinting. Research confirms that curvilinear sprinting induces asymmetrical loading and requires players to adopt specific trunk lean angles to generate the necessary centripetal force to maintain velocity (11,12).

Specifically, during a curve, the "outer" leg plays a dominant role in generating greater resultant and centripetal ground reaction forces compared to the inside leg (11). Studies utilizing accelerometry have shown that the outside leg experiences significantly higher impact magnitudes, reflecting its role in propelling the athlete laterally and maintaining stability against centrifugal forces (12). Furthermore, the outer leg exhibits increased activation in muscles such as the gluteus medius and biceps femoris, which are critical for controlling frontal plane stability and lateral force production (13).

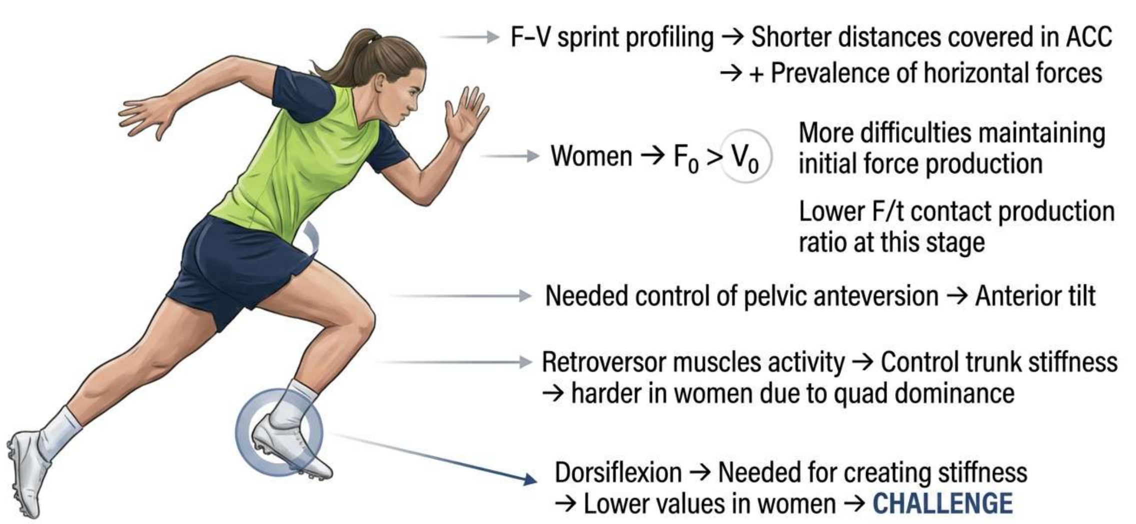

Fig. 1. **The linear acceleration biomechanics of the female athlete.**

Comprehensive Biomechanical Analysis of the Female Striking Mechanism

The optimization of the striking mechanism in female football players requires a strategic integration of pelvic retroversion and hip flexor dynamics to mitigate common morphological and functional constraints. According to the provided figure, many female athletes operate within a dysfunctional cycle where increased anterior pelvic tilt leads to a significant reduction in iliopsoas activity during the kicking motion (14). This mechanical disadvantage triggers a compensatory reliance on the rectus femoris, which manifests as quadriceps dominance—a state that often impairs the hip flexors' ability to efficiently decelerate the leg's oscillation during the follow-through phase. To counteract this, the "kick down mechanism" is proposed as a corrective training intervention that utilizes posterior pelvic tilt (retroversion) to establish a stable foundation for force absorption followed by movement generation. By challenging the hip flexors through a wide range of motion and intentionally avoiding anterior tilt compensation, players can more effectively generate the relative force $\mathbf{F}_{\text{relative}}$ required for ball displacement. This is scientifically critical because, although the mass of a standard soccer ball remains constant (410-450g), female players generally possess lower absolute muscle mass than males, meaning they must produce significantly higher levels of force relative to their body weight to achieve elite-level ball velocity and distance (15).

Furthermore, the integration of these pelvic control strategies serves as a vital injury prevention measure; by shifting the load from the rectus femoris back to the deep iliopsoas through posterior tilt, the athlete reduces the shear stress on the knee and hip joints typically associated with quadriceps-heavy movement patterns (16). This "kick down" approach essentially re-trains the neuromuscular system to prioritize core stability and eccentric hip control, ensuring that the kinetic chain remains intact from the plant foot to the moment of impact (17).

Biomechanical analysis of the sidestep cutting maneuver of the female athlete

The high rate of Anterior Cruciate Ligament (ACL) injuries in female football players compared to their male counterparts is a multifaceted issue deeply rooted in suboptimal biomechanical profiles and neuromuscular control strategies. As illustrated in the research by Landry et al. (18), female athletes often execute high-demand movements—such as cutting, pivoting, and landing—using a "stiff" landing pattern. This is characterized by a kinematic chain starting at the trunk and descending to the ankle: a position closest to trunk extension, decreased hip flexion, and increased knee extension. When the hip and knee joints are maintained in these extended positions, the body's ability to attenuate ground reaction forces through soft tissue (muscles and tendons) is significantly diminished, forcing the skeletal structure and ligaments to absorb the impact (5).

A critical component of this risk profile is the development of dynamic valgus. This occurs through a combination of increased adductor momentum and internal rotation of the femur, often exacerbated by increased ankle eversion. This collapse of the kinetic chain creates a "no-go" zone for the knee joint, where the ACL is placed under maximum tension. To counteract these medial-directed forces, there is an urgent demand for the adductor and external rotator muscles (specifically the gluteus medius and maximus) to provide lateral stability. However, research indicates that many female athletes possess a "quadriceps-dominant" strategy, or anterior dominance, where the quadriceps are recruited prematurely and more intensely than the hamstrings (2). This isolation of ACL agonist muscles leads to significant anterior tibia translation, pulling the tibia forward relative to the femur and directly stressing the ACL.

The theoretical "battle" within the joint is defined by the Posterior Chain Muscle Complex vs. Anterior Tibia Translation. The posterior chain, comprising the hamstrings, gluteals, and gastrocnemius, acts as a functional synergist to the ACL. By producing a posterior pull on the tibia, these muscles shield the ligament from excessive shear forces (20). Unfortunately, the biomechanical characteristics identified—such as decreased hip flexion—inhibit the mechanical advantage of the gluteals and hamstrings. This justifies the implementation of targeted Strength Training as a corrective modality. Optimization through training must focus on transitioning the athlete from a quadriceps-dominant, upright posture to a "hip-dominant" strategy. By strengthening the posterior chain and improving neuromuscular firing patterns, athletes can increase hip and knee flexion angles, neutralize dynamic valgus, and provide the muscular bracing necessary to mitigate the risk of negatively determinant ligamentous failure (20).

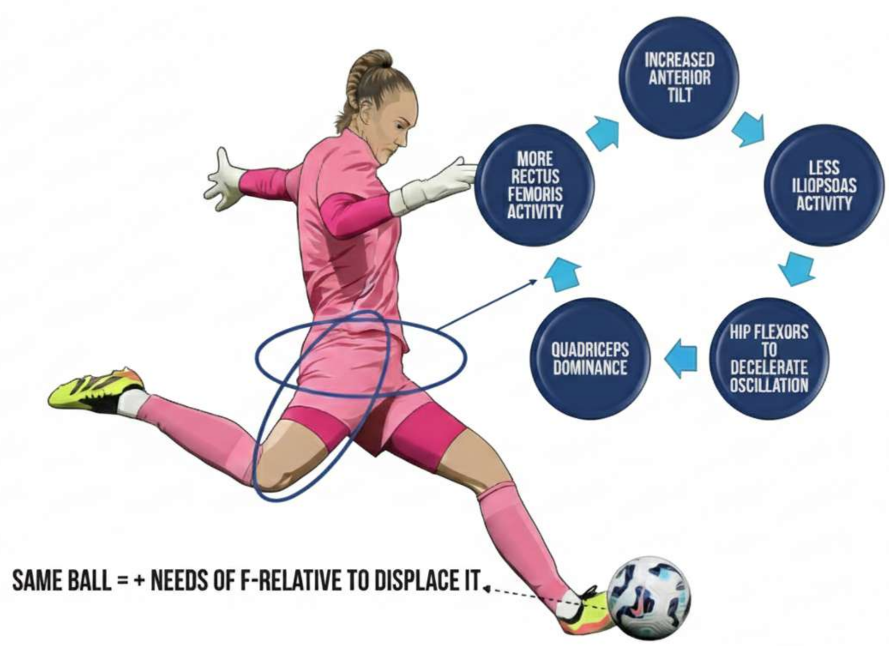

Fig. 2. **Biomechanical analysis of the female athlete ball striking mechanism.**

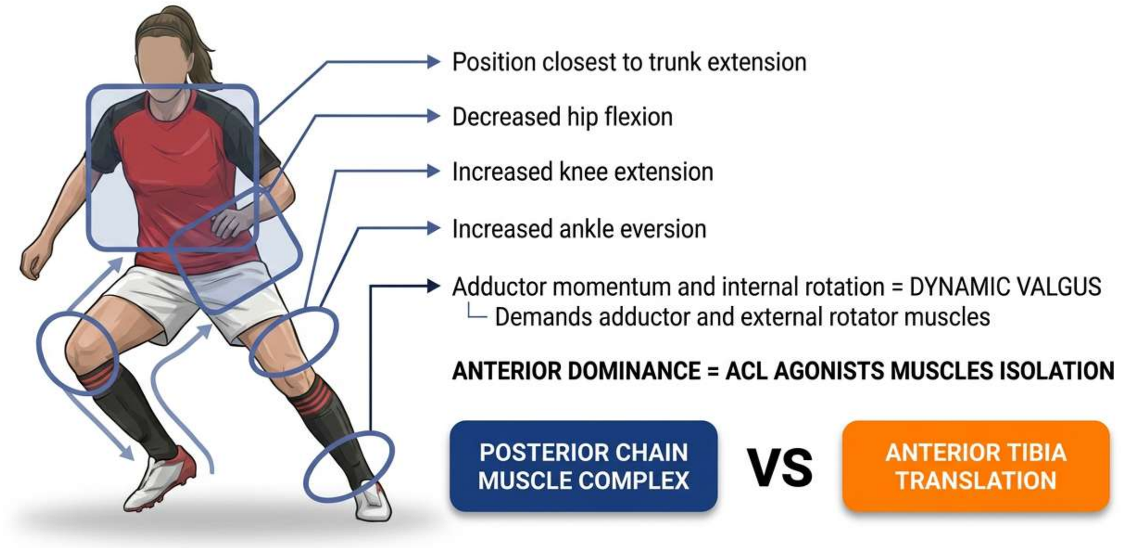

Fig. 3. **Biomechanical analysis of the sidestep cutting maneuver of the female athlete.**

The Biomechanics of Deceleration and Landing

The optimization of female football players through strength training necessitates a deep understanding of dynamic knee valgus, a multi-planar collapse often observed during high-intensity maneuvers. As established by Landry et al. (21), a primary driver of this instability is the decreased activity of posterior stabilizers (gluteus maximus) and hip external rotators (gluteus medius). This deficit leads to poor control of the femur, resulting in excessive adduction and internal rotation. Furthermore, the figure highlights an "altered timing of muscle recruitment," specifically a quadriceps-dominant strategy. This occurs when the rectus femoris exhibits increased activity relative to a "lagging" or inhibited hamstring group [18]. Because the hamstrings act as an agonist to the ACL by pulling the tibia posteriorly, their diminished recruitment in females results in increased anterior tibial translation, significantly elevating the risk of ligamentous rupture during sudden perturbations (22).

Deceleration is arguably the most dangerous phase of football, as it requires the absorption of several times the athlete's body weight in milliseconds. Research indicates that female players tend to decelerate and land with increased knee extension (a "stiff" landing) compared to males (23). This upright posture minimizes the shock-absorbing capacity of the musculature and maximizes the shear force on the knee joint.

Additionally, the distal mechanics described in the figure (Fig. 4) —specifically the increased lateral gastrocnemius activity and decreased medial head EMG—create a force imbalance at the ankle. This imbalance promotes excessive foot pronation, which triggers a "bottom-up" kinetic chain reaction: the foot rolls inward, the tibia rotates internally, and the knee is forced into a valgus position (23). Recent studies (24) confirm that this lack of distal stability is a critical, yet often overlooked, component of the ACL injury mechanism in female athletes.

Weekly periodization model & theorical backup

The proposed model (Fig. 5) utilizes a "Match Day" (MD) approach, splitting the training load into two primary high-demand cycles: intensive and extensive dynamics (25).

- **Intensive Dynamic Sessions (MD-4):** These sessions focus on "braking" and "starting" capacities, prioritizing acceleration, deceleration, and rapid changes of direction (COD), as well as improving the eccentric capacity of the quadriceps and the "braking" mechanics of the soleus These are typically executed through small-to-medium-sided drills that provoke high neuromuscular and metabolic loads (26). The field-gym link approach systematically bridges traditional strength training with sport-specific movement demands, allowing coaches to apply progressive external loads to acceleration, deceleration, and change-of-direction patterns while maintaining sport-specific movement constraints.
- **Extensive Dynamic Sessions (MD-3):** These sessions prioritize "engine" capacities, focusing on high-speed running (HSR) and maximum velocity ($\boldsymbol{V}max$) exposure. Consistent exposure to speeds above 95% of individual maximum velocity is considered a "vaccine" against hamstring injuries, provided the volume is strictly managed to avoid spikes in fatigue (27,28). For female athletes, this exposure must be carefully dosed to avoid the "U-shaped" risk curve

where both under-exposure and over-exposure increase injury risk.

- **Microdosing (MD-1):** The model advocates for "micro-dose" sessions—short, high-intensity stimuli—to maintain neural activation without inducing significant fatigue before the match.

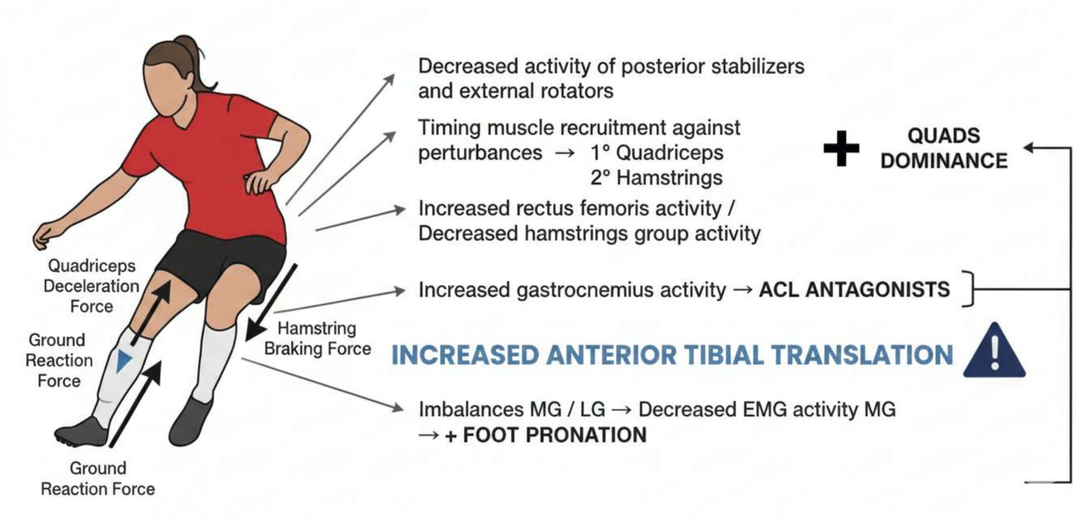

Fig. 4. The biomechanics of deceleration and landing in the female athlete.

	MD + 2	MD – 4	MD – 3	MD – 1
	RE-BALANCE DAY	NEUROMUSCULAR PREVALENCE	HIGH SPEED RUNNING EXPOSURE	PRE-GAME OPTIMIZATION
INDIVIDUAL PREHAB	Upper-body strength Individual readiness Weak-links based prehab Core system general health	Individual weak-links based prehab Individual body-map	Individual weak-links based prehab Individual body-map Isometric activation	Individual weak-links based prehab Individual readiness
TEAM MICRO-DOSE SESSION	Basic movement patterns' restoration	ACC – DCC – COD mechanics Body position preparation/education Quality of movement	Heavy ISO – tendon health focus Linear and curve running attractors	Reaction drills Decision making Social component Team building games
ON-FIELD FOOTBALL SESSION	Global movement Width stimuli spectrum High-intensity exposure re-balancing team chronic load	Neuromuscular load focus High ACC – DCC – COD Neuromuscular position-specific demands	Locomotive position-specific demands High-speed running >95% Max Speed training	Reaction and quickness Decision-making process Sprint-distance exposure
GYM-BASED DEVELOPMENT	Upper-body strength Anti-movements stability Rotational upper-limb force production Dynamic instability	Football movements training Position-specific robustness Rotational force production Plyometric continuum	Basic strength training periodization Individual extra complements	Post-activation potentiation training Concentric phase Low volume – High intensity

Fig. 5. Weekly Microcicle structure from MD+2 to MD-1. Detailed individual prehabilitation, team micro-dose sessions, on-field football sessions and gym-based development.

INTENSIVE DYNAMICS SESSIONS – FOOTBALL MOVEMENTS TRAINING									
		PRE-TRAINING MICRODOSE				ON-FIELD STRENGTH SESSION			
Linear Acceleration	Triple extension extension mechanism	Sled Drag – Firsts Steps focus	Sled push	Loaded triple extension		Triple extension double box - loaded	10 m sled run – 50% BW	Aquavest linear run	
Curvilinear Speed	Inside leg action	Wall lean isometric push		Lateral triple extension		Soft angle curve running	Pronounced angle curve running	SACR - Aquavest	PACR - Aquavest
	Outside leg action	Wall lean isometric push		Lateral triple extension					
Sprint Capacity		Arm swing coordination and trunk stiffness				20 m linear sprint – resisted sled 25% BW			
Deceleration	Frontal	Banded deceleration steps		Vertical drop split squats		180° Change of direction with return			
	Lateral	Banded lateral decelerations		Lateral deceleration box steps		Sideways run with deceleration focus – Aquavest loaded (unplanned movements)			
Change of Direction Optimization	Shuffle side-step	Loaded sled side-steps		Reacceleration Step	From box landing to 3° extension	Sideways run – Lateral Acceleration SWR Loaded sled – 25% BW SWR with return – Aquavest loaded (unplanned movements) Shuffle steps – Loaded sled 40% BW			
	Crossover Step	Loaded sled crossover		Open Step	Bilateral landing to 45° step	Sideways run with return – Aquavest loaded (unplanned movements)		Crossover steps – Loaded sled 40% BW	
	Backpedals	Loaded sled backpedals		Drop Step	Bilateral landing to 135° step	10 m backpedals run – heavy loaded sled – 50% BW		Combined COD multiple angles sequence – weighted vest loaded	
Ball striking mechanism	Hip flexors action	Reverse Nordic curls		Combined	Isometric full mechanism	Loaded reverse Nordic curls			
	Knee extensors action	Isometric kicking knee extension				Banded crossed chain pattern movement - eccentric focus			
Unilateral landings & Plyometrics	One plane	Vertical Horizontal				Over hurdle Frontal		Over box Lateral	
	Multiplane	Vertical to horizontal Horizontal to vertical Lateral to frontal Frontal to lateral				From landing to sideways jump From lateral jump to vertical jump – Combining hurdles position & angles – Variating jump's direction with landing's direction			

Fig. 6. **Intensive Dynamics Sessions. Football Movements Strength Training Sessions. Gym-based microdose and on-field strength sessions.**

Results

The program included a microdose session prior to training with a focus on multiplanar landing mechanics, heavy-loaded sled steps, combined plyometrics, an isometric rectus femoris stimulus and an on-field strength session with resisted sprints, curvilinear resisted running, weighted vest change of direction drills and resisted backpedals for the intensive dynamic sessions. For the extensive dynamics sessions, a microdose session focused on heavy isometrics for triceps surae, patellar tendon, and both distal and proximal hamstring tendons was proposed. For the strength training session, delivered right after the on-field session, a velocity-based training session separated into four components was created: multiarticular bilateral movement, multiarticular unilateral movement, hip dominant posterior chain exercise, knee dominant posterior chain exercise and loaded jump. This session was controlled by *velocity-based training* (VBT) devices, where the aim was to prescribe the relative load for all players in every exercise, aiming for a range between 0.7-1.1 m/s, commonly used for building high-force power needed for strength and speed development and optimisation (*Strength-speed*).

The program: linking the pitch periodization with the gym

1. **Microdosing and Neural Potentiation**
   The "microdose" strategy aims to maintain high levels of athletic performance while managing fatigue by using frequent, low-volume sessions (29). Incorporating multiplanar landing mechanics and sled steps acts as a primer for the nervous system, improving neuromuscular readiness and stretch-shortening cycle function before intensive dynamic work (30). Specifically, the use of isometric stimuli (such as for the rectus femoris) has been shown to enhance neuromuscular activation and rate of force development (31).
2. **Tendon Resilience and Heavy Isometrics** For extensive sessions, the focus on heavy isometrics for the triceps surae, patellar, and hamstring tendons is supported by research indicating that high-intensity mechanical loading (approx. 80-90% MVC) is required to increase tendon stiffness (32).
   - **Tendon Adaptation:** Long-duration isometric holds (e.g., 20 seconds) have been found to yield greater adaptations in the patellar tendon compared to rapid contractions (33).
   - **Hamstring Protection:** Targeting both distal and proximal hamstring tendons helps mitigate injury risks associated with the high eccentric loads of sprinting and deceleration (34).
3. **On-Field Dynamics: Resisted and Curvilinear Running** The transition to resisted sprints and curvilinear running addresses specific mechanical demands:
   - **Resisted Sprints:** These are effective for enhancing acceleration by forcing the athlete to apply greater horizontal force (9,35).
   - **Curvilinear Mechanics:** Research indicates that linear and curvilinear sprinting are distinct capacities; specific training in curved trajectories is necessary to reduce unilateral deficits and optimize "weak side" performance (36,37).
   - **Kicking & Ball Striking:** Female players often rely on shorter passes and side-step kicking motions rather than instep kicks, which may involve different hip joint kinematics.
   - **Cutting & COD:** The side-step (SS) technique is effective for rapid direction changes but incurs higher knee extension moments and negative work for ankle plantar flexors. In contrast, the crossover step (CS) minimizes the reduction in horizontal velocity and involves greater hip abduction moments to prevent joint collapse.
   - **Injury Risk Mechanisms:** Nearly 80% of ACL injuries in women's football occur during horizontal movements like sprinting, COD, and pressing. Female players often exhibit "valgus collapse" and decreased knee flexion during landing, which are associated with increased anterior knee shear.
4. **Velocity-Based Training (VBT) for Strength-Speed**
   Prescribing loads based on a velocity range of 0.7–1.1 m/s specifically targets the strength-speed zone, which represents the strength-speed zone where athletes seek to develop high-force power capabilities without sacrificing movement velocity. This method is often superior to traditional percentage-based training because it accounts for daily fluctuations in athlete readiness (38). The force-velocity profile is fundamental to understanding athletic performance, as it characterizes the relationship between the force an individual can produce and the velocity at which that force is expressed. (10). This mechanical profile is particularly important because ballistic performance is determined not only by maximal power output but also by an individual's force-velocity imbalance—the difference between their actual and optimal profile relative to their sport demands The practical application of VBT devices in field settings has become increasingly feasible with technological advances. The evidence suggests that when coaches implement velocity-based prescription systematically, they can achieve meaningful enhancements in sport-specific power production while maintaining technical efficiency.
   The incorporation of multiarticular bilateral and unilateral movements represents a cornerstone principle in modern strength and conditioning programming. Multiarticular exercises, such as squats, deadlifts, and various bilateral and unilateral movements, provide superior stimulus for neuromuscular adaptation compared to single-joint movements because they recruit larger muscle groups and activate more motor units (39). The use of multiple joint movements is particularly important in periodized training programs aimed at developing strength and power, as these exercises facilitate greater mechanical and metabolic stress while improving intra- and intermuscular coordination (40).
   Multiarticular exercises also demonstrate superior transfer to sport-specific movements compared with isolated single-joint exercises. The concept of exercise specificity indicates that training adaptations reflect the nature of the stimulus applied, meaning athletes should prioritize exercises that mimic the biomechanical and metabolic demands of their sport while building foundational strength. When selecting multiarticular exercises, both open-chain and closed-chain variations and compound movements were considered, in order to engage multiple muscle groups in coordinated patterns (40).

Gym-Based Strength Session (Post-Pitch). The Four-Component Strength Block

The strength session is divided into four components to address total-body force requirements:

1. **Multiarticular Bilateral Movement:** (e.g., Back Squat) for maximal force development. Bilateral exercises, including movements like bilateral squats and deadlifts, recruit substantial muscle mass and allow for greater absolute

loads to be used, which is essential for developing maximal strength (41). However, bilateral movements alone may not address asymmetries that develop from sport-specific demands and repetitive patterns. The integration of unilateral movements into training programs serves multiple functions beyond strength development.

2. **Multiarticular Unilateral Movement:** (e.g., Bulgarian Split Squat) to address lateral and rotational stability. Unilateral exercises such as single-leg squats, deadlift variations, and stepping patterns improve inter-limb symmetry, enhance neuromuscular control and develop stabilizer muscles that are often undertrained with bilateral movements alone. The evidence suggests that an optimal training program should incorporate both bilateral movements for developing substantial loading capacity and unilateral movements for addressing asymmetries and improving functional stability.
3. Knee-Dominant Posterior Chain & Hip-Dominant Posterior Chain: focusing on proximal hamstring strength and eccentric capacity. The posterior chain—comprising the erector spinae, gluteus maximus, hamstrings, and calf muscles—plays a critical role in athletic performance across virtually all sports. The distinction between hip-dominant and knee-dominant posterior chain exercises is essential for comprehensive posterior chain development and addressing specific performance limitations. Hip-dominant exercises emphasize the gluteus maximus and hamstrings through hip extension movements, while knee-dominant exercises load the knee extensors more prominently while still engaging the posterior chain units (39). Research examining rapid strength production in lower compartment circuit resistance training found significant improvements in strength and power when resistance exercises targeting hip extension, ankle inversion, ankle eversion, and various lower body movements were systematically applied. The combination of hip and knee dominant movements provides comprehensive lower limb development, as hip-dominant movements excel at developing hip extensors while knee-dominant movements enhance quadriceps strength and lower limb power output needed for ballistic movements (42).
4. **Loaded Jumps:** Loaded jump training represents a bridge between traditional resistance training and ballistic power development, combining the benefits of external loading with the explosive nature of jumping movements. The countermovement jump (CMJ) and squat jump (SJ) are among the most commonly assessed markers of lower limb power in athletic populations, and research consistently demonstrates that appropriate jump training produces substantial improvements in these measures. A short-term ballistic training program conducted with elite youth female soccer players over just four weeks demonstrated remarkable improvements in both strength and power measures: significant improvements were observed in squat jump, countermovement jump, sprint speed, and one-repetition maximum strength, with effect sizes ranging from 1.18 to 1.66 (43). The effectiveness of loaded jump training lies in its ability to develop the capacity to rapidly apply force during dynamic movements, which is fundamental to strength-speed development. Athletes performed maximal-velocity jump exercises at 30% of their one-repetition maximum, which aligns well with the 0.7-1.1 m/s velocity range for strength-speed development, as this load-velocity combination permits high voluntary activation while maintaining sufficient mechanical stress for adaptation. Importantly, the research noted that elite youth female soccer players improved strength, power, and speed capacities without compromising force production at higher movement velocities, suggesting that ballistic exercise programming need not impair the ability to generate force at heavy loads (43).

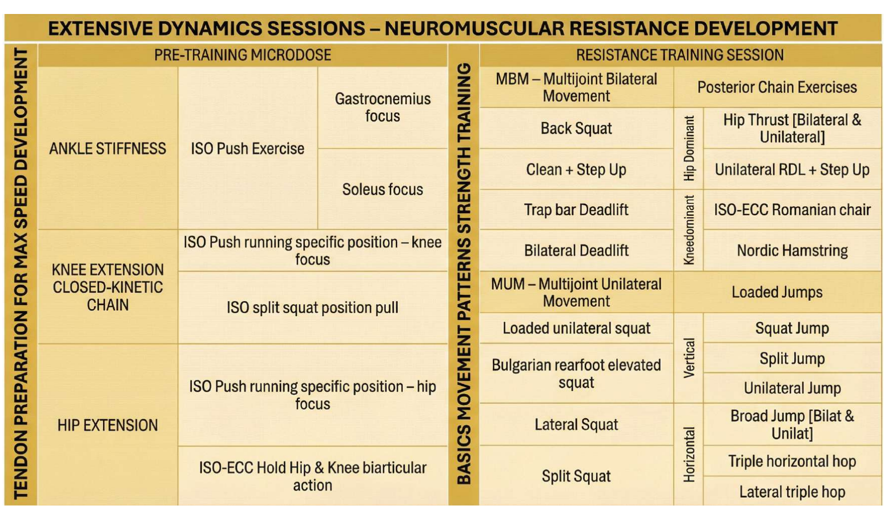

Fig. 7. Pre Training Isometric-based microdose. Gym-Based Strength Session (Post-Pitch). The Four-Component Strength Block.

Conclusions

In elite women's football, the integration of movement mechanics, resisted sprinting, and multi-directional optimization is no longer optional but a fundamental requirement for performance and longevity (44). Modern scientific literature (2024–2026) emphasizes that superior physical preparation must transition from general fitness to sport-specific "mechanical efficiency."

The refinement of movement quality is the cornerstone of injury resilience. Research by Baharuddin et al. (45) and expanded in 2025 emphasizes that female athletes frequently exhibit "dynamic knee valgus" during high-velocity maneuvers—a primary risk factor for non-contact ACL ruptures (47). Structured neuromuscular training (NMT) programs focusing on trunk stability and hip-dominant landing mechanics have demonstrated up to a 64% reduction in ACL injury incidence [48,49]. These interventions address the "proficiency barrier" in motor control, ensuring that players can maintain joint stability under the cognitive and physical fatigue of a match (50).

While linear speed is vital, the ability to accelerate rapidly is often the "match-winner." Recent meta-analyses indicate that Resisted Sprint Training (RST)—using sleds or wearable resistance—is superior to unresisted sprinting for improving the first 0–10 meters of acceleration (51). For elite female players, progressive sled loading (ranging from 20% to 80% of body mass) has been shown to improve maximal velocity and step length without negatively altering natural sprint kinematics (35). This "mechanical overload" specifically targets the horizontal force-velocity profile, allowing players to produce more power at low velocities during the critical initial steps of a sprint (52).

The most demanding actions in women's football are often the "braking" phases. Solleiro-Duran et al. (13) highlight that elite players perform nearly as many high-intensity decelerations as accelerations. Optimization of deceleration through eccentric-focused training (specially "break-and-cut" drills) is essential for rapid re-acceleration. Research confirms that vertical resisted sprinting (using weighted vests) is particularly effective for COD enhancement because it overloads the eccentric "braking" force required to change direction (51). Furthermore, training programs that combine linear sprints with COD drills (LSCD) are more effective than small-sided games alone for improving multidirectional speed and power in elite cohorts (53).

However, and as a main conclusion, while phenotypic and biomechanical differences between genders exist in football, these distinctions should not be inherently pathologized as risk factors for female athletes. Rather, such differences can be effectively attenuated through evidence-based interventions including targeted strength development and optimized biomechanical training protocols (54). Therefore, a shift in focus toward comprehensive neuromuscular and biomechanical training programs represents a more efficacious approach to enhancing both participation quality and athlete longevity in women's football than discourse that constrains gender-based physiological variations within a pathological risk framework.

Limitations of the Study

- Expert Consensus Design: While the proposed framework is grounded in a synthesis of current scientific literature and expert consensus, it functions as a theoretical methodological framework. Further empirical longitudinal studies are required to quantify the specific impact of this periodization on injury rates and physical performance across different competitive levels.
- Technological Requirements: The practical implementation of this model relies heavily on advanced technology, such as Velocity-Based Training (VBT) devices and accelerometry for tracking high-speed running. This may limit the applicability of the framework in environments with restricted access to such specialized sports science equipment.
- Contextual Variables: The study focuses on the physical and biomechanical dimensions of periodization. However, it does not account for external factors that significantly influence female athletic performance, such as menstrual cycle fluctuations or the psychological load of the competitive season.

Practical Applications

- Integrated Periodization: Strength coaches should synchronize gym-based "Intensive" and "Extensive" cycles with on-field tactical demands. Intensive sessions (MD-4) should prioritize acceleration and deceleration mechanics through eccentric-focused training, while Extensive sessions (MD-3) must focus on high-speed running exposure and tendon resilience.
- Movement-Specific Gym Reinforcement: Rather than traditional muscle-isolated hypertrophy, programs should prioritize "transfer-of-training" exercises. This includes implementing the "kick down mechanism" (posterior pelvic tilt) to improve ball-striking efficiency and using unilateral landing tasks to enhance joint stability against dynamic valgus.
- Neuromuscular "Microdosing": Practitioners can utilize frequent, low-volume "microdose" sessions (MD-1) to maintain high levels of neural activation and neuromuscular readiness without inducing pre-match fatigue.
- Gender-Specific Injury Mitigation: To address the higher risk of non-contact ACL injuries in women, training must transition athletes from a "quadriceps-dominant" strategy to a "hip-dominant" strategy. This is achieved by strengthening the posterior chain (hamstrings and gluteals) to provide the necessary muscular bracing during high-demand cutting and landing maneuvers.
- Velocity-Based Training (VBT) Implementation: Using VBT to prescribe relative loads (targeting 0.7–1.1 m/s) allows for daily adjustment based on athlete readiness, ensuring that players develop high-force power (strength-speed) without compromising technical movement quality.

Future research lines

Subsequent research endeavours are warranted to explore the ramifications of the aforementioned methodology on the physical attributes of female athletes, alongside its potential efficacy in mitigating the likelihood of sustaining injuries. Moreover, forthcoming investigations ought to delve into the enduring implications of this comprehensive periodization approach on the physical capacities of female athletes. It is imperative to meticulously assess the influence of $\boldsymbol{V}max$ exposure and VBT-regulated microdosing in diminishing the incidence of non-contact ACL and hamstring injuries across multiple competitive seasons. Furthermore, expanding the scope to encompass strength training periodization within varied football periodization frameworks is advised. Emphasizing the imperative nature of persistently examining and refining the integration of strength training tailored to the specific biomechanics of female footballers is essential for advancing the current understanding in this domain.

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