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Research article

The Effect of Speed Endurance Versus Core Training on The Repeated Sprint Ability of Youth Male Soccer Players – A Randomized Controlled Trial

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Abstract

The effects of specific training protocols to improve repeated sprint ability are well known; however, the utility of non-specific training for this purpose is doubtful. Therefore, this study aimed to compare the effects of a specific (sport-related) vs. non-specific (general physical development) eight-week training protocol on developing or maintaining repeated sprint ability in soccer players. Thirty-eight male soccer players (aged 17.1 ± 0.3 years) were randomly divided into a speed endurance group (n = 18) and a core training group (n = 20). The speed endurance group performed 4 sprints lasting 15 seconds with a recovery of 75 seconds, while the core training group performed 2 sets of 4 exercises for 30 seconds with 15 seconds of recovery. Both protocols were performed twice a week. All players performed the Running-Based Anaerobic Sprint Test (6 consecutive 35-meter sprints with 10-seconds recovery intervals). A mixed two-way ANOVA was performed with no significant effects in the interaction term. On average, the speed endurance and the core training groups improved their repeated sprint ability by 7.9% and 8.0%, respectively, from pre- to post-assessment ($p < 0.001$, $\eta^2_p = 0.459$). No significant between-group differences were detected for the Running-Based Anaerobic Sprint Test total time or maximum power. In principle, specific and non-specific low-volume training protocols may improve repeated sprint ability over eight weeks in soccer players. However, the improvements may have been derived from the continued soccer-specific training, which is the reason why future studies should include a passive control group and test whether high session volumes produce different results.

Key words: Speed endurance maintenance, repeated sprint training, stability training, team sports, football, complementary training.

Introduction

Soccer is a team sport characterized by its intermittent high-intensity nature, where players must repeatedly produce maximal or near-maximal sprints with short recovery periods (Bangsbo et. al, 1991; Spencer et. al, 2005). For instance, in the German Bundesliga, linear sprint amounted to 61% of the actions of the scoring player in goal situations and 67% of the actions of the assisting player (Faude et. al, 2012). As the game progresses, multiple high-intensity actions accumulate, potentially reducing the capacity to perform these actions repeatedly over time (Mohr et. al, 2003). Fatigue or reduced performance occurs at different stages of the match, which may inhibit the players' ability to perform maximally (Mohr et. al, 2005). Even so, professional football players are requested to perform maximal-intensity sprints in the last periods of the match under high fatigue conditions (Oliva-Lozano et. al, 2023). Given the need to perform consecutive sprints with reduced recovery (<60 seconds [s]), termed as repeated-sprint ability (RSA), throughout the match, this ability needs to be developed (Mohr and Iaia, 2014).

Anaerobic training is commonly used by practitioners to enhance RSA and can be grouped into speed training and speed endurance training (SET), which is further divided into SET production (SET-P) and SET maintenance (SET-M). A production-type SET comprises 4 - 12 repetitions of 15 - 40s maximum sprints and a work:rest ratio of 1:5 to 1:8. On the other hand, a maintenance-type of SET may present different ranges of duration (5 - 15s or 15 - 90s), repetitions (10 - 25 or 6 - 12) and work:rest ratios (1:2 to 1:5 or 1:1 to 1:3), depending if it refers to a short- or long-intervals protocol, respectively (Hostrup and Bangsbo, 2023). These different types of SET should be used according to the specific aims of the training intervention, with the SET-P targeting the ability to perform high-intensity actions repeatedly and the SET-M aiming to minimize the acute fatigue effects during high-intensity efforts. In this regard, in a study with male sub-elite players (Mohr and Krustrup, 2016), a SET-P was revealed to be more effective in enhancing the RSA than SET-M. Also, a similar protocol to SET-P was employed by (Nedrehagen and Saeterbakken, 2015) however, designed as repeated sprint training, was more effective in improving RSA than the active control group.

With the reduced number of weekly training hours resulting from increased match frequency, training sessions tend to overly focus on tactical-technical aspects, potentially neglecting the development or maintenance of essential capacities such as the RSA (Dupont et. al, 2010). This seems to be a generalized challenge among soccer teams since previous research with Dutch (Stevens et. al,

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2017), Portuguese (Clemente et. al, 2019), and Norwegian (Baptista et. al, 2019) soccer teams have observed similar trends regarding the reduced high-speed demands during the training process, particularly when compared to match demands. Thus, the coaching staff should carefully design training strategies to improve this capacity while considering the demands of the competition schedule. Although different strategies to optimize the training process have previously been proposed, it is unknown to what extent they have been used in practice. Those proposals include using warm-ups as an opportunity to develop some skills or capacities (Afonso et. al, 2024), or the implementation of complementary training programs before or after regular practice (Thurlow et. al, 2023). Such strategies may apply specific or non-specific (i.e., general) stimuli. Specific approaches emulate the sport task, while non-specific exercises focus more on general physical development (Bompa and Buzzichelli, 2019). For example, specific training aiming to improve RSA may be represented by performing small-side games, followed by repeated sprints and non-specific training represented by performing a general conditioning high-intensity aerobic interval training with long bouts of continued running (Rodríguez-Fernández et. al, 2020).

Recently, a review on the effectiveness of different training methods (Michailidis, 2022) observed that larger improvements in the RSA were reported in studies using specific training programs (i.e., moderate to large effect size) when compared to other studies using non-specific programs (i.e., trivial to moderate effect size), such as plyometric training, strength training and FIFA11+, which could be explained by the training specificity (Small et. al, 2009). However, the addition of non-specific programs to soccer training (e.g., core training protocols) has been reported to improve skill-related physical fitness, including power, speed, balance, and agility (Luo et. al, 2022). A core training program with professional female futsal players showed a positive time effect on a repeated sprint test (Lago-Fuentes et. al, 2018).This may be explained by the key role of the trunk muscles, allowing a better torque transference between upper and lower limbs enabling a more efficient movement during whole-body exercises such as sprints (Lago-Fuentes et. al, 2018). Additionally, core training also improves the stability of the centre of gravity during fast running and reduces fluctuations in it (Luo et. al, 2022). Moreover, Luo et. al (2022) included four studies in their systematic review where higher improvements in RSA were observed in core training groups when compared to control groups.

Therefore, this randomized controlled trial aimed to compare the effects of adding either an eight-week specific (i.e., SET) or non-specific (i.e., core training) training protocols to the usual soccer training routine on the RSA of national-level youth male soccer players. We hypothesize that significant differences will be noted in both groups; though higher improvements will be observed in the group performing the SET. This hypothesis is partly in line with the conclusions of previous research, where RSA was defined as a complex fitness component that can be improved by using different strategies and training forms (Bishop et. al, 2011).

Methods

Experimental approach to the problem

This investigation followed the CONSORT guidelines using a randomized multi-group trial with a parallel-group design (Juszczak et. al, 2019), implementing an eight-week SET-M and core programs. The study lasted ten weeks at the training center of the club enrolled in the study. This duration was chosen according to previous research on SET (Nyberg et. al, 2016) and core training (Lago-Fuentes et. al, 2018), with both having reported significant improvements in sprint ability after implementing protocols with similar durations. The pre-testing was conducted two days before the beginning of the intervention, during the first week, and post-testing was conducted two days after the end of the intervention during the last week. A familiarization period for the participants (performing the Running-Based Anaerobic Sprint Test [RAST]) and for the coaches (running the repeated sprint and core training protocols) was held two weeks prior to the start of the intervention. This research was approved by the Ethical Committee of the Faculty of Sport of the University of Porto, with the following approval code assigned CEFADE 03 2022, and performed in accordance with the ethical standards of the Declaration of Helsinki (64th WMA Assembly, Fortaleza, Brazil, 2013).

Subjects

An *a priori* power analysis was performed using the G*Power software, version 3.1 (University of Düsseldorf in Germany). Employing a within-between interaction effect (2 groups × 2 times) for a sampling power of 0.90 and an *a priori* effect size of 0.06 (eta partial square, η^2_p), based on previous research on the topic (Iaia et. al, 2017), with an α error of 0.05% and an expected correlation of 0.5, a sample size of 46 subjects was required. A convenience sample was used from the club to which the main researcher had access. Forty-eight young male athletes from a Portuguese soccer club, aged 15 - 19 years old and belonging to three different age categories (U16, U18, and U19), were recruited. In agreement with a classification framework, age categories can be classified according to the training and performance caliber. Thus, the U16 and U18 were allocated to tier 2 (i.e., Trained/Developmental), and the U19 was allocated to tier 3 (i.e., Highly Trained/National Level) (McKay et. al, 2022). About the training experience, all players had at least five years of soccer training practice. A final sample of 38 players was obtained after using the following exclusion criteria: a) players who did not attend the pre- and post-intervention assessment protocols.; b) injured players; c) players who did not fully complete the eight weeks foreseen by the protocol. Accordingly, ten of the 48 eligible athletes were excluded due to injury unrelated to the protocols and were balanced across the groups (n = 6 in the speed endurance group [SEG] and n = 4 in the core training group [CTG]). Considering the exclusions, we ran a sensitivity power analysis and we were able to detect effects of 0.09 or larger and 0.05 or larger for a power of 90% and a sample size of 30 and 48, respectively. Also, these sample sizes would be able to detect an effect of 0.07 or larger (n = 30) and 0.04

(n = 48) or larger for a power of 80%.

The participants were divided into two groups: the SEG and the CTG. All three teams were in the competitive period during the study conduction. Using Microsoft Excel, randomization was performed by randomly attributing a number to each participant and ensuring a 1:1 ratio within each age group by a researcher not involved in implementing the interventions. The allocation sequence was concealed from the main researcher until the beginning of the intervention. In each age category, the participants were randomized into the SEG (after dropouts: SEG U16 = 10 participants; SEG U18 = 5 participants; SEG U19 = 9 participants) and the CTG (after dropouts: CTG U16 = 10 participants; CTG U18 = 6 participants; CTG U19 = 8 participants) (Figure 1). The baseline characteristics of the sample (SEG and CTG), referring to the mean ± SD, are presented in Table 1.

Table 1. Baseline characteristics between groups.

Variables	SEG	CTG
Age (years)	17.2 ± 0.4	17.1 ± 0.3
Height (cm)	173.2 ± 1.6	174.6 ± 1.3
Weight (kg)	65.8 ± 1.8	70.0 ± 1.4
RAST time (s)	33.0 ± 3.6	34.6 ± 3.8
Peak Power (W)	670.0 ± 181.5	642.4 ± 214.4
$RAST_{Sdec}$ (%)	10.8 ± 3.3	10.5 ± 3.1

The data are presented in mean ± SD. SEG = Speed endurance group, CTG = Core training group, RAST = Running-Based Anaerobic Sprint Test, $RAST_{Sdec}$ = RAST sprint decrement score.

During the investigation period, both groups (SEG and CTG) performed a total of 16 training sessions focused on RSA (SEG) or a volume-equated (i.e., number of sessions and duration per session) core strengthening program (CTG), in addition to the regular soccer training. Regular soccer training sessions were consistent between groups and were composed of warm-up exercises (with and without the ball), a combination of small-, medium-, and large-sided game, and a plethora of tactical-technical drills. The players included in the study performed four to five soccer-specific training sessions, each lasting approximately 75 min and one official match per week. In addition, the subjects were instructed not to change their diet or lifestyle over the experimental period. All participants and legal guardians of underage players signed an informed consent. Adult players signed their informed consent. All the participants were informed about the study procedures and the possibility of withdrawing from the study at any moment without any sanction.

Procedures

The speed endurance intervention consisted of 4 sprints of 15s each, with passive recovery intervals between bouts of 75s (work: rest ratio = 1: 5). Each sprint was executed with slight adjustments in direction to seamlessly align with the pitch, as represented in Figure 2. For eight weeks, both groups performed their usual training schedules defined by the coaching staff. Twice a week, the SEG performed the speed endurance protocol. At the same time, the CTG completed a volume-equated core strengthening program, which consisted of 4 exercises (ball hamstring curls, ball pikes, ball degree pikes and superman with ball), totaling 2 sets of the 30s of work with 15s passive rest between exercises and 60s between sets. These protocols were chosen according to previous literature (Bangsbo, 2015; Lago-Fuentes et. al, 2018), adjusted with the time limitations imposed by the technical staff and conducted on the same days for both SEG and CTG.

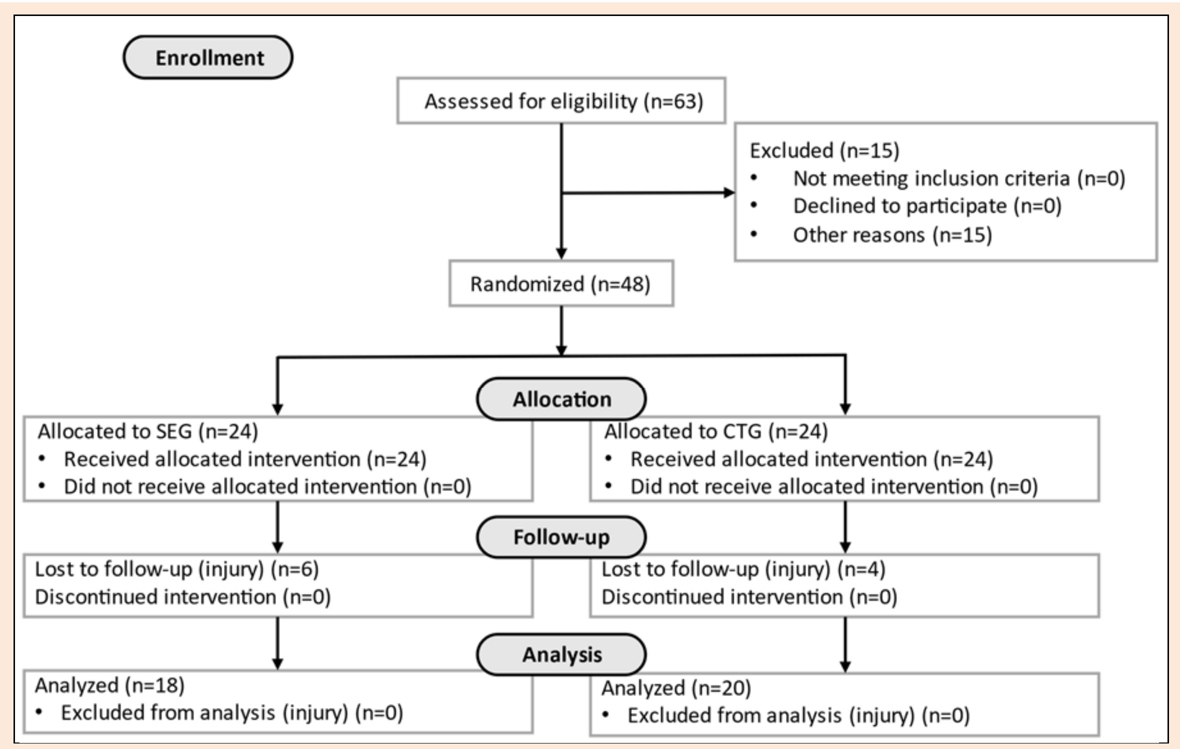

Figure 1. CONSORT flow diagram. SEG = Speed endurance group. CTG = Core training group.

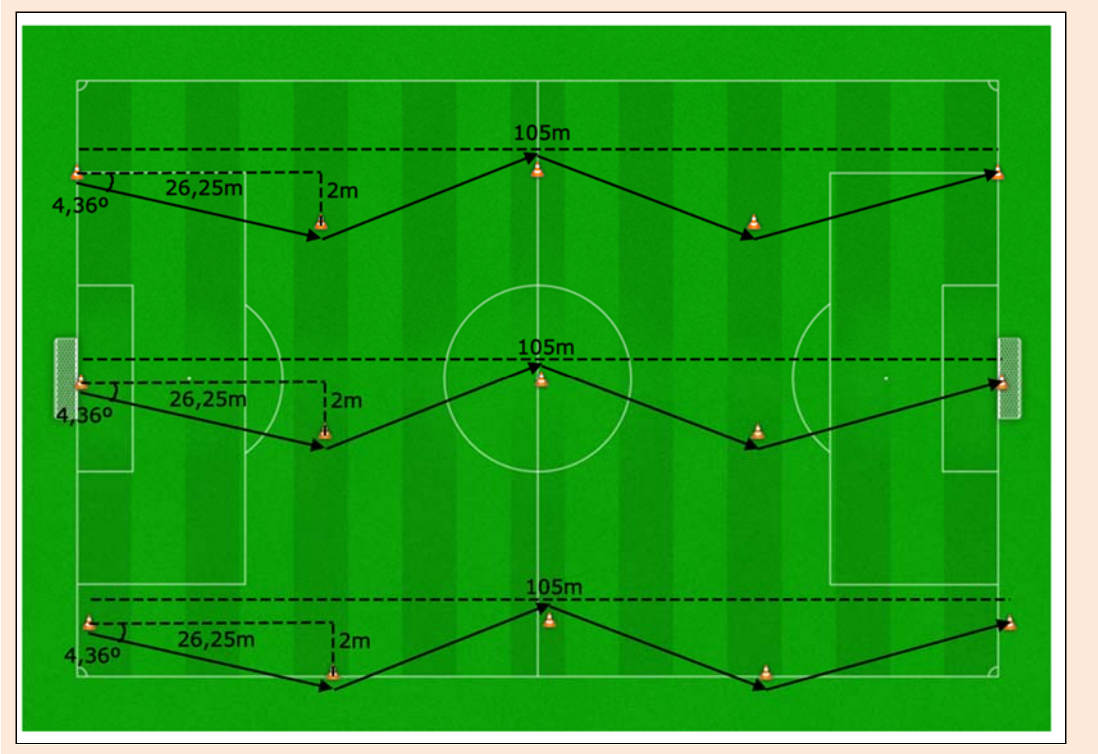

Figure 2. Schematic representation of SEG intervention protocol. SEG = Speed endurance group.

Both protocols were performed at the beginning of the training session, after a 10-min soccer-specific warm-up (i.e., tactical-technical drills mimicking soccer-specific demands with or without ball included), designed according to the following session demands, and had a similar duration of ~6-min. After 16-min, the teams started the regular soccer training. To each group, different UEFA-B-qualified coaches were assigned to constantly supervise the protocol implementation and monitor the strict application of the exclusion criteria.

Outcomes

A pre- and post-intervention RAST was performed on the same synthetic turf where the players used to train. The test consisted of 6 maximal linear 35-m sprints with 10s rest between each bout (Draper and Whyte, 1997). Photoelectric cells (Leonardo Smart Sensors), with a typical error of ±0.5 ms (according to manufacturer's data), were placed at the start and end of the course to collect the times of each sprint. Immediately before the RAST started, each cell was calibrated following the manufacturer's guidelines. The Leonardo software version 2.0.9 was used with the cells to record the sprinting time of the players. Total time was considered the sum of the 6 sprints performed by each athlete in the RAST. The peak power was also calculated based on the best sprint performed in the RAST, using the formula: power = (body mass × distance^2)/time^3) (Zagatto et. al, 2009). In addition, and according to previous research (Glaister et. al, 2008), to quantify fatigue during the RAST, the percentage decrement score ($RAST_{Sdec}$) was calculated as follows:

$$RASTSdec = ([(S1+S2+S3+\ldots+S_{final}) / (S_{best} \times number\ of\ sprints)]-1) \times 100$$

All athletes were assessed in the late afternoon (~7:00 PM) under comparable weather conditions (temperature, 11 - 15°C; wind, 16.7 - 25.9 km/h). Players were assessed on three occasions: (i) two weeks before the beginning of the protocol, for familiarization with the tests (data not used for statistical purposes); (ii) immediately before starting the protocol; and (iii) after the end of the last week of the protocol (i.e., beginning of the 10th week of the study). To ensure blinding, external assessors applied the tests without previous information regarding players or interventional groups. On the first assessment, the testing arrangement was to familiarize the participants with the testing procedures and instructions, avoiding unfamiliar or misunderstanding of testing procedures. Therefore, since this assessment does not provide an accurate evaluation of RSA, it was used only for a familiarization purpose.

Statistical analyses

The normality and homogeneity (Kolmogorov-Smirnov and Levene test, respectively) were conducted before analysis, and the normality assumptions were verified. All data were presented in mean ± standard deviation (SD), and 95% confidence intervals (CIs) were adopted. A mixed ANOVA (within- and between-factors) was used to analyze the differences in the RAST (pre- and post-intervention period) and to assess the interaction. Since several dropouts were not considered due to missing data, this should be viewed as a per-protocol analysis (even though the dropouts were balanced between groups). The magnitude of the effect was calculated with the partial eta squared (η^2_p), and the values of 0.01 to <0.06; 0.06 to <0.14 and ≥0.14 were considered small, medium, and large, respectively (Pallant, 2020). A significance level of $p \leq 0.05$ was chosen. Data analysis and processing were performed using the IBM SPSS software (Statistical Package for the Social Sciences) version 27.

Results

In Table 2, mixed ANOVA analysis does not indicate a significant interaction between group and time ($p > 0.05$). However, large effect magnitudes were observed in the main effect of time in the RAST performance ($p < 0.001$, $\eta^2_p = 0.459$), in the peak power ($p < 0.001$, $\eta^2_p = 0.296$), and in the $RAST_{Sdec}$ ($p = 0.001$, $\eta^2_p = 0.278$) between the two assessment moments. Lastly, the between-group effect [SEG (n = 18) vs. CTG (n = 20)] was not significant for all measures after eight weeks of intervention ($p > 0.05$).

Table 2. Baseline and post-training measurements.

Variables	SEG			CTG			*p*			
	Pre	Post	Δ (%)	Pre	Post	Δ (%)	Time	η^2_p	G × T	Group
RAST time (sec)	33.0 ± 3.6	30.6 ± 1.6	7.9	34.5 ± 3.8	31.9 ± 1.5	8.0	<0.001	0.459	0.865	0.091
Peak power (w)	670.6 ± 181.5	766.3 ± 125.2	12.5	643.9 ± 213.0	735.1 ± 139.0	12.4	<0.001	0.296	0.923	0.563
$RAST_{Sdec}$ (%)	10.8 ± 3.3	7.8 ± 3.3	28.0	10.5 ± 3.1	8.7 ± 3.7	16.6	0.001	0.278	0.324	0.727

Statistical analysis of mixed ANOVA 2 (group) × 2(time). The data are presented in mean ± SD. CTG = Core training group, SEG = Speed endurance group, G × T = interaction between group and time, η^2_p = eta partial square, RAST = Running-Based Anaerobic Sprint Test, $RAST_{Sdec}$= RAST sprint decrement score.

Discussion

Speed endurance vs. core training

This study revealed that specific (i.e., SET) and non-specific (i.e., core training) protocols were sufficient to improve RSA after only eight weeks. However, the improvements were not significantly different between the two interventions. While these results suggest that training specificity may not be required for improving RSA, it should be noted that both programs applied a very low training volume and, in the absence of an active control group, it is possible that the regular soccer training may have also contributed to the improvements in both groups.

The training volume used in our SET is comparable to the lowest reported in a recent narrative review (Hostrup and Bangsbo, 2023) and lower than all the 40 studies from various sports included in a recent meta-analysis (Thurlow et al., 2023). Thus, the lack of significant differences in the improvements between the CTG and the SEG in the total time of the RAST test can be (partially) explained by an insufficient SET volume. Therefore, a higher volume session will be needed in future research to elucidate this scenario fully.

Speed endurance protocols and repeated sprint ability

Certain SET-P have been shown to improve soccer player's lactic anaerobic capacity and, consequently, their capacity to perform repeated sprints (Castagna et. al, 2019). Different SET-P protocols can be used depending on the number of repetitions, execution time, execution intensity, and rest time (Bangsbo, 2015). Considering the references proposed by Bangsbo (2015) for SET-P (10 to 40s of maximal effort exercise, 2 to 10 repetitions with a work:rest ratio of 1:5), the dose applied in our repeated sprint protocol may have been too low to stimulate the development of the anaerobic capacity, and consequently to promote higher improvements in RSA than those observed in the CTG. Besides that, all the players involved in this study were highly trained due to the moment of the season they were in (i.e., in-season period), which challenges the improvement of physical capacities due to the training principle of diminishing returns (Hoffman, 2014), or still a possible ceiling effect may occur for the volume employed in the intervention. In a study with male football players, Gunnarsson et al. (2012) applied a SET-P (6 - 9 repetitions of 30s of 90 – 95% of maximal intensity with 3-min of recovery between repetitions) and observed an improvement of 11.0% in the performance of the Yo-Yo Intermittent Recovery Test, level 2 (Yo-Yo IR2). However, besides using of a different performance assessment tool, the SET included a higher number of repeated sprints than ours.

Regardless, our results showed large magnitude effect sizes for the improvements in both groups, suggesting that relatively low volumes of complementary training may still be beneficial. Soccer is a multifactorial sport where small margins likely strongly impact the players' and teams' match performances. These performances, in turn, are optimized by coaching staff at the smallest detail. Thus, training protocols with effect sizes like the ones observed in the present study can potentially boost players' physical performances, particularly during repeated high-intensity actions.

In the research by Iaia et. al (2015), SET-P and SET-M were applied three times a week for five weeks. The SET-P consisted of performing 6 to 8 maximum intensity sprinting bouts during 20s, with a recovery period of 2-min. The investigators reported a 10.1% improvement in the performance of the Yo-Yo IR2 test and a significant improvement in the capacity to perform repeated sprints by 2.5%, assessed by the total time in the RSA test, which was below the improvements observed in our study (i.e., 7.9%). Nevertheless, these improvements were reported only for the SET-P, with non-significant differences reported for the SET-M. Although the positive effects found for the RSA, the dose used by Iaia et. al (2015) was considerably higher (6 - 9 bouts of 20 - 30s, with 40 - 120s recovery) than the dose used in the present investigation (4 sprints of 15s, with 75s recovery). Another in-season study with female and male soccer players showed that a weekly training session of speed endurance was sufficient to promote increments in RSA (Nedrehagen and Saeterbakken, 2015). However, the training session volume (i.e., 4 to 6 shuttle runs of 20 + 10 m repeated for 3 to 4 series) was higher than in the current protocol. Buchheit et. al (2010) reported similar improvements to those found in our results for the RSA in young elite soccer players, employing repeated shuttle sprint training once a week for ten weeks.

Speed endurance training and fatigue resistance

Speed endurance protocols (8 repetitions of 30s bouts, with 90s recovery) have previously been suggested as an effective method to develop fatigue resistance, with decreases in fatigue index observed during a repeated sprint test (Mohr et. al, 2007). Previous research with young male soccer players (Iaia et. al, 2015) compared the effects of fatigue resistance development of two speed endurance training regimens. The authors applied 6-8 repetitions of 20s all-out runs in both protocols while varying the recovery time between bouts (SET-M = 40s; SET-P = 2 min). The results revealed that the training intervention with shorter recovery periods was superior for minimizing the decline in muscle force/speed production during repeated sprint efforts compared to the intervention with longer recovery periods. These effects observed in interventions with shorter recovery periods are likely linked to the resultant perturbations in ion homeostasis (Mohr et. al, 2007) and pronounced metabolic disturbances (Saraslanidis et. al, 2011).

Notwithstanding, effects on fatigue resistance were further investigated by research on repeated sprint training (Iaia et. al, 2017), by comparing two protocols of 6 repetitions of 5s sprints with different rest periods (work:rest ratios of 1:3 and 1:6). The results showed improvements >30% in RSA_{Sdes} for both groups, irrespectively of the recovery period length. The SET-P protocol used in our study included a work:rest ratio of 1:5 and similar results were observed regarding the improvement in $RAST_{Sdes}$ (i.e., 28%). As different training volumes were used between our study and the study of Iaia et. al (2017), the similarity in percentage improvements observed may have different reasons: i) from a certain training volume, additional improvements may be limited (law of diminishing returns), ii) other variables (e.g., exercise complexity and training density) than the volume may have a decisive role, iii) influence of different training status of the participants.

Core training and repeated sprint ability

The improvements observed in the CTG may also be explained by the specific role of the trunk as a linkage between the upper and lower extremities and by generating superior neuromuscular adaptations. These adaptations facilitate the torque transfer and angular momentum in a more efficient form to the limbs, diminishing the energy loss in the torso during the execution of whole-body movements such as sprints (Lago-Fuentes et. al, 2018). Besides that, improvements in the stability of the centre of gravity during fast running may also be expected when players are exposed to core training programs (Luo et. al, 2022). Nevertheless, the effects of core training (i.e., non-specific training) in the RSA remain poorly investigated, and these results do not allow us to draw conclusion about its effects on RSA. The improvements in the RAST test in both groups, can partly be associated with the regular soccer training process, which was common to all participants. However, all training interventions for team sports players are implemented in-season, where sport-specific training is inevitable and indispensable. Therefore, the focus should be merely on comparing changes induced by two (or more) additional training programs implemented simultaneously (Buchheit, 2012).

Other effects

Our study encompasses different age groups (U16, U18 and U19), challenging the capacity to ensure that all three teams were exposed to similar training loads and that variations observed in RSA were not age-related. Despite controlling the groups for the exposure of regular soccer training volume (i.e., duration and frequency of training sessions), we cannot warrant that the external training load was the same across age groups. Moreover, speculation in this matter is rebutted by previous research findings, with some studies observing higher external load in younger age groups (Hauer et. al, 2021), while others report higher external load values with increasing age (Rábano-Muñoz et. al, 2019). Additionally, the assumption that RSA may have significantly differed between age groups is rebutted by the findings of previous research, where no significant improvements in RSA were observed between the U-15 and U-18 groups (Mujika et. al, 2009). Age-related improvements in sprint running performances have been more associated with differences in maturation rather than with differences in anthropometric factors (Mendez-Villanueva et. al, 2011).

Study limitations and further research

This study has some limitations that should be addressed: (i) the final sample size was lower than the one estimated *a priori*; nevertheless, the final size detected effects of interest. (ii) The sample's tier classification and age categories are not homogeneous, though both were equally allocated between the groups at the beginning of the study. (iii) Both the SEG and CTG performed the intervention protocols in addition to their usual soccer training routine. Therefore, the teams' regular soccer training might partly explain the results. Nonetheless, both groups were submitted at the same soccer training volume. (iv) The absence of a passive control group does not allow us to conclude whether the interventions or the regular soccer training may exclusively explain the results. However, comparing the effect of an additional SET program with a control group would not be very informative since a greater training stimulus would likely lead to a greater performance improvement (Buchheit, 2012).

Practical applications

Based on our results, soccer coaches should be aware of the utility of a low-volume SET protocol or core training to improve RSA outcomes. As long as their volume is equated (and for up to eight weeks, at least), complementary training may not be specific to RSA and still generate relevant improvements. Nevertheless, in the absence of a passive control group, the improvements may also be derived from soccer-specific training; this remains hypothetical and needs further investigation, and we also suggest further research to detail the sample features due to the possible moderation effect of these features in results. Meanwhile, by employing specific and non-specific training protocols with similar volumes to those used in this research, coaches may decide to vary these complementary programs during the season while assuming the context and performance specificity. Trying to avoid monotony and/or provide leeway for athletes to choose their program based on personal preferences, potentially increasing adherence and fidelity.

Conclusion

In conclusion, a low-volume, eight-week speed endurance training protocol was as efficient as a core training protocol in improving RSA. The absence of significant between-group differences suggests that (i) low-volume complementary training may suffice to improve RSA; and (ii) training specificity may not be a necessary feature for improving RSA.

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Key points

- Similar improvements in RSA were observed by adding a SET protocol and a core training protocol to regular soccer training, over eight weeks, in youth players.
- The improvements observed with the specific speed training were not superior to the non-specific core training, suggesting that non-specific and specific training may have a similar contribution to enhance RSA.
- In the absence of a passive control group, it is unclear to what extent the improvements in RSA observed were influenced by the regular soccer training applied to the whole team.

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