## Original Article

# Effects of speed exercises on acceleration and agility performance in 13-year-old female soccer players

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**Abstract**
The aim of the recent study was to examine the effect of a high-intensity sprint program on adolescent female soccer players. A training group of 13 female soccer players, mean age (± SD) 13.6 years (± 0.2) followed an eight-week intervention program for one hour per week, and a group of 13 female soccer players of corresponding age, mean age 13.7 years (± 0.3) served as a control group. Pre- and post-tests assessed 10-m linear sprint, 20-m linear sprint and agility performance.
Results showed a significant improvement in agility performance, pre 8.56 s (±0.54) to post 8.03 s (± 0.38) ($p<0.01$), and a significant improvement in 10-m linear sprint, pre 2.13 s (± 0,08) to post 2.02 s (± 0.12) ($p<0.05$), and in 20-m linear sprint, pre 3.75 s (± 0.15) to post 3.62 s (± 0.22). The correlation between 10-m sprint and agility was $r = 0.70$ ($p<0.01$), and between 20-m straight sprint and agility performance, $r = 0.78$ ($p<0.01$). These findings demonstrate that organizing the training sessions with short sprint bouts at maximum effort, interspersed with adequate recovery time, results in improvements in both in linear sprint (acceleration) and in agility performance in adolescent female soccer players.
**Key words**: speed training, agility, adolescent female

**Introduction**

Running at high speed is component of children's play, and have been shown to promote development of the muscular system and to stimulate to the long-term effect on higher bone density in the skeletal system (Rowland, 2005). Agility can be recognized as the ability to change directions rapidly while sprinting or to start and stop quickly (Little & Williams, 2005). These movements develop coordination, balance, and motor learning (Jullien et al., 2008; Pearson, 2001), and are therefore important not only regarding youth athlete training, but also in physical education sessions.

The age between 13 to15 years is a 'window' for developing speed (Hughes et al., 2012; Reilly et al., 2000b), however, very few studies have reported the effect of sprint training, especially among adolescent females (Wong et al., 2010). Some reports on youth males have shown an improvement in speed (Pettersen & Mathisen, 2012; Mujika et al., 2009; Venturelli et al, 2008), however, others have shown no effect, possibly because of insufficient training load and duration (Milanovic et al., 2012; Rowland, 2005).

Explosive actions are elements of success in soccer; sprint times is often only 2-4 seconds (Castanga et al., 2003), and sprints occurs approximately every 90 seconds (Wong et al., 2010). Short sprint bouts at maximum or near-maximum effort are supposed to have implications for the short-term energy system and the central nervous system (Brown & Ferrigno, 2005); however, the effect of training is not well understood in the youth population (Hughes et al., 2012; Rowland, 2005). Another aspect is that a higher rate of knee ligament injuries have been reported in youth female athletes, and it have been speculated that if the program focused on improving athlete performance, such as speed and agility, it would also prevent injuries (Noyes et al., 2013). Considering that no study has been conducted with young females aged 13 years or younger, we wanted to assess the effect on this group. Most previous programs with children and youths have been conducted with adult training methods (Venturelli et al., 2008); therefore, we wanted to use a method involving more playful and competeive exercises to motivate them to maximal effort (Pettersen & Mathisen, 2012). It was hypothesized that the current program would enhance speed and agility more than ordinary soccer training alone.

**Method**
*Experimental approach*

To study the effects, we tested (pre and post) 10-m and 20-m linear sprint and agility performance with 13-year-old female soccer players. The intervention took place in the preseason period, and the exercises were

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completed with a one-hour session per week for a total of eight weeks. The training group (TG) replaced one of the three ordinary soccer training sessions with the current program, and followed a strict regime. Each session started with a 10-minute warm-up and was followed by 50 minutes of short-burst running straight-line sprints-, or change-of-direction sprints of 15 to 20 meters, interspersed with recovery periods lasting 40 to 90 seconds. The program consisted of eight partner-resisted sprints (15-m), eight 20-m linear sprints, eight change of direction sprints (15-m) with 60° and 90° turns, and finished with relay races with 90° turns, each participant competing eight races. Thus, the session consisted of a total of 32 short-burst sprints. The participants were instructed to complete the sprints at maximal speed, and the exercises were performed as competitive sprinting in order to assure optimal motivation. In addition to the intervention program, the participants in TG undertook two one-hour organized traditional soccer training sessions, consisting of technical drills and small-sided games. The control group (CG) followed an ordinary soccer-training program, and undertook the same volume of training during the period consisting of three one-hour session per week, consisting of technical drills and small-sided games.

*Participants*

Thirteen female soccer players from a local club, with mean age 13.6 years (± 0.2), participated in the study. Thirteen female soccer players, with mean age 13.7 years (± 0.3) from the same league, served as a control group (CG). Written informed consent to participate in the study was obtained from both the participants and their parents in both groups. The study was conducted according to the Declaration of Helsinki, was given institutional ethical approval, and met the ethical standards in sports and exercise science research (Harris & Atkinson, 2011).

**Table I.** Anthropometric characteristic of the two groups (mean±SD)

|  | Training Group | | Control Group | |
| --- | --- | --- | --- | --- |
|  | Pre | Post | Pre | Post |
| Age (years) | 13.6 (0.2) | 13.8 (0.2) | 13.7 (0.3) | 13.9 (0.3)* |
| Height (cm) | 157.6 (3.8) | 158.4 (3.7) | 159.6 (5.7) | 160.3 (4.7)* |
| Weight (kg) | 52.5 (9.3) | 53.3 (8.7) | 53.8 (7.8) | 54.1 (7.8)* |
| No significant differences between groups | | | | |

*Testing procedures*

The sprint-test consisted of a 20-m track with 10-m split-time recording. The photocells were placed at 20-cm height in the starting position, and at 100-cm height at 10 m and 20 m in the straight-line test. All tests were completed from a standing start, with the front foot placed 30 cm behind the photocells' start line. The agility test course was a 20-m standardized course used in previous studies, starting with 5-m straight sprint followed by a 90° turn, 2.5 m sprint followed by a 180° turn, 5-m slightly curved sprint followed by 180° turn, 2.5 m straight sprint followed by a 90° turn, and 5-m straight sprint (Pettersen & Mathisen, 2012). Three 120-cm high coaching sticks, which were not allowed to be touched, were used to ensure correct passage in the turns. The test was executed with the same starting procedure as the straight-line test and with photocells placed at 100-cm height at the finish line. Each participant performed two trials with three minutes' recovery between; times were recorded to the nearest 0.01 s, and the better of the two times was recorded. Trials run to familiarize participants with the sprint and agility track were conducted during both the pre- and post-tests with two sub-maximal trials prior to the start of the test. Electronic photocells timing gates were used to record split and completion times (Brower Timing System, USA). The exercises and the tests were executed in a gym with a parquet floor at a temperature of 20° C. Prior to the testing the participants followed the same warm-up procedure with jogging and sprint drills.

*Statistical Analyses*

Data were checked for normality by a histogram plot and by using the Shapiro-Wilk's normality distribution test. Descriptive statistics were then calculated and reported as mean ± standard deviations (SD) of the mean for each group of players on each variable. Students *t*-test showed no difference in baseline between groups. A two way analysis of variance (ANOVA) was conducted for the mean difference between training group and control-group before and after the intervention. The relationship between performances in linear sprints and agility tests was determined by using Pearson's correlation (*r*). The same procedure was used to detect any correlation among linear sprint, agility, and anthropometrical variables. The reliability of tests was assessed using ICC, and the test-retest reliability of parameters describing the players' running and agility performance showed good reliability in the tests. All calculations were carried out using SPSS v 19.0 (Inc., Chicago, Il., USA).

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## Results
**Table II.** Pre- and post-test results for sprint and agility performance (mean±SD) for training group (TG) and control group (CG).

| | Training Group | | Control Group | |
|---|---|---|---|---|
| Test | Pre | Post | Pre | Post |
| 10 m sprint (sec) | 2.13 (0.08) | 2.02 (0.12)* | 2.09 (0.11) | 2.09 (0.10) |
| 20 m sprint (sec) | 3.75 (0.15) | 3.62 (0.22)* | 3.67 (0.22) | 3.68 (0.22) |
| Agility (sec) | 8.56 (0.54) | 8.03 (0.38)* | 8.58 (0.51) | 8.62 (0.50) |
| Pre- and post-tests between-group change in performance, significant* $p<0.05$ | | | | |

**Table III.** The relationship between the results in linear sprint and agility performance, pre TG and CG (n=26)

| Relationship assessed | Pearson's $r$ |
|---|---|
| 10-m linear sprint vs agility | 0.70* |
| 20-m linear sprint vs agility | 0.78* |
| Correlation significant* $p<0.01$ | |

## Discussion

In the present study we tested the effect of a high-intensity speed-training program on youth female soccer players (Table 1). The main result is a significant improvement (6.2%) in agility performance (Table 2), and this is in accordance with findings in youth males aged 11 to 12 years (Pettersen & Mathisen, 2012), and to our knowledge this is the first study carried out with the 13-year-old or younger females. It is claimed that initial acceleration and short sprint are more difficult to enhance than maximal velocity (Meylan & Malatesta, 2009), but this study shows a significant improvement in the acceleration phase (5.1%) in 10-m straight sprint, and (3.5%) in 20-m straight sprint (Table 2). Faster completion of acceleration and agility indicates that the intervention program is effective regarding performance enhancement in the TG. It has been suggested that soccer practice alone may contribute to speed development because of the high frequency of short maximal sprints (Michailidis et al., 2013), and growth and maturation may contribute to performance gains, however, no significant changes in sprint and agility performance were found in the CG (Table 2).

The development of running speed in youth females is not parallel with that of youth males; however, the results from the current study are in accordance with similar programs consisting of short-speed regimes in youth males (Pettersen & Mathisen, 2012; Mujika et al. 2009; Bloomfield et al., 2007). Other reports shows discrepancy in the results (Milanovic et al., 2012), possibly because of insufficient training load and duration. In the current investigation, experienced training staff leading all training sessions, thus ensuring high intensity, with a focus on executing all exercises with maximal effort and controlling the recovery times. It is supposed that, by muscular contraction force at high-speed, as in the current program, explosive actions such as acceleration and agility can be improved (Bangsbo, 1994). High-speed actions need an adequate rest interval because incomplete recovery may reduce the force of shortening and muscle power. Two to five minutes of rest have been recommended for adults to ensure the quality of each repetition; in youth athletes, the recovery from high-intensity activities has been reported to be better than in adults (Ramirez-Campillo et al., 2014). Thus, the recovery period of 40 to 90 seconds used in the present program is supposed to be sufficient, and is in line with findings from a study with youth soccer-players, with rest intervals between 30 to 120 seconds (Ramirez-Campillo et al., 2014). Task-specificity in the program appears to be essential (Young et al., 2001), and the program in the current study consisted of straight-line sprinting, and sprinting with change of directions, acceleration and deceleration with maximal effort. However, the literature are unclear as to which mechanisms may support the development. Adaptions gained from the sprint program is supposed connected to the neural plasticity of puberty, and it is believed that the improvement is due to neuromuscular adaptions including the recruitment and activation of motor units and coordination (Hughes et al., 2012; Thomas et al., 2009; Rowland, 2005). We suppose the performance is influenced by strength, balance and neuromuscular coordination through the training program (Meylan & Malatesta, 2009; Brown & Ferrigno, 2005; Aagaard, 2003).

Furthermore, linear sprint and agility have been found to be independent abilities that are specific and produce limited transfer to each other in adult athletes (Little & Williams, 2005; Young et al, 2001), and both acceleration and agility are regarded as independent predictors of soccer performance in youth soccer (Reilly et al., 2000a, 2000b). Previous studies with youth males, aged 11 to 14 years, found a stronger correlation in straight-line sprint and agility performance than in adults (Jakovljevic et al., 2012; Pettersen & Mathisen, 2012), and in the current study we showed a significant correlation between linear speed and agility; 10-m vs agility $r=0.70$, and 20-m vs agility $r=0.78$ (Table 3). We can speculate whether the youth population shares common physiological and biomechanical determination, implying transfer to each other, and that the specificity is more pronounced in the adult population. Agility has a high relevance for team sports like soccer because of change-of-directions actions in response to an opponent (Little & Williams, 2005). Speed and agility have shown

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differences between elite and sub-elite youth soccer players (Reilly et al., 2000a), and high-speed actions are believed to have implications for the outcome of match-play. Further research should focus on volume and frequency for optimal improvement, and investigate the effectiveness of combined speed training with strength or plyometric training.

**Conclusions**

The aim of the recent study was to examine the effect of a high-intensity sprint program on 13-year-old female soccer players. The participants showed significant improvement in both linear speed up to 20 meter (acceleration), and in agility performance, however no change was found in the control group with a program of traditional soccer training alone. The result of the study highlights the potential of using a program consisting of competitive exercises of short sprint bouts at maximum effort in adolescent female training.

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