THE EFFECT OF 40 M REPEATED SPRINT TRAINING ON PHYSICAL PERFORMANCE IN YOUNG ELITE MALE SOCCER PLAYERS

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Abstract The purpose of this study was to investigate the effect of eight-week repeated sprint training program on maximum sprinting speed, endurance sprinting speed, jump height and the ability to repeat and recover from high-intensity exercise (Yo-Yo IR1). Fifteen young, well-trained, elite male soccer players aged (±SD) 16.3 ±0.5 years, body mass 68.1 ±9.4 kg, and stature 178.5 ±7.3 cm, volunteered to participate in this study. All subjects were tested on 40 m sprint, 10x40 m repeated sprint, 3–6–9 agility with a 180° turn, countermovement jump (CMJ), squat jump (SJ), and Yo-Yo IR1 test. Subjects were randomly assigned to one of two groups: a training group and a control group. The training group followed a repeated sprint training program twice a week. The results indicate significant improvement within the training group from pre- to post-test in 10x40 m repeated sprint time (-0.29 s), 40 m sprint time (-0.33 s), 0–20 m sprint time (-0.19 s), 20–40 m sprint time (-0.15 s) and CMJ (1.3 cm). The control group results showed notable improvements in 0–40 m sprint time (-0.11 s), 10x40 m repeated sprint time (-0.09 s) and 0–20 m sprint time (-0.10 s). A comparison between groups indicates that there were marked differences between the two groups in 40 m sprint time (-0.22 s), 10x40 m repeated sprint time (-0.20 s) and 20–40 m sprint time (-0.15 s). We concluded that repeated sprint ability is trainable and the larger improvement within the training group as compared to the control group could be explained by the extra weekly repeated sprint training.

Key words: RSA, CMJ, YoYo-IR1, recovery, training load

INTRODUCTION

Research indicates that physical performance in soccer depends on various characteristics [4]. Specifically, endurance, strength, speed, power and agility must all be well developed in order to achieve a high performance level in soccer [12, 13, 19, 23]. Soccer match activities cover a range of intensities from low through moderate to high [19, 25]. Hence, a well-developed aerobic energy delivery system is important as it can assist players to maintain high-intensity and total work, and also help them to adjust the distance covered at low intensities so they perform at higher intensities when the game demands [5, 9, 24, 32]. Previous research has revealed that the most successful teams in modern soccer have the ability to perform and repeat high-speed actions more often than less successful teams [14]. These actions have been reported to characterise the crucial moments of a soccer match (e.g. scoring, winning position of scoring or likewise losing important defensive position) [26]. Furthermore, high-speed running and sprinting activities during a soccer match are proven to relate both to the ability to repeatedly sprint and the Yo-Yo IR1 test performance [1, 17, 22]. Such a merging relationship could be caused by both the similarities in the energy production of the two activities [1, 5, 8] and the concurrent demands on a certain degree of muscular power [8].

Analyses of elite soccer matches show that a player's sprint actions during a match can be categorised into actions of acceleration, deceleration, maximal speed and agility (alternation in the direction of motion) [19, 25]. Further analyses reveal that high-speed sprinting actions represent 1-11% of the total distance covered during a soccer match [19, 21, 29]. The majority of players conduct short sprints (2-4 s) every 60-90 s depending on the role and position of the player [4, 6, 26, 33, 34]. Hence, the duration of these high-speed sprinting actions highlights a major demand on acceleration speed. However, as sprints in soccer mainly start while the players are already running, the demand for maximum speed (flying speed

above 20 m) can be high as well [19, 26, 29, 34]. The fact that the distance covered and the amount of high-intensity running and repeated sprinting decrease from the first to the second half of a soccer match [18, 21] suggests a high demand on speed endurance. Thus, the practice of repeated sprints (< 10 s) with short breaks that allow for near full recovery (30-120 s) is required to maintain soccer players' sprinting speed over time [2, 3]. An improvement in running speed has been observed following speed endurance training combined with resistance training [11]. Such training has previously been reported to be linked to an enhanced anaerobic metabolism [8, 14], fibre hypertrophy and beneficial neural adaptations [10, 29], and an improvement in the ability to store elastic energy in leg extensors [15, 20]. However, to date, the effect of specialised repeated sprint training stimuli, which do not involve strength, plyometric or agility training, on soccer players' repeated sprint ability (RSA) has not been explored except in one study [31].

Consequently, the main purpose of this study was to investigate the effect of an eight-week specialised repeated sprint training programme on elite junior soccer players' RSA. A secondary purpose of the study was to examine if this repeated sprint training programme would have any effect on other physical performance abilities such as Yo-Yo Intermittent Recovery test Level 1 (Yo-Yo IR1), 40 m maximum sprinting speed, agility, countermovement jump (CMJ) and squat jump (SJ).

MATERIALS AND METHODS

SUBJECTS

One team of eighteen young, well-trained elite male soccer players who volunteered to participate in this study. Three subjects dropped out and the study continued with fifteen subjects aged 16.3 ±0.5 years, body mass 68.1 ±9.4 kg, and stature 178.5 ±7.3 cm. The subjects trained for 12.4 ±2.5 hours per week and their team played among the four best junior teams in the country. All participants gave their voluntary and informed written consent approved by their parents, and the study was approved by our University Committee.

INSTRUMENTS AND TESTING SETUP

The stature was measured using a wall-mounted stadiometer (KaWe Medizintechnik, Asperg, Germany); jump height was estimated using force platform-based determinations of impulse and velocity at take-off. The force platform used was an AMTI model OR6-5-1. The data were amplified (AMTI Model SGA6-3), digitised (DT 2801), and saved to a stationary computer (PC Pentium 4 running Windows XP) using the special software program, Biopack MP 100. The agility sprint 3–6–9 m with a 180° turn, 40 m maximal sprints and repeated sprint were measured on artificial grass in an indoor soccer stadium using Newtest Powertimer 300s infrared photocells. The photocells were connected to a laptop (PC Pentium 3 running Windows XP) using PowertimerPC, a special program that measures time to the nearest 0.001 s. The Yo-Yo IR1 test was conducted on an indoor basketball court following the procedure previously described by Krustrup et al [17]. A CD-player (DC 1015, Denon Brand Company, Japan) with an amplifier (F590ES) and loudspeakers (SS-E420, Sony Corporation, Japan) was used to play the Yo-Yo IR1 CD track. Two digital video cameras (SDR-H80, Panasonic Corporation, Japan) were used to record the Yo-Yo IR1-test in order to maximise objectivity when analysing the results.

The subjects were matched according to their 40 m sprint time from the pre-test. Then they were randomly assigned to one of the two groups: the training group (n=8) and the control group (n=7). The study took part in the pre-competition phase of the subjects' training program and ended 13 weeks before the start of the season; the duration of the pre-competition period was 26 weeks. The length of the mesocycle was eight weeks. Each test round was conducted on two consecutive days with no training in between. On test day one, 3-6-9 m agility with a 180° turn, 40 m maximal sprint, and 10x40 m repeated sprint were measured; on test day two, countermovement jump (CMJ), squat jump (SJ), and Yo-Yo IR1 test performance were assessed.

TESTING PROCEDURES

To familiarise themselves with the tests, the subjects completed a training session on the testing procedure one week prior to the pre-test.

On the first day of the pre-test, stature was measured before the subjects started with a 15 min general warm-up running at 60-70% of maximum heart rate, which ended with 4-5 accelerations over 50 m. Next, 3-6-9 m agility with a 180° turn and maximum running speed over 40 m were tested; a 5 min recovery was allowed between each of the tests. On both agility and 40 m sprint, the subjects were allowed three attempts each, with at least 3 min recovery between attempts. The 3-6-9 m agility with a 180° turn test used in this study involved positioning three lines on the field: one at 3 m, 6 m, and 9 m each. A photocell was placed at the start/finish line. The subject would sprint to the first line (3 m) and touch it with his foot, do a 180° turn and sprint back to the starting line, touching it with his foot again. Next, the subject would sprint to

the second line (6 m) and repeat the procedure described above; finally, the subject would do the same with the third line (9 m) and sprint back to complete the test by crossing the start/finish line. The timer started when the subject passed the photocell at the start/finish line (time zero) and stopped when the subject passed the photocell after finishing the last run. In the 40 m maximum sprint test, the subjects started from a standing position by placing the front foot on the starting line, and when the test leader gave the signal, the subject started the sprint to the finish photocell (40 m). The time started automatically when the subject broke the beam from the first photocell, placed at the starting line (time zero), and stopped when he passed the photocells at both 20 m and 40 m. Times were measured for the 0-20 m sprint and the 20-40 m sprint. The best results were retained for analysis. The endurance sprinting time test was measured by 10x40 m maximum sprints with 60 s recovery between each sprint, using the same procedure as in the maximum 40 m sprint. The subjects were asked to sprint as fast as possible in each run. The mean time for the 10 sprints was used for analysis as it had been described as a good indicator of a player's ability to perform several sprints [30].

On the second day of the pre-test, the subjects started with the same warm-up procedure as described on the first pre-test day. The subjects were then asked to complete the CMJ and the SJ tests before the Yo-Yo IR1 test. The CMJ was performed by the subject standing on the force platform with the plantar part of the foot in contact with the ground, hands on hips; from an erect standing position with a knee angle of 180°, a countermovement was performed until the knee angle decreased to approximately 90°; an immediate jump followed. The SJ test was performed from a semi-squat position with no countermovement. At the start, the knee was restricted to approximately 90°, with the plantar part of the foot in contact with the ground. The hands were on the hips and the trunk was erect. Next, the subject would jump immediately. On both CMJ and SJ, three attempts each were allowed with at least 3 min recovery between attempts. The best result from both jumping tests was retained for analysis.

The Yo-Yo IR1 test started after the test leader had measured and marked the running lanes with cones to 2 m width and 20 m length, and a recovery area, where cones were placed 5 m behind the finishing line. Then the Yo-Yo IR1 CD (the soundtrack) and the CD player were checked (by timing of the intervals) to ensure the soundtrack would be played at the right speed [17] between the sound signals (Beep). Then, the Yo-Yo IR1 test was conducted by two experienced test leaders who were responsible for making sure that the participants fulfilled the testing criteria according to the procedures described by Krustrup et al [17]. Verbal encouragement was given from both test leaders and team coaches prior to and continuously during the test, with the purpose of motivating the participants to work to exhaustion.

THE TRAINING INTERVENTION

Both groups in this study performed Nordic hamstring exercise, balance training (ankle strength on balance board), sit-ups, the plank, push-ups and the alternating back and arm rise twice a week during their regular soccer team training. Furthermore, the control group was instructed to continue with the team's original training plan. The training group completed two extra training sessions with repeated speed training. The training program completed by the training group included sprinting four sets of 5x40 m with 90 s recovery between repetitions and 10 min recovery between sets. The training was conducted every Monday at 10:00 AM and every Thursday at 06:00 PM. The team had soccer trainings on Mondays, Tuesdays, Wednesdays and Fridays. Before the speed training, the subjects completed both general and specific warm-up. The participants had to complete at least 90% of the training period and had to be able to complete all the tests to be included in further analysis.

STATISTICAL ANALYSIS

Raw data were transferred to the SPSS 16.0 for Windows and Microsoft Excel for analysis. The normality of the data was examined by assessing the Shapiro-Wilk test on all measured variables in this study for both groups; the results indicated that all measured variables followed normality. Therefore, to detect differences in measurements between the pre- and post-tests, the paired sample t-test was performed to evaluate the difference in means between the paired samples (within group). To test for a difference in means between groups, the independent sample t-test was assessed. In order to determine the effectiveness of the applied RSA training, the effect size (Cohen's d) was calculated according to Rosnow and Rosenthal [27]. Furthermore, to determine whether the effect size was trivial ($d>0.2$), small ($d=0.2-0.6$), moderate ($d=0.6-1.2$), large ($d=1.2-2.0$), or very large ($d>2.0$), the scale developed by Batterham and Hopkins [7] was used. Differences were considered significant at $P \le 0.05$, and the results were expressed as means and standard deviations. The 95% confidence interval was also calculated for all measurements.

RESULTS

Differences within and between groups in a variety of physiological measures are shown in Table 1. The results indicate that there were significant improvements within the training group from pre- to post-test in 10x40 m repeated sprint time, 40 m sprint time, 0–20 m sprint time, 20–40 m sprint time and CMJ. The results

also showed significant improvements within the control group in 40 m sprint time, 10x40 m repeated sprint time and 0–20 m sprint time. A comparison between groups demonstrates statistically marked differences between the two groups in 40 m sprint time, 10x40 m repeated sprint time and 20-40 m sprint time.

Table 1. Mean results of 10x40m repeated sprint, 40m sprint, 20m acceleration, 20m top speed, SJ, CMJ, Yo-Yo IR1 , agility and body mass between and within groups from pre to post-test (±SD)

Variable	Training-Group				Control-Group				Between Groups differences				
	Pre-test	Post-test	Change	95% CI	Pre-test	Post-test	Change	95% CI	TG	CG	Difference	95% CI	E.S.
10x40 m (s)	5.92 ±0.26	5.63 ±0.15	-0.29 ±0.13	-0.39 to -0.19**	5.84 ±0.27	5.74 ±0.25	-0.09 ±0.03	-0.12 to -0.07**	-0.29 ±0.13	-0.09 ±0.03	-0.20 ±0.05	-0.30 to -0.09**	2.1
0-40 m time (s)	5.82 ±0.27	5.49 ±0.18	-0.33 ±0.13	-0.44 to -0.22**	5.69 ±0.25	5.58 ±0.23	-0.11 ±0.06	-0.17 to -0.06**	-0.33 ±0.13	-0.11 ±0.06	-0.22 ±0.05	-0.34 to -0.10**	2.1
0-20 m time (s)	3.29 ±0.14	3.10 ±0.08	-0.19 ±0.10	-0.27 to -0.10**	3.22 ±0.17	3.11 ±0.12	-0.10 ±0.06	-0.16 to -0.04**	-0.19 ±0.10	-0.10 ±0.06	-0.08 ±0.04	-0.18 to 0.01	1.1
20-40 m time (s)	2.53 ±0.16	2.39 ±0.14	-0.15 ±0.08	-0.21 to -0.08**	2.46 ±0.11	2.46 ±0.13	-0.00 ±0.05	-0.05 to 0.05	-0.15 ±0.08	-0.00 ±0.05	-0.15 ±0.03	-0.22 to -0.07**	2.2
CMJ (cm)	31.1 ±2.6	32.3 ±2.6	1.3 ±1.2	0.28 to 2.27*	33.0 ±5.1	32.1 ±5.4	-0.9 ±2.6	-3.23 to 1.49	1.3 ±1.2	-0.9 ±2.6	2.2 ±1.0	-0.03 to 4.32	1.1
SJ (cm)	30.9 ±3.5	31.8 ±1.7	0.9 ±2.0	-0.81 to 2.59	30.7 ±4.8	30.2 ±5.5	-0.5 ±2.5	-2.85 to 1.80	0.9 ±2.0	-0.5 ±2.5	1.4 ±1.2	-1.12 to 3.96	0.6
Yo-Yo IR1 (level)	17.3 ±0.8	17.1 ±0.9	-0.2 ±0.6	-0.66 to 0.26	17.1 ±1.4	16.5 ±1.4	-0.5 ±0.8	-1.26 to 0.23	-0.2 ±0.6	-0.5 ±0.8	0.3 ±0.4	-0.45 to 1.08	0.4
Agility (s)	9.29 ±0.24	9.19 ±0.22	-0.10 ±0.15	-0.22 to 0.03	9.50 ±0.47	9.42 ±0.49	-0.08 ±0.23	-0.29 to 0.14	-0.10 ±0.15	-0.08 ±0.23	-0.02 ±0.10	-0.23 to 0.19	0.1
Body mass (kg)	68.0 ±10.0	68.7 ±9.0	0.8 ±1.4	-0.39 to 1.88	68.3 ±9.4	69.0 ±9.1	0.7 ±0.9	-0.08 to 1.56	0.8 ±1.4	0.7 ±0.9	0.0 ±0.6	-1.29 to 1.31	0.1

* = p < 0.05, ** = p < 0.01, TG =Training-Group, CG= Control-Group, E.S.= Effect size (Cohen's *d*)

The effect size of the training program between the groups shows that even though there were no statistically significant differences between the groups in 0–20 m sprint time, CMJ and SJ, the effect of repeated sprint training on the training group was large and close to very large in 0–20 m sprint time and CMJ (Table 1).

DISCUSSION

The observed improvement in the RSA within the training group is substantial, especially considering that the subjects trained soccer for 13 hours per week on average and only engaged in a specific speed training twice a week over eight weeks. Nevertheless, the results demonstrate that this type of training is effective, and that the RSA appears to be trainable using only a repeated sprint training program with no involvement of strength, plyometric or agility training. Previous research indicated that the improvement in the RSA could be due to a positive change in the anaerobic metabolic contribution [8, 14] and/or an improvement in the participants' ability to utilise the stored elastic energy in leg extensors caused by the negative and then positive work in leg extensors during repeated sprint training [14, 15, 20]. Furthermore, the subjects' limited previous experience in sprint training, combined with the timing of the study may also have contributed to the RSA improvement observed in the training group. Kraemer et al [16] reported that the basal concentration of testosterone significantly increased one week after the season, reflecting a dramatic reduction in total stress related to the season, which would cause a faster adaptation to training stimuli. On the other hand, the RSA improvement detected within the control group could be attributed to the timing of the study, as well as to the impact of players' daily soccer training [30]. These explanations could also apply to the improvement noted in the training group's 0-40 m sprint time; the split time shows that the improvement occurred in both 0-20 m and 20-40 m sprint times. Comparison with the control group reveals that the training group exhibited a considerably larger improvement in the 20-40 m sprint time (Table 1). Despite the fact that speed is believed to be a skill with a genetic quality, and less dependent on training [28], one could speculate from the results presented here that specialised training of running speed could result in an improvement in soccer players' sprinting speed. Similar results indicating a gain in acceleration following a similar but resisted sprint training programme have been reported [11].

Concerning jumping ability, the RSA training programme had a positive and significant effect on CMJ performance within the training group (Table 1). The control group, on the other hand, experienced no significant change in CMJ performance, which could be discerned from the very large SD within this group (Table 1). The lack of improvement within the control group CMJ could have been caused by not performing the two extra weekly training sessions of the training group, which may have affected the strength–velocity, force–time, or SSC contractile abilities of leg extensors. The improvement in CMJ reflects an enhancement (as with the RSA) in the ability to utilise the stored elastic energy and indirectly assists in the first phase of force–time curve initiated by the rate of force development (RFD) occurring in the first 180-250 ms in leg extensors within the training group. The improvement in CMJ could be further explained by findings from other studies where speed, leaping power and strength have been reported to affect each other if an improvement in any one of them occurs [29, 34]. Neither group experienced a statistically significant change in SJ.

No marked changes in Yo-Yo IR1 performance were observed within the training group in this study. This is in contrast to the results of Bravo et al [8] that revealed improved Yo-Yo IR1 performance following repeated sprint training. We speculate that the lack of Yo-Yo IR1 performance improvement within our training group could be due to the long breaks between the sprints in our training programme, resulting in

the aerobic energy production not being sufficiently triggered to cause any effect [1, 36]. No changes in Yo-Yo IR1 performance were detected in the control group.

No notable improvement in the performance of the 3-6-9 (m) agility test with a 180° turn was exhibited by either group. This was expected because the relationship between sprinting and agility had been shown to be weak, and the training methods used for enhancing agility and speed are specific and produce limited interactive effects [19, 35, 36]. This could be due to the differences in performing each skill – the RSA training programme used here involved only sprints in a straight line (closed skill), whereas agility often involves actions requiring change of direction and rapid start and stop [36].

CONCLUSION AND PRACTICAL APPLICATION

In the present study, two weekly sessions of repeated sprint training (10.7% of the total training time) were only a small part of the subjects' total training load. However, the marked improvement observed within the training group compared to the control group could be explained by the extra repeated sprint training, confirming that the RSA is trainable. However, due to the fact that the results of this study demonstrate a positive effect on RSA, it would be of interest to repeat the study on elite soccer players from a higher division and examine whether it would lead to similar improvements.

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