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The Importance of In-Season Strength and Power Training in Football Athletes: A Brief Review and Recommendations

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ABSTRACT

Football (soccer) performance requires a diversity of physical attributes and biomotorabilities, such as strength, power, jump mechanics, repeat sprint ability, change of direction and on-ball skills. In-season training focus is often based on metabolic conditioning activities such as small sided games, tactical and technical football drills and traditional running drills in order to further develop and maintain aerobic and anaerobic capacity. However, this often comes at the expense of strength training, which may be compromised for additional time on the pitch. Therefore, the purpose of this review is to provide an evidenced-based approach, to the periodisation of strength and power during a football season. Secondly, the increased popularity of incorporating on-pitch pre-rehabilitation and injury prevention programs that utilise unstable exercises during the entire season to maintain strength and power will also be discussed. Collectively, literature suggests that strength and power maintenance can be achieved with one strength session per week for football athletes. However, it is important for strength and conditioning coaches to continue the development of strength and power characteristics during a football season, which not only assists on-pitch performance but may also attribute to reduction of injury risk. Evidence supporting the effectivenessof on-pitch pre-rehabilitation programming centred on unstable training is lacking at this time.

Keywords: strength training, injury prevention, periodisation, athletic performance.

INTRODUCTION

Football is a sport that places a variety of physical and psychological demands on players, and as such requires physical attributes, including jumping, running, sprinting, and change of direction (7, 11, 14, 16, 19, 27). Aerobic capacity is considered extremely important for successful football performance with match duration 90 minutes excluding overtime. Players can cover distances up to 14km during a match (7, 11, 14, 27, 34). With maximal speed and repeat sprint ability (RSA) crucial studies report velocities above 30km/h for around 5% of the match (14,19, 25, 27). The movement demands placed on a player include approximately 25 jumping actions, 500 change of direction, 10 maximal accelerations (20km/h) and 15 decelerations (10km/h) (5). Development of strength (r=0.852) and power (r=0.814) are significantly correlated to the quickness of an athlete (26), with faster athletes possessing superior performance markers (2-4, 9, 13, 17, 22, 28-33, 35), including counter movement jump (CMJ), squat jump (SJ), maximum speed, maximum velocity, change of direction (COD) and relative and absolute strength (squats) than slower athletes (2, 3, 9, 13, 17, 22, 29). Additionally, stronger athletes are reported to be more resilient to fatigue, possess greater capacity to preserve power output at a given intensity (7,15), and greater RSA tasks (5).

Fatigue has been defined as reversible loss of ability to maintain the required power output to continue muscular work at a given intensity, associated with decrement in muscularperformance and increase susceptibility to injury (2,7,15).

In recent years programs have targeted proprioceptive, balance and postural stability activities rather than development and/or maintenance of strength and power characteristics during the competitive period (8, 10). Limited evidence supports the notion that such proprioceptive exercises are more beneficial than traditional strength training to improve performance outcomes (10). Football players may suffer from overuse and traumatic lower limb injuries (1, 12, 21), including anterior cruciate ligament (ACL), and ankle sprains which are the most commonly affected lower limb regions areas (1, 12, 21), with hamstring strains caused, in part, by fatigue-induced strength loss in the lower extremities (1, 21, 32). Conversely, there is strong evidence supporting the contention thatdevelopment of the strength characteristics may reduce injury risks (1,12,32). For example, there is growing evidence that the implementation of targeted hamstring strength exercises not only increase strength which may reduce posterior thigh injuries, thereby providing greater benefit to the player compared to minimally loaded, unstable proprioceptive exercises (1, 6, 20). Notably, Ronnestad et.al (32) suggested that implementing one strength training session per week for football players,' aids in maintaining strength characteristics developed in the pre-season period. In the context of a periodized in-season program this is an important consideration.

Therefore, the purposeof this brief review is to explore the evidence-base for in-season periodization and programming for strength and power training in football players. Specifically, literature describing the maintenance of strength and/or power during a competitive football season, and the effectiveness of prehabilitation/rehabilitation programs, incorporating unstable exercises will be addressed.

METHODS

Ten university databases (Google Scholar, ECU Library One Search, SPORT Discus, PubMed, and specific journal database searches including the Australian Journal of Strength and Conditioning, Journal of Strength and Conditioning Research, Strength and Conditioning Journal, Strength and Conditioning Journal,Journal of Sports Science and Medicine), were accessed through the Beijing Sports Universityto conduct this review. Literature that examined and reviewed only human research were selected. Articles published in peer reviewed journals between 2001-2017 were considered in this review, resulting in 38 studies meeting the inclusion criteria. Three stages were utilized to reduce most relevant papers to be considered for the review. Stage one included a search for relevant titles and abstracts that identified strength and power training in soccer. Stage two involved a searchfor full-text articles. Stage three included additional reference searches of the full-text articles within the identified databases. The initial search in Google Scholar was searching terms, such as; "In-Season Strength and Power"and returned over 43,600 articles. This was subsequently reduced to 9,150 when specifying "Strength and Power in Soccer". Additional key specific database were *"football", "strength training", "sprint", "fatigue", "in-season", "maintaining".*

The appropriateness of the inclusion of articles into this review was based on the following criteria: (i) Participants included male and female football (soccer) players competing in any amateur or professional league; (ii) Evaluation of strength and power training programs aimed to increase or maintain strength and power (bodyweight, free weights, elastic tubing, machine weights, plyometric); and (iii) Included randomized control trials.

DISCUSSION

Performance Attributes for Football

Football is one of the most popular sports performed worldwide (11, 14, 15, 17, 27, 34). The game has diverse components involving multiple motor skills, such as running, jumping, kicking, tackling, dribbling, accelerating, decelerating, agility and changeof direction tasks (11, 14, 27). The tactical and skill component of an athlete with the ball is essential in order to be successful, and the individual's physical and physiological condition should also reach the highest capacity, in order to be at peak performance each match (11, 14, 15, 27). The aerobic component for a football player is important as a game of football has a duration of 90 minutes, where each player covers between 8km to 14km, depending on their position (7, 11), at approximately 70% VO2Max (14, 15, 34). Players perform a turning movement every 2 to 4 seconds for the duration of the match (34), averaging five hundred turning movements a match (11). Therefore, agility and change of direction attributes are essential for a footballer (11, 14, 34). Maximal acceleration covers between 5 to 11% of the total match duration, with 90% of the efforts less than 6 seconds (7, 11, 14). During the game athletes start sprinting actions randomly (from walking or jogging position), with recovery times <60 seconds (5, 11, 15, 34). Therefore, the ability for faster recovery between efforts is a significant attribute for a football athlete. In elite football, athletes average 25 explosive jumps (5, 14) during a match, and between 90 and 140 interactions withthe ball. These can include passing or shooting the ball and while the literature is limited to the amount of tackling performed during a game, the development of strength and power is crucial for football players, as strength contributes to the major biomotor abilities that football requires (5, 14, 27).

Strength and Power Training

Haff and Nimphius (15) defined strength as the foundation required to develop power, suggesting that a stronger athlete will perform higher power outputs. Strength is considered a main component for biomotor abilities such as power, maximal strength, endurance, agility and speed (9, 13, 29, 30). Power is the product between force and velocity and mostly relies on the ability of the neuromuscular system to produce the greatest impulse in a period of time (16, 20, 34). Force is a product of strength and velocity and is the product of motor unit coding, synchronization, recruitment and neuromuscular inhibition. Therefore, the development of maximal strength is required to effectively produce power (30).

Storen et al (37) established that maximal strength training has a positive effect in running economy (RE) as well as maintaining maximal oxygen uptake (VO2max). The results demonstrated that well trained athletes significantly improved their one repetition maximum (1RM) by 33.2%, rate of force development (RFD) by 26.0%, RE by 5.0%, and time to exhaustion 21.3%, following eight weeks of strength training. Seventeen well-trained athletes were divided into two groups, the intervention group (4 males and 4 females, 28.6 ± 10.1) and performed their normal running training session as well as the 8-weeks resistance training program. The control group (5 males and 4 females, 29.7 ± 7.0) performed the running training sessions only. The 8-weeks training consisted of four sets of four repetitions at 4RM with 3 minutes rest in between sets, 3 times per week in half squats. Additionally, the eight weeks resistance training was designed to emphasise maximal strength training rather than muscle hypertrophy as high load and few repetitions were performed. Similarly, Hoff (20) concluded that a maximal strength training intervention performed by football players resulted in significant improvements in RE, 1RM and RFD (4.7%, 33%, 52.3% respectively) without changes in VO2max and body weight (BW) of the individuals. The same study also suggested that neural adaptations and changes in recruitment patterns are the main factors responsible for training improvements and responses.

Maximal acceleration has an important role for footballers as efforts can be classified into two categories. The first category is reflected acceleration, a short distance sprint with a maximum of 10 metres at maximum effort, and the second category is known as long sprints exceeding 30 metres (17). In football, most of the sprints are < 6 seconds duration and more than 90% of the time maximal acceleration is covered in less than 30 metre efforts. Additionally, in footballers, a positive correlation (r = 0.836 and r = 0.856, respectively) (27) is reported between strength, power and acceleration. This is relevant given the accelerating, sprinting, and jumping demands of the game (7,11, 16, 17, 26, 33). Wisloff et al. (39), analysed maximal strength in the half squat, sprint efforts (0-10m and 0-30m sprint), 10m shuttle run and vertical jump of 17 international football players (25.8 ± 2.9 years, height 177.3 ± 4.1 cm, weight 76.5 ± 7.6 kg, and VO2max of 65.5 ± 4.3 ml/kg/min). The authors reported a significant positive correlation between maximal strength in half squat and sprint performance, shuttle run and jump height. Significantly correlations were reported between the 1RM half squat and 10m sprint (r = 0.94, p<0.001), vertical jump (r=0.78, p<0.02), 30m sprint (r=0.71, p<0.01) and the 10m shuttle run (r=0.68, p<0.02). Nuzzo et al (27) analysed the countermovement jump (CMJ) performance variables CMJ peak force (PF), peak power (PP), peak velocity (PV) and height, compared multi-joint dynamic strength exercises, and multi-joint isometric (ISO) strength exercises. The results indicate that 1RM back squat and 1RM power clean have a stronger correlation (r = 0.836 and r = 0.856, respectively) to CMJ performance variables compared to ISO squat and ISO mid-thigh pull (r = 0.706 and r = 0.750, respectively). However, the implementation of the back squat and power clean exercises in a training program contributes to the optimization of strength and power lower body development.

The ability to constantly change direction is crucial as the player is required to rapidly change direction, velocity, decelerate, accelerate, and perform turning movements in response to reach the ball or face an opponent (11, 20). Spiteri et al (34) determined the correlation between lower body strength and power components (concentric, eccentric, maximal dynamic strength, isometric and power), COD (505 and T-Tests), and agility performances in twelve professional female basketball players (age: 24.25 ± 2.55 years; height: 177.69 ± 7.25 cm; body mass: 75.56 ±14.55 kg). The results demonstrated a significant negative correlation for maximal dynamic strength, eccentric, concentric, and isometric strength with both COD tests (T-test: r=-0.79 to -0.89, p=0.001; 505 tests: r= -0.79 to –0.87, p= 0.001). Furthermore, eccentric squats have a negative significant correlation to both COD tests (505 tests: 0.892 and T-test: 0.878). Finally, lower body strength and power attributes do not correlate with agility performance (r=-0.19 to -0.46), although strength and power play an important role in agility movements as they required rapid and reactive actions when executed.

An important performance attribute for football players is repeated sprint ability (RSA), which the literature defines as the ability to recover rapidly from an effort, therefore, producing the same or similar performance in subsequence efforts (25). Fatigue, and the decrement of peak power or work, are two characteristics that are present when athletes perform maximal velocity sprints repeatedly with short recovery (19). In addition, fatigue is present when there is a decrease in overall performance and peak power, which has significant correlation to anaerobic power (r=0.87, p<0.05) (17, 19). Recently, Baldi et al (5) examined the relationship between RSA (6 x 40m (20m + 20m) with 20-s resting time), neurological, aerobic and anaerobic variables in 26 male football players. Testing included CMJ, squat jump (SJ), standing long jump (LJ), VO2max, velocity at onset of blood accumulation, maximal aerobic speed and peak blood lactate accumulation (paLA). The individuals were also tested on a different day with best and mean times for RSA. The study concluded that RSA best times (r=-0.73 and r= -0.54, p<0.01) and mean times (r=0.69 and 0.62, p<0.01) were negatively correlated to CMJ and LJ performances. As the CMJ is significantly correlated to power (23, 33), strength and power training for lower extremities should be targeted in order to improve RSA performances.

Periodisation

Periodisation is defined as a strategic pre-structured plan to vigorously monitor athlete's loading, with the goal to maximise athlete performance, and minimising the risk of injury (2, 9, 30, 35). Additionally, the literature has shown that several types of periodisation structures have positive outcomes in maximising strength and power, when athletes perform one or more sessions per week (2, 3, 4, 13, 26, 29, 30, 35). In order to maintain strength levels, Ronnestad et al (32) concluded that football athletes can maintain strength and sprint performance during the season, by performing one strength session per week. The study examined fourteen professional football players from the Norway first Division League. One group performed one strength training session per week during the competition season, whereas the other group performed one strength training session every second week. The strength session consisted of 3 sets of 4 repetitions at 90% 1RM half squat, for both groups. The results of the study have shown that the strength level developed in pre-season was maintained for a 12 weeks' period for group 1, therefore the individuals in this group were able to half squat from 139 ± 7kg to 163 ± 8kg during the seasonal period, and the same group resulted to maintain 40-m sprint performance from 5.39 ± 0.07 seconds to 5.29 ± 0.05 seconds. Contrary, group 2 results showed significant reduction in both strength and sprint performance for the trimester period (10 ± 4%, p< 0.05; 1.1 ± 0.3%, p< 0.05, respectively).

Table 1 presents two possible scenarios (A and B) for the organization of the weekly training schedule according to the number of matches, with the previous match played on Saturdays (26). Table 2 demonstrates an Example Mixed Method Approach for Developing Power (13). Table 3 presents an example in-season strength maintenance program with one session per week (31).

Scenario		Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
A: One -match	AM		OFF	Light	Intense	Gym	Intense	Light	
	PM	*Match	OFF	Light	Light	OFF	Light	Light	*Match
B: Two -matches	AM		OFF	OFF	Moderate		Light	Light	
	PM	*Match	OFF	Gym	Light	*Match	Light	Light	*Match

Table 1: Organization of the weekly training schedule according to the number of matches with two possible scenarios, A and B. Previous match played on Saturdays (11).

Exercise	Sets	Reps	Load (% 1RM)	Force/Velocity
Power Clean	3	5	75-85%	High Force – High Velocity
Back Squat	3	5	80-85%	High Force – Low Velocity
Jump Squat	3	5	0-30%	Low Force – High Velocity
Depth Jump	3	5	0%	High Force – High Velocity

Table 2: Example mixed method approach for developing power (14).

Exercise	Sets	Reps	Load (% 1RM)	Force/Velocity
Half Back Squat	3	4	85-90%	High Force – Low Velocity

Table 3: Example in-season one session per week strength maintenance (31).

Unstable Exercises and Injury Prevention

Injuries of the lower extremities are the most prevalent in football players (8, 21, 32) with traumatic injuries classified as sprains, and non-traumatic injuries classified as strains or overuse injuries (8, 21). Ankle and knee sprains have been reported to have the highest injury occurrence in football players, caused during tackling actions and contacts between players (21, 32). Although these are contact injuries, Griffin et al (14) suggested that lower limb strength reduces the risk of a non-contact ACL injury. There is evidence to suggest that hamstring strains are also extremely prevalent due to a lack of strength in the hamstringregion and fatigue (8, 21, 32). Askling et al (1) concluded that specific strength training for hamstrings, that included eccentric overloading, would benefit football athletes by maximising performance and reducing risk of injury. The study analysed thirty players from the two main Sweden divisions where subjects were divided into two groups; a training group and a control group. The training group performed a total of 16 specific hamstring strength training sessions, one to two times per week, with 4 sets of 8 repetitions in the lying hamstring curl machine for 10 weeks. The results of the study showed that the training significantly increased both eccentric and concentric knee flexor strength (19 and 15%, respectively, $p<0.05$), and the same group significantly increased sprinting time in 30 meters (2.4%, $p<0.05$). Notably, after a monitoring period of 10 months (one season) where the training group individuals reported a ($p<0.05$) lower number of hamstring injuries (3/15) compared to the control group (10/15).

Unstable exercise training (UST) may assist athletes with existing injuries to return to sport and are often used in rehabilitation programs (8, 10, 18). However, UST may be misinterpreted and programmed by strength and conditioning coaches for uninjured athletes to improve performance (10, 18). In fact, Cressey et al (12) concluded that proprioceptive activity, including UST type exercises, does not reflect an improvement in performance or maintenance for uninjured athletes. Nineteen Division 1 male soccer players were divided into two groups, with experimental group performing lower-body exercises on an unstable disc as well as their normal conditioning training. The control group (ST) performed the same exercises and training regime on a stable surface. Lower-body exercises consisted of 2-5 sets of 5-15 repetitions, for 27 sessions over a 10 weeks period, including unilateral and bilateral exercises for both groups (unstable and stable surfaces). After post-training testing in week 11, the results ofthe study have shown that both groups significantly improved in 10 and 40 metres, and T-test (ST: -3.9%, -7.6% and -4.4%, respectively and US: -1.8%,-4.0% and -4.4%, respectively), however Bounce Drop Jump and CMJ significantly ($p<0.05$) improved on the athletes that trained on the stable surfaces (3.2%, 2.4%, respectively).

CONCLUSIONS AND PRACTICAL APPLICATIONS

Football is a team sport that requires diverse types of physical attributes. Strength and power are the main physical attributes for a footballer, as well as aerobic and anaerobic abilities. This paper aimed to review the literature according to all football attributes and identify how the maintenance of strength and power during a seasonal period becomes important, not only to maximise performance, but also to reduce the risk of injury. The review also aimed to provide strength and conditioning coaches evidenced based information to assist in periodisation for strength and power maintenance and optimisation during a football season, rather than incorporating only injury prevention programs. Speed, COD, acceleration, deceleration, muscular endurance, RSA, maximal strength and power are all biomotor abilities that require strength as foundation for optimisation. The literature has also shown that the implementation of heavy resistance training during the competition period not only improves the biomotor abilities previously mentioned, but it also does not affect aerobic performance capacity (VO2max). When a sequenced, integrated, and scientific based macrocycle plan is implemented for football players, the risk of injury is reduced. In conclusion, strength and conditioning coaches for football should understand the importance of maintaining strength and power, and therefore implement strength and power training sessions at least once per week during the season, rather than replace strength and power sessions with proprioceptive types of training.

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