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Effects of in-season strength maintenance training frequency in professional soccer players

Running head: Strength maintenance training in professional soccer players

Authors: Bent R. Rønnestad[1], Bernt S. Nymark[1], and Truls Raastad[2]
[1]Lillehammer University College, Lillehammer, Norway
[2]Norwegian School of Sport Sciences, Oslo, Norway

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Corresponding author:
Bent R. Rønnestad
Lillehammer University College
PB. 952, 2604 Lillehammer
Norway

E-mail: bent.ronnestad@hil.no Phone: +47 61288193 Fax: +47 61288200

Effects of in-season strength maintenance training frequency in professional soccer players

Abstract

The aim of the present study was to examine the effect of in-season strength maintenance training frequency on strength, jump height, and 40-meter 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 one strength maintenance training session per week (*group 2+1*; n=7), while the other group performed one session every second week (*group 2+0.5*; n=7). Only the strength training frequency during the in-season differed between the groups, while the exercise, sets and number of RM as well as number of soccer sessions was similar in the two groups. The preseason strength training resulted in increased strength, sprint and jump height ($p<0.05$). During the 12 first weeks of the in-season, the initial gain in strength and 40-m sprint performance was maintained in *group 2+1*, while 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 two groups during the 12 first weeks of the in-season. In conclusion, performing one 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 one strength maintenance session every second week during the in-season resulted in reduced leg strength and 40-meter sprint performance. The practical recommendation from the present study is that during a 12-week period, one 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 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 as well as 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. The main question asked by coaches might therefore 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. 2, 12, 25), no one has so far investigated the effects of in-season strength training frequency.

Maximal strength is a basic quality which 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 increased strength is often followed by improved sprint and jump performance (e.g. 6, 27). Thus maximal strength is one important factor which potentially affects soccer performance. Therefore, it seems important to maintain strength during the competition period. It has been observed reduction of the initial strength gain achieved during the preparatory period in pubescent male athletes who quit strength training during a 12-week competitive season (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. 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 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 are 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 (15). Therefore, whether it is possible to maintain an initial gain in strength and power related performance with strength training once per week or once every second week during the 12 first 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 (17). 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 two 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 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 one session per week versus one 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 one 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 one 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. Due to a tight match program, there is limited time available to maintain strength during the in-season. Thus optimizing of the in-season strength training frequency is important and in present study the effect of performing one session of heavy strength training once a week was compared with one session every second week. Changes in the dependent variables 1RM, SJ, and sprint performance were tested at three time points: 1) at the beginning of a 10-week preparatory period (pre-intervention) that preceded the competition season, 2) after the preparatory period (pre-competition season), and 3) 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 two groups.

One group performed one strength training session per week during the competition season (*group 2+1*; n=7, age 22±2 years, body mass 76±1 kg, height 184±3 cm), while the other group performed one strength training session every second week (*group 2+0.5*; n=7, age 26±2 years, body mass 83±3 kg, height 186±2 cm). Only the strength training frequency during the competition season differed between the groups, while the exercise, sets and number of RM as well as number of soccer sessions was identical in the two groups.

Subjects

A total of 19 Norwegian professional male soccer players (playing at the next highest level in Norway; Championship) volunteered to participate in this study. The players had performed in average 5-7 training sessions a week during the last 3 years. The study was approved by the Regional Ethics Committee of Norway. All participants signed an informed consent form prior to participation. During the preparatory period two new players arrived and two 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 one test session and in the following order: 40-m sprint, SJ, 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 pre-tests, and 3-5 days after the last strength-training session.

40-meter sprint

All players performed a standardized warm-up prior to the sprint test by jogging for a 15-minute period at a moderate pace and finishing with 4-5 40-meter submaximal runs. After warm-up, players performed 3-4 maximal sprints over a distance of 40 meters. 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, Utah, USA) placed at the start line and after 40m. The best 40m sprint time was chosen for statistical analysis of sprint performance.

Jumping height

The maximal vertical jump ability was tested three minutes after the last sprint on a force plate (FP 4, HUR Labs Oy, Tampere, Finland) with a sampling rate at 1200 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 90º of flexion, the players were instructed to execute a maximal vertical jump without any downward movement prior to the maximal vertical jump. The force curves were inspected to verify no downward movements prior to 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 four 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 was calculated using Matlab. Jumping height was determined as the centre of mass displacement calculated from force development and measured body mass.

1 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 pre-test depth of the buttock. Thus the subject had to reach his individually 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 two strength workouts per week on non-consecutive 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 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 two groups (Table 1). Players were encouraged to continuously increase their RM loads during the intervention. Players were allowed assistance on the last rep. 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 sec). Number of sets was always three. During the in-season, *group 2+1*performed one strength training session per week, while *group 2+0.5* performed one 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, while the exercise, sets and number of reps as well as number of soccer sessions, was similar in the two groups.

(Insert Table 1 approximately here)

A regular training week for both groups consisted of 6-8 soccer sessions lasting approximately 90 minutes focusing on physical conditioning, 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 hrs (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.

(Insert Table 2 approximately here)

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 one group of players. Paired *t*-test was used to test for changes during the pre-season. 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* group. In the 40 m sprint test there was a statistical power of 80% to detect differences from start of the in-season to 12 weeks into the in-season of 0.85%, using a significance level (alpha) of 0.05 (two-tailed). Test-retest reliabilities (intraclass correlations; ICC) 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 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 sec to 5.29±0.05 sec; $p<0.05$). 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; $p<0.05$), while there was a tendency towards improved CMJ performance (from 39.3±1.6 cm to 41.1±1.3 cm; $p=0.056$).

In-season adaptations

During the 12 first weeks of the in-season, the initial gain in strength was maintained in *group 2+1*, while 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*, while it was reduced by 1.1±0.3% in *group 2+0.5* (p<0.05; Figure 2). There was no statistical significant change in SJ or CMJ in any of the two groups during the 12 first weeks of the in-season (Figure 3 and 4).

(Insert Figures 1, 2, 3, and 4 approximately here)

DISCUSSION

Two strength training sessions per week during the preparatory period resulted in increased strength, sprint and vertical jump performance in professional soccer players. The novel finding in this study was that one 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, one strength training session every second week resulted in reduction in strength and sprint performance, while the vertical jumping ability was maintained.

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 which 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 increased strength is often followed by improved sprint and jump performance (e.g. 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 reduced maximal strength and power output (14), as well as 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 one strength training session per week during the 12 first weeks of the in-season maintained the initial gain in strength achieved during the preparatory period. This is in line with 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 (17). 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. Due to the increased demands of competition, 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 avoid a too large stimulus and thereby causing an acute overtraining. The finding of Kraemer et al. (17) indicates that two 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 one 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 one strength training session every second week is in contrast to 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 (15) and thus potentially 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 to 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 reduced vertical jumping ability (5), strength (5, 19), and unchanged or slightly reduced CSA of muscle fibers (9, 15, 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 12 first weeks of the in-season in both 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 to not 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 due to 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 indicates 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 one 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 one 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-meter sprint and vertical jump ability. On the other hand, performing one strength maintenance session every second week during the in-season resulted in reduction in leg strength and 40-meter 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 as well as jump and 40-m sprint performance in professional soccer players. During the 12 first 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 one 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 1-2 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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Figure Legends

Figure 1: 1 repetition maximum in half squat before the start of the in-season (Pre-season) and after 12 weeks of in-season (Mid-season) in the group which performed one strength maintenance training per week (*Group 2+1*), and the group which performed one 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 Pre-season ($p<0.05$).

Figure 2: 40-meter sprint time before the start of the in-season (Pre-season) and after 12 weeks of in-season (Mid-season) in the group which performed one strength maintenance training per week (*Group 2+1*), and the group which performed one 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 Pre-season ($p<0.05$).

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

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

FIGURE 1

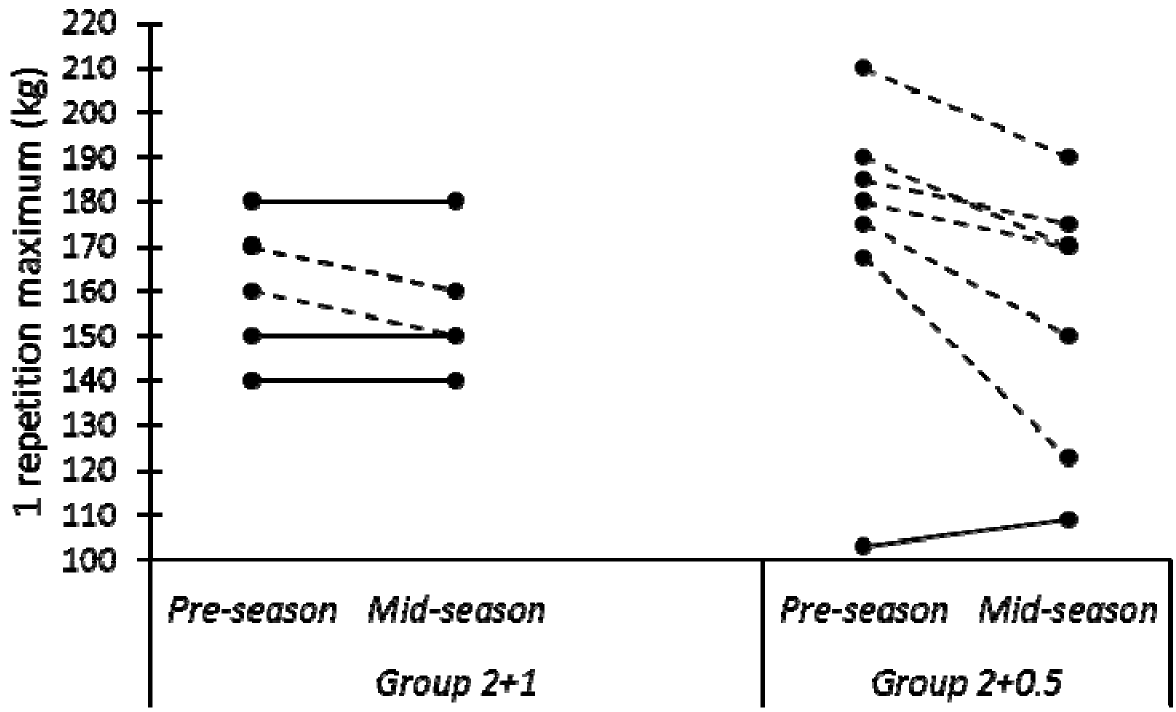

FIGURE 2

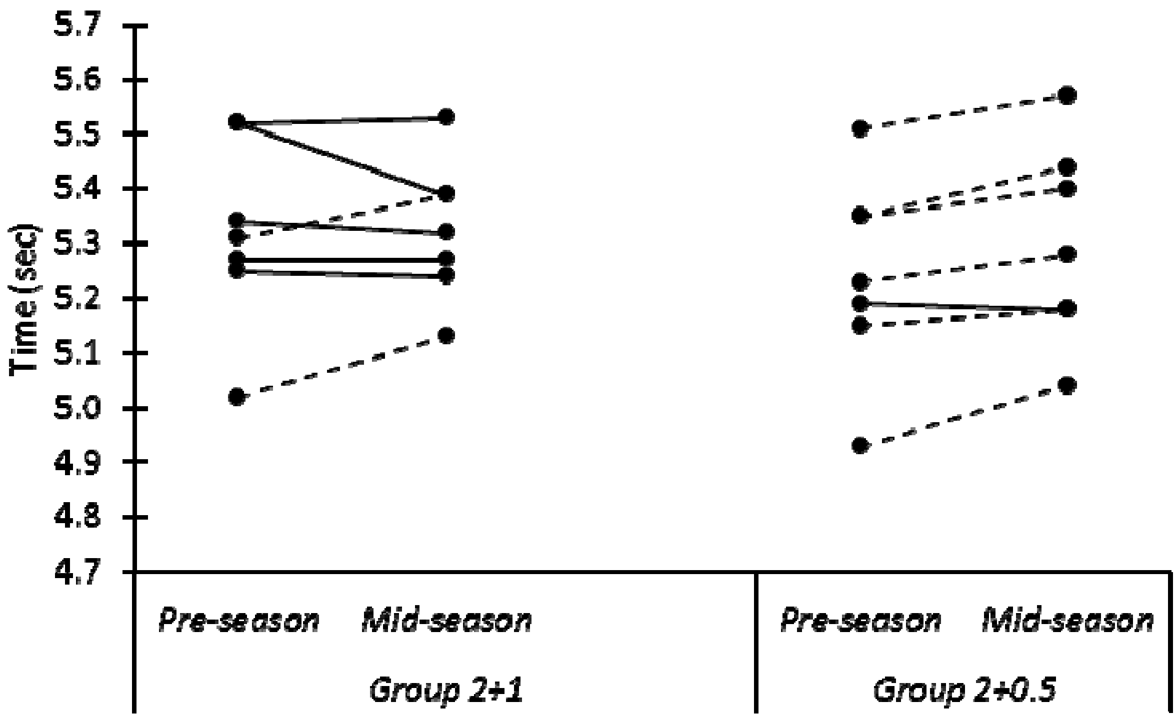

FIGURE 3

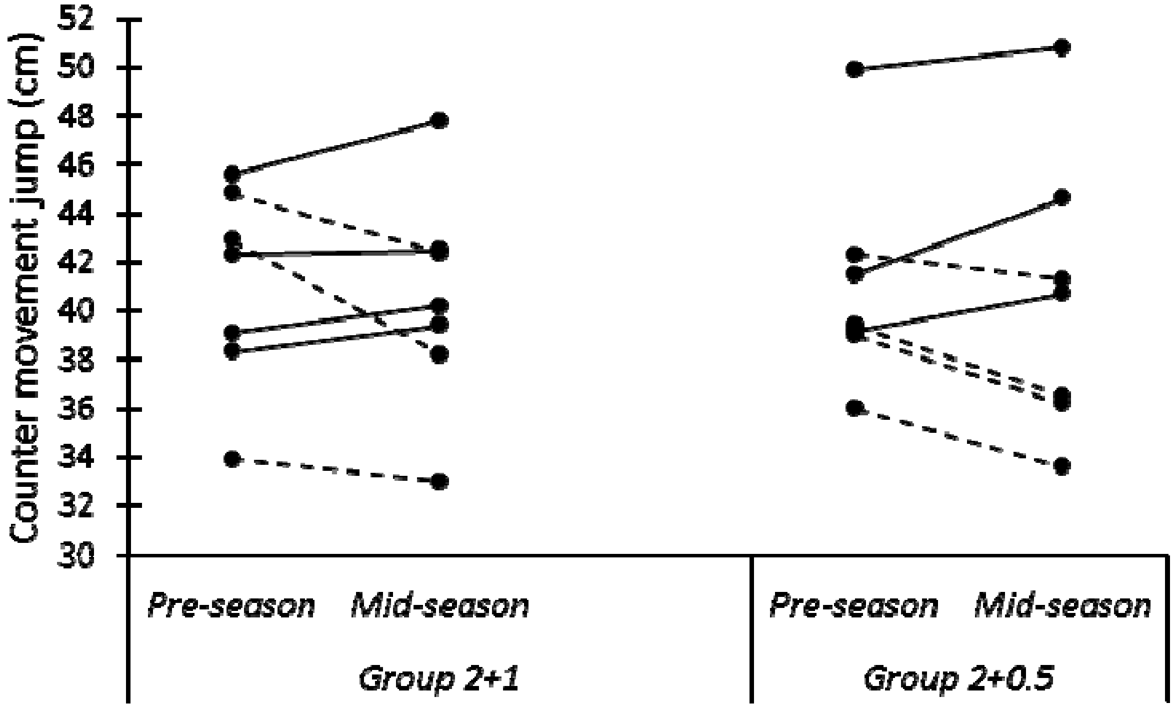

FIGURE 4

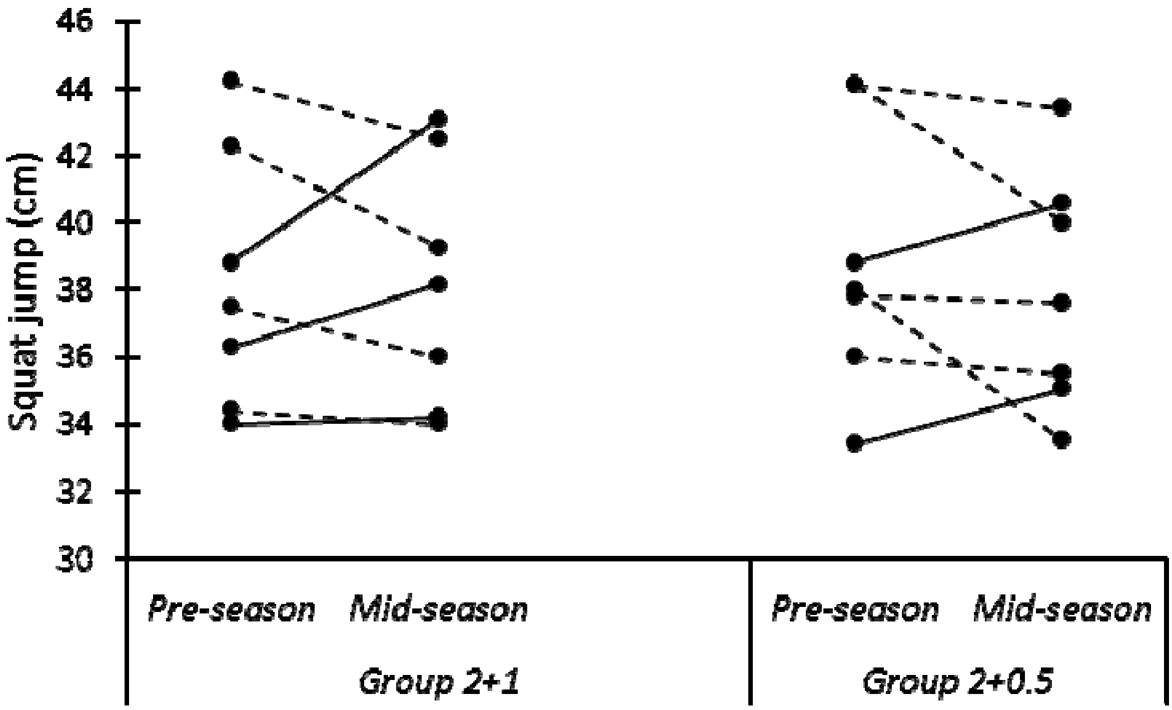

Table 1 Strength training program during the preseason and in-season. The strength training program was identical for bothgroups. The only difference was the strength training frequency; one group performed one strength maintenance training per week, while the other group performed one strength maintenance training every second week.

	Pre-season						**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	3x10RM	3x6RM	3x8RM	3x5RM	3x6RM	3x4RM	3x4RM

Table 2 Weekly duration (in hours) of the training distributed into different training intensities and weekly number of friendly matches during the 10-weeks pre-season and during the 12 first weeks of the in-season. Note that this training was performed by both the group that performed one strength training session per week and the group that performed one strength training session every second week.

	Pre-season	**In-season**
Intensity distribution:		
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

Values are mean±SE.