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Effects of 6 weeks of Weight Training and Complex Training on Y-balance Test in High School Soccer Players

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Abstract

Purpose: The purpose of this study is to determine the effects of a 6-week weight training and complex training program on the Y-balance test (YBT) in high school soccer players. **Research design, data, and methodology**: This study included 26 high school soccer players from City S. Subjects were divided into a weight training group (WTG: n=13) and a complex training group (CTG: n=13) based on their willingness to participate without medical problems. The YBT measured anterior (AT), posteromedial (PM), posterolateral (PL), and composite scores (CS), and was measured twice: before the start and after the end of training. The data were analyzed using the SPSS 25.0 statistical program to compare pre- and post-training using paired-t tests, between training groups using independent-t tests, and left-right comparisons using independent-t tests. **Results**: Training resulted in a significant pre- to post-training change in PL in the left foot WTG group ($p<.05$), with no significant change in the other measures. There were no significant differences between training groups and between left and right sides. **Conclusion**: To improve YBT in high school soccer players, a program to improve ankle and hip mobility and strength should be added along with improving large muscle strength through weights and comflex training.

Keywords: Weight training, Complex training, Y-balance test

JEL Classification Code: H1, I3, I31

1. Introduction

Soccer is the most popular sport that people around the world participate in, directly or indirectly (Yoo & Ahn, 2010), and as of March 2020, 211 countries around the world are members of the Federation International de Football Association (FIFA) (FIFA, 2020). In South Korea, soccer has gained popularity and interest in the country based on its achievements, including a fourth-place finish at the 2002 World Cup co-hosted by South Korea and Japan, a bronze medal at the 2012 London Olympics, a second-place finish at the 2020 U-20 World Cup in Poland, and qualification to the round of 16 at the 2022 World Cup in Qatar. Performance-related fitness factors required for soccer players include agility, quickness, speed, cardio-pulmonary endurance, and equilibrium (Jung et al., 2019). Soccer requires a continuous aerobic energy consumption of 60% to 90% for 90 minutes (Kim et al., 2012). Soccer typically requires about 80% of energy from the ATP-PC (adenosine triphosphate-phosphocreatine) system and about 20% from the lactate system. It has been reported that defenders and defensive midfielders require about 60% of energy from the ATP-PC system, about 20% from aerobic metabolism, and about 20% from the lactic acid system, with slight differences in the proportion of energy systems mobilized for each position (Lee et al., 2019).

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The amount of activity varies somewhat from position to position, but it is estimated to be around 8 to 13 kilometers per game. Functional fitness is also very important, as players are required to perform a variety of movements such as power, acceleration and deceleration, jumping, sharp changes of direction, sprinting, passing, and shooting in a context-appropriate manner (Nobari et al., 2021).

Soccer players require systematic and continuous training to maintain their best physical condition, including game-related fitness and functional fitness (Choi et al., 2013). A 6-week strength training program for Korean professional soccer players was reported to have a significant effect on improving physical fitness factors such as power, speed, and agility (Kim et al., 2011). In particular, weight training is the most preferred reinforcement exercise for soccer players (Kang et al., 2020). In addition to weight training, complex training is also gaining popularity. Complex training is a training method that combines plyometric and weight training to efficiently increase maximal strength and power simultaneously by triggering post-activation potentiation (PAP) through high-intensity training at high weights followed by high-velocity training at low weights (Robbins, 2005). Previous research has shown that exercise protocols utilizing PAP can help improve athletic performance when performed prior to sporting events or training (Seitz & Haff, 2016).

The importance of dynamic balance has been emphasized in soccer due to the high number of dynamic and quick movements that occur during training and matches (Onofrei et al., 2019). In particular, soccer players frequently change direction during the game, and an analysis of the directional movements of English Premier League(EPL) soccer players reported an average of about 1200 to 1400 directional movements and about 730 turning movements per game (Hammami et al., 2018). In other words, soccer players need to be prepared with dynamic balance, high speed, and agility, and soccer players who show good dynamic balance show better athletic performance and league performance (Davlin, 2004).

In recent years, the Y-balance test (YBT) has been widely used to assess dynamic balance in athletes. The YBT is known as a measurement tool that can assess anterior (AT), posterior (PM), and posterolateral (PL) balance as well as joint and muscle flexibility (Butler et al., 2016; Plisky et al., 2021). According to Kiesel et al (2007), the YBT has been used as a tool to assess ankle joint dynamic balance and asymmetry, determine lower extremity joint range of motion, and predict ankle injury. Previous studies have shown that a YBT composite score of less than 89.6% is associated with an increased rate of non-contact injury (Plisky et al., 2009). Asymmetries in limb reach in the AT, PM, and PL directions were associated with a 2- times increased risk of ankle joint injury during lower extremity injury, and bilateral lower extremity asymmetry was associated with deficits in dynamic balance and lower extremity injury risk (Fusco et al., 2020).

Therefore, the purpose of this study was to investigate the effects of weight training and complex training, which are known to be effective for soccer players, on the YBT, which assesses dynamic stability and asymmetry, over a 6-week period and to suggest efficient ways to develop training programs for injury prevention and performance improvement.

2. Methods

2.1. Subjects

In this study, 26 high school soccer players from City S were randomized into a weight training group (WTG) and a complex training group (CTG). The subjects had no medical problems, and the purpose of the study and the contents of the experiment were explained to the subjects before the start of the experiment, and the players were excluded from the measurement if they were unwilling or had injuries. The physical characteristics of the subjects are shown in <Table 1>.

Table 1. Physical characteristics of the subjects by groups

Group(n)	Age (years)	Height (cm)	Weight (kg)	Skeletal muscle (kg)	Body fat (cm)
WTG(13)	16.68±.58	178.1±6.9	71.1±7.9	35.73±3.7	11.8±2.4
CTG(13)	16.88±.74	175.3±4.4	68.2±7.2	34.15±3.9	12.1±3.5

Note. Means ± SD, WTG: Weight Training Group, CTG: Complex Training Group

2.2. Metrics and Methods

2.2.1. Dynamic balance checking with Y-balance test

To evaluate the dynamic balance ability of high school soccer players, the Y-Balance Test Kit (Functional Movement System, USA) was utilized. The athletes were warmed up prior to measurement and then tested. The assessment test consisted of subjects stepping onto the YBT and standing with one foot raised, measuring left and

right anterior (AT), posterior medial (PM), and posterior lateral (PL) reach distances. Before starting the test, the athletes performed three practices to acclimatize, measuring twice left and right for each direction and recording the highest value. In addition, each reach was expressed in centimeters (cm). If the measuring foot did not return to its original position during the subject's movement, or if the subject used the rebound to extend, a remeasurement was taken. Since the length of the lower limb in the Y-Balance Test is influenced by the Composite Score (CS), we measured the subject's leg length. This was measured from the anterior superior iliac spine to the medial malleolus in a supine position. The evaluation of the Y-Balance Test was analyzed as a composite score by adding the reach of AT, PM, and PL, dividing by the leg length times 3, and multiplying by 100 (Fusco et al., 2020).

2.2.2. Training program

The program in this study was performed for 60 minutes per session, three times per week for six weeks. The training consisted of two weeks of adaptation and four weeks of maximal strength, and the training details were modified from the program by Arazi et al. (2018). Both WTG and CTG performed the same weight training, and CTG performed 1 set of weight training followed by 1 set of plyometric. The details are shown in <Table 2> and <Table 3>.

Table 2. Adaptation phase 1～2w

Day of the week		1	2
Exercise Type		Lower Limb Exercises Squat / jump 4 times Lunge / lunge jump 4 times Calf raise / snapping 10 times	Lower Limb Exercises Dead lift / Jump 4 times One leg dead lift / One leg jump 4 times Step up / Box one-legged jump 4 times
Training Details	Load	60～70%	
	Repetitions	10～12RM, Plyometric 1 week: Non-countermovement jump, 2 week: Countermovement jump	
	Sets	3set	
	Rest	3min	

Table 3. Maximum strength phase 3~6w

Day of the week		1	2
Exercise Type		Lower Limb Exercises Squat / jump 5 times Lunge / lunge jump 6 times Calf raise / snapping 10 times	Lower Limb Exercises Dead lift / Jump 4 times One leg dead lift / One leg jump 4 times Step up / Box one-legged jump 4 times
Training Details	Load	85～100%	
	Repetitions	5RM, Plyometric 3 to 4 week: Countermovement jump , 5 to 6 week: Double contact jump	
	Sets	3set	
	Rest	3min	

2.2.3 Data Processing

The SPSS 25.0 statistical program was used to analyze the data of this study. Mean (M) and standard deviation (SD) were calculated to present the descriptive statistics of all dependent variables. Paired t-tests were used to test for within-group differences, and independent t-tests were used to test for between-group differences and left-right differences. The statistical significance level was .05.

3. Results

3.1. Comparison of Y-balance test

The results of lower extremity dynamic balance measured by YBT in high school soccer players after 6 weeks of weight training and complex training are shown in Table 2. The pre- to post-training comparison between WTG and CTG showed a significant difference in the left PL in the WTG group ($p<.05$). However, all other variables did not show significant pre- to post-training differences ($p>.05$). Comparing the scores for the left and right feet within the training groups for WTG and CTG did not reveal any significant differences, and comparisons between

training groups did not reveal significant differences between groups for any of the variables (p>.05)

Table 4. Changes of Y-balance test during 6weeks of exercise training

Variables		Groups	n	Pre M±SD	Post M±SD	t	sig.	
WTG.	AT(cm)	Lt	13	68.15±10.21	69.15±10.12	-.269	.793	
		Rt	13	67.23±7.66	70.15±11.41	-.738	.474	
	PM(cm)	Lt	13	109.54±7.42	106.23±10.85	.982	.346	
		Rt	13	107.00±5.46	107.23±9.20	-.080	.937	
	PL(cm)	Lt	13	107.46±8.22	113.69±6.89	-2.536	.025	*
		Rt	13	105.62±8.37	111.31±8.00	-1.976	.072	
	CS(%)	Lt	13	102.51±5.92	103.92±7.38	-.583	.571	
		Rt	13	100.66±5.41	103.93±8.76	-1.246	.237	
CTG	AT(cm)	Lt	13	66.46±7.12	65.31±7.93	.492	.632	
		Rt	13	66.54±7.39	66.31±9.03	.095	.926	
	PM(cm)	Lt	13	110.69±7.53	108.38±7.22	1.228	.243	
		Rt	13	107.69±5.09	108.38±4.94	-.332	.746	
	PL(cm)	Lt	13	108.31±6.42	110.77±7.63	-1.183	.260	
		Rt	13	108.00±10.08	111.92±8.12	-1.390	.190	
	CS(%)	Lt	13	105.27±7.75	104.78±5.02	-.785	.448	
		Rt	13	104.12±8.31	105.60±5.50	-.785	.448	

Values are expressed as Mean ± SD, WTG: weight training group, CTG: complex training group
AR, anterior; PM, posteromedial; PL, posterolateral; CS, composite score
+p<.05: significant difference between groups, *p<.05: significant difference within times

4. Discussion

Dynamic balance is the ability to regain postural stability and balance under changing or continuous conditions during competition, requiring a variety of sensory information (Davlin, 2004). Previous studies have reported that lower body strength and kinesthetic sensation are very important to maintain balance ability, and lower body muscle activation plays an important role in dynamic balance ability (Hammami et al., 2016).

The purpose of this study was to determine the effects of 6 weeks of lower extremity weight training and compound training on dynamic balance performance (YBT) in high school soccer players. The results showed a significant change (p<.05) in the left PL of the WTG and no other significant changes. Previous research has shown that during dynamic balance testing by YBT, the ankle is the first mechanism used for balance control by activating the muscles around the ankle joint, while the knee and hip are the second mechanisms to help control balance after ankle coordination (Horan et al.,2014). In the dynamic balance test (YBT), scores in the posteromedial (PM) and posterolateral (PL) directions were significantly positively correlated with the composite score (CS), suggesting that higher levels of anterior tibialis activation are required for postural control in the posteromedial (PM) and posterolateral (PL) directions than in the other directions (Robinson & Gribble, 2008). Hubbard et al. (2007)

studied the relationship between functional instability and dynamic balance in young adult males and females with Chronic Ankle Instability (CAI) and reported that ankle flexor strength and hip abductor and extensor strength were highly correlated with posteromedial (PM) and posterolateral (PL) reach during dynamic balance testing. These results suggest that deficits in dynamic balance can be improved by strengthening the hip abductors and extensors (Zeller et al., 2003). Previous research has shown that dynamic balance is maintained by multi-joint (hip, knee, ankle) functional capabilities, but in soccer players in particular, reduced ankle joint motion due to overuse causes compensatory actions in the surrounding joints and increases the risk of decreased performance and sports injuries.

In collegiate athletes, a left-right AT asymmetry greater than 4 cm has been reported to increase the risk of injury by 2.33 times (Smith et al., 2015). In this study, there was no significant difference in YBT AT between the left and right lower extremities, but 9 high school soccer players (33%) had a left-right AR difference greater than 4 cm. Therefore, one third of high school soccer players are at high risk of injury. Plisky et al. (2021) reported that the risk of lower extremity injury in female high school basketball players increased 6.5-fold when their CS on the SEBT was less than 89.6%. While there are some differences between the previous study using the Star Excursion Balance Test (SEBT) and this study using the YBT, the methods for measuring and calculating CS are similar. In this study, there were three high school soccer players with a CS of less than 94%, representing 9.9% of all players. This means that approximately 10% of players are at high risk of injury.

The study was limited by a small sample size and the fact that the participants were limited to a specific group of high school soccer players, which makes it difficult to fully reflect the effects of six weeks of training. The training program's emphasis on the development of large muscle groups may have contributed to the results of the study, which did not have a significant effect on improving the strength of the ankle stabilizing muscles, gluteus medius and adductors, which are known to influence dynamic balance ability, and the need for additional programs to improve ankle and hip mobility. While the YBT is a useful tool for assessing dynamic stability, it was limited in its ability to assess all balance components and further evaluation is needed.

5. Conclusion

The purpose of this study was to determine the effects of weight training and complex training on the YBT, a measure of dynamic balance ability. The results of this study showed a significant post-training change ($p<.05$) in the left PL of the WTG, but no significant changes were found in the pre- and post-training comparisons. As the YBT is being used as a tool to predict injury in athletes, there is a need to add programs to improve the mobility and strength of the ankle and hip joints as well as the large muscles in training. Further research is needed to understand the relationship between ankle joint range of motion, dynamic balance, and lower extremity strength in soccer players.

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