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The effect of plyometric training versus resistance training on repeated sprinting ability (RSA)

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Abstract
The ultimate of this research was to compare the effect of different training interventions on RSA performance (repeated sprinting ability in 7X35 meter). As antecedents of RSA; fatigue index (FI), explosive power and 40 meter sprinting speed were assessed after the different intervention training in three different groups. And the improvement achieved was evaluated. For this, three different groups (“resistance group”, “plyometric group” and “combined group”) were given different training intervention as an experimental design. The “resistance group” was given resistance training plus RSE, the “plyometric group” was given plyometric training plus RSE and the “combined group” was given resistance training combined with plyometric training plus RSE. This way, each group received their specific training 2 days per week The RSE, which is similar for all groups, was given 2 days per week for about 4 weeks. The pretest was carried out in each fitness element and specifically the RSA prêt-test score has been used to assign the subjects in each group randomly after they have given ranks (3 ranks/levels based on the pre-test RSA score). Each subject from each rank has been randomly allocated in each treatment group. On the basis of the pre-test and post-test value for each fitness element paired sample t-test was conducted with the critical value $P<0.05$. In addition, with an intention of comparing the means of the three groups post-test 40 meter sprinting speed and RSA score, one-way ANOVA has been carried out. Even though only the “plyometric group” and the “combined” achieved significant improvement in RSA test score, the variance between the groups was found to be non-significant. The three groups achieved a statistically significant improvement in the 40 meter sprinting speed, though the variance was found to be non-significant. As a main factor for RSA performance, aerobic fitness (VO_2 max) or exercises/training intervention need to be included during RSA workouts. Unless we improve our aerobic fitness, our anaerobic fitness could not be too effective or functional to have a better RSA performance score. Furthermore, the length of the intervention during athletic training for performance or research purpose need to be more than 4 weeks for a visible or potent effect to be seen.

Keywords: Repeated sprinting ability, performance, multi-sprint, plyometric, and resistance training

1. Introduction

Physical fitness leads to better athletic performance (Buchheit *et al* 2009) [5], and persistent training will usually develop physical fitness (Buchheit 2010a and 2010b) [6, 7]. In addition to sport-specific technical and tactical skills, strength, explosive power, speed (Mikulic 2010) [24], cardiorespiratory fitness and repeated sprint ability (RSA) (David Bishop & Olivvier Girard 2013) [13,] have been shown to be important factors determining success in many team sports. Consequently, the optimal design and implementation of training strategies that enhance these specific athletic qualities in talented young players is of significant interest to team sport coaches and players (Markovic S, 2013) [25]. Improvement in athletic qualities such as peak sprinting speed or maximal aerobic speed is generally thought to be training specific, with specially designed speed and explosive strength training programs shown to improve peak running speed and jumping height, and high-intensity running exercises reported to develop both aerobic maximal power and endurance capacity in team sport players. However, the most effective strategy to enhance RSA is less evident.

Those common team sports as handball, basketball and soccer are among the sports which place an intensive physical demand on the players. For example, the sport of handball requires players to possess various fitness components (e.g. jumping ability, speed, endurance) to reach the highest levels *(*Marques and Gonzalez-Badillo, 2006; Ronglan *et al*., 2006; Buchheit *et al*., 2009; Ingebrigtsen and Jeffreys, 2012) [23, 35, 5, 22]. Soccer, one of the most widely played sports in the world, is a sport characterized by short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling. Generally, soccer is a complex sport, and performance depends on a number of factors, such as physical fitness, psychological factors, player technique, and team tactics. During a 90-min soccer match an elite player covers on the average distance between 10 and 12 km per game with 40-60 sprints over varying distance. (Arni Arnason *et al*, 2004) [1]. Generally, many team sports require participants to repeatedly produce maximal or near maximal sprints of short duration (1-8 s), David Bishop *et al*, 2011 [12] and Gliaster M. 2008 [17], with brief recovery periods, over an extended period of time (30-120 min). Therefore, an important fitness component of these sports is what has been termed repeated sprint ability (RSA). Players with good RSA would be likely to perform better than athletes who are less able to repeat sprint efforts at a similar intensity (David John Bishop: 2012) [11]. Given the importance of RSA for team sport players, it would appear important to develop a training strategy or type of exercises which best improves this invaluable biomotor quality for multi-sprint team sports (Z. Gharbi *et al* 2015) [43]. The subjects or participants of the study were second year sport science students, who were taking those multi-sprint team sports as basketball, handball and soccer. Thus it was found highly helpful to assess their level and having an intervention to enable them having or developing this important performance related fitness. However, the ultimate or the focus of the research was to identify an effective training strategy or exercise type to develop repeated sprinting ability. Even though a lot of researches has been done and indicate the role of repeated spring ability in team sports, the best or the most effective training strategy is remain less vivid. Repeated-sprint ability (RSA) is one area that has received relatively little research attention until recent times. (Spencer M., Bishop, *et al*, 2005) [38]. Even the studies which have been done on the issue were unable to clearly indicate the methods which can be effective in developing this desirable fitness component. The potential impact of speed-versus-endurance-oriented training programs on RSA in team sport players is unclear. In addition, it is uncertain whether “dissociated” training (emphasis on separate fitness qualities individually) will have a greater impact on RSA than “compound” training (emphasis on both neuromuscular and metabolic fitness qualities simultaneously) (Martin Buchhei, *et al*, 2010) [26].

The training strategies targeting the development of maximal sprint velocity, metabolic function, or both simultaneously, may account for an improvement in RSA (Martin Buchheit *et al*, 2010) [26]. No study has been carried out comparing the effect of RSE plus resistance training with plyometric training plus RSE on RSA or the combined effect of resistance training and plyometric training together with RSE. Thus it would show the effect of weight training on RSA or plyometric training or the combined effect of these training strategies on RSA. Thus, the main objective of the study was to evaluation of the effect of plyometric training and resistance training on RSA test scores. It was hypothesized that:

(i) The plyometric group will achieve a better RSA performance than the resistance group.
(ii) The combined group will show a greater RSA performance than both the resistance and the plyometric group.
(iii) Each group will have a significant greater post RSA test score than the pre-test RSA test score.

2. Method

True experimental design has been used for this research. Static-group comparison design with pre-test- post-test approach in three different treatment groups was the methodology employed in this study. Comparison of the effect of each treatment has been done against some selected parameters as strength gain, power gain, speed and RSA performance improvements.

2.1 Participants

Fifteen male second year under graduate students (age, 19 $\pm$ 3year; weight, 58$\pm$ 3.58kg;) from Bahir Dar University Sport Academy were the subject of the study. All of the participants were informed to have only the intervention exercise in their respective group. Starting from the pretest week to the post-test week, the subjects were not having any kind of exercise except their respective group intervention. They were informed about the purpose of the research and the effect of the intervention and a written consent has been obtained.

2.2 Experimental procedure

Three different groups for different training intervention were used. Each of the three groups was receiving different treatment (i.e., resistance training for “the resistance group, plyomteric exercise for “the plyometric group and resistance training plus plyometric training for the “combined group”. In addition to that of their respective treatment the three groups were receiving the same kind of training that is RSE two days per week for about four weeks. Thus each group was having four training sessions per week for about four weeks.

Table 1: the training schedule

	Week 1	Week 2	Week 3	Week 4
Monday	RSE	RSE	RSE	RSE
Tuesday	Rest	Rest	Rest	Rest
Wednesday	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG.	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG
Thursday	Rest	Rest	Rest	Rest
Friday	RSE	RSE	RSE	RSE
Saturday	Rest	Rest	Rest	Rest
Sunday	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG.	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG	1. Resistance training for RG. 2. Plyometric training for PG. 3. Combined training for CG

Key: RSE=repeated sprinting exercise, RG=resistance group, PG=plyometric group, and CG=combined group.

2.3 The tests
A number of tests for RSA and its antecedents have been taken a week before the intervention starts. On the basis of the test result (i.e. the pre-test result of RSA test score), the students were categorized as level I, level II, and level III. Then the subject from each category or status has been randomly assigned to the three intervention groups.

2.4 Strength and Power test
Vertical jump test for leg explosive power was used. The measurement of leg explosive power was conducted with three trials of vertical jump tests and then the average score has been taken.

2.5 Sprinting speed test
So as to measure single sprinting speed, 40 meter sprint test has been used. For this, three trails were given for all subjects and the best time was used as a score.

2.6 RSA test
If the focus is on a "pure" assessment of RSA, perhaps before or after a training program it is suggested that a single set tests of the type trailed by a Spencer *et al* would be preferred. This way, in this study, 35m with 7 repetition and 25 seconds of active recovery between each sprint was the test protocol of RSA.
The RSA test consisted of 7X35m sprint interspersed with 25 seconds active recovery period was used as a method. Each sprint run was performed without change of direction. This distance or exercise mode was chosen as time-motion analysis indicated that 35m run as upper-range distance covered at a high intensity during a game by team sport players (multi-sprint games) (Brian Dawson, 2012) [4]. The other thing that has been done during the pre and post RSA test was that the participants were verbally encouraged during the sprint so as to get their maximum speed.
All the tests has been done a week before the intervention (pre-test) and in the first week after the intervention (post-test). The same test and exactly the same testing protocol (i.e. the same type of warming up, testing ground and time of the day) were employed.
All the trainings and tests conducted throughout the study were having a ten minute general warming up and five minute specific warming up. Though the principle of individuality was not considered, it was strictly adhered to the principle of specificity and progression.
As performance parameter in RSA, power and fatigue index were calculated using Fitzsimon, 1993, *et al* [16] formula.

$$\text{Fatigue index (FI)} = \frac{\text{(Total time-1) X 100}}{\text{(Best time X number of sprints)}}$$

2.7 Method of data analysis
Statistical analysis has been done. Those statistical measures as mean, standard deviation, paired difference have been carried out. With an intention of comparing (quantifying) the effect of each intervention or training strategy, paired sample t-test has been used. Furthermore, one way ANOVA was employed so as to see the difference (the significance of the variance) performance improvement between groups (the critical value for all the statistical analysis was set to be $p<0.05$. For this statistical computation IBM SPSS statistics20 has been used.

3. Result and discussion
3.1 Explosive power

Table 2: explosive power of all the intervention groups with its paired sample t-test

Group	Mean	N	Sd	Std er	Sig	T
Ex.pow, RG.pre	40.2040	5	5.12370	2.29139	0.276	-1.259
Ex.pow, RG.post	41.0000	5	4.58258	2.04939		
Ex.pow, Plyo.pre	41.1380	5	5.86100	2.62112	0.007	-5.023
Ex.pow, Plyo.post	46.6000	5	4.06817	1.81934		
Ex.pow, Comb.pre	41.7700	5	2.76747	1.23765	0.002	-7.663
Ex.pow, Comb.post	45.6000	5	2.27486	1.01735		

"The resistance group" has showed no significant (p=0.276) improvement in explosive power test. While the "plyometric group" (p=0.007) and "combined group" (p=0.002) has shown such a statistically significant improvement in explosive power test. The nature of resistance training is not suited to improve force production in an explosive manner, though strength and force generation improvement is well guaranteed with. It has been found that plyometric exercises can yield greater improvement in explosive power with the lower extremities of the body. Even the combination of plyometric exercise with resistance training resulted noticeable improvement (3.83 meter) in vertical jump test of lower body parts explosive power. Yannis Michailidis, 2015 [41], indicated that plyometric exercises can improve jumping (power) performance.

3.2 Sprinting speed

Table 3: 40 meter sprinting speed of the three groups and paired sample t-test result

Group	Mean	N	Sd	Std er	Sig	T
Sprinting, RG.pre	6.2000	5	.30125	.13472	0.003	6.637
Sprinting, RG.post	5.2220	5	.11054	.04944		
Sprinting, Plyo.pre	6.2040	5	.28431	.12715	0.001	7.742
Sprinting, Plyo.post	5.0840	5	.07701	.03444		
Sprinting, Comb.pre	6.1580	5	.10330	.04620	0.000	39.597
Sprinting,Comb.post	5.1300	5	.07000	.03130		

With different kinds of intervention in the 3 groups, such a significant (p=0.003, 0.001 and 0.000 for the resistance group, plyometric group and combined group respectively) improvement in 40 meter sprinting speed has been achieved. The treatment that was the same for the three groups was the inclusion of 2 sessions of RSE per week in a progressive manner for about 4 weeks. Thus, regardless of what is added for each group, this training (RSE) alone can have its positive effect on the improvement achieved. Short-sprint efforts over 4 to 12 weeks can improve single-set RSA performance (Brain Dawson 2012) [4]. Still this can be aided by strength or power training from each specific intervention. For example, hypertrophy (strength development) and general power exercises can enhance sports performance (Warren B. Young, 2006) [40]. Thus, the ability to generate force and the speed at which we produce it (power) is believed to be an important factor in speed performances and so in 40 meter sprinting speed (Warren B. Young, 2006) [40].

The greatest improvement is achieved with that of the combined group (1.028 second decrement). Here with this group, the intervention involves resistance training (hypertrophy), plyometric exercise (power development) and RSE (sprinting ability improvement). Thus, this is just due to the cumulative effect of all the exercises and/or the development of different qualities. Considerable research has indicated significant correlation between sprinting performance over various distances and range of measures of strength and power (Harris *et al*, 2007 & 2008 & Markovic 2010) [18, 19, 24]. This might suggest that improvement in strength and power (Carlos B Fernandez *et al* 2014) [37] may lead to improvement in sprint performance. Harris *et al* mentioned that it was possible to get a statistically significant gain in 40 meter sprinting speed after 8 weeks of squat training. In addition, (Sleivert G. and Taingahue M. 2004) [36], found such a significant performance improvement in 10 meter sprinting due to 8 weeks of plyometric training. Furthermore the cumulative effect of such kinds of exercises in combination demonstrates well when a 9 week training that incorporates sprinting and plyometric program improved sprint performance in 10 meter more than sprinting alone (Warren B. Young 2006) [40]. Thus, the bottom line is that the combination of resistance training, plyometric training (S. Lopez *et al*, 2014) [37] and RSE can potentially result more improvement in 40 meter sprinting performance than any of these alone.

3.3 Repeated sprinting ability (RSA)

Table 4: RSA of the three groups and paired sample t-test result

Group	Mean	N	Sd	Std er	Sig	T
RSA,RG.pre	5.9160	5	.41729	.18662	0.462	.858
RSA,RG.post	5.3700	5	.18762	.08390		
RSA,Plyo.pre	5.8880	5	.43712	.19548	0.045	2.873
RSA,Plyo.post	5.3660	5	.58718	.26259		
RSA, Comb.pre	5.8040	5	.36136	.16160	0.017	3.954
RSA, Comb.post	5.2960	5	.14758	.06600		

As table 4 depicts, “the resistance group” do not achieved a significant (p=0.46) improvement in repeated sprinting ability (7 X 35 meters RSA tests). Thus resistance training do not result significant improvement in RSA test. For this there may be physiological reasons. One may be the physiological adaptations associated with resistance training can potentially produce either positive or negative transfer to sports performance. Negative transfer could occur if there is increased coactivation of antagonist muscles (Baker D. 2001) [3]. Generally if there is no coordination (technically called intermuscular coordination), no improvement in sprint performance (David Bishop *et al* 2011) [12]. Here with this group simple/general strength training may not elicit such muscular adaptation. That is why a combination of general and specific resistance training method are mainly recommended to develop all the neuromuscular factors contributing to sports where strength and power matters (Warren B. Young, 2006). [40]

The plyometric group achieved a significant (p=0.045) improvement in RSA test. It is well established that CMJ is a good predictor of RSA in multi-sprint team sport athletes or players or there is a strong inverse correlation between CMJ and RSA (r =-0.74) as concluded by (Nigel K, *et al*, 2008) [31] generally there is a relationship between RSA and vertical jump performance (Carlos B, et al 2014) [8]. For this reason coaches and strength and conditioning professionals should devote additional time for explosive strength development in athletes’ preparation to enhance RSA performance (Vissing K. *et al*, 2008) [39]. To sum up, plyometric exercises need to be part of the training regimen when we want to have RSA improvement.

The “combined group” achieved a statistically significant (p=0.017) improvement in RSA performance. The effect of the combination of strength or resistance training, plyometric training and RSE can develop varied biomotor qualities together and in harmony. There can be hypertrophy (strength gain), power development and speed in short distance (15-40 meter) and ultimately RSA. The all-out-effort during short distance sprints (from 15-40 meter) is anaerobic type of exercise, though there is aerobic metabolism during the recovery (30 second) between consecutive sprints. This implies that RSE exercises of this type can largely impact the anaerobic fitness of the trainees or subjects and thus it improves RSA. Because, “multiple anaerobic running exercise” as a specific anaerobic protocol is most important predictor of RSA performance (Z. Gharbi, 2015 and Mac Neely E. 2014) [43, 28]. Adding to, Z. Gharbi, showed that anaerobic running fitness could be a determinant factor of RSA performance.

The absence of significant (p=0.462) improvement in RSA with that of the resistance group could be due to the nature of the exercises done. It was not specific enough to directly impact speed or RSA performance. Beside this, 4 week strength training may not be enough to allow strength gain and to be transferred into other performance parameters as RSA. General strength might be beneficial for athletes because of the potential to enhance the force generating capabilities of muscle, increase total body mass, reduce the risk of sports injuries, and improve core stability. However, direct transfer to improve sports performance might be limited by such training. Although non-specific resistance training can induce neural adaptations and increase the power production of individual muscles, it appears that to maximize transfer to specific sports skills, training should be as specific as possible, especially with regard to movement pattern and contraction velocity (Warren B. Young, 2006 [40] and Natalia Verkhoshanky 2012) [30]. The physiological, mechanical and adaptational characteristics of training and human body can cause the difference in the level of performance achieved with the different intervention (treatment) groups. To sum up, sprint performance may be more related to power than strength (Warren B. Young, 2006) [40].

3.4 Fatigue index (FI) during RSA

Table 5: the calculated FI of the three groups and the paired sample t-test result

Group	Mean	N	Sd	Std er	Sig	T
FI, RG. pre	6.8480	5	2.51659	1.12545	0.003	6.264
FI, RG. post	2.5100	5	.99114	.44325		
FI, Plyo. pre	6.0420	5	2.63503	1.17842	0.099	2.138
FI, Plyo.post	3.3480	5	1.26411	.56533		
FI, Comb.pre	5.7000	5	2.81563	1.25919	0.666	0.465
FI, Cmb. post	5.0440	5	2.33825	1.04570		

The resistance group showed a statistically significant (p=0.003) improvement in fatigue index (4.338 units decrement). As a well known fact, fatigue is directly proportional with that of intensity or rate of work. Going in parallel with this physiological fact is that, this group achieved non-significant (p=0.462) improvement in RSA performance test (i.e., there was no significant change in the total work done or power output). Thus, a little efficiency in RSA can highly result a higher change or improvement in fatigue index. The logic for this assumption is that with a little work (power output) there will only be a small fatigue (metabolic or other physiological by products as hydrogen ion/H^+ accumulation). As performance (power output) in RSA increases, it can potentially result higher lactate production or fatigue. Therefore this group achieved a significantly lower post FI score than the pre FI score.

Fatigue index (FI) with both the "plyometric group" and "combined group" has been found to achieve non-significant (p=0.099 and 0.666 respectively) improvement. This could be due to increased sprinting speed or RSA performance. As the level of intensity or the rate of work increases, the onset of fatigue is much more likely to be pronounced. The other reason could be the aerobic fitness of the subjects. There is a positive association between aerobic fitness and the ability to resist fatigue during RSA exercises (Z. Gharbi *et al* 2015) [43]. In this study, there was no aerobic exercise with an intention of improving aerobic fitness in the intervention. From the 40 meter sprinting test and RSA test both of these groups showed a significant improvement, and this increment in speed or power output can potentially cause accumulation of metabolities. This is because that fatigue can be caused by the accumulation of lactic acid (H^+) within the muscle fiber because of high intensity exercise or higher level of power output (because of higher work rate) (Oliver Girard and his colleagues 2015) [32]. Sometimes the method by which fatigue (FI) is estimated or calculated could be not accurate enough. For example, a marathon runner with a low average sprint performance, but a very low fatigue index, would not be classified as having good repeated sprint ability (David Bishops *et al*, 2012) [11]. For this, David Bishop recommends that it is important to note that good RSA is better described by a high average sprint performance, with or without a low fatigue index.

Table 6: 40 meter sprinting speed one-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.049	2	.025	3.213	.076
Within Groups	.092	12	.008		
Total	.142	14			

The one-way analysis of variance showed as there is no a statistically significant (p=0.076) variance between the three groups. The fact is that the three groups were receiving a different training intervention for about the specified period of time. However, 4 week long training intervention may not result or exert its full effect on the trainees. In most instances, so as to see the exact effect of a specified training approach or exercise type, the training or the intervention time is recommended to be 8-12 or more weeks (Chelly M, *et al*, 2010 & Chelly *et al* 2014) [9, 10]. The implication is that only 4 week training was not enough to see the real and specific effects of each intervention and this could potentially contribute for the occurrence of a non-significant variance between the intervention groups.

Though each group was receiving different types of training, 2 days per week, all of the three groups were receiving the same training or exercise in the other 2 days per week. This common training or treatment for all of the groups was RSE in the same way for about 4 weeks of 2 sessions per week. These RSE can improve single set sprinting speed regardless of what is added. The bottom line is that the inclusion of RSE might be accounted for the variance to be non-significant or for the variance to be as small as it is.

Sprinting speed as a biomotor quality can be affected by diverse factors. The training that we do have, the way we train, the motivation or commitment that we have about and most of all, the genetic make that we are born with can potentially matter our speed. It is a well known fact that the muscle fiber type (fast twitch or slow twitch) that we have dominantly is the most important factor. Regardless of the muscle fiber that dominantly present, we can improve our sprinting speed with training, however, the maximum achievement that we can accomplish or reach on is determined by our genetic makeup. We can improve our speed, but we cannot be as speedy as Usian Bolt of Jamaica unless we are born with what Usian Bolt born with. And surprisingly, experts in the field account the contribution of heredity for speed to be approximately as high as 85-95%. Only 5-15% is accounted for training. Here we can logically not anecdotally conclude that, heredity is one major factor for the variance between the groups to be non-significant.

A. Result and discussion of the RSA one-way ANOVA result

Table 7: RSA one-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.020	2	.010	.075	.928
Within Groups	1.574	12	.131		
Total	1.594	14			

When we see the RSA paired sample t-test of each group, the resistance group do not achieved a statistically significant ($p=0.46$) improvement. But the remaining two groups (the "plyometric group" and the "combined group") achieved a statistically significant improvement in RSA test score. But when we see the variance in RSA improvement between groups is found to be non-significant ($p= 0.928$). As the intervention differs across these groups, it was expected to have different effects on the subjects and subsequently varying effect on RSA performance score, but the variance is not in parallel with this. For this a number of limiting factors can contribute.

Only four week intervention of training is commonly known to be enough only to see the minimum effect on performance (Edge J, et al, 2006) [14]. Even this time period may not be enough for transfer of fitness into other performance parameters. Beside this, it is clear that both the resistance and plyometric exercises were not specific enough to result immediate and direct transfer to that of RSA. Instead it was recommended to use more specific exercise with relevant velocity or force production/generation mechanisms. This could limit the specific or potent effect that each intervention (exercise type) could have upon RSA. Thus, this poor specificity and relevancy of the exercise can contribute for the variance to be non-significant.

When the paired sample t-test was done, all the groups showed a statistically significant improvement in 40 meter sprinting speed. In addition to this, there was no significant ($p=0.7$) variance between the three groups in terms of 40 meter sprinting speed. Even though 40 meter sprinting speed is not an exact predictor of RSA it could have still an impact on RSA. For this we can account the non-significant variance in 40 meter sprinting speed to be one factor for the variance to be non-significant between the groups.

Aerobic fitness or more technically VO_2 max is highly correlated with RSA performance. And even experts in the field recommend aerobic training to be part of the RSA improvement training regimen (Aziz A. *et al*, 2007) [2]. But still each sprint during RSA test mainly relies on anaerobic energy pathway and anaerobic fitness is key in RSA performance (Edge J, *et al*, 2006) [14]. The one who is good in aerobic fitness can better recover during the given 30 second recovery period and this enable him to perform better in the subsequent sprints because of the fast ATP replenishment and lactate removal (Zagatto A, *et al* 2011) [42]. Here it is to mean that, if there was aerobic fitness training, the effect of each intervention will potentially be revealed and the variance could be clearly seen. This (the absence of aerobic training) could be one major factor for the variance between groups to be non-significant.

4. Conclusion

The fitness elements against which the groups (training interventions) compared were fatigue index (FI), explosive power, 40 meter sprinting speed and RSA. With the help of paired sample t-test, the effect of each training intervention (in each group) has been evaluated by comparing the pre-test score with the post-test score against each fitness component (FI, explosive power, 40 meter sprinting speed and RSA).

The combination of resistance training with plyometric exercise can yield a better result over a short period of time (4 weeks). Plyometric exercises can develop explosive power more than the resistance training or combination of plyometric exercise and resistance training. In this regard the resistance group does not achieve a statistically significant improvement in the explosive power test score. Therefore, still the combined approach of resistance training with plyometric training is better in developing explosive power than the resistance training alone.

All the training interventions groups showed a statistically significant improvement in the 40 meter sprinting speed test. However, the combined approach (resistance training with plyometric training plus RSE) can improve more than resistance training or plyometric training alone can do. The "combined group" achieved more improvement in 40 meter sprinting speed than the "resistance group" or the "plyometric group". Still plyometric training and resistance can improve 40 meter sprinting speed.

A training program which combines resistance training with plyometric training can better improve RSA than the other interventions. Still plyometric training can improve RSA performance

The variance between the three groups in 40m sprinting speed and RSA performance in the post-test score is statistically non-significant. The length of the intervention time, the relevancy of the exercises and the tests could potentially limit the effect of each intervention training up on RSA. And this can make the variance to be non-significant. Aerobic fitness as important factor in RSA performance may help the effect of relevant exercises/training intervention to be pronounced on RSA. Therefore exclusion aerobic fitness exercise has contributed for the variance in RSA to be non-significant.

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