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THE EFFECT OF REPEATED AGILITY TRAINING vs. REPEATED SPRINT TRAINING ON ELITE FEMALE SOCCER PLAYERS' PHYSICAL PERFORMANCE

UČINEK PONAVLJAJOČEGA SE TRENINGA AGILNOSTI NA TELESNO ZMOGLJIVOST VRHUNSKIH NOGOMETAŠIC V PRIMERJAVI S PONAVLJAJOČIM SE TRENINGOM ŠPRINTA

ABSTRACT

To compare the effects of repeated agility training along with repeated sprint training on elite female soccer players' linear single sprint speed, vertical jump, agility, repeated sprint ability and Yo-Yo Intermittent Recovery level 1 test (Yo-Yo IR1) performances.
Seventeen elite female soccer players aged 21.2 ± 2.6 years from the upper Norwegian league were randomised into one of two groups: a repeated agility group and a repeated sprint group. During the intervention period, both groups performed one extra weekly training session in addition to their regular soccer training. The study took place in the pre-season period and lasted for 8 weeks. The participants were tested before and after the intervention period.
The results from the within-group analysis showed significant improvements in 10 × 40 m RSA, agility, and Yo-Yo IR1 performances for the agility group. The repeated sprint group showed significant improvements in 10 × 40 m RSA, 20 m top speed, 40 m linear sprint, CMJ vertical jump, and Yo-Yo IR1. The between-groups comparison revealed no significant differences between groups in any of the measured variables. Further, the results indicate that the both training programmes had a similar effect on both groups.
The present study adds further support to the notion that common principles of training such as specificity, progression and periodisation are clearly present in the sprint training of soccer players.

Key words: physical conditioning, sprinting skills, training effects

IZVLEČEK

Cilj raziskave je bil raziskati učinke ponavljajočega agilnostnega teka, v primerjavi s ponavljajočim šprintom, na hitrost enega linearnega šprinta, vertikalen skok, agilnost, sposobnost ponavljajočih se šprintov (RSA) in intervalni prekinjajoči test 1. stopnje (Yo-Yo IR1) pri vrhunskih nogometašicah.
Sedemnajst vrhunskih nogometašic iz norveške prve lige, starih 21.2 ± 2.6 let, je bilo naključno razdeljenih v dve skupini: skupina s ponavljajočimi se agilnostnimi teki in skupina s ponavljajočimi se šprinti. V času raziskave sta obe skupini poleg svojih rednih treningov nogometa opravili še en dodaten trening na teden. Raziskava je potekala v obdobju pred nogometno sezono in je trajala osem tednov. Sodelujoče igralke so opravile teste pred obdobjem raziskave in po njem.
Rezultati analize znotraj skupine so pokazali pomembno izboljšanje v skupini, ki je opravila trening agilnosti, in sicer pri 10 x 10 m RSA, agilnosti in Yo-Yo IR1. V skupini, Ki je izvajala ponavljajoči se šprint, je prišlo do pomembnega izboljšanja pri 10 x 10 m RSA, hitrosti šprinta na 20 m, lineranem šprintu na 40 m, vertikalnem skoku z nasprotnim gibanjem in Yo-Yo IR1. Primerjava med skupinama ni pokazala nobenih pomembnih razlik med skupinama v katerikoli merjeni spremenljivki. Poleg tega rezultati kažejo, da je učinek obeh programov treninga podoben za obe skupini.
Raziskava tako še dodatno podpira ugotovitev, da so običajna načela treniranja, kot so specifičnost, napredovanje in periodizacija, nedvomno prisotna v treningu šprinta nogometašev.

Ključne besede: kondicijski trening, šprint, učinki treninga

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INTRODUCTION

Sprinting is the most frequent action in goal-scoring situations (Faude, Koch, and Meyer 2012). Top-class players perform 150 – 250 brief, intense actions such as sprinting, jumping, tackling and shooting during a match (Bangsbo, Mohr, & Krustrup, 2006) and high-intensity activity in the range of 1 – 4 s occur approximately once every 60 – 90 s during games (Di Salvo et al., 2007; Reilly, Bangsbo, & Franks, 2000).

In the research literature, sprinting skills are commonly categorised as linear sprint, agility and repeated sprint ability (RSA). Linear sprint is the ability to accelerate and maintain a high linear sprint speed (Chapman & Sheppard, 2011). Agility refers to the ability to rapidly change direction and speed of movement as a result of a stimulus (Bishop, Girard, & Mendez-Villanueva, 2011). RSA is the ability to perform repeated sprints with brief recovery intervals (Bishop et al., 2011; Glaister, 2005). Several studies have concluded that agility and linear sprint are specific and independent qualities (Little & Williams, 2005; Sporis, Jukic, Milanovic, & Vucetic, 2010; Vescovi & McGuigan, 2008; Young, McDowell, & Scarlett, 2001).

Professionals or elite players are reported to have better sprinting skills than players of a lower playing level (Haugen, Tønnessen, & Seiler, 2012a, 2012b; Impellizzeri et al., 2008; Reilly et al., 2000). Unfortunately, only a few intervention studies including agility or repeated sprint training of elite or professional soccer players have been reported. Mujika, Santisteban, and Castagna (2009) reported an improvement in 15 m sprint and vertical jump performance after 6 training sessions with repeated short sprints. Similarly, Spinks, Murphy, Spinks, and Lockie (2007) observed that short-sprint training with and without resistance over 8 weeks improved 15 m sprint and counter-movement vertical jump (CMJ vertical jump) performance. Jovanovic, Sporis, Omrcen, and Fiorentini (2011) reported improved 5 – 10 m sprint and CMJ vertical jump performance after an 8-week conditioning period consisting of speed, agility and quickness. In a study by Ferrari

Bravo et al., (2008), repeated shuttle sprints induced greater Yo-Yo Intermittent Recovery level 1 test (Yo-Yo IR1) and RSA improvement compared to high-intensity interval training, whereas 10 m sprint and vertical jump performance remained unchanged for both intervention groups.

Tønnessen, Shalfawi, Haugen, & Enoksen (2011) performed a repeated sprint training intervention similar to the model used by athletic sprinters. Their training group showed a significant improvement in RSA and peak velocity compared to the control group. The effect sizes were also moderate between the groups for CMJ vertical jump and the multi-stage fitness test (bleep test), although no significant differences were detected. However, the effect of repeated sprint training compared to repeated agility training on similar tests has so far not been explored. Wong del, Chan, & Smith, (2012) reported a relationship between repeated sprint ability and repeated change of direction. Therefore, it should be in the interest of coaches and soccer players to investigate whether repeated agility training within a similar periodisation model to repeated sprint training can lead to equivalent or even superior outcomes. Further, despite the high number of women participating in soccer, few studies have been conducted with female soccer players performing at the highest division level in traditionally leading soccer nations. Therefore, there is scope for more research on women's soccer.

The aim of the present study was to compare the effects of repeated agility training versus repeated sprint training on female soccer players' linear single sprint speed, vertical jump, agility, repeated sprint ability and Yo-Yo IR1 performances. This could provide valuable information for the planning of physical training in female soccer as well as other sports involving repeated explosive action demands. We hypothesised that repeated agility training would induce more positive effects on agility performance, while repeated sprint training would enhance RSA and single sprint performance.

MATERIALS AND METHODS

Participants

Twenty well-trained players volunteered to participate in the study. Three participants dropped out, leaving seventeen participants with the following age, body mass and stature (mean ± SD): 21.2 ± 2.6 years, 64.0 ± 5.9 kg and 168.8 ± 4.6 cm, respectively. Their regular weekly training programme consisted of 3 – 6 soccer sessions per week, plus one friendly match in some of the weeks during the intervention period. The soccer sessions had a typical duration of 1.5 hours and consisted of technical and tactical drills in addition to playing in small and large areas, usually with teams of 4 – 8 vs. 4 – 8. Further, all participants had 1 – 2 strength training sessions per week using bodyweight or 6 – 12 RM sets. In total, the participants trained on average for 9.3 ±2.0 hours per week distributed over 5 – 8 training sessions. All participants gave their written voluntary informed consent, and the institutional review board approval was granted.

Procedures

To compare the effects of repeated agility training compared to repeated sprint training on female soccer players, a pre-test–post-test randomised-group research design was applied. Participants were randomly assigned to either a repeated agility training group ($n = 8$) or a repeated sprint training group ($n = 9$). Both groups trained according to their team's original training plan. The repeated agility group completed one extra training session per week consisting of repeated agility training (Table 1), while the repeated sprint group completed one extra training session per week of repeated sprint training (Table 2). The intervention took place during the pre-season period (February and March). The programmes were planned and carried out by an expert at the Norwegian Olympic Training Centre who, amongst others, is a former national coach in track and field sprinting who holds a PhD in training methodology. The participants were required to complete at least 90% of the training sessions and all the tests in order to be included in further analyses. A soccer-specific test battery was completed by the participants before and after the 8-week intervention period. The pre- and post-tests were conducted on two consecutive days. All participants completed the pre- and post-tests in the same order and at the same location. Test day one consisted of a 40 m maximal sprint, agility, CMJ vertical jump and repeated sprint test. On test day two, the athletes completed the soccer-specific Yo-Yo IR1 test.

Prior to testing, the participants completed a standard warm-up programme consisting of a 10 min general warm-up at 50 – 70% of maximum heart rate either on a treadmill or spinning cycle, followed by 3 – 4 repetitions of 40 m sprints with a progressive increase in speed. To ensure familiarisation with the test procedures, all athletes completed 1 – 2 sub-maximal trials prior to each test. The timing system at the Norwegian Olympic Training Centre was used for all sprint tests. The tests were performed on a dedicated indoor 40 m track with 8 mm Mondo track FTS surface (Mondo, Conshohocken, USA) and electronic timing equipment. A 60 × 60 cm start pad was placed under the track at the start line. The clock was initiated when the front foot stepped off the pad. Infrared photocells with transmitters and reflectors were placed in pairs on each side of the running course with a 1.6 m transmitter-reflector spacing approximately 140 cm above the floor. The beams had to be broken to trigger each photo cell. Electronic times were transferred to computer software (Biorun, made in MatLab by Biomekanikk AS, Oslo, Norway). The timing system has recently been validated (Enoksen, Tønnessen, & Shalfawi, 2009; Haugen, Tønnessen, & Seiler, 2012c).

Linear single sprint

The distance of 40 m was chosen for the sprint tests in order to evaluate both acceleration and maximum sprint capabilities. The 0 – 20 m split time was defined as acceleration, while the 20 – 40 m split time was defined as the maximal sprint velocity. The participants started from a standing position. Two trials were permitted with a minimum 4 min recovery given between the trials, and the best result for each player was retained for analysis.

Agility

The agility tests were performed immediately after the linear sprint tests. The agility test had a total running distance of 40 m and included four 180° turns. Lines were marked with tape at 7.5 m, 12.5 m and at the finish line at 20 m. The participants sprinted from 0 – 12.5 m, back to the 7.5 m line, forward to the 12.5 m line, back to the 7.5 m line for the last time and finally forward to the finish line at 20 m. Two trials were permitted, separated by a minimum of 4 min recovery. The best result for each player was retained for analysis.

CMJ vertical jump

The CMJ vertical jump tests were performed after the agility test. Each athlete was weighed on a force platform for system calibration before performing the three trials of CMJ vertical jump with 45 – 60 s recovery in between. In order to isolate the test to leg extensor muscles and minimise technical elements, the jumps were performed with hands placed on the hips. The participants were required to bend their knees to approximately 90° and then rebound in a maximal vertical jump. The best result for each player was retained for analysis. All CMJ vertical jump tests were performed on a 122 × 62 cm AMTI force platform; model OR6-5-1 (Watertown, USA). Force data were sampled at 1000 Hz for 5 s with a resolution of 0.1 N. The data were amplified (AMTI Model SGA6-3), digitised (DT 2801) and saved in specially made computer software (Biojump, Oslo, Norway). The force platform has recently been assessed for its accuracy and reliability (Enoksen et al., 2009).

Repeated sprint test

After the vertical jump testing, the participants performed a 10 × 40 m repeated sprint test with 60 s recovery between each sprint. The distance of 40 m was chosen in order to include both acceleration and maximum sprinting velocity. In line with the frequency of all-out sprints reported from match analyses, the sprints were executed every 60 s. Starting and timing procedures were similar to the linear single sprint and agility tests. The mean 40 m sprint time was retained for analysis.

Yo-Yo IR1

On test day two, the Yo-Yo IR1 test was performed after a standard warm up of 10 min jogging with a progressive increase in running intensity from 70 – 80% of the maximum heart rate. The test set-up was in accordance with the guidelines by Krustrup et al. (2003).

The Yo-Yo IR1 test was performed in an indoor handball arena with a PULASTIC SP surface (Combi Floor and Roof technique AS, Oslo, Norway) at the Norwegian School of Sport Sciences. The standardised audio file for Yo-Yo IR1 was played by an iPod (Apple, CA, USA) connected to a JVC Powered Woofer CD-system (RV-NB51W).

Intervention programmes

The training intervention consisted of one extra weekly session of either repeated sprint training or repeated agility training over 8 weeks. For both groups the training sessions followed a stepwise increase in workload each week, interposed by a lighter workload in weeks 4 and 8. Photocells were used in each training session to control the running speed and thereby the training intensity. All participants received feedback from a sprint training expert regarding their technique during the training intervention. The repeated agility training involved a total running distance of 40 m and included four 180° turns, with the participants sprinting from 0 – 12.5 m, back to the 7.5 m line, forwards to the 12.5 m line, back to the 7.5 m line for the last time and finally forwards to the finish line at 20 m (Figure 1). Since the repeated agility run lasts approximately 4 s longer than the repeated sprint training, the repeated agility programme was designed to allow between 15 – 20% fewer repetitions and a 30 s longer recovery period between each run to better match the total training loads. Table 1 describes the periodised repeated agility training programme performed by the repeated agility group, while Table 2 describes the periodised repeated sprint training programme performed by the repeated sprint group. The programmes were designed to include warm-up procedures before each training session that were similar to the procedures prior to the sprint testing described above.

Table 1: Periodization of the repeated agility training.

Week 0	Pre-test
Week 1	2x4x agility run, R=2min, SR=10min, I=95-100%
Week 2	2x5x agility run, R=2min, SR=10min, I=95-100%
Week 3	2x6x agility run, R=2min, SR=10min, I=95-100%
Week 4	2x4x agility run, R=2min, SR=10min, I=95-100%
Week 5	2x6x agility run, R=2min, SR=10min, I=95-100%
Week 6	2x7x agility run, R=2min, SR=10min, I=100%
Week 7	2x8x agility run, R=2min, SR=10min, I=100%
Week 8	2x6x agility run, R=2min, SR=10min, I=100%
Week 9	Post-test

R = Recovery between exercises.
SR = Recovery between sets.
I = Intensity.

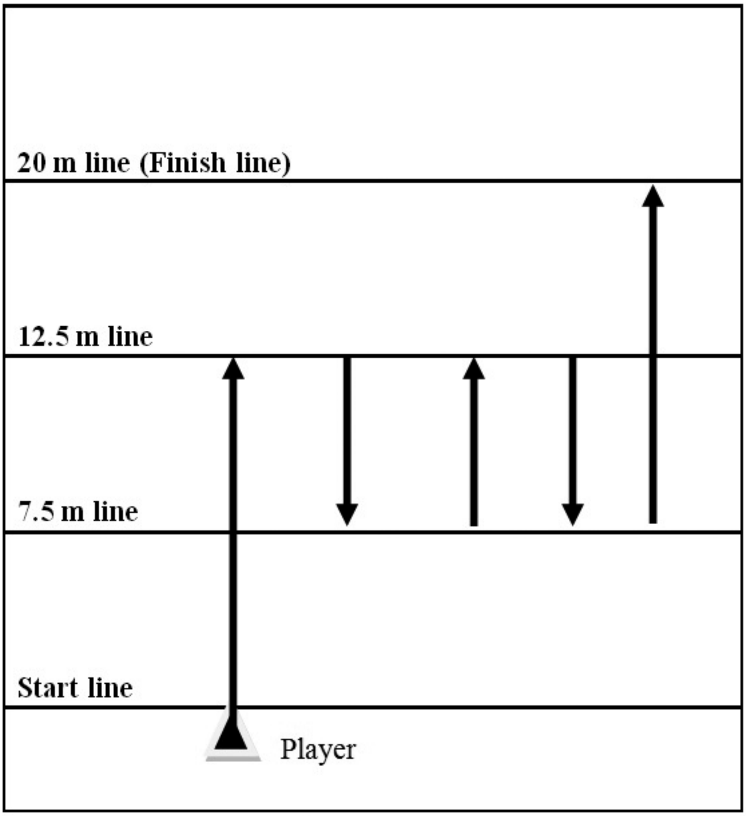

Figure 1: The repeated agility exercise performed by the repeated agility training group during the intervention period.

Table 2: Periodization of the linear repeated sprint training.

Week 0	Pre-test
Week 1	2x5x40m, R=1:30min, SR=10min, I=95-100 %
Week 2	2x6x40m, R=1:30min, SR=10min, I=95-100 %
Week 3	2x7x40m, R=1:30min, SR=10min, I=95-100 %
Week 4	2x5x40m, R=1:30min, SR=10min, I=95-100 %
Week 5	2x7x40m, R=1:30min, SR=10min, I=95-100 %
Week 6	2x8x40m, R=1:30min, SR=10min, I=100 %
Week 7	2x9x40m, R=1:30min, SR=10min, I=100 %
Week 8	2x7x40m, R=1:30min, SR=10min, I=100 %
Week 9	Post-test

R = Recovery between exercises.
SR = Recovery between sets.
I = Intensity.

Statistical Analyses

All statistical analyses were carried out using SPSS 17.0 for Windows (SPSS Inc., Chicago). A 2 x 2 mixed-model analysis of variance (also known as a split-plot ANOVA) was used to test for differences between the groups' results from pre- to post-test. To test the assumption of normality, the data were explored by a histogram plot and tested using the Shapiro-Wilk test for all groups. To test the assumption of homogeneity in variance, Levene's test of equality of error variances was applied. To test the assumption of differences in the quality of covariance's matrices, Box's test of equality of covariance matrices was applied. If the assumptions were met, the interaction effect (did both groups have a similar improvement from pre- to post-test?) was examined using Wilks' Lambda in Multivariate Tests. One-way repeated measures ANOVA was used to determine within-group differences from pre- to post-test. All descriptive statistics were calculated and reported as mean and standard deviations (SD) of the mean for each group of players on each variable. To determine whether the effect size was small (0.10), medium 0.25) or large (0.40), the scale developed by Cohen, J. (1988) was used. Significance was accepted at the $p \leq 0.05$ level. The 95% confidence interval (95% CI) was also calculated for all measures. Two-way mixed Intra-class Correlation (ICC) reliability was calculated for all the dependent measures in this study.

RESULTS

Reliability

The test-retest reliability for the CMJ vertical jump was intra-class correlated (ICC) (ICC = 0.96, $p < 0.01$), for the 40 m (ICC = 0.94, $p < 0.01$), the agility sprint time (ICC = 0.84, $p < 0.01$), for the RSA sprint time (ICC = 0.96, $p < 0.01$), and for the Yo-Yo IR1 (ICC = 0.94, $p < 0.01$).

Within-group analysis

The results from the agility training group showed significant improvements in 10 × 40 m RSA (a very large effect), agility (a very large effect) and Yo-Yo IR1 (a large effect) performances (Table 3). The repeated sprint group showed significant improvements in 10 × 40 m RSA (a very large effect), 20 m top speed (a large effect), 40 m linear sprint (a large effect), CMJ vertical jump (a very large effect), and Yo-Yo IR1 (a very large effect) (Table 4).

Table 3: Agility training group Pairwise comparison from the pre- and post-test results in all measured variables.

Variable	Pre-test	Post-test	Change (Std. Error)	95% CI	Partial Eta Squared	Pearson *r*
10x40m RSA (s)	6.15 (0.40)	5.95 (0.33)	0.203 (0.047)	0.92 – 0.313*	0.728	0.952**
Agility	10.02 (0.34)	9.7 (0.35)	0.326 (0.041)	0.230 – 0.423**	0.901	0.945**
20m acceleration (s)	3.15 (0.18)	3.11 (0.15)	0.041 (0.035)	-0.41 – 0.123	0.169	0.846**
20m top speed (s)	2.71 (0.19)	2.69 (0.12)	0.022 (0.035)	-0.060 – 0.105	0.056	0.876**
40m maximum (s)	5.86 (0.35)	5.80 (0.25)	0.064 (0.051)	-0.057 – 0.185	0.182	0.945**
CMJ	26.4 (4.4)	28.2 (4.6)	1.79 (0.78)	-3.643 – 0.058	0.428	0.882**
Yo-Yo IR1 (m)	1025 (274)	1120 (285)	95 (37)	5 – 184*	0.475	0.928**
Body weight	66.3 (5.7)	66.3 (5.6)	0.15 (0.453)	-1.05 – 1.09	0.001	0.975**

* = $P < 0.05$
** = $P < 0.01$
Partial Eta Squared = Effect size

Table 4: Repeated sprint group Pairwise comparison from the pre- and post-test results in all measured variables.

Variable	Pre-test	Post-test	Change (Std. Error)	95% CI	Partial Eta Squared	Pearson *r*
10x40m RSA (s)	6.19 (0.25)	5.94 (0.24)	0.248 (0.038)	0.161 – 0.335**	0.844	0.895**
Agility	9.81 (0.45)	9.91 (0.42)	0.108 (0.085)	-0.304 – 0.088	0.167	0.832**
20m acceleration (s)	3.15 (0.13)	3.10 (0.13)	0.057 (0.042)	-0.040 – 0.154	0.185	0.514
20m top speed (s)	2.75 (0.15)	2.67 (0.18)	-0.072 (0.026)	0.013 – 0.132*	0.494	0.896**
40m maximum (s)	5.90 (0.24)	5.77 (0.26)	0.129 (0.040)	0.036 – 0.221*	0.563	0.891**
CMJ	24.9 (4.6)	26.8 (4.6)	1.98 (0.427)	0.941 – 2.912**	0.718	0.961**
Yo-Yo IR1 (m)	920 (293)	1173 (288)	253 (35)	171 – 334**	0.866	0.934**
Body weight	61.9 (5.5)	62.7 (5.3)	0.722 (0.368)	-0.127 – 1.57	0.324	0.961**

* = $P < 0.05$
** = $P < 0.01$
Partial Eta Squared = Effect size

Between-groups analysis

The results from the 2 x 2 mixed-design analysis of variance model showed that the data presented in this study met the assumptions of homogeneity and the assumption of the equality of covariance matrices (Table 5). The between-groups comparison revealed that no significant differences between groups were observed for any of the measured variables (a very small effect by group differences), indicating that the effect of both training programmes was similar for both groups. The data also show that both groups had a similar improvement in the agility and Yo-Yo IR1 tests from pre- to post-test (Table 5).

Table 5: Tests of Between-Subjects Effects by group, Levene's Test of Equality of Error Variances and the Box's Test of Equality of Covariance Matrices.

	Levene's Test (P-value)	Box's Test (P-value)	Wilks' Lambda by group (P-value)	Between-groups (P-value)	Partial Eta Squared
10x40m RSA (s) Pre-test	0.193	0.653	0.459	0.908	0.001
10x40m RSA (s) Post-test	0.440				
Agility Pre-test	0.453	0.273	0.001	0.994	0.001
Agility Post-test	0.730				
20m acceleration (s) Pre-test	0.238	0.622	0.784	0.905	0.001
20m acceleration (s) Post-test	0.853				
20m top speed (s) Pre-test	0.817	0.254	0.264	0.876	0.002
20m top speed (s) Post-test	0.193				
CMJ Pre-test	0.755	0.600	0.879	0.503	0.031
CMJ Post-test	0.856				
Yo-Yo IR1 (m) Pre-test	0.784	0.994	0.008	0.852	0.002
Yo-Yo IR1 (m) Post-test	0.890				
Body weight Pre-test	0.745	0.979	0.222	0.156	0.130
Body weight Post-test	0.770				

- Levene's Test = Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
- Box's Test = Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.
- Partial Eta Squared = Effect size
- Wilks' Lambda = tests the interaction effect (did both groups have a similar improvement from pre- to post-test).

DISCUSSION AND CONCLUSIONS

In the present study, the intervention programmes resulted in different effects on the soccer players' physical capabilities only when examining each group separately (within groups). No differences between groups were observed. The improvement in agility and Yo-Yo IR1 was significantly similar for both groups ($p < 0.01$) as reported by the Wilk Lambda test.

The fact that no between-group differences were observed in any of the measured variables indicates that the within-group differences were as a result of the training programmes implemented in the present study. However, the improvement in agility from the within-group analysis for both groups (Tables 3 & 4) was expected and in accordance with our hypothesis and the principle of task specificity (Vescovi & McGuigan, 2008; Young, et al., 2001). In support of the present findings, Young, et al. (2001) demonstrated that linear sprint training did not improve performance in sprints with changes of direction. Wojtys, Huston, Taylor, and Bastian (1996) reported neuromuscular adaptations to agility training in the form of improved spinal reflex and cortical response times in typical lower limb muscles activated in sprinting. Since the agility training implemented in the present study was exactly the same as the test conducted, the improvements were likely related to adaptations in specific coordination and agility of the neuromuscular system (Ross, Leveritt, & Riek, 2001).

The repeated agility group performed 15 – 20% fewer sprint repetitions and had 30 s longer recovery periods between each run and this varying workload between the groups' training programmes could have caused the improvement of the repeated sprint training group's Yo-Yo IR1 performance with a very large effect margin compared to the improvement in the repeated agility group (Tables 3 & 4). Our conditioning expert chose this design because each agility sprint lasted ~4 s longer on average than each linear sprint. Accordingly, the repeated agility training sessions were probably more anaerobic in terms of lactate production. The present repeated sprint group results are in accordance with the results of Tønnessen et al. (2011) who reported a moderate improvement in bleep test performance as a result of repeated sprint training.

No significant RSA (10 × 40 m) differences were observed between the groups, and the absolute improvements were quite similar for the repeated agility group and repeated sprint group (~0.20 and ~0.25 s, respectively). However, the magnitude of the RSA improvement was small for both groups (Table 5). Running speed is a quotient of running distance covered and running time. Using this formula we calculated that both groups completed the 10 × 40 m pre-test sprinting at 95% of maximum running speed, and 97% at the post-test in both groups. This demonstrates the ability to complete repeated sprints with an intensity closer to maximum capacity. Similar developments were observed in the study by Tønnessen et al. (2011).

Even though the repeated sprint training group improved the 40 m single linear sprint and CMJ performance by a significant margin and with a very large effect (Table 4), no between-group differences were observed for these capabilities (Table 5). Since the effect size for both groups was > large for the single sprint and CMJ (Tables 3 & 4), the observed improvement in both groups can therefore be classified as a random effect, i.e. caused by the remaining soccer training. Sporis, Jovanovic, Omrcen, and Matkovic (2011) reported that soccer-specific training likely plays an important role in developing and maintaining sprinting abilities. Tønnessen et al. (2011) and Shalfawi et al. (2012) observed improved performance in a control group's single sprint caused by soccer training.

The athletes' initial training status may have affected the outcome of the present conditioning programme. In their review of strength training, Kraemer et al. (2002) reported a specific trend of slower progression rates of a trainable characteristic with training experience. Untrained individuals respond positively to most training interventions, making it more challenging to evaluate the training outcomes. A well-trained soccer player can be considered untrained in terms of sprint training. Further, sprinting skills depend heavily upon technical elements, increasing the need for feedback during practice. All training sessions in this study were supervised by a former national coach in track and field sprinting which possibly had an effect on the positive training outcomes in the present study (Coutts, Murphy, & Dascombe, 2004; Mazzetti et al., 2000). Research has shown that the basal concentration of testosterone significantly increases 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 (Kraemer et al. 2004). Therefore, the improvements observed in both groups could have been influenced by the timing of the present study (the pre-season period).

Our findings confirm that common principles of training such as specificity, progression and periodisation are clearly present in the sprint training of soccer players. Repeated agility training induces specific agility enhancement, while repeated linear sprint training improves intermittent running ability to a greater extent than agility training. Those training principles could help improve the sequencing of muscle activation and improve the recruitment of muscle fibres involved in the exercise. The fact that sprinting abilities are depend greatly on technical elements suggests that direct supervision of sprint training is a factor of success. The fact that the present study did not have a control group made it harder for us to determine to what extent the training programmes contributed to the improvements observed within the groups. Therefore, repeating the study with a control group is highly advisable.

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