Effect of CST versus RST on Physical Parameters in College Level Football Players

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Abstract:- The primary purpose of the this study was to explore the effects of a solely repeat sprint training (RST) regime compared to combined training (COM) consisting of RST, aerobic interval- , continuous aerobic- & explosive leg power-training on various physical parameters of football conditioning. Forty-six male college level football players (22 ± 2 years; 66 ± 8 kg; 52 ± 6 ml/min/kg) participated in the study. Players were allocated to either a RST, COM or control (CON) group. Players trained for six-weeks during the pre-season phase. Outcome variables assessed included aerobic capacity, yo-yo intermittent recovery test 2 (YYIRT2), 30-meter sprint, agility and explosive power. Both the RST and COM training groups significantly improved distance ran on the YYIRT2 and the maximum velocity on the VO2 max test compared to CON after six weeks of training (p<0.01). Only the RST group improved VO2 max compared to CON (p<0.05). No other significant between-group differences were found. Conditioning coaches of sub-elite football players have the opportunity to use either RST or COM training during the preparation of their players in the pre-season but RST provides an additional benefit of improved VO2 max and which has also been shown to correlate with physical performance in elite football matches.

Keywords: *Sprint Performance, Physical Preparation.*

I. INTRODUCTION

The use of repeated sprint training (RST) in football is well documented (Iaia et al., 2009; Ferrari Bravo et al., 2008). It involves repeated intervals of high intensity sprinting with brief recovery periods. Benefits of RST in football players include an improved VO2 max, maximum aerobic speed and improved distance on the football specific yo-yo intermittent recovery test (YYIRT) (Ferrari Bravo et al., 2008). Contradictory evidence exists regarding the improvement in speed and jumping ability (Hill-Haas et al., 2009; Ferrari Bravo et al., 2008; Dupont et al., 2004). A recent meta-analysis indicated that RST is beneficial to improve repeat sprint ability, high intensity intermittent running and sprinting performance (Taylor et al., 2015). RST is also related to physical performance in elite football matches (Rampinini et al., 2007). This study determined the construct validity of RST and found significant correlations and predictions with official match related physical performance measures in top level professional football players.

Other training modalities have similarly demonstrated significant improvements as RST while improvements in speed and agility was also less clear (Babu et al., 2014; Faude et al., 2013; Bucheit et al., 2010; Ferrari-Bravo et al., 2008; Impellizzeri et al., 2006; Helgerud et al., 2001). These training modalities usually include either continuous aerobic training (CAT), aerobic interval training (AIT) or explosive leg power training. Aerobic interval training also involves intervals (as RST) but they are longer in duration (usually four minutes repeated four times with three minutes of rest between intervals) (Impellizzeri et al., 2006; Helgerud et al., 2001). This training strategy is well recognized to improve endurance performance in elite and sub-elite football players and is closely related to mean match intensities (Hoff, 2005; Stolen et al., 2005). Explosive leg strength training is commonly used to improve neuromuscular qualities (maximal speed, acceleration and power) in football and involves a series of exercises such as counter movement jumps, calf and squat plyometric jumps and short sprints (Bucheit et al., 2010). Continuous aerobic training involves an aerobic activity of 30 or more minutes of continuous running at close to 65 to 80% of VO2 peak (Faude et al., 2013; Ciolac et al., 2011; Burgomaster et al., 2008). A high aerobic capacity is needed to aid recovery between high-intensity activity spurts in football (Reilly, 1997). The importance of CAT training (especially in the pre-season) despite the significant benefits of interval training is well described in Seiler et al. (2009). The inclusion of these training modalities (RST, AIT, CAT, explosive leg power) as a combination (COM) may all contribute to physical conditioning as time motion analysis indicated football to be an aerobic and anaerobic activity where many repeated running and sprinting bouts, stopping, turning, resting, accelerating, and jumping movements occur throughout a match (Stolen et al., 2005). Moreover, Ferrari Bravo et al. (2008) requested future studies to determine the effect of combining different training strategies (shown to be effective in isolation) on physical parameters of football conditioning. Bucheit (2012) and Bishop et al. (2011) reiterated the use of a combined training approach. Recently, it has been purported that a combined repeat sprint and squat training intervention significantly improved speed and repeat sprint ability in recreationally active young adults and rugby players (Marques et al., 2015; Suarez-Arrones et al., 2014). On the other hand, a combined squat and RST regimen resulted in no improvement of RSA or high intensity intermittent running in football players (Campos-Vazquez et al., 2015). However, RST was only trained once a week and performed during the final phase of the season when players were already competitively fit.

It is possible that RST may provide the same or even superior benefits compared to combined (COM) training as RST is related to physical performance and success in football (Impellizzeri et al., 2008; Rampinini et al., 2007; Krustrup et al., 2003). It has been demonstrated that the use of RST is superior with regard to repeat sprint ability when compared to an individual CAT, AIT or explosive leg power training regimen (Cicioni- Kolsky et al., 2013; Bucheit et al., 2010; Burgomaster et al., 2008; Ferarri-Bravo et al., 2008). For instance, RST is superior compared to AIT for improving performance on the YYIRT and repeat sprint ability tests of football players and physically active individuals (Cicioni-Kolsky et al., 2013; Ferarri-Bravo et al., 2008). The use of interval training (RST or AIT) is also superior for improving aerobic capacity compared to CAT in the general population (Hwang et al., 2011; Ciolac et al., 2011; Burgomaster et al., 2008). Lastly, Bucheit et al. (2010) reported RST more significant in improving repeat sprint ability than explosive leg power training in football players, even though jumping ability was improved in the leg strength training group only.

Therefore the research question arises whether a RST or combined training program (RST, AIT, CAT and explosive leg power) will provide similar aerobic, anaerobic, agility, speed or explosive leg power benefits? Consequently, the primary purpose of the study is to explore the effects of a RST intervention compared to COM training.

II. METHODS

➢ *Participants:*

Forty-six male college level football players agreed to participate in this study (age, 21.7 ± 1.8 years, body mass 65.5 ± 8.1 kg, and height 173 ± 0.1 cm). In order to be included, participants had to sign a consent form and be free from injuries.

➢ *Study Design:*

A three group, parallel, longitudinal (pretest-posttest), single blind experimental design was used. Players were allocated to either a RST or combined training (COM) or control (CON) group. It was not possible to distribute the players randomly to one of the allocated groups as the coaches wanted the teams to remain grouped. The intervention period lasted six weeks (from June to September). The study was carried out during the pre-season and ended just prior to the competitive season.

➢ *Procedures:*

All field tests were performed indoors on a non-slippery surface. Baseline tests occurred over a two week period. Participants were all familiar with testing procedures as they regularly completed them. Upon first visit, the body mass and height of participants were taken. Participants were then given time to warm up (10 minutes) and completed the standing long jump and vertical jump tests. After 30 minutes of rest, participants completed the agility and 30 meter sprint tests. Five participants were tested simultaneously. Following a day of rest, participants completed the YYIRT2 (Krustrup et al., 2006). For this test, participants were tested individually.

➢ *Tests:*

- *Body Mass and Height:*

Body mass and standing height were measured with a Seca scale and stadiometer (Seca, Hamburg, Germany) to the nearest 0.1cm and 0.1kg. Participants wore light weight trunks only. For height measurements, participants stood with heels together and upper back, buttocks and heels against the stadiometer. The height (m) squared and weight (kg) was used to determine body mass index (BMI).

- *Maximal Aerobic Test:*

The VO2 max test was performed in the Exercise Physiology Laboratory. Participants completed a 15 minute warm up at a velocity of 10 km/h. The test started at 12 km/h and increased 1 km/h every 150 seconds.

Gas exchange variables were continually measured (breath by breath) with the Cosmed Quark CPET (Cosmed, Rome, Italy) metabolic system. The system was calibrated with known volumes and concentrations of gasses (N2, O2 and CO2) prior to each test. Subjects were fitted with the Cosmed heart rate (HR) monitor, with HR continuously measured. All raw values were filtered and averaged to every 10 seconds ensuring the exclusion of outliers. Participants ran until volitional exhaustion. The test was considered maximum if three of the following four criteria were met: (1) HR max was 90% or more of age predicted maximum HR; (2) absolute VO2 increase of less than 150ml/min; (3) rating of perceived exertion of nineteen or more and (4) an RER value of more than 1.1. Exercise testing was terminated when the participant grasped for the handrails.

- *Yo-Yo Intermittent Recovery Test 2:*

The YYIRT2 consisted of 20-metre shuttle runs performed at increasing velocities with ten-second active recovery between runs (Krustrup et al., 2006). Audio cues were broadcasted with a portable CD player. The test was terminated when the participant failed to reach the front line on two consecutive occasions or when he felt unable to complete another shuttle. The total distance covered during the YYIRT2 was recorded as the test score.

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- *30 Meter Sprint Test:*

Straight line sprinting was assessed using a 30 metre sprint (Australian Institute of Sport, 2013; Faude et al., 2013). Sprint times were measured manually by two independent assessors with a stopwatch. If time measured between assessors differed by more than 0.05 seconds, the trial was repeated. Players started from a standing position with front foot on the line. Participants sprinted three times with five minutes of rest between sprints. The average of the two best scores were recorded.

- *Agility T-Test:*

Agility was evaluated by a T-test (Australian Institute of Sport, 2013; Semenick, 1990). The players started with both feet behind the starting line (Point A). Participants sprinted forward for 10 metres and touched a cone (Point B) with their hand, then sprinted to the left (90 degree turn) for 5 meters and touched a cone, then sprinted to the right (180 degree turn) for 10 meters and touched a marker. Finally they sprinted back to point B (180 degree turn), turned 90 degrees and sprinted to point A. Three trials were administered. The average of the best two trials were recorded. Measurements were taken manually by two independent assessors with a stop watch.

- *Vertical Jump:*

Lower limb explosive power was assessed using a vertical jump test (Australian Institute of Sport, 2013). Procedures were followed according to those provided in the Australian Institute of Sport. Reach height was recorded with the participant extending his arm parallel and vertically against the wall. The participant was instructed to perform a maximum vertical jump with arm swing. Jump height was recorded as the difference between maximum jump distance and reach height. Three jumps were performed and the average of best two trials were recorded.

- *Standing Long Jump:*

Lower limb strength in a horizontal direction was also assessed with a standing long jump (Eurofit test battery, Council of Europe, 1988). Procedures were followed according to those provided in the Eurofit test battery. Participant's jumped from a stationary position with feet next to each other and behind a marked line. Upon landing, participants were not permitted to fall forwards or backwards. Participants performed three jumps and the average of best two trials were recorded.

- *Training Program:*

Training took place, three times a week on non-consecutive days for six weeks. For RST, participants performed three sets of six 40 meter maximal shuttle sprints (720 meter per session, 25 minutes). Ten seconds of passive recovery between sprints and four minutes of active rest between sets were provided. Shuttles consisted of all out sprints with 180 degree directional change after 20 meters. RST training procedures were followed according those outlined in Ferrari Bravo et al. (2008). Concerning combined training, participants performed RST, CAT, AIT and explosive leg power training on a cyclical basis. In other words, participants performed RST on Monday, AIT on Wednesday and CAT training on Friday. The following week Monday they performed explosive leg strength training. This cycle was repeated on the Wednesday again. CAT training was performed at an intensity representative of 75% of VO2 peak for 25 minutes (Ciolac et al., 2011; Burgomaster et al., 2008). AIT was performed with four, four-minute intervals at 90% minutes of maximum heart rate (HR) with three minutes of passive recovery between sets (Ferarri Bravo et al., 2008). Training time was 25 minutes. HR was monitored with Polar HR monitors for CAT and AIT (Polar Electro Oy, Kempele, Finland). Explosive leg power training was also performed for 25 minutes and included countermovement jumps, calf and squat plyometric jumps, stair jumps (one-legged, two legged, frontal and sideways) and short sprints (5 meters). The jumps was performed on a sports stadium staircase (20 steps). All jumping exercises included three sets of 20 repetitions each (work to rest ratio (1:2)). Rest included walking back to the starting position. The 5-meter sprint test was repeated 10 times. A two-minute passive rest period was allocated between the nine exercises. The CON group performed no supervised training. After three weeks of training all training modalities increased in duration to 30 minutes (these included one more set for RST, AIT and explosive leg strength training). The intensity of CAT training increased to 80% of VO2 max, AIT to 95% of maximal heart rate. All training was supervised by an exercise physiologist, biokinetecist and soccer conditioning coach.

- *Statistical Analysis:*

All data were analysed with a commercially available statistical software program (Statistical Package for the Social Sciences, SPSS 20.0, SPSS Chicago, IL, USA). The distribution (normality and homogeneity) of the variables was assessed with Kolmogorov-Smirnov and Levene tests respectively. Data are expressed as mean and standard deviation (SD). To evaluate pre–post differences between groups, a repeated analysis of covariance (ANCOVA) with post-hoc Bonferroni test was performed (group x time interaction effects) adjusting for baseline values.

III. RESULTS

No serious or adverse events occurred during the baseline tests, training programs or post-intervention tests. Compliance during the six weeks of training was moderate to strong (82%). All participants performed more than 70% of all training sessions. There was no significant difference between the amount of training session attended for RST and COM. All participants completed baseline and post-intervention tests. General and anthropometric data are provided in Table I. There were no significant differences for baseline tests between groups for all physical fitness tests (except absolute VO2 max) (Table II). The VO2 max test was performed to maximal exertion for all participants. Mean and standard deviations for all physical tests are provided in Table II.

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As depicted in Table II, both the RST and COM training groups significantly improved distance ran on the YYIRT2 compared to CON after six weeks of training ($p<0.01$). Both groups also significantly improved the maximum velocity reached on the maximal aerobic test compared to CON ($p<0.01$). Only the RST group improved VO2 max ($p<0.05$). Within group (pre vs post), significant differences resulted for both groups regarding the 30 meter sprint and vertical jump tests.

Table 1 General and anthropometrical variables in the interval training, combined training and control group. Values are mean and standard deviation in parenthesis.

Variables	**RST(n=17)**		**COM(n=17)**		**CON(n=13)**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
General						
Age	22 (1.3)	22.1 (1.3)	21.1 (1.6)	21.2 (1.6)	22.2 (2.6)	22.2 (2.6)
Anthropometry						
Weight (kg)	70.0 (7.7)	68.9 (7.1)	58.7 (4.9)	58.8 (5.0)	68.4 (6.3)	68.7 (6.5)
Height (cm)	175.5 (7.7)	175.5 (7.6)	169.8 (5.5)	169.7 (5.6)	176 (6.7)	175.6 (6.3)
BMI (kg/m^2)	22.8 (2.1)	22.4 (1.8)	20.4 (1.4)	20.4 (1.1)	22.1 (1.5)	22.2 (1.5)

N: amount; IT: interval training; COM: combined training; CON: control; BMI: body mass index; *: Significant differences between baseline RST/COM and CON ($p<0.05$).

Table 2 Physical fitness associated variables in the interval training, combined training and control group. Values are mean and standard deviation in parenthesis.

Variables	**RST(n=17)**		**COM(n=17)**		**CON(n=13)**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Physical Fitness						
Peak VO2 (ml/min/kg)	51.5 (6.7)	53.6 (6.6) *	53.1 (5.2)	54.0 (6.7)	51.6 (5.7)	49.4 (4.7)
Abs. peak VO2 (ml/min)	3572.4 (369.2)	3676.0 (448.6)	3116.8 (376.3)	3164.1 (404.4)	3526.4 (482.2)	3385.3 (415.6)
VE (L/min)	133.6 (13.6)	134.6 (16.0)	133.6 (22.8)	130.7 (23.9)	132.8 (17.7)	131.9 (15.7)
RER	1.1 (0.06)	1.13 (0.06)	1.13 (0.06)	1.15 (0.07)	1.11 (0.06)	1.12 (0.07)
Peak velocity (km/h)	16.9 (1.5)	17.8 (1.3)*	16.9 (1.3)	17.4 (1.6)*	16.5 (1.1)	16.1 (1.3)
Peak HR (bpm)	190.0 (9.1)	189.7 (8.0)	189.0 (10.8)	187.9 (12.1)	190.8 (8.8)	192.0 (9.8)
Yo-yo (m)	435.3(174.9)	788.2 (199.9)*	399.4 (104.8)	741.8(242.8)*	415.4 (160.4)	507.7(196.2)
SLJ (cm)	216.3 (17.0)	224.4 (18.7)	209.5 (21.5)	213.1 (23.3)	215.1 (22.1)	219.4 (14.6)
VJ (cm)	53.2 (7.0)	57.3 (8.0)	48.3 (7.9)	51.8 (7.7)	53.1 (5.8)	54.2 (7.8)
Speed (s)	4.2 (0.2)	4.1 (0.2)	4.3 (0.2)	4.2 (0.2)	4.2 (0.2)	4.2 (0.3)
Agility (s)	9.3 (0.5)	9.1 (0.4)	9.6 (0.3)	9.3 (0.3)	9.3 (0.4)	9.4 (0.6)

Abs: absolute; N: amount; COM: combined training; CON: control; HR: heart rate; IT: interval training; RER: respiratory exchange ratio; SLJ: standing long jump; VE: minute ventilation; VJ: vertical jump; VO2: volume of oxygen; *: Significant differences between RST/COM and CON ($p<0.05$).

Effect sizes according to the Cohen's D method are reported as no effect, trivial, small, medium and large in Table III for RST, COM and control. Large effect sizes (Cohen's D > 0.80) are r.

Table 3 Effect sizes of physical fitness variables in repeat sprint training, combined training and control. Eported for both training groups regarding YYIRT2.

Variables	**RST(n=17)**		**COM(n=17)**		**CON(n=13)**	
	ES	**Magnitude**	**ES**	**Magnitude**	**ES**	**Magnitude**
Physical Fitness						
Peak VO2 (L/min)	0.33	Small	0.14	Trivial	N/A	None
Peak velocity (km/h)	0.63	Medium	0.39	Small	N/A	None
Yo-yo (m)	1.94	Large	1.89	Large	0.51	Medium
SLJ (cm)	0.47	Small	0.16	Trivial	0.23	Small
VJ (cm)	0.56	Medium	0.46	Small	0.15	Trivial
Speed (s)	0.61	Medium	0.62	Medium	0.03	None
Agility (s)	0.43	Small	0.79	Medium	N/A	None

Exchange ratio; SLJ: standing long jump; VE: minute ventilation; VJ: vertical jump; VO2: volume of oxygen.

IV. DISCUSSION

The primary purpose of the current study was to explore the effects of a RST intervention compared to COM training in sub-elite football players in South Africa. As far as we are aware, no studies have explored the effect of COM (RST, AIT, CAT and explosive leg power) versus RST training on the physical parameters of sub-elite football players. The results of the current study demonstrated the both training groups improved significantly on the YYIRT2 and maximal aerobic speed compared to CON but only the RST group improved significantly on VO_2 max.

➢ *Football Specific Yo-Yo Intermittent Recovery Test:*

The YYIRT2 highly taxes both the aerobic and anaerobic energy systems (Castagna et al., 2006). Significant improvements were reported for both intervention groups in the YYIRT2. It has been reported that RST and AIT improved performance on the YYIRT in professional football players (Ferrari-Bravo et al., 2008). However, the improvement was more significant in the RST group in this study. In the current study the COM training group performed RST, AIT, CAT and explosive leg power training that collectively demonstrated the same significant improvement compared to RST (+342m & +353m). It is possible that the differing training stimuli provided the same improvements in YYIRT2 distance but with different physiological adaptations. However, physiological adaptations such as stroke volume, mitochondrial size and number, number of capillaries, aerobic and anaerobic enzymes, muscle fiber type and distribution etc. were not measured. Even though explosive movements such as vertical jump and standing long jump and aerobic capacity (VO_2 max) were not significantly improved in the COM group (compared to CON), the different training strategies could have contributed in a trivial manner to the collective improvement of YYIRT2 distance. Irrespective of training the modality used (RST or COM), the improvement of YYIRT distance is significant as performance in this test is related to the amount of high intensity activity completed during a football match (Krustrup et al., 2003) and physical performance (Rampinini et al., 2007). A recent meta-analysis with RST as training modality also demonstrated significant improvements in high-intensity intermittent running (Taylor at al., 2015). However, a recent study employing combined RST and explosive leg strength training found no significant improvements in high intensity intermittent running (Campos-Vazquez et al., 2015). The RST was only performed once a week and training occurred during the final phase of the season when players were already competitively fit.

➢ *Aerobic Fitness:*

Even though both training groups demonstrated significant improvement in maximal aerobic speed compared to CON, aerobic capacity (VO_2 max) improved in the RST group (+4%) only. This is similar to a RST program in a study performed on elite/sub elite football players (Ferrari Bravo et al., 2008). On the other hand, another study conducted on elite junior football players did not result in an improved aerobic capacity (Hill-Haas et al., 2009). Hill-Haas et al. (2009) explained that the training intensity and time spent at higher exercise intensities are formidable factors for improving VO_2 max. The short duration intervals (<90 seconds) and consequent reduced amount of time at high exercise intensity (>90% of HR max) may have contributed to a lack of improvement in VO_2 max. Our study followed RST guidelines similar to those presented in Ferrari Bravo et al. (2008) and we reported similar improvements in VO_2 max (5% vs 4%). Ferrari Bravo et al. (2008) reported that a single set of RST resulted in average HR values of 93% of maximum with blood lactate values of 14 mmol/L and a blood pH of 7.19. The fact that the VO_2 max of COM training in the current study did not improve, could possibly be attributed to the CAT and explosive leg power training sessions. The addition of these training sessions resulted in less AIT and RST training. It has been demonstrated in the general population that interval training (AIT or RST) is superior to CAT training for improving VO_2 max (Ciolac et al., 2011; Hwang et al., 2011; Burgomaster et al., 2008; Rognmo et al, 2004). Due to the rest periods between intervals, participants can work at higher intensities allowing the stroke volume, mitochondrial capacity and CA^{2+} cycling to improve more with interval training compared to CAT (Tjonna et al., 2009; Daussin et al., 2008; Tjonna et al., 2008). Concerning leg strength training, a previous study conducted in the general population did not result in an improved aerobic capacity measured by VO_2 max (Campos et al., 2002).

However, a high VO2 max is essential in elite or sub-elite football but not necessarily the most important factor involved in physical football performance. Krustrup et al. (2005) demonstrated that YYIRT correlated with the distance covered during a football match and not VO2 max. Furthermore match analysis demonstrated that football requires players to repeatedly produce maximal sprints of short durations and brief recovery periods which closely resembles a RST protocol and not a continuous incremental laboratory test to exhaustion (Spencer et al., 2005; Bangsbo et al., 1991; Withers et al., 1982).

➢ *Speed, Explosive Power and Agility:*

No between groups improvements were reported for speed, agility and explosive power for both training groups. Other studies also reported no improvement in sprinting and explosive movements after interval training (AIT and RST) (Hill-Haas et al., 2009; Ferrari Bravo et al., 2008; Helgerud et al., 2001). In the current study RST and COM training did not have a negative impact on these variables as similarly reported in Hill- Haas et al. (2009) and Ferrari Bravo et al. (2008). However, within groups (pre-post) changes in the current study were observed for sprinting and vertical jump (RST and COM). A recent study reported that combined sprint and squat training resulted in a significantly improved sprinting performance in recreationally active young adults (Marques et al., 2015).

More sprinting exercise during the intervention period could possibly be responsible for this finding. Bucheit et al. (2014) demonstrated that horizontal force production capability is essential to improve sprinting performance over short distances.

Standing long jump was only improved within in the RST group. The repeated shuttle sprints with 180 degree directional changes and consequent repeated accelerations probably provided the stimuli for improved explosive power in a horizontal direction. It has been reported that intermittent shuttle running (with 180 degree changes) are physiologically taxing on the legs (Dellal et al., 2010). Most explosive power movements during the COM training was performed in the vertical position and may be the reason for a lack of improvement in the horizontal position.

None of the training groups of the current study improved their agility between or within groups. This was also demonstrated in elite female football players where combined agility and RST was performed (Shalfawi et al., 2013). We are not aware of any other studies that have assessed agility after an interval training intervention (Hill-Haas et al., 2009; Ferrari-Bravo et al., 2008; Sporis et al., 2008; Impellizzeri et al., 2006; Dupont et al., 2004; Helgerud et al., 2001). This information may be of value to conditioning coaches so that they can add specific agility-type exercises (with or without ball) to improve the agility of elite or sub-elite football players as reported by Milanovic et al. (2013) and Jullien et al. (2008).

❖ *Limitations:*

The limitations of the current study are that speed and agility tests could not be performed with a photocells system due to limited access and funds to equipment of this nature. However, measurements and procedures were followed closely as outlined in the Australian Institute of Sport (Australian Institute of Sport, 2013:202 & 237). The average of the two best measurements were taken to improve measurement precision. In our pilot study, test-retest intraclass correlation coefficients (ICC) values for the 30 meter sprint test and T-test were 0.83 and 0.85 respectively. Secondly, it was not possible to randomly allocate participants to any group as the coaches demanded teams to remain grouped. However, there was no significant difference between baseline values for the three groups regarding all physical fitness tests (relative VO2 peak, YYIRT2, speed, agility, explosive power). Lastly, the training strategies was matched for time and not necessarily isocaloric. It was too complex to match under these conditions, as caloric expenditure of the explosive leg power training was difficult to determine.

V. CONCLUSION

This is the first study that we are aware of that has assessed a RST intervention compared to combined training on various physiological parameters in sub-elite football players. The COM and RST groups significantly improved performance on the YYIRT2 which is related to the physical performance of elite football players. Both training programs in the current study did not negatively influence sprinting, agility or jumping movements. Maximal aerobic running speed also increased significantly in both training groups but the VO2 max only improved in the RST group. Conditioning coaches of sub-elite football players have the opportunity to use either RST or COM training during the preparation of their players in the pre-season.

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