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The effects of plyometric and resistance training on linear sprinting speed and repeated sprinting ability of youth players in Ethiopia

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ABSTRACT

The study investigated the effects of resistance training, plyometric training, and resistance and plyometric training combined on linear-speed and repeated sprinting ability (RSA) of youth soccer players. The authors used a randomized block design, randomly assigning thirty-six male soccer players (aged 18 ± 1.212 years, with a body weight of 57 ± 3.580 kg) to one of three groups: plyometric exercise, combined plyometric and resistance exercise, and resistance exercise. The authors analyzed each group's performance gains by comparing the pretest and post-test performance scores using paired sample t-test. All three training groups achieved significant performance gains in linear speed and repeated sprinting ability (RSA) ($p<0.05$). The plyometric and combined groups achieved higher linear-speed performance than the resistance training group ($p<0.05$). However, there was no significant difference among the three groups in repeated-sprinting-ability scores ($p>0.05$). In conclusion, plyometric and combined exercises are important training methods to impact speed for soccer players. Thus, when the focus is on soccer-specific linear speed and repeated sprinting ability, coaches and their training programs should emphasize methods that incorporate appropriate plyometrics and resistance training. This fitness-oriented training has to be considered in line with the technical and tactical trainings as they are helpful to get the most from the players' technical-tactical qualities.

KEYWORDS

Resistance Training; Plyometric Training; Youth Soccer Player; Ethiopia

1. INTRODUCTION

Success in soccer, which can be expressed with higher winning rate and ability of championship with trophy, is the ultimate goal of today's soccer (Bradley et al., 2013). Accounting to their work (method) of training, coaches with the higher winning rate or number of trophies are highly sought by clubs or national teams with huge money deals. Soccer is a highly commercialized sport, which attracts big business enterprises (i.e., Medias and companies) because of the expected money gain, which is guaranteed for winning teams and clubs. All these, however, rely on the players' level of performance. Thus, the resulting business gain or loss is highly dependent on the players' level of performance (Bangsbo et al., 2006). Still performance in contemporary soccer is the result of varied factors or performance parameters.

The psychological make-up (i.e., level of motivation, aggression, confidence, perseverance, winning mentality, etc.), physical fitness (aerobic and anaerobic fitness) and technical-tactical ability are ingredients which enable a player to be capable of playing soccer with its demand and modern essence (Alghannam, 2013; Bradley et al., 2013; Durate et al., 2012). It is well-established that an optimal level with the required balance among the factors (performance parameters) is too important. For example, though aerobic fitness is necessary to a certain level, anaerobic fitness is the most important and highly sought physical fitness (Barnes et al, 2014). Basically the most frequent anaerobic actions including sprinting, acceleration, jumping, charging and change of direction accounts only smaller portion of the players activity profile (Barnes et al., 2014; Girard et al., 2011). However, the most decisive phases or moments of goal scoring or defending highly rely on anaerobic fitness qualities of the players (Faude et al., 2012). To this end, the concern of developing and maintaining anaerobic fitness is the ultimate of coaches and strength and conditioning specialists.

Soccer specific anaerobic fitness including linear speed and repeated sprinting ability (RSA) are fitness segments (Gabbett, 2016; Haugen et al., 2014: Nedelec et al., 2015; Schimpchen et al., 2015), which can be determined by different factors like genetic make-up (endowed muscle fiber type), maturity (Aughey et al., 2016), and training (Bompa & Haff, 2009). In some way linear speed and RSA are associated to overall weekly training load. On the other way, the development of soccer related speed is connected with soccer specific exercises in the form of small-sided games (SSG) (Eniseler et al., 2017). Other findings reported the most effective method to develop linear speed and RSA is simply by having repeated sprinting exercises (Cipryan et al., 2017: Taylor et al., 2015).

Strength and conditioning experts recommend there to be resistance training to cultivate speed and related fitness qualities for soccer (Ullrich et al., 2018). Some other recent findings recommend plyometric exercise for a better adaptive response in terms of speed development (Hammami et al., 2016). It is also a common recommendation and approach to have plyometric exercises in the microcycles of the competition period so as to maintain speed and speed related fitness in soccer (Ramirez-Campillo et al., 2015).

However, regardless of all these, the effect that resistance training and plyometric training had on speed and RSA is not compared and studied. Moreover, the effect that a combined training (resistance exercise plus plyometric exercise in each session) had on linear speed and RSA is not clearly known. Thus, a study that compares resistance training, plyometric training and combined training is worthy of investigation. Therefore, this study was done to examine the effect that resistance training and plyometric training had on speed or RSA when they are used alone (isolated). In addition, the study aims at revealing how a combined training regimen of resistance exercise plus plyometric affects speed and RSA. To this end, different training intervention as resistance training, plyometric training and combined training has been compared against speed and RSA performance improvement. As such it was hypothesized that all these training methods can significantly improve linear speed and RSA without significant differences among.

2. METHODS

2.1. Study design and participants

An experimental design was used for this research. A randomized block design with three treatment groups named as resistance group (RG), plyometric group (PG) and combined group (CG) with a different treatment or training regimen as outlined in the procedure section were used.

Thirty six male soccer players` 18±1.212 years of age and 57±3.580kg of body weight voluntarily participated in the study. These players are Bahir Dar University`s U20 team members. The researcher selected these study participants purposely because of convenience, familiarity and they are the one at the age level to have the predisposition for sport specific physical fitness development. All the participants were informed to have only their team based normal soccer training and the study intervention exercise in their respective group which were both guided by the coach. The soccer specific training was the same for all the groups as the players were from the same team.

First, players were grouped based on their main playing position then randomly assigned into the treatment groups. The players in the common playing positions such as center backs, fullbacks, holding midfielders, outside midfielders, attacking midfielders and strikers were randomly assigned to the three intervention groups. Thus, the randomization was after grouping of the players as different position players are expected to have a certain fitness qualities which they are believed to be better than other position players. All the players were informed about the purpose of the study and they were volunteer to participate. Comparison of the effect and effect magnitude of each training regimen on performance gains of some selected physical fitness parameters as linear speed over 40m and RSA total time has been done.

2.2. Experimental Procedure

Since the ultimate of the study is to compare different exercise/training regimens to improve linear speed and RSA, three different groups for different training intervention were used. In each treatment group 12 players from each playing position assigned randomly with a simple lottery method. The first group was having resistance training for about four weeks. For this, the group was designated as resistance group (RG). The second group, the plyometric group (PG), was having plyometric trainings for about four weeks in addition to the common soccer specific training. The third group, named the combined group (CG), received both resistance and plyometric training combined in each of the intervention sessions. Thus, each group was having their intervention specific training sessions 3 times a week and the same soccer specific training together 3 times a week.

A week before the intervention, each group was assessed in terms of their linear speed and RSA performance the same way they were tested in the post-test. Based on their pretest result, it was confirmed that there was no any significant difference among the groups in terms of their linear speed and RSA total time performance score. A summary of the intervention training and the training program or protocol employed is outlined here under (Table 1 & 2).

Table 1. The intervention training regimen and exercise prescriptions

Week	Resistance Group (RG)			Plyometric Group (PG)			Combined Group (CG)		
	Exercise	Repetition	Set	Exercise	Repetition	Set	Exercise	Repetition	Set
Week 1	Leg extension	7	3	Jump to box	7	3	Jump t	7	3
	Squat rock	4	3	Tuck jumps	4	3	leg extension	4	3
	Lunge	6	3	Bounding with rings	6	3	Tuck jumps	6	3
	Seated calf raise	6	3	Lateral hurdle jump	6	3	Squat rock	6	3
	Calf raise	8	3	Single leg lateral hops	8	3	Single leg lateral hops	8	3
Week 2	Leg extension	6	3	Jump to box	6	3	Jump to box	6	3
	Squat rock	6	3	Tuck jumps	6	3	Leg extension	6	3
	Lunge	8	4	Bounding with rings	8	4	Bounding with rings	8	4
	Seated calf raise	8	4	Lateral hurdle jump	8	4	Lunge	8	4
	Calf raise	8	4	Single leg lateral hops	8	4	Depth jumps	8	4
Week 3	Leg extension	10	3	Tuck jumps	10	3	Jump to box	10	3
	Squat rock	10	4	Bounding with rings	10	4	Squat rock	10	4
	Lunge	10-12	4	Lateral hurdle jump	10-12	4	Bounding with rings	10-12	4
	Seated calf raise	10-12	4	Single leg lateral hops	10-12	4	Lunge	10-12	4
	Calf raise	10-12	4	Depth jumps	10-12	4	Depth jumps	10-12	4
Week 4	Leg extension	10-12	4	Tuck jumps	10-12	4	Jump to box	10-12	4
	Squat rock	10-12	4	Bounding with rings	10-12	4	Squat rock	10-12	4
	Lunge	10-12	4	Lateral hurdle jump	10-12	4	Single leg lateral hops	10-12	4
	Seated calf raise	10-12	4	Single leg lateral hops	10-12	4	Lunge	10-12	4
	Calf raise	10-12	4	Depth jump	10-12	4	Depth jumps	10-12	4

Table 2. The four weeks training program

Day	Week 1	Week 2	Week 3	Week 4
Monday	Normal soccer training	Normal soccer training	Normal soccer training	Normal soccer training
Tuesday	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG
Wednesday	Normal soccer training	Normal soccer training	Normal soccer training	Normal soccer training
Thursday	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG
Friday	Normal soccer training	Normal soccer training	Normal soccer training	Normal soccer training
Saturday	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG	❖ Resistance training for the RG ❖ Plyometric training for the PG ❖ Combined training for the CG
Sunday	Rest	Rest	Rest	Rest

2.3. Testing Methods

40m dash linear speed was used to test sprinting speed. To test40m dash linear sprinting speed, each participant was given three trials and the best time score was taken as a score for analysis. For RSA total time measure, the participants tested using the 6*35 test protocol. This test involves sprinting over 35m for about 6 times with 30 seconds recovery time between each sprint. The time in second for each of the 6 sprint was summed up to get the RSA total time score.

2.4. Statistical Analyses

Using the Statistical Package for Social Science (SPSS) version 23, paired sample t-test and one way MANOVA with a post hoc test was used. After identifying the presence of significance in differences, Cohen`s d and partial eta-squared (ηp2) are computed to estimate the effect size of the intervention. For the overall analysis, the p value was set to .05.

3. RESULTS

Table 3 presents the descriptive statistics of pre- and post-test score of speed and RSA (in seconds).

Table 3. Descriptive statistics of pre and post test score of speed and RSA (in seconds)

	RSA total Pre			RSA Total Post			40m speed Pre			40m speed Post		
	RG	PG	CG	RG	PG	CG	RG	PG	CG	RG	PG	CG
Mean	41.015	41.372	40.798	39.148	38.154	37.095	6.155	6.179	6.133	5.275	5.093	5.122
SD	2.548	2.609	2.147	2.730	3.102	1.509	0.247	0.228	0.123	0.137	0.073	0.072
Minimum	38.190	36.700	36.950	36.050	34.420	34.270	5.800	5.920	5.920	5.100	5.000	5.020
Maximum	44.620	44.460	43.630	44.080	44.710	40.240	6.680	6.680	6.330	5.590	5.240	5.230

The descriptive statistics shows the performance score of the RSA (6*35m) total time that each intervention group scored. The resistance group (RG) had a mean value of 41.015 seconds to the test, while the plyometric group (PG) had a mean score of 41.372 in the pretest (table 3). The mean pretest score of the combined group (CG) is 40.798 seconds. Despite the different figures, there was no a significant difference among the three groups in their pretest performance score (appendix A). The post test score however was 39.148, 38.154 and 37.095 seconds for the RG, PG and CG respectively.

In terms of linear sprinting speed over 40m, 6.155, 6.179 and 6.133 seconds were taken by the RG, PG and CG each to cover the distance during the pretest (table 3). With this score, there was no significant difference among the groups (appendix A), which can be accounted to the methodological approach of employing block randomization. However, the post test score for the RG, PG and CG was 5.275, 5.093 and 5.122 seconds respectively (Table 4).

Table 4. Paired sample t-test comparing the pretest score with the post test for each group

Treatment Group			t	df	*p*	Mean Difference	Cohen`s d
RG	RSA pre	RSA post	2.509	11	0.029	1.867	0.724
	40m speed	40m speed	10.309	11	< .001	0.880	2.976
PG	RSA pre	RSA post	6.298	11	< .001	3.217	1.818
	40m speed	40m speed	16.204	11	< .001	1.087	4.678
CG	RSA pre	RSA post	9.710	11	< .001	0.381	2.803
	40m speed	40m speed	25.586	11	< .001	0.040	7.386

The RG achieved a statistically significant performance increment in 40m dash linear speed, t (11) = 10.309, p<.001, ES = 2.976 and in 6*35m RSA performance t (11) = 2.509, p=.029, ES = 0.724 after the intervention training. The PG also achieved a significant linear speed performance gain after the training, t (11) = 16.204, p<.001, ES = 4.678. The same way, the PG has a significant RSA performance gain as the pre-post difference is significant, t (11) = 6.298, p<.001, ES = 1.818. The CG achieved a significant performance increment in both linear speed, t (11) = 25.586, p<.001, ES = 7.386 and RSA, t (11) = 9.710, p<.001, ES = 2.803 (table 4). In terms of mean difference, the PG achieved the greatest linear speed gain (mean difference is 1.88). In this case the RG and CG has a mean difference of 0.880 and 1.87 respectively. With that of RSA the PG still had the greatest gain with a mean difference of 3.217 seconds, when the RG and CG had 1.867 and 0.381 seconds each (Table 5).

Table 5. ANOVA result of the three training methods (groups) based on their posttest performance score

Performance Measures		Sum of Squares	df	Mean Square	F	*p*	ηp2
RSA Total Post	Between Groups	25.306	2	12.653	1.961	.157	
	Within Groups	212.889	33	6.451			
	Total	238.195	35				
Linear Speed 40m Post	Between Groups	.231	2	.115	11.758	.000	0.416
	Within Groups	.324	33	.010			
	Total	.554	35				

RSA total time measure or performance gain difference is not statistically significant among the three groups of the RG, PG and CG, though each grouped has showed significant performance improvement after their respective training. But, linear speed performance gain level was significantly different among the three groups F (2, 33) = 11.758, p>.001, ηp2 = 0.416 (Table 6).

After testing the difference in performance gain among the three training methods, post hoc test (Benferroni) was used to have multiple comparisons. This way, each group was compared one another pair wise. The mean time taken by the PG to cover the 40m dash is visibly smaller.

Table 6. Post hoc result (multiple comparison) of 40 linear speed post score

(I) Treatment group	(J) Treatment group	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
RG	PG	.18250*	.04043	.000	.0805	.2845
	CG	.15333*	.04043	.002	.0514	.2553
PG	RG	-.18250*	.04043	.000	-.2845	-.0805
	CG	-.02917	.04043	1.000	-.1311	.0728
CG	RG	-.15333*	.04043	.002	-.2553	-.0514
	PG	.02917	.04043	1.000	-.0728	.1311

With the post hoc result, it is found that the RG linear speed performance gain is significantly lower than both the PG ($p<.001$) and the CG ($p=.002$). However, there is no a significant difference in 40m linear sprinting speed performance gain between the PG and CG. Thus, the plyometric training group and the combined training group are superior in linear speed gains than the resistance training group.

Table 7. The pretest ANOVA to indicate that there was no difference in the dependent variable before the treatment

Performance Measures		Sum of Squares	df	Mean Square	F	*p*
Linear Speed 40m Pre	Between Groups	.013	2	.006	.148	.863
	Within Groups	1.409	33	.043		
	Total	1.422	35			
RSA total Pre	Between Groups	2.011	2	1.006	.168	.846
	Within Groups	197.006	33	5.970		
	Total	199.017	35			

4. DISCUSSION

The ultimate of the study was identifying the kind of training regimen that can help to get the most out of training based on 40m linear sprinting speed and 6*35m RSA performance test score. Three intervention groups designated as RG, PG and CG were used for different intervention and to make subsequent comparison. Therefore, the effect of resistance exercises, plyometric exercises and the combined training (resistance plus plyometric exercise) on linear speed and RSA were compared.

The study revealed that resistance training, plyometric training or the combination of resistance and plyometric training can improve linear speed and RSA performance. It is found that plyometric exercises or the combination of resistance and plyometric exercises in each session can yield a greater linear speed performance increment than resistance exercise alone. This can be accounted to the kind of muscle contraction caused during resistance and plyometric exercise. The speed of movement was not considered in this study. But speed of movement when doing resistance training is one factor to impact the transfer of strength gained from resistance training to speed performance (Blazevich & Jenkins, 2002). With that of plyometric exercise the movement is inherently fast and explosive using own body weight. This is the kind of muscle contraction too necessary during sprinting. But with that of resistance training, the focus is on generating the maximum possible contraction repeatedly without a due consideration of speed of movement or rate of force generation. With resistance training, the muscle mostly accustomed to force generation regardless of rate of force generation or explosiveness. On the contrary, plyometric exercises are mainly explosive which is meant there is quick force generation. Thus, explosiveness with force generation can cause the muscle to adapt to the ability of quick force generation, which can help to be speedy enough (Behm et al., 2017). Thus, the significant difference in linear speed with the three training regimens is convincing and acceptable.

As a training intervention, the significant performance increment in linear speed and RSA is inherent with all the intervention groups of RG, PG and CG. Still the existence of non-significant RSA total time performance score among the groups can be accounted to different factors. RSA can rely to other physiological factors as aerobic capacity (da Silva et al., 2010) to an extent. The physiologic burden of each bout needs to be counted during the recovery between sprints as it relies on the aerobic capacity of clearing lactate to enable the muscle to produce the required force during the subsequent sprints. However, RSA more relates with anaerobic fitness of strength and explosive power (Kenney et al., 2015; Lopez-Segovia et al., 2015). Here it needs to be recalled that all the intervention trainings are mainly anaerobic exercises, which can impact the anaerobic adaptation. Findings in this regard showed that RSA performance measures as RSA mean time and most commonly RSA total time depends on aerobic fitness (da Silva et al., 2010) and anaerobic fitness (Dardour et al., 2014; Lopez-Segovia et al., 2015). Thus, for the performance gain in RSA total time to be low may be the negligence of aerobic fitness development and appropriate training regimens to impact in addition. Future researches on the area can benefit by considering the consideration and acknowledgement of the effect of aerobic capacity on RSA performance or the effect of RSA performance enhancement targeting interventions.

This superior improvement in the RG can be attributed to adaptations like increases in the thickness, fascicle length and pennation angle of knee flexor and extensor muscles (Ullrich et al., 2018). A number of study findings goes in parallel with this study as plyometric or plyometric plus resistance training can positively affect performance of lower limbs (Ozbar et al., 2014; Ramirez-Campillo et al., 2018; Ramirez-Campillo et al., 2016; Ullrich et al., 2018).

5. CONCLUSIONS

Resistance training, plyometric or combination of resistance and plyometric exercises are capable of improving soccer specific linear speed and RSA performance level. A 4 week additional trainings of resistance, plyometric or combination of the two in addition to a normal soccer specific training can help to improve U20 soccer players linear speed and RSA total time performance.

Linear speed over 40m dash can be improved more by plyometric or combination of plyometric exercise with resistance training than resistance training alone. The most effective kind of training to impact soccer specific linear speed is plyometric kind of exercises.

RSA performance improvement can be equally developed by resistance training, plyometric exercise or by the combination of resistance and plyometric exercise equally if aerobic fitness improvement is not considered.

6. IMPLICATIONS

When the focus is improvement of pure linear speed, the inclusion and/or addition of plyometric exercises is too important. The inclusion of plyometric training in the preparation period and as well during the competitive period is therefore, ought to be considered. Players who lack linear speed can highly benefit from plyometric training regimen or the addition of plyometric exercises with soccer specific trainings. Youth or promising youngsters who are at a stage with the predisposition to develop linear speed are advised to consider the inclusion of plyometric exercises.

Interventions or trainings which target RSA total time performance need to have plyometric or (combination of plyometric with resistance) trainings with a due consideration of incorporating exercises which can improve aerobic capacity or fitness as well.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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