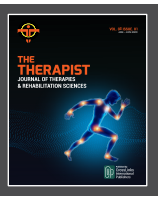
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Review Article

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Biomechanical Changes in Football Players Post Functional Strength Training: A Review paper

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ABSTRACT

The assessment of how functional strength training (FST) influences movement efficiency alongside core stability together with sprint mechanics and agility and injury prevention forms the foundation of this review. The data demonstrates how better posture, reduced energy costs together with enhanced movements result in noticeable improvements. Functional strength training allowed neuromuscular adaptations such as increased excitatory drive that can lead to an elevated jumping frequency and higher number of activated motor units. Further, neuromuscular adaptations enhance dynamic postural stability and core stabilizing capacities and prove effective for improving hip movements and stride efficiency in sprinting and running techniques. The effectiveness of FST is further supported by increased agility, which is shown by better cutting and pivoting mechanics. The injury risk protection offered by FST stems from its ability to fix muscular weaknesses along with provision of balance between different areas. Functional training also significantly enhances athletes' cardiorespiratory endurance performance. Various data points including joint angles alongside ground reaction forces together with muscle activation levels have also been documented in the literature. Future research should focus on the training protocols tailored to the specific capabilities required for improving athletics' performance because the positions in which the player is playing are different, and the training protocol should be specified accordingly.

INTRODUCTION

Athletes participating in football need to develop strength as well as agility, endurance, and power because the sport always demands high-intensity performance. High-intensity movements that involve sprinting along with jumping, multidirectional changes and tackling form the critical foundation for field success in football. The sequence of intense movements happens back-to-back during games [1]. Running intensity in football depends strongly on the variables between positions and team strategies but also competition strength. Top-tier players execute more high-intensity movements when compared to average players in their playing field [2]. Successful football performance requires highly specialized strength and conditioning for athletes. The intense physical nature of football also raises the risks of developing injuries which most commonly affect the lower body areas. The knees and ankles make up 61.2% of all reported injuries based on analysis [3]. The strength capability of player joints and muscles needs to sustain these forces. Different combinations of weak muscles along with insufficient endurance and muscle flexibility together with physical weaknesses create potential risk for knee injuries [4]. Traditional strength training receives less attention among football players because researchers advocate functional strength training as a superior method. The main goal of FST is to build athletic performance through strengthened movements along with improved body mechanics for better functionality [5]. The combination of strength training boosts athletic performance as well as minimizes risks of harm during complicated high-intensity athletic

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activities. By correcting muscle imbalances and improving knee joint stability in professional football players, individualized resistance training may provide further advantages [6]. This review explores how FST benefits football players by improving running mechanics, core stability, and movement efficiency while also playing a significant role in injury prevention. Participation in football sports demands a combination of powerful force input with outstanding balance and movement coordination from players [7]. The strength ability by itself proves insufficient since athletes also need training that allows them to apply this strength through dynamic movements required in their respective sports. Lower-body power synergizes with neuromuscular control to perform sprinting and lateral movements and rapid decelerations. Both jumping moves and ball heading activities need powered force together with stability during positions in the mid-air [8]. A sudden and quick response in the field demands not only the strength of lower body parts but also necessitates an appropriate and coordinated movement of upper body. Football matches exceed usually ninety minutes and thus require players to maintain their energy levels throughout the entire game duration [9]. Weightlifting alone does not suffice for this purpose, so training needs to include movements which can simulate authentic on-field situations together with performance-enhancing features. The core concept of functional strength training is to enhance movement efficiency above everything else because it meets the biomechanical specifications [10]. The approach provides training benefits which directly translate into real-life performance making it an optimal choice specifically for athletes. FST delivers different benefits than weightlifting since it uses multi-joint, multi-plane movements that optimize coordination besides neuromuscular function. Athletes who perform exercises that include kettlebell swings in combination with sled pushes and resistance band drills and squats and lunges improve their performance-related strength [11]. During FST training people engage with unstable surfaces and perform balance exercises and exercises which demand proprioceptive exercises to make muscles operate together while enhancing total coordination and stability [12]. The most crucial component of functional training enables the individual to work independently of any machine, utilizing the limitations of his own body. The individual can accomplish his aim by using the four fundamental movements in this program. These motions include rotation, level shifting, pushing and pulling, and pausing and switching [13, 14]. Success in sports rises in tandem with the renewal of sports records and training techniques through scientific study and approaches, as well as with the aid of science and technology that are developing daily. Long-term, methodical implementation of a well-designed functional training program is crucial to lowering injury risk and enhancing athletes' performance [15]. Extensive research demonstrates that FST provides valuable advantages to football players, leading to progress in running methods and body movement quality and core control development [13]. The performance of specific running techniques serves as essential for attaining speed and accelerated speed while preventing injuries. The muscular strength obtained through FST makes foot and ankle movements more efficient during sprinting by improving hamstring power and activation with gluteal and hip flexor strength [16]. Placing the feet properly while exercising with ground reaction force components helps athletes sustain proper posture as it reduces energy drains during their high-speed movements. Athletes can shift in all directions with speed and preserve their stability through increased movement efficiency during high-intensity football moments. The strengthening of a person's core represents a primary advantage of FST [17]. A powerful and stable core functions as a power conduit that distributes energy between lower and upper body segments to execute essential abilities such as shooting, passing along with ball protection. The performance-based exercises including plank variations and rotational medicine ball throws and stability ball drills increase core strength aspects which help football-specific movements Planks increase core strength by engaging multiple muscles in the abdominal region such as rectus abdominis, external oblique and erector spinae and transverse abdominis, that is a deep core muscle capable of stabilizing the spine, thus improving overall trunk stability and posture when held in a contracted position; essentially, by isometrically contracting these muscles for a sustained period, you build strength throughout the core [18], (Table 1). Among all FST benefits, injury prevention represents a crucial advantage that stands as the most vital point. Professional football athletes face high risks of sustaining knee and ankle injuries together with hamstring injuries during their matches since the sport demands repetitive sprints and quick turns and frequent physical collisions [19]. Weak stabilizer muscles together with muscle imbalances serve as common causes behind most injuries. The major muscles get stronger through traditional training yet smaller muscles that sustain joints receive insufficient attention. The approach of functional training solves this issue because it combines exercises which train the major muscle groups alongside their stabilizing counterparts [20]. Wrestlers can enhance knee protection by performing squats and lateral band walks which build strength in the crucial gluteus medius muscle The Bulgarian split squat is a unilateral exercise that increases

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the demand on the glutes while also enhancing stability and coordination. Research has shown that unilateral exercises like the Bulgarian split squat are highly effective for targeting the gluteus medius, a crucial muscle for hip stability [21]. Lateral band walks are a simple but effective exercise for targeting the gluteus medius. A study in the Journal of Orthopaedic & Sports Physical Therapy found that lateral band walks significantly activate the gluteus medius, an often-underdeveloped muscle that plays a key role in hip stability. Joint stability improves from performing proprioceptive exercises which include balance board drills and eccentric hamstring curls leading to diminished risks of ligament injuries such as ACL tears [22]. Specific FST training routines created for individual athletes lead to improved athletic performance together with better resistance against injuries. A football team requires specific physical qualities in their positions which must be addressed through individually designed training programs [23]. The ability of strikers to accelerate and jump improves with explosive sprint training while midfielders need endurance alongside dynamic strength exercises for maintaining their game performance. To succeed in defensive situations players must train their upper body and conduct reaction-based agility workouts against approaching attackers [24]. The training focus of goalkeepers includes reaction-based instruction as well as core stability exercises and explosive lower-body movements that enhance diving performance and speed of movement shifts. A correctly designed functional training system takes into account the specific needs of different positions and features activities that replicate actual gameplay movements. Numerous scientific studies show that FST produces effective results for football athletes [25]. Athletes who use functional strength programs perform their movements better while making fewer injuries happen and achieving better nerve-muscle control than athletes who train their strength according to traditional methods. Scientists analyzed FST effects on elite footballers by monitoring players who did functional exercises that led to better sprinting and improved balance, enhanced agility skills. Research showed that neuromuscular training exercises reduce knee and ankle injuries during football matches when performed by players [26]. At the molecular level, the total force-generating capacity is determined by the size and contractile characteristics of the muscle fibers, the frequency of operation, and the number of activated motor units. Increased excitatory drive-in trained individuals can result in a higher frequency of jumping and a greater number of activated motor units, among other brain changes. Additionally, the increased force output following training is a result of decreased antagonist coactivation and increased agonist, synergist, and stabilizer activation [27–30]. But the only information available for many of these neuromuscular adaptations comes from rodent models [31]. Currently professional football teams are using FST training as part of their programs because coaches and sports scientists are demonstrating its benefits for extending player careers and reducing injury-related time off [32]. Furthermore, some research has shown a strong positive correlation between balance, muscle strength, and flexibility [33]. One plausible explanation for this finding is that functional training strengthens the subjects' core muscles, which enhances their ability to control their spine and pelvis, coordinates their shift in center of gravity and posture adjustment during movement, and improves their ability to balance [34](Figure 1).

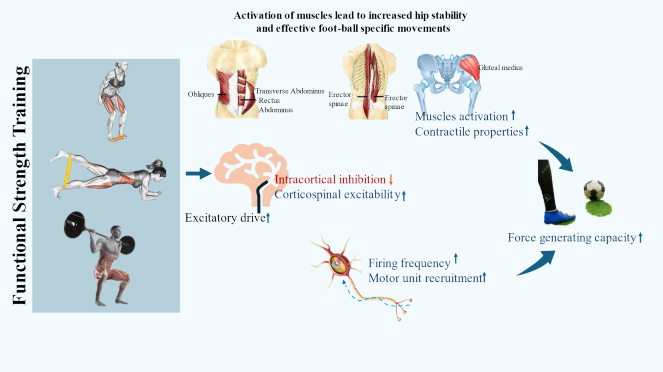


Figure 1: Different Exercises in FST lead to improvements in Football-Related Movements

Table 1: Exercises and their Intended Improvement

Exercise	Targeted Biomechanical Improvement
Single-Leg Squats	glute activation, stability of knee, maintenance of balance
Bulgarian Split Squats	mobility of hip, strength in lower-body parts
Sled Pushes	Acceleration of sprints, explosive force production
Medicine Ball Throws	Core rotation strength, power transfer
Lateral Band Walks	Preventing injury, activating Hip abductor

Additional research has shown that functional training greatly improved athletes' cardiorespiratory endurance performance; yet one study found no discernible variation in the group's postintervention results. These findings might be explained by the fact that long-term elite athletes or those who have been a part of regularly scheduled exercise programs for longer than three years have significantly altered their bodies [35], and improvements in cardiorespiratory endurance directly affect athletic performance [36]. FST provides athletes with a game-changing method to enhance their performance while building resilience because it applies biomechanical football requirements to its training strategies [37]. FST functions as a valuable contemporary football conditioning technique because it provides specific movement strength

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with core stability and joint protective support. Functional training principles spread throughout professional and grassroots football now allow all footballers from different developmental levels to obtain benefits from training methods which emphasize functional movements before isolated strength gain. Research data proves FST has vital importance for football training because it delivers optimal performance and injury protection for professional athletes from beginning to end of their careers [38]. The study review highlights how important functional strength training (FST) is for improving football performance and lowering injury risks. To effectively execute high-intensity movements, football players need a blend of strength, agility, and endurance. Improved running mechanics, core stability, and movement efficiency are just a few of the well-established biomechanical advantages of FST. Furthermore, by correcting muscle imbalances and improving joint stability, the incorporation of customized training regimens reduces the risk of injuries, especially in the knees and ankles. Despite the encouraging outcomes, the findings' generalizability is constrained by the variations in study designs and short-term interventions. Implementing thorough FST programs is further hampered by practical issues in professional football, such as player workloads and match schedules. The long-term effects of FST, the creation of standardized training regimens, and the requirements of various playing positions should be the focus of future studies. The field can advance toward optimizing training methods that protect players' health and improve performance by closing these gaps. Evidence-based strategies like FST will be essential in addressing the physical demands of the game while putting an emphasis on injury prevention as the sport develops. Additionally, programs of training must concentrate on the particular skills needed to enhance performance. The player plays a variety of roles, just like in soccer, so the training regimen should be tailored to each position.

CONCLUSIONS

Football athletes achieve better biomechanical performance through functional strength training that enhances their patterned movements together with stability and neuromuscular coordination system. Training with specific sports engagements allows an improved generation of force while enhancing balance and agility during performance. The players gain better joint stability, low risk of injuries together with stronger sprinting power output, better jumping abilities and improved directional control. The activation of core muscles together with better postural alignment during functional strength training creates better energy transfer between body segments while decreasing additional body movements. Future research must concentrate on duration-based biomechanical changes, injury-preventative training solutions and the most reliable training plans for distinct positions in the field. Post-training movement analysis alongside muscle activation evaluation gives complete insight regarding both performance boost approaches and prevention of athletic injuries.

Authors Contribution

Conceptualization: LB
Methodology: HFT, LB, SS
Formal analysis: HFT, LB, SS
Writing review and editing: HFT, LB, SS

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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