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THE EFFECT OF 40M REPEATED SPRINT TRAINING ON MAXIMUM SPRINTING SPEED, REPEATED SPRINT SPEED ENDURANCE, VERTICAL JUMP AND AEROBIC CAPACITY IN YOUNG ELITE MALE SOCCER PLAYERS

Running Head: Repeated Sprint Training

Laboratory: The Norwegian Olympic Sport Centre

ABSTRACT

The Purpose of this study was to examine the effect of 10 weeks 40m repeated sprint training program that does not involve strength training on sprinting speed and repeated sprint speed on young elite soccer players. Twenty young well-trained elite males' soccer players aged (\pm SD) (16.4 ± 0.9 years), body mass (67.2 ± 9.1 kg) and stature (176.3 ± 7.4 cm) volunteered to participate in this study. All participants were tested on 40m running speed, 10x40m repeated sprint speed, 20m acceleration speed, 20m top speed, Counter movement jump (CMJ), and aerobic endurance (beep-test). Participants were divided into training group (TG) (n=10) and control group (CG) (n=10). The study took part in the pre-competition phase of the training program for the participants and ended 13 weeks before the start of the season, the period of the pre-competition period was 26 weeks. The TG followed a Periodized repeated sprint training program once a week. The training program consisted of running 40m with different intensities and duration from week to week. Within group results indicate that TG had a statistically marked improvement in their performance from pre- to post-test in 40m maximum sprint (-0.06s), 10x40m repeated sprint speed (-0.12s), 20-40m top speed (-0.05s) and CMJ (2.7cm). The CG showed only a statistically notable improvement from pre- to post-test in 10x40m repeated sprint speed (-0.06s). Between groups differences showed a statistically marked improvement for the

TG over the CG in 10x40m repeated sprint speed (-0.07s) and 20-40m top speed (-0.05s) but the effect of the improvement was moderate. The results further indicate that a weekly training with repeated sprint gave a moderate but not statistically marked improvement in 40m sprinting, CMJ and beep-test. The results of this study indicate that the repeated sprint program had a positive effect on several of the parameters tested. However, due to the fact that the sample size in this study is 20 participants, the results are valid only for those who took part in this study. Therefore, we advice to use repeated sprint training similar to the one in this study only in periods where the players have no speed training included in their program. Furthermore, the participants in this study should probably trained strength but in this case benefits were observed even without strength training is most likely to be due to training specificity.

Key words:

RSA; CMJ; Beep-test; Recovery; Training load

INTRODUCTION

Research indicates that performance in soccer depends on various physical qualities and skills including tactical and technical skills as the two most important factors affecting performance in soccer (3, 4, 25, 28). Other studies support this assumption, but also claim that physical capabilities such as aerobic endurance, strength, and running speed must be well developed in order to reach a high performance level in soccer (13, 14, 19, 27). These physical abilities do not have to be extremely developed, but they must be on a high level (28, 29). Exactly how high, depends on the competition level and the player position in the field. On international level, aerobic endurance is the most required quality among midfield players, while strength and running speed are of great importance for attackers (19, 28, 38, 40). High running speed makes the players able to use their technical and tactical skills efficiently. Fast wingers may challenge the back players by well practiced feints, while fast forwards can reach the ball before the defense player.

Soccer game analyses on male elite players indicate that the players sprint between 1-11 % of the total game time on high speed (37). Furthermore, the duration of the sprints is normally between 2 to 4s, but the duration varies according to the role and position of the player (28, 29, 38). Usually, midfielders have the shortest sprint duration, while the wingers and attackers on average have the longest sprinting duration (2). The duration of the sprints indicate that there is a large demand on acceleration speed, and less demand on maximum speed. Studies show that sprint starts mainly while the players already running, which indicate that the demand for maximum speed is larger than what the duration of the sprinting indicates (37).

Analysis of soccer games on an elite level, show that the majority of the players conduct short sprint runs (2–4s) every 60–90s, which equals about 60–90 sprints during a game (28, 37). Wingers and forwards run significantly more sprint accelerations than central defenders and midfielders, while the midfielders run the longest total distance during a game (3, 28, 37). Furthermore, fast sprint runs with relatively short breaks indicate that the demand for endurance running speed is high during the season. Which indicate the players needs to practice on repeated acceleration with short breaks (30-120s) to be able to maintain their speed over time. Such training may cause metabolic changes and delay fatigue within muscle (36). Studies have shown that performance reduction in 36.7m sprint was observed in college soccer players toward the end of the season (18). Furthermore, the cortisol and testosterone which has been identified as reliable markers of training stress were found to be within the normal range throughout the season but low following pre-season conditioning (18).

Speed is believed to be genetic quality skill, and less dependent on training (31). Furthermore, it is believed that specialized training on running speed may result in significant improvement on soccer players with little speed training experience. Harrison & Burke (12) has reported significant improvement in rugby players running speed after specialized training. Several studies have shown that training on running speed combined with strength and Plyometrics training could significantly develop strength, jump ability and running speed after only 8-13 weeks (7, 9, 17, 23, 34, 35). This could be due to both muscular and neural responses (21, 31). An improvement of 0.1s on a 40m sprint equals around 0.7m in distance. In soccer, this can be the difference between winning and losing an important duel.

Research has pointed out the demands for speed among male soccer players. By this date, there are no studies available where one has studied soccer players on a high national level with only sprinting training stimuli similar to that model used with elite athletes in track and field. Based on our role at the Norwegian Olympic center as a training facility for a large number of teams at different performance levels, including national squads, we decided to investigate the effect of 10 weeks 40m repeated sprint training program that does not involve strength training on maximum sprinting speed and endurance running speed. Since also jumping height and aerobic capacity are important skills in soccer, we have chosen to examine what effect the training would have on these skills.

METHODS

Experimental Approach to the Problem

To test the effect of 40m repeated strength training on repeated sprint ability (RSA), jumping height and aerobic capacity, the 20m and 40m maximal sprints and repeated sprint were measured at the Norwegian Olympic Committee and Confederation of Sports using a start mat and two pairs of double infrared photocells, which were connected via cables and connected to a computer (PC Pentium 3) that measures time to the nearest 0.001s. The photocells were mounted on a 50m sprint running track. Jump height was estimated in the laboratory of the Norwegian Olympic Committee and Confederation of Sports using force platform- based determinations of impulse and thus velocity at take-off. The force platform used was an AMTI model OR6-5-1. The data were amplified (AMTI Model SGA6-3), digitized (DT 2801), and saved to a computer (PC Pentium 3) with the aid of the special software program Biopack MP 100. Aerobic capacity was measured using Beep-test; the Beep-test was conducted on an indoor artificial grass pitch following a procedure that was developed by Ramsbottom et al. (26). JVC Boombuster (RVNB51WEN) was used to play the Beep-test CD that came with the test package.

The participants were matched according to their pre-test results in the 40m sprint test. Then they were randomly assigned into one of two groups, a Training group (TG) and a control group (CG). The study took part in the pre-competition phase of the training program for the participants and ended 13 weeks before the start of the season, the period of the pre-competition period was 26 weeks. The length of the mesocycle was 10 weeks. The pre-tests and the post-tests were conducted on two separate days with two days with light training in between. On test day one 40m maximal sprint, 10X40m repeated sprint and CMJ were measured, and on test day two aerobic capacity (Beep-test) was assessed.

Subjects

Twenty young well-trained elite males' soccer players aged (\pm SD) (16.4 ± 0.9 years), body mass (67.2 ± 9.1 kg) and stature (176.3 ± 7.4 cm) volunteered to participate in the present study. The participants were all highly committed to training, Training 14.1 ± 2.5 hours per week (5- 7 training sessions a week). The participants play among the best 3 junior teams in Norway. Furthermore, 10 participants were chosen to take part with the national team at their age class. All participants and their parents gave their written voluntary informed consent and the local ethics committee at the Norwegian School of Sport Sciences approved the study. The participants did not have any systematically strength training in the form of weight training but they had aerobic endurance training in the form of interval training and long-run (2- 4 times a week), and enduring strength training of the abdominal, back and torso muscles. Nordic hamstring was the only strength training performed by the subjects (2- 4 sets with 10 repetitions per week). The duration of the soccer trainings was 1.5 hour, where about 30 minutes used for warming up and cool down. Approximately one hour was spent on pure soccer training. Warming up was often in the form of short passing exercises or coordination exercises with ball (less than 75% of maximum heart rate), followed by more intensive exercises such as cuts, moves with and without ball, turns with and without ball, and feint with and without ball. Most often the main soccer practice consisted of a variation of playing using small and large fields. The practice was performed with 3v3, 4v4 and 7-11v7-11. Such training was carried out 3-4 times per week. On training days with light training loads, the exercises were focused on defense tactical drills, attack tactical drills and dead balls.

Procedures

To make the participants familiar with the testing procedure, they were asked to complete a full training session on testing procedure one week prior to pre-test 2. To measure reliability, the participants were tested during this week and that was considered pre-test 1. On the pre-test 1 and before the testing took place the participants' stature were measured.

On pre-test 1 & 2 (test day 1) the participants started with a 15 minutes general warm up, consisted of running at 60-70 % of maximum heart rate. After the general warm up the participants were asked to do 4-5 accelerations over 50m. Then maximum running speed was tested by sprinting 3x40m with 4 minutes recovery between trials. The best result was retained for analysis. The time was measured for 0-20m (acceleration speed) and for 20-40m (maximum sprinting speed). The participant started from a standing up possession placing the front foot on a starting mat; when the test leader gave the signal, the participant started the sprint using the shortest time possible to the finish the 40m. The time started automatically when the athlete left the starting mat, and stopped when passed the photocells at both 20m and 40m.

After the maximum running speed test, the participants took 5 minutes recovery and then completed the countermovement jump test (CMJ). The CMJ test was performed by standing on the force platform mat with the plantar part of the foot contacting the ground, and with hands on hip, and from erect standing position on the force platform with a knee angle of 180°, a counter-movement down until the knee angle around 90° was performed. Then, immediately the participant jumps. Three trials were allowed. The best result was retained for analysis. Greater than three minutes recovery between trials was provided.

After another 5 minutes recovery, the participants were asked to complete the 40m repeated sprinting test by sprinting 10 maximum sprints with 60s recovery between each sprint. The participants were asked to sprint as fast as possible on each sprint. The participant started from a standing up position placing the front foot on the starting mat; time started automatically when the athlete left the starting mat, and stopped when passed the photocell placed on the 40m mark. The mean time for the ten runs was used for analysis.

On pre-test 2 day 2, the participants started with the same warm up procedure as described on test day 1. Beep-test started after the test leader measured and marked a distance of 20m with cones and a marked line. Then the CD (the soundtrack) and the CD player were checked to make sure the soundtrack would be played at the right speed between the sound signals (Beep). Afterward, the participants were informed of the test procedure. Four experienced test leaders were responsible to make sure that the participants fulfill the testing criteria.

The training intervention

The CG was instructed to continue the teams' original training plan. TG completed one extra training session with repeated speed training. The speed training was planned and carried out by an expert on running speed. The training expert has a PhD in training methodology and has been a coach for the Norwegian national team and for some of the best female sprinters in Norway. The training program completed by TG is described in Table 1.

****Table 1 about here****

Before the speed training, the participants completed both a general and specific warm up. The general warm up consisted of 15 minutes of jogging at a low intensity. During the special warm ups, the athletes ran 5-7 accelerations over 40-50 meters, with a recovery of 2-3 minutes between each run. The participants had to complete at least 90 % of the training period and had to be able to complete all the tests to include in further analysis.

Statistical Analyses

Raw data was transferred to SPSS 16.0 for Windows and Microsoft Excel for analysis. Intraclass correlation coefficient (ICC) was assessed on the data from pre-test 1 and pre-test 2 to examine reliability of performance tests. To detect differences in measures between pre-test 2 and post test, paired t-test was performed to test for a difference in central location (mean) between the paired samples (within group). To test for a difference in central location (mean) between groups, the independent sample t-test was applied; and the effect size was calculated according to Rosnow & Rosenthal (30) to determine how effective the applied repeated sprint training was. To determine if the effect size was trivial, small, moderate, large or very large, the scale used is based on the argument presented in Batterham & Hopkins (5); Hopkins, Hawley, & Burke (15). Differences were considered significant at $P < 0.05$, and the results are expressed as means and standard deviation. The 95 % Confidence Interval (95% CI) was also calculated for all measures.

RESULTS

Differences within groups and between groups of a variety of physiological measures are shown in Table 2. The results indicate that there were a notable improvement within the TG-group from pre to posttest on 40m sprint, 10x40m repeated sprint speed, 20m top speed, and CMJ.

The results indicate that there was a notable improvement within the CG-group on 10x40m repeated sprint speed only. A comparison between groups indicates that there were notable differences between the 2 groups on 10x40m repeated sprint with moderate effect size of $d = 1.0$ and 20m top speed with $d = 0.9$. Furthermore, the effect size was moderate in 40m sprint, CMJ and Beep-test results even though there was no marked statistical significance, while small effect was observed on 20m acceleration speed and body weight (Table 2).

****Table 2 about here****

The day-to-day reliability of measurements gave an ICC of $r=0.99$ for mean 40m maximum sprint speed, $r=0.95$ for mean 10x40m RSA, $r=0.94$ for mean 20m acceleration speed, $r=0.97$ for mean 20m top speed, $r=0.91$ for mean CMJ and $r=0.85$ for mean Beep-test.

DISCUSSION

The main finding in this study indicates that both the TG and the CG had a marked improvement in the 10x40m repeated sprint ability (RSA) by 0.12s and 0.06s, respectively. When between groups results were examined, the TG showed a statistical significant progress than did the CG ($p < 0.05$) on RSA and 20m top speed with a moderate effect (Table 2). No other studies have documented a similar effect on RSA. The improvement of performance on the RSA is substantial, especially when the athletes worked out only with specific speed training once a week over ten weeks. Since the participants in the study trained soccer 14 hours per week on average, there was a slight concern if a one speed training a week would be enough to develop RSA. However, the participants did not perform any sprint training beyond this one exercise per week in the form of sprint drills. The participants performed interval training during their regular soccer training but the interval training implemented was not in the form of sprint drills. The Interval training was aerobic endurance training that was carried out with short intervals and was under 75 % of the maximum sprinting speed. This training could have a positive effect on both TG and CG performance on RSA only (Table 2). Furthermore, the RSA improvement noticed on both CG and TG can be due to the athletes' daily soccer training and (or) the learning benefits from the training between the pre- to post-test. This could be a result of improving technique and the participants' ability to utilize their capacity better (11). Nevertheless, the notable and moderate improvement of TG over CG could be explained by the weekly extra speed training.

Running speed is a quotient of covered running distance and running time. With this formula we have calculated that both TG and CG completed the 10x40m sprinting pretest with 96 % of maximum running speed. After calculating the equivalent percentage for the posttest, it was found to be 97 % for both groups. This shows that the participants have the ability to complete

repeated sprint with intensity closer to maximum capacity. Since both groups improved in this percentage, the results could be explained by their ordinary soccer training as well as the repeated sprint training program.

The within group results indicate that TG had a marked progress of 0.06s on the 40m maximum sprinting speed test (Table 2). The split time of the 40m maximum test, shows that the improvement had occurred on the top running speed phase (20-40m). The results show however, that TG had a notable improvement in performance in 20m top speed when compared to CG (Table 2). However, there was no significant progress in the athletes' ability to accelerate (0-20m) and the effect size ($d = 0.2$) of the repeated sprint program was small on acceleration phase. This was surprising, since a previous study of rugby players reported significant progress in acceleration speed after similar training (12). One explanation could be that these studies have not been carried out on elite athletes or that one session per week in this study gave too little stimulant. Another explanation could be that participants in Harrison & Burke (12) study completed several maximum sprints up to 20m both in regular Rugby training and in games. Consequently this could have stimulated and improved their ability to accelerate. Repeated sprinting over a longer distance (40m) can be a new and unaccustomed stimulant for soccer players, which again can result in muscular and neural responses (21, 31). Improvement in running performances in 60m, 100m and 200m was noticed in track and field training (phosphate-training) (10, 39). The results in this study indicate that the RSA seems to be as trainable as the ability to develop maximum speed. Spencer et al. (36) indicate that this is due to metabolic conditions such as energy system contribution, adenosine triphosphate depletion and resynthesis, phosphocreatine degradation and resynthesis, glycolysis and glycogenolysis, and

purine nucleotide loss. Komi & Bosco (16) and Mero et al. (22) suggested that it could be due to better utilization of stored elastic energy in leg extensors of the sprinters.

The results of this study indicate that speed endurance training can have a positive effect on the athletes' leaping power. The within groups results shows that the TG made notable progress on CMJ. This is further clear when examining the effect size of the training on the CMJ ability (Table 2). In the examining of the effect size we noticed that even though there was no statistically notable differences between the groups, there was a moderate effect of the repeated sprint program and this improvement was not unexpected since previous studies have documented that speed, leaping power, and strength can affect each other positively (7, 9, 34, 35).

The progress made by the TG on the beep test was close to being statistically significant. The CG was not close to experiencing a statistically significant improvement. However, the comparison between groups shows that the effect size of the repeated sprint training program had a moderate effect on Beep test performance and that was surprising since there are certain studies, which imply a connection between repeated sprinting ability and maximum oxygen uptake (1, 6, 8, 20). However, other studies have not found such a connection (2). Another possible explanation for the improved beep-test performance could be that the participants work economy has developed through the repeated sprint training. Furthermore, several studies have documented that strength training, bounding, and speed training as a supplement to endurance training, can improve work economy in running (24, 32, 33). Increased stiffness in muscles, better ability to store elastic energy, and improved rate of force development could be an explanation of the progress in work economy and the observed results in this study (24, 32).

PRACTICAL APPLICATIONS

The results indicate that the RSA training implemented in this study had a positive effect on several of the measured variables including RSA performance. Repeating the study on more participants is needed to generally draw a conclusion. Furthermore and according to the results of the present study we can advise the use of repeated sprint training similar to the one in this study only in periods where the players have no speed training included in their program. Furthermore, due to the fact that the sample size in this study is 20 participants, the results are valid only for those who took part in this study. Furthermore, the participants in this study should probably trained strength but in this case benefits were observed even without strength training is most likely to be due to training specificity.

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| Table 1. The 10 week training program completed by the TG | |
|---|--|
| Week (work load) | Training Prescription |
| Week 0 | PRETEST |
| Week 1 (middles) | 3x4x40m, R=1:30min, SR=10min, I=95-100 % |
| Week 2 (high) | 4x4x40m, R=1:30min, SR=10min, I=95-100 % |
| Week 3 (high) | 5x4x40m, R=1:30min, SR=10min, I=95-100 % |
| Week 4 (Light) | 2x5x40m, R=1:30min, SR=10min, I=95-100 % |
| Week 5 (middles) | 3x5x40m, R=1:30min, SR=10min, I=95-100 % |
| Week 6 (high) | 4x5x40m, R=1:30-2min, SR=10min, I=98-100 % |
| Week 7 (light) | 2x5x40m, R=1:30-2min, SR=10min, I=98-100 % |
| Week 8(middles) | 3x5x40m, R=1:30-2min, SR=10min, I=98-100 % |
| Week 9 (high) | 4x5x40m, R=1:30-2min, SR=10min, I=98-100 % |
| Week 10 (light) | 2x4x40m, R=1:30-2min, SR=10min, I=98-100 % |
| Week 11 | POSTTEST |
| R= Recovery. SR= Set Recovery I= Intensity | |

Table 1: Mean results of 40m sprint, 10x40m repeated sprint, 20m acceleration, 20m top speed, CMJ, beep-test and body weight between and within groups from pre to post-test.

| 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. |
| 40m maximum (s) | 5.21 ±0.21 | 5.15 ±0.20 | -0.06 ±0.37 | -0.08 to -0.03** | 5.20 ±0.23 | 5.19 ±0.18 | -0.02 ±0.07 | -0.07 to 0.04 | -0.06 ±0.04 | -0.02 ±0.07 | 0.04 ±0.03 | -0.01 to 0.09 | 0.7 |
| 10x40m RSA (s) | 5.42 ±0.18 | 5.30 ±0.14 | -0.12 ±0.07 | -0.17 to -0.07** | 5.41 ±0.19 | 5.35 ±0.18 | -0.06 ±0.05 | -0.10 to -0.02** | -0.12 ±0.07 | -0.06 ±0.05 | -0.07 ±0.03 | -0.12 to -0.01* | 1.0 |
| 20m acceleration (s) | 2.82 ±0.11 | 2.82 ±0.09 | -0.01 ±0.05 | -0.04 to 0.03 | 2.83 ±0.12 | 2.82 ±0.11 | -0.01 ±0.05 | -0.04 to 0.02 | -0.01 ±0.05 | -0.02 ±0.04 | -0.01 ±0.02 | -0.05 to 0.03 | 0.2 |
| 20m top speed (s) | 2.38 ±0.11 | 2.33 ±0.13 | -0.05 ±0.03 | -0.08 to -0.03** | 2.38 ±0.12 | 2.37 ±0.10 | -0.01 ±0.05 | -0.04 to 0.03 | -0.05 ±0.04 | -0.01 ±0.05 | -0.05 ±0.02 | 0.01 to -0.09* | 0.9 |
| CMJ | 35.2 ±3.9 | 37.9 ±5.7 | 2.7 ±2.8 | 0.71 to 4.72* | 35.7 ±3.5 | 36.7 ±2.9 | 1.0 ±1.8 | -0.33 to 2.27 | 2.7 ±2.8 | 1.0 ±1.8 | 1.8 ±1.1 | -0.47 to 3.97 | 0.7 |
| Beep-test (level) | 12.0 ±1.2 | 12.6 ±1.2 | 0.6 ±0.8 | -0.01 to 1.19 | 12.4 ±1.3 | 12.6 ±1.5 | 0.2 ±0.6 | -0.23 to 0.59 | 0.6 ±0.8 | 0.2 ±0.6 | 0.4 ±0.3 | -0.27 to 1.09 | 0.6 |
| Body weight | 66.2 ±7.6 | 66.0 ±6.7 | -0.2 ±2.5 | -1.94 to 1.57 | 68.3 ±10.6 | 69.0 ±10.9 | 0.7 ±1.4 | -0.35 to 1.71 | -0.2 ±2.5 | 0.7 ±1.4 | -0.9 ±0.9 | -2.76 to 1.02 | 0.4 |

* = p < 0.05

** = p < 0.01

TG = Training-Group

CG = Control-Group

E.S. = Cohen's d (effect size)