Effects of In-Season Strength Maintenance Training Frequency in Professional Soccer Players

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Abstract

Rønnestad, BR, Nymark, BS, and Raastad, T. Effects of in-season strength maintenance training frequency in professional soccer players. *J Strength Cond Res* 25(X): 000–000, 2011—The aim of the present study was to examine the effect of in-season strength maintenance training frequency on strength, jump height, and 40-m sprint performance in professional soccer players. The players performed the same strength training program twice a week during a 10-week preparatory period. In-season, one group of players performed 1 strength maintenance training session per week (group 2 + 1; $n = 7$), whereas the other group performed 1 session every second week (group 2 + 0.5; $n = 7$). Only the strength training frequency during the in-season differed between the groups, whereas the exercise, sets and number of repetition maximum as well as soccer sessions were similar in the 2 groups. The preseason strength training resulted in an increased strength, sprint, and jump height ($p < 0.05$). During the first 12 weeks of the in-season, the initial gain in strength and 40-m sprint performance was maintained in group 2 + 1, whereas both strength and sprint performance were reduced in group 2 + 0.5 ($p < 0.05$). There was no statistical significant change in jump height in any of the 2 groups during the first 12 weeks of the in-season. In conclusion, performing 1 weekly strength maintenance session during the first 12 weeks of the in-season allowed professional soccer players to maintain the improved strength, sprint, and jump performance achieved during a preceding 10-week preparatory period. On the other hand, performing only 1 strength maintenance session every second week during the in-season resulted in reduced leg strength and 40-m sprint performance. The practical recommendation from the present study is that during a 12-week period, 1 strength maintenance session per week may be sufficient to maintain initial gain in strength and sprint performance achieved during a preceding preparatory period.

Key Words sprint performance, vertical jump ability, one repetition maximum

Introduction

Conditioning for sport has usually been divided into preparatory, in-season, and postseason phases. One major goal for the preparatory period in team sports like soccer is to maximize the fitness parameters, like jumping ability, sprint performance, and maximal dynamic strength. During the in-season, professional soccer players have limited time available for strength training. This is because coaches have to plan for recovery from and preparations to 1–3 matches per week and for an increased focus on tactical and technical training sessions. Because of the increased demands of competition and the increased focus on technical and tactical training, in-season strength training is usually intended to maintain the fitness level achieved during the preparatory period. However, already fit players are likely to need a relatively high training stress to maintain their maximal strength level. Consequently, it is important to optimize the in-season strength training frequency and volume so that strength can be maintained with as little interference on other football-specific skills as possible. Therefore, the main question asked by coaches might be what is the minimum amount of strength training necessary to maintain strength and power in leg extensors during a season? Despite a large body of soccer-specific scientific work (e.g., Refs. (2,14,25), no one has so far investigated the effects of in-season strength training frequency.

Maximal strength is a basic quality that influences power performance; an increase in maximal strength is usually connected with an improvement of power abilities. Significant correlations are observed between maximum strength in the lower body and sprint and jump performance (8,24,31,32), and an increased strength is often followed by an improved sprint and jump performance (e.g., Refs. (6,27)). Thus, maximal strength is an important factor that potentially affects soccer performance. Therefore, it seems important to maintain strength during the competition period. However, strength

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gain achieved during the preparatory period in pubescent male athletes has been observed to be reduced during a 12-week competitive season without any strength maintenance training (7). Consequently, it is necessary to perform some kind of in-season strength maintenance training to avoid a decline in strength and power. It is well known that when strength training is terminated, the maximal strength declines (e.g., Refs. (13,29)), and it has been reported that only a small part (0–45%) of the strength gained during a previous strength training period is preserved after 8–12 weeks without strength training (1,11,22). Furthermore, it has been shown that soccer training alone has no effect on maximal strength (23,27).

In the National Collegiate Athletic Association Division I men's soccer, performing strength and plyometric sessions approximately once a week during a 16-week competitive season maintained maximal strength, sprint performance, and vertical jump ability (28). Furthermore, Morehouse (20) concluded that strength gains can be maintained by training once every second week during an 8-week maintenance period in college-aged men. However, the frequency of strength training sessions per week is likely to be affected by the initial training status and the length of the in-season. Furthermore, it has been observed that adding large volumes of endurance training to strength training may inhibit adaptations to strength training (17). Therefore, whether it is possible to maintain an initial gain in strength-related and power-related performance with strength training once per week or once every second week during the first 12 weeks of the in-season with a concurrent large aerobic stress is unclear. Interestingly, by performing in-season strength training twice per week during an 11-week soccer season, a reduction in isokinetic strength, vertical jump height, and sprint performance was observed (15). In the latter study, a predominance of catabolic processes was observed leading the authors to suggest that the players had a too large stress stimulus, leading to an acute overtraining. This large stress is likely to partly be caused by the 2 strength training sessions per week. It is thus important to further optimize the in-season strength training frequency to reassure enough stimuli to maintain the initial strength gain and, on the other hand, to avoid a too large stimulus that might cause acute overtraining.

The aim of the present study was to investigate the effect of performing strength maintenance training during the competitive season as 1 session per week versus 1 session every second week on strength, jump, and sprint performance in professional soccer players. The hypothesis was that the strength maintenance training program consisting of 1 weekly session would preserve the increases in muscle strength sprint and vertical jump performance achieved during the preparatory period to a greater extent than the program consisting of only 1 session every second week.

Methods

Experimental Approach to the Problem

The present study was designed to investigate the effects of in-season strength training frequency on strength, jump, and sprint performance in professional soccer players. Because of a tight match program, there is limited time available to maintain strength during the in-season. Thus, optimizing the in-season strength training frequency is important, and in present study, the effect of performing 1 session of heavy strength training once a week was compared with 1 session every second week. Changes in the dependent variables, such as 1 repetition maximum (RM), squat jump (SJ), and sprint performance, were tested at 3 time points: (a) at the beginning of a 10-week preparatory period (preintervention) that preceded the competition season, (b) after the preparatory period (precompetition season), and (c) at 12 weeks into the competition season (at the middle of the competition season). All soccer players performed the same strength training program twice a week during the preparatory period. They were thereafter randomly divided into 2 groups. One group performed 1 strength training session per week during the competition season (group 2 + 1; $n = 7$, age 22 $\pm$ 2 years, body mass 76 $\pm$ 1 kg, height 184 $\pm$ 3 cm), whereas the other group performed 1 strength training session every second week (group 2 + 0.5; $n = 7$, age 26 $\pm$ 2 years, body mass 83 $\pm$ 3 kg, height 186 $\pm$ 2 cm). Only the strength training frequency during the competition season differed between the groups, whereas the exercise, sets and number of RM and soccer sessions were identical in the 2 groups.

Subjects

A total of 19 Norwegian professional male soccer players (playing at the next highest level in Norway - the Norwegian Championship) volunteered to participate in this study. The players had performed in average 5–7 training sessions a week during the past 3 years. The study was approved by the Regional Ethics Committee of Norway. All participants signed an informed consent form before participation. During the preparatory period, 2 new players arrived and 2 players departed. The new players were not included in the data representing changes during the preparatory period ($n = 12$), but they were randomly allocated into different groups and included in the in-season data ($n = 14$). In addition to transfer, injury and illness led to the dropout of 5 players. In total, 14 players completed the in-season study.

Procedures

All tests were performed in 1 test session and in the following order: 40-m sprint, SJ, countermovement jump (CMJ), and 1RM. All test sessions were performed with the same equipment with identical subject-equipment positioning overseen by the same trained investigator. The preseason and mid-season tests were accomplished at the same time of the day as the pretests and 3–5 days after the last strength-training session.

Forty-Meter Sprint

All players performed a standardized warm-up before the sprint test by jogging for a 15-minute period at a moderate pace and finishing with 4–5 40-m submaximal runs. After warm-up, players performed 3–4 maximal sprints over a distance of 40 m.

Table 1. Strength training program during the preseason and in-season.*

	Preseason						In-season
	Week 1–3		Week 4–6		Week 7–10		Week 11–22
	1 Bout	2 Bout	1 Bout	2 Bout	1 Bout	2 Bout	Bout
Half squat	3 × 10RM	3 × 6RM	3 × 8RM	3 × 5RM	3 × 6RM	3 × 4RM	3 × 4RM

*The strength training program was identical for both the groups. The only difference was the strength training frequency; one group performed 1 strength maintenance training per week, whereas the other group performed 1 strength maintenance training every second week.

The sprints were performed on a hard even surface in an indoor facility. All players used adapted indoor shoes. The sprints were separated by approximately 3 minutes to ensure full recovery between sprints. Players commenced each sprint from a standing (static) position in which they positioned their front foot 50 cm behind the start line. Players decided themselves when to start each run with the time being recorded when the subject intercepted the photocell beam. Players were instructed to sprint as fast as possible through the distance. Times were recorded by photocells (Speedtrap 2; Brower Timing Systems, Draper, Utah, USA) placed at the start line and after 40 m. The best 40-m sprint time was chosen for statistical analysis of sprint performance.

Jumping Height

The maximal vertical jump ability was tested 3 minutes after the last sprint on a force plate (FP 4; HUR Labs Oy, Tampere, Finland) with a sampling rate at 1,200 Hz for 5 seconds. Players performed CMJ and SJ with the hands kept on the hips throughout the jumps. During SJ, from a knee angle of 90° of flexion, the players were instructed to execute a maximal vertical jump without any downward movement before the maximal vertical jump. The force curves were inspected to verify no downward movements before the vertical jump. During CMJ, the angular displacement of the knees was standardized so that the players were required to bend their knees to approximately 90° and then rebound upward in a maximal vertical jump. Each subject had 4 attempts interspersed with approximately 1.5-minute rest between each jump in both SJ and CMJ. The best jump from each subject was used in data analysis, and all data were calculated using Matlab (MathWorks, Natick, MA, USA). Jumping height was determined as the centre of mass displacement calculated from force development and measured body mass.

Table 2. Weekly duration (in hours) of the training distributed into different training intensities and weekly number of friendly matches during the 10-week preseason and during the first 12 weeks of the in-season.*

Intensity distribution	Preseason (mean ± *SE*)	In-season (mean ± *SE*)
Low intensity	2.4 ± 0.2	2.4 ± 0.2
Medium intensity	3.0 ± 0.4	2.1 ± 0.3
High intensity	4.3 ± 0.3	3.6 ± 0.3
Weekly number of friendly matches	0.9 ± 0.1	0
Weekly number of competitive matches	0	1.8 ± 0.2

*This training was performed by both the group that performed 1 strength training session per week and the group that performed 1 strength training session every second week.

One Repetition Maximum

Maximal strength in leg extensors was measured as 1RM in half squat. Before the 1RM squat test, players performed a standardized specific warm-up consisting of 3 sets with gradually increasing load (40–75–85% of expected 1RM) and decreasing number of reps (12–7–3). The depth of squat in the 1RM test was set to a knee angle of 90°. To assure similar knee angle in all test sessions for all the players, the squat depth was individually marked at the pretest depth of the buttock. Thus, the subject had to reach his individual depth in all test sessions to get the lift accepted. The first attempt in the test was performed with a load approximately 5% below the expected 1RM load. After each successful attempt, the load was increased by 2–5% until failure in lifting the same load in 2–3 following attempts. The rest period between each attempt was 3 minutes.

Training

The 10 weeks preparatory period consisted of 2 strength workouts per week on nonconsecutive days. Each workout consisted of the half squat exercise only. After a 15-minute warm-up with light jogging or cycling, players performed 2–3

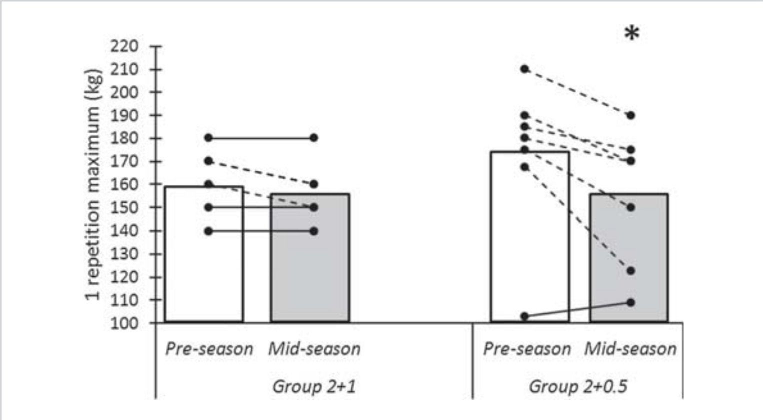

Figure 1. One repetition maximum in half squat before the start of the in-season (Preseason) and after 12 weeks of in-season (Mid-season) in the group that performed 1 strength maintenance training per week (group 2 + 1) and the group that performed 1 strength maintenance training every second week (group 2 + 0.5). Individual data points are shown, and the columns represent the mean value. *Smaller than at Preseason ($p < 0.05$).

warm-up sets with gradually increased load. All players were supervised by one of the physical trainers at all strength training sessions during the entire intervention period. The training load was 4–10RM and similar for the 2 groups (Table 1). Players were encouraged to continuously increase their RM loads during the intervention. Players were allowed assistance on the last repetition. Based on the assumption that it is the intended rather than actual velocity that determines the velocity-specific training response (3), strength training was conducted with emphasizing maximal mobilization in concentric phase, while the eccentric phase had a slower speed (approximately 2–3 seconds). Number of sets was always 3. During the in-season, group 2 + 1 performed 1 strength training session per week, whereas group 2 + 0.5 performed 1 strength training session every second week. The in-season strength training consisted of half squat and 3 sets of 4RM (Table 1). Only the strength training frequency during the competition season differed between the groups, whereas the exercise, sets and number of RM and soccer sessions were similar in the 2 groups.

A regular training week for both groups consisted of 6–8 soccer sessions lasting approximately 90 minutes focusing on physical conditioning, and technical and tactical aspects of the game. The intensity during the soccer sessions was divided into low, medium, and high intensity. The total weekly training duration (including strength training) during the preparatory period was 12.7 ± 1.0 hours (Table 2). The distribution of weekly duration in low, medium, and high exercise intensity zones during the intervention period is presented in Table 2. The mean number of soccer matches per week during the in-season was 1.8 ± 0.2.

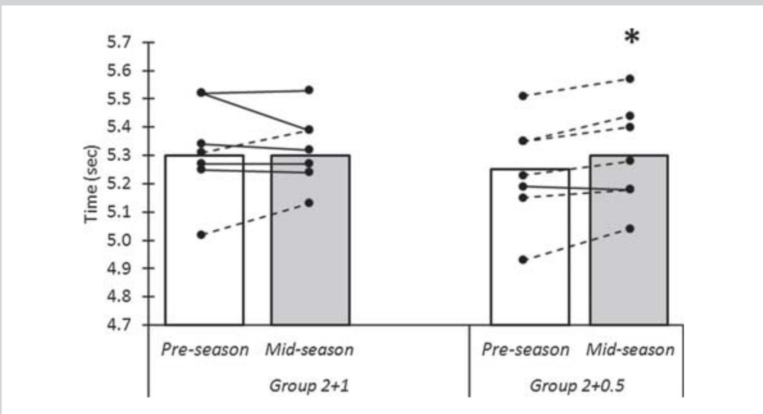

Figure 2. Forty-meter sprint time before the start of the in-season (Preseason) and after 12 weeks of in-season (Mid-season) in the group that performed 1 strength maintenance training per week (group 2 + 1) and the group that performed 1 strength maintenance training every second week (group 2 + 0.5). Individual data points are shown, and the columns represent the mean value. *Larger than at Preseason ($p < 0.05$).

Statistical Analyses

All values given in the text, figures, and tables are mean ± *SE*. During the pre-season, all players performed the same strength training protocol twice per week. The data from this period is thus pooled in 1 group of players. Paired *t*-test was used to test for changes during the preseason. To test for changes within groups from the start of the in-season to 12 weeks into the in-season, a paired *t*-test was used. Unpaired *t*-tests were used to compare relative changes from before the competitive season to mid-season between the 2 + 1 and 2 + 0.5 groups. In the 40-m sprint test, there was a statistical power of 80% to

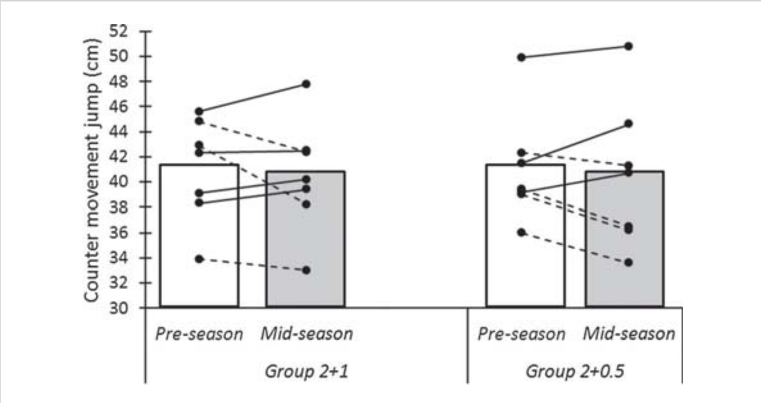

Figure 3. Counter movement jump height before the start of the in-season (Preseason) and after 12 weeks of in-season (Mid-season) in the group that performed 1 strength maintenance training per week (group 2 + 1) and the group that performed 1 strength maintenance training every second week (group 2 + 0.5). Individual data points are shown, and the columns represent the mean value.

detect differences from start of the in-season to 12 weeks into the in-season of 0.85%, using a significance level (α) of 0.05 (2 tailed). Test-retest reliabilities (intraclass correlations) for 40-m sprint, 1RM, and SJ was 0.95, 0.97, and 0.97, respectively, with a coefficient of variation of <3% for all parameters. The level of significance was set at $p \leq 0.05$ for all statistical analyses.

Results

There were no differences between the groups in anthropometric parameters or the test variables before the in-season.

Adaptations During the Preparatory Period

Strength measured as 1RM in half squat increased by 19 ± 5% during the preparatory period (from 139 ± 7 kg to 163 ± 8 kg; $p < 0.01$). Time used on 40-m sprint decreased during the preparatory period by 1.8% (from 5.39 ± 0.07 seconds to 5.29 ± 0.05 seconds; $p < 0.05$). Regarding vertical jump ability, SJ increased by 3.3 ± 1.2% during the preparatory period (from 37.1 ± 1.1 cm to 38.3 ± 1.1 cm; $p < 0.05$), whereas there was a tendency toward an improved CMJ performance (from 39.3 ± 1.6 cm to 41.1 ± 1.3 cm; $p = 0.056$).

In-season Adaptations

During the first 12 weeks of the in-season, the initial gain in strength was maintained in group 2 + 1, whereas the strength was reduced by 10 ± 4% in group 2 + 0.5 ($p < 0.05$; Figure 1). The 40-m sprint performance was maintained in group 2 + 1, whereas it was reduced by 1.1 ± 0.3% in group 2 + 0.5 ($p < 0.05$; Figure 2). There was no statistically significant change in SJ or CMJ in any of the 2 groups during the first 12 weeks of the in-season (Figures 3 and 4).

Discussion

Two strength training sessions per week during the preparatory period resulted in an increased strength, sprint, and vertical jump performance in professional soccer players. The novel finding in this study was that 1 strength training session per week during the first 12 weeks of the in-season maintained the initial gain in strength, sprint, and jump ability achieved during the preparatory period. On the other hand, 1 strength training session every second week resulted in a reduction in strength and sprint performance, while the vertical jumping ability was maintained.

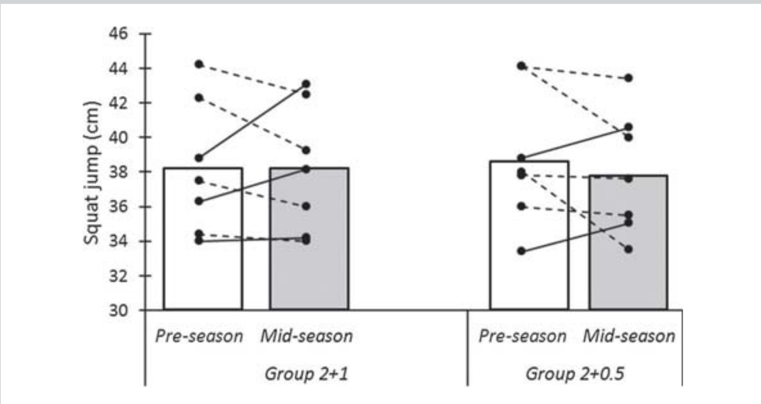

Figure 4. Squat jump height before the start of the in-season (Preseason) and after 12 weeks of in-season (Mid-season) in the group that performed 1 strength maintenance training per week (group 2 + 1) and the group that performed 1 strength maintenance training every second week (group 2 + 0.5). Individual data points are shown, and the columns represent the mean value.

The increase in 1RM half squat during the preparatory period is in line with the 20–25% increase reported in other studies on professional male soccer players with a similar training protocol (27,35). Maximal strength is a basic quality that influences power performance, and an increase in maximal strength is usually connected with an improvement of power abilities. Significant correlations are observed between maximum strength in the lower-body performance and sprint and jump performance (8,24,31,32), and an increased strength is often followed by an improved sprint and jump performance (e.g., Refs. (6,27,35)). The finding of concomitant improvement in jump and sprint performance during the preparatory period when the strength increased was therefore expected.

In other team sports like handball and volleyball, it has been observed that 6–7 weeks without strength training in the competitive season resulted in a reduced maximal strength and power output (12), as well as a reduced ball throw velocity, despite normal training sessions and competitions were maintained (18). These findings highlight the quest for strength maintenance training during the in-season. In the present study, it was observed that 1 strength training session per week during the first 12 weeks of the in-season maintained the initial gain in strength achieved during the preparatory period. This is in line with the previous findings in recreationally strength-trained subjects, collegiate soccer players, and cyclists (11,26,28). The present finding supports the suggestion that high-intensity muscle actions and low weekly training volume and frequency are capable of maintaining initial strength gain (11,21). Interestingly, by performing in-season strength training twice per week during an 11-week soccer season, a reduction in strength, jump height, and sprint performance was observed (15). In the latter study, a predominance of catabolic processes was observed leading the authors to suggest that the players got too large stress resulting in an acute overtraining. Because of the increased demands of competition, and technical and tactical training, in-season strength training is usually intended to maintain the fitness level achieved during the preparatory period. The in-season strength training should therefore aim to maintain the initial strength gain and, on the other hand, to avoid a too large stimulus, thereby causing an acute overtraining. The finding of Kraemer et al. (15) indicates that 2 in-season strength training sessions per week may in some cases be too much, at least when combined with the heavy match load in that study. Furthermore, the present study indicates that 1 strength training session every second week is not enough to maintained the initial gain in strength in professional soccer players.

The present finding of reduced strength after 1 strength training session every second week is in contrast with the finding of maintained strength by training once every second week during an 8-week maintenance period (20). However, this discrepancy may be explained by the fact that the latter study was conducted on college students with no prior strength training experience, and there was no report of any concurrent endurance training during the maintenance period. Professional soccer players have a larger strength training experience and thus needs a larger strength training frequency to maintain the initial strength, and they perform a relative large volume of endurance training. Large volumes of endurance training may inhibit adaptations to strength training (17) and thus potential quest for a larger frequency of strength maintenance training. Indeed, endurance training has been shown to lower the maximum shortening velocity of type II fibers, reduce motor unit discharge rates, and slightly reduce peak tension development in all fiber types (9,10,30,33,34). In accordance with the latter findings, endurance training has been associated with a reduced vertical jumping ability (5), strength (5,19), and unchanged or slightly reduced cross sectional area (CSA) of muscle fibers (9,17,33,34). Based on the negative effects of endurance training on explosive abilities, and the observed reduction in strength, the impaired sprint performance when performing strength training only once every second week was not unexpected.

Vertical jump ability was preserved during the first 12 weeks of the in-season in both the groups. The reason to why strength training every second week was enough to maintain vertical jump performance but not strength and sprint performance remains unclear. However, 6–7 weeks without strength training has been observed not to reduce vertical jump ability in both recreationally strength-trained participants and professional handball players (16,18). Furthermore, 12 weeks without strength training have been shown to only slightly reduce jump ability despite more pronounced reduction in strength (4). It has been suggested that maintenance of vertical jump ability despite reduction in other performance measurements may be because of the importance of jump technique (16). Furthermore, it has also been suggested that maintenance of explosive jumping performance may be more dependent on training frequency when more explosive-type strength or plyometric training programs have been performed in advance (16). The present data indicate that strength maintenance training once every second week in addition to specific soccer practices (including plyometric muscle actions) and matches maintains the vertical jump ability in professional soccer players during the first 12 weeks of the in-season.

To our knowledge, the present study is the first to demonstrate that professional soccer players can maintain the initial strength, sprint, and jump improvements attained during the preparatory period with just a single low-volume heavy strength training session per week during the first 12 weeks of the in-season, while 1 session every second week do not maintain strength and sprint performance. It is important to note that the present findings were done in a short maintenance period of 12 weeks. If the maintenance period is of a longer duration or the initial strength level is higher, then it might be necessary with a higher strength training frequency to maintain strength and sprint performance.

In conclusion, performing 1 weekly strength maintenance session during the first 12 weeks of the in-season allowed professional soccer players to maintain the improved leg strength that were attained during a preceding 10-week preparatory period. Of even greater practical importance, the in-season maintenance of the strength training adaptations resulted in maintenance of performance-related factors like 40-m sprint and vertical jump ability. On the other hand, performing 1 strength maintenance session every second week during the in-season resulted in a reduction in leg strength and 40-m sprint performance but maintained the jump performance.

Practical Applications

Our data indicate that strength training twice a week during the preparatory period can be an important factor in increasing maximal strength and jump and 40-m sprint performance in professional soccer players. During the first 12 weeks of the in-season, strength maintenance training once a week was enough to maintain the initial gain in strength, jump, and sprint performance. On the contrary, strength maintenance training every second week did not maintain the initial gain in strength and sprint performance. To maintain initial gain in strength and explosive movements achieved during the preparatory period, we recommend using 1 strength maintenance session per week during the in-season. Depending on the number of matches per week, this strength maintenance session are recommended to be performed between 1 and 2 days after a match and 2–3 days before the next match. The specific mechanisms responsible for the observed findings cannot be determined from the current study. It is important to note that the present findings were done in a short maintenance period of 12 weeks. If the maintenance period is of a longer duration or the initial strength level is higher, then it might be necessary with a higher strength training frequency to maintain strength and sprint performance.

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