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The Effect of Resistance Band Exercises on Strength Parameters in Pubertal Soccer Players

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Abstract

The aim of this study was to investigate the effect of resistance band training for 6 weeks on the strength performance development of puberty boys participating in soccer. Pre-test - post-test control group research design was used. The study was randomly divided into two groups as resistance band group (n=15) and control group (n=15) by randomization method. While the resistance band and control groups continued their regular soccer training, the resistance band group performed resistance band exercises before training 2 days a week for 6 weeks in addition to soccer training. Resistance band and control groups were tested for strength performance; explosive strength; vertical jump, standing long jump, backward medicine ball throw, upper body and core muscular endurance; plank test, 30 seconds push-ups, 30 seconds sit-ups, maximal strength; back and leg strength test, and for anaerobic power; pediatric rast test were applied. At the end of 6-week training, the two-way ANOVA test with repeated measures was used to determine the difference between the repeated measurement results obtained at two different time points in the dependent groups. Significance level was determined as $p<0.05$ in all calculations. When the pre-test and post-test differences of the resistance band group and the control group were examined, it was found that there was a statistically significant difference in explosive strength, muscular endurance, maximal strength values and a statistically significant difference in anaerobic power parameter.
Keywords: Anaerobic power and capacity, Explosive strength, Isometric strength, Strength training

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INTRODUCTION

Increasing the physical abilities of athletes during the development period has attracted significant interest in sports science, with research on this topic growing in recent years (Bonilla et al., 2021; Kokorev et al., 2023; Martínez-Aranda et al., 2024; Melin et al., 2024; Ojeda-Aravena et al., 2023; Ramirez-Campillo et al., 2022; Spiering et al., 2021). Athletes' physical fitness levels are closely linked to their health during training (Halson, 2014), which is critical for enhancing performance and ensuring long-term health (Burke et al., 2011). Proper strategies to enhance athletes' performance help them achieve their objectives, and balancing health with performance has become a crucial goal (Kraemer & Fleck, 2007). Consistent and structured training has been shown to significantly improve performance and promote long-term health outcomes (Burke et al., 2011; Smith & Norris, 2002). Strength training plays a pivotal role in the athletic progression of young athletes, offering advantages such as enhanced explosive power, increased speed and agility, and improved joint stability (Suchomel et al., 2016). Research demonstrates that strength training not only enhances muscle strength but also tendon endurance and joint stability, reducing the likelihood of injuries, particularly in critical areas like the knee and hip (Faigenbaum & Myer, 2010). Studies have found that young football players engaging in regular resistance training exhibit a reduced risk of injury, enhanced joint stability during repetitive motions, and an increased ability to withstand stress loads (Lesinski et al., 2016). Despite concerns about the safety of strength training during growth, they are often believed to stunt growth or cause permanent damage to growth plates—there is no evidence to support these claims (Lloyd et al., 2014). On the contrary, appropriate strength training has been found to improve athletic performance without negatively affecting growth (Myer et al., 2011).

In addition to traditional strength exercises, squat, lunge, and resistance band exercises are recognized for their potential to increase muscle mass and endurance (Behm et al., 2008). Resistance bands, known for their portability, affordability, and effectiveness, are an indispensable tool for strength training in young football players (Lesinski et al., 2016). These bands can enhance muscle mass, improve endurance, and support joint stability (Lesinski et al., 2016). Moreover, resistance bands have been shown to improve performance parameters such as speed, agility, and vertical jump (Mor et al., 2022). Resistance training with bands is particularly effective for developing motor control and intermuscular coordination, which improves skills such as passing and shooting in young football players (Lloyd et al., 2014). The use of resistance bands in training can also improve long-term health and physical activity levels in young athletes (Faigenbaum & Myer, 2010; Myer et al., 2011).

Despite the growing body of evidence supporting the positive effects of resistance band exercises on strength and functional capacity (Martins et al., 2021), research on their impact on pubertal athletes remains limited. Few studies focus on how elastic band exercises influence neuromuscular performance indicators such as reactive strength, dynamic strength, vertical jump, and postural sway (Lee et al., 2020). Strength development in children is influenced by the central nervous system's functioning, hormonal development, and the ability to tolerate oxygen debt (Rhea et al., 2003). While strength training in children primarily aims to improve neuromuscular connection rather than hypertrophy (Faigenbaum et al., 2001), resistance training, including resistance band exercises, has been shown to rapidly enhance physical capacities and reduce injury risk (Hammami et al., 2022). Given the importance of strength in football performance, it is believed that resistance band exercises can produce positive results in young athletes (Mor et al., 2022; Suchomel et al., 2018). This study aims to investigate the effects of resistance band exercises as part of standard in-season training programs on the performance of pubertal football players. Ultimately, it seeks to contribute to training methodologies that support the athletic development of young athletes.

METHOD

Research Model

A structured pre-test post-test experimental design with a control group was used to analyze the effects of a six-week resistance band training program on strength performance. Thirty male volunteers in puberty from Kastamonu, who had played football for at least two years, formed the study group, enabling a thorough investigation into the training's effectiveness and its implications for adolescent athletes' physical development.

Research Groups

Voluntary consent form and parental consent form approval were obtained from the participants. The participants included in the study were divided into two groups as the experimental group (n=15) and the control group (n=15) by the randomization method. All participants were given information about vertical jump, standing long jump, backward medicine ball throw, 30-second push-up test, 30-second sit-up test, plank test, back leg strength test and PRAST tests, and then pre-test and post-test were performed. The mean age of the participants was determined as 11.46±0.51 Y/M in the resistance band group and 11.40±0.50 Y/M in the control group, their mean height was determined as 149.4±8.8 cm in the resistance band group and 147.4±8.47 cm in the control group, and their mean body weight was determined as 43.92±8.73 cm in the resistance band group and 42.26±9.21 kg in the control group.

Data Collection Tools

Height: The athletes' height was measured with a Mesilife MR-200 brand stadiometer with a precision of ± 1 cm

Body Weight: Participants' body fat percentages and body weight measurements were made with bare feet on an impedance analyzer (Omron BF-511 Digital Body Analysis Scale).

Medicine Ball Throwing Backwards; Medicine Ball Throwing Backwards: The athlete takes a position by placing the heels of his feet in front of the line and will throw, without crossing the line, and with his knees slightly bent, holds a 1-kilogram ball in front of his body with his arms stretched, and throws it with all his strength overhead and backwards to the maximum distance can throw. The distance between the line the athlete threw and the point where the medicine ball touched the ground was recorded in meters. The test was applied to the athlete twice, and the best result was recorded (Stockbrugger & Haennel, 2001).

30 Sec. Push-Up Test: The athlete places his hands on the ground in a prone position with hands shoulder-width apart and moves body properly with the angle created by arms. The participant lowers body down and bends elbows until chest is close enough to the ground. When the athlete's elbows are close enough to the ground, takes the starting position again. The application is limited by time. Each correct push-up is recorded (Diker & Müniroğlu, 2016).

30 Sec. Sit-Up Test: In this test, the highest number of sit-ups that the participant achieved in 30 seconds was recorded, in which abdominal muscle endurance was evaluated. Athletes were asked to lie on their backs, with their knees bent at 90 degrees and the soles of their feet on the ground, with their hands clasped behind their heads. The participant's position was fixed by the coach and the test teammate. The sit-up test was started by the coach with the start command. The participant lifted forehead past his knees for 30 seconds and returned to the starting position. Each correct sit-up performed by the participant was recorded (Diker & Müniroğlu, 2016).

Plank Test: This test is one of the basic static measurement tests used for back/core endurance. The participants were asked to lie face down and stand with their hands shoulder-width apart, and to stand on their toes, lifting their hips and keeping their hips, back, shoulders and neck parallel to the ground, and to maintain this position (Plank position). The time spent until the participant got tired and their posture deteriorated was recorded in seconds (Reiman and Manske, 2009).

Vertical Jump Test: Before the vertical jump test measurements were performed, the test protocol was explained to the athletes and the trials were performed on the mat. During the vertical jump test, a portable and controllable tablet was used to record the jump height in cm on the mat with a wide sensor area. The participant takes the starting position by standing on the contact mat area with the hands on the hips, knees bent at a 180-degree angle. The participant jumps to the highest distance that can be reached after the knees come to a 90-degree angle by receiving force from the arms. After the jump, the athlete contacts the mat again and comes to the starting position. The Microgate Witty device recorded the participant's jump height in centimeters. Three repetitions were made, and the best jump height values were recorded (Fatouros et al, 2000).

Standing Long Jump Test: The participant athlete positioned in front of the starting line with feet together and arms extended and performed a forward jump. The distance reached by the participant was measured in centimeters and jump was performed in two repetitions. The participant's best standing long jump was recorded. The test was performed on artificial turf.

Pediatric Running Based Sprinting Test (PRAST): The Pediatric RAST (PRAST) test includes 6 repeated sprint runs over a distance of 15 meters with ten-second rests in between. The only difference between the Pediatric RAST test and the RAST is the running distance area. While the RAST is performed at 35 meters, the Pediatric RAST test is performed at a distance of 15 meters. The Microgate photocell is positioned on both sides of the running area as the start and finish positions. The protocol was explained to the participants in detail and the test familiarization processes were provided (Bongers et al., 2014). The participant started his sprint with the three-two-one start command while standing one meter behind the starting photocell. After finishing the first sprint, the rest period was kept for 10 seconds with the help of a stopwatch. The participant started the second sprint after resting for 10 seconds from where they finished the first sprint. This process in the test was performed in a way that would be 6 repeated sprints in total. The participant was asked to run quickly during all sprints. The participant was verbally motivated during the sprint process. The running times for each sprint run in the test were recorded in seconds. After all runs, the body weight of each participant was considered and the power outputs for each sprint run were calculated separately with the formula "Power = Body weight (kg) * Running distance squared (m2) / Running time cubed (s3)". The running time expressed with the formula was calculated in seconds (sec.), power outputs in Watts (W), running distance in meters (m) and body weight in kilograms (kg). After the power outputs for the sprint run were calculated, the lowest power output was recorded as minimum power, the highest power output as peak power and the arithmetic average of 6 power outputs as average power in absolute (Watt) values. The fatigue index was also calculated within a certain formula (Bongers et al., 2014).

Ethics Approval

The data collection process was carried out at Kastamonu Kuzeykent Hasan Doğan Sports Facilities Artificial Turf Football Field. Pre-tests and post-tests were applied with a total of 3 coaches and were carried out in 1 day between 18.00 and 19.00. The research was conducted with the decision of Kastamonu University Clinical Research Ethics Committee 2020-KAEK: 143-135 (Date: 12/01/2020).

Collection of Data

Both groups participated in Football training for six weeks and two days a week. The experimental group applied a special exercise program for the upper extremity, core region and lower extremity within a specially designed program with resistance bands during the warm-up phase for six weeks and two days a week, and after the resistance band exercises were completed, they were included in the main phase of the training. The movements in the resistance band training program are presented in detail in Table 1. and the 6-week training program is presented in Table 2. The control group participated only in their own Football training two days a week throughout the research period. The movements applied by the resistance band group were applied with a red resistance band (5 kg) for the first two weeks, with a blue resistance band (6 kg) for the following two weeks, and with a black resistance band (7 kg) for the last two weeks by increasing the band resistance level. Each movement was performed as 3 sets of 12 repetitions, and the rest period within the set was 15 seconds and the transition period between movements was 30 seconds (Tetik & Sevinç, 2019). The increasing loading principle was used as the loading principle in the training. Three coaches provided support to the athletes during the training process to ensure that they could perform the movements in the correct form.

Table 1. Detailed resistance band exercise program for the experimental group

1	2	3	4	5
Banded Plank (Core)	Side Plank Banded Leg Raises Right	Side Plank Banded Leg Raises Left	Banded Butterfly Bridge	Banded Crunch Slo-Mo
6	7	8	9	10
Biceps Curl Banded	Front Raise Banded	Latpull Down Banded	Standing Leg Abductions	Banded Hamstring Curl
11	12	13	14	15
Banded Lateral Lunge	Banded Side Steps	Banded Forward Lunge	Banded Back Lunge	Banded Squat+Leg Lift

Table 2. Resistance band exercise content

Movement	**Training Number (Weekly)**	**Set**	**Rpt.**	**Rest Between Movements**	**Rest Between Sets**	**Type of Res. Band**		
						1.2. Week	**3.4. Week**	**5.6. Week**
1	2	3	12	15 sec.	30sec.	Red	Blue	Black
2	2	3	12	15 sec.	30sec.	Red	Blue	Black
3	2	3	12	15 sec.	30sec.	Red	Blue	Black
4	2	3	12	15 sec.	30sec.	Red	Blue	Black
5	2	3	12	15 sec.	30sec.	Red	Blue	Black
6	2	3	12	15 sec.	30sec.	Red	Blue	Black
7	2	3	12	15 sec.	30sec.	Red	Blue	Black
8	2	3	12	15 sec.	30sec.	Red	Blue	Black
9	2	3	12	15 sec.	30sec.	Red	Blue	Black
10	2	3	12	15 sec.	30sec.	Red	Blue	Black
11	2	3	12	15 sec.	30sec.	Red	Blue	Black
12	2	3	12	15 sec.	30sec.	Red	Blue	Black
13	2	3	12	15 sec.	30sec.	Red	Blue	Black
14	2	3	12	15 sec.	30sec.	Red	Blue	Black
15	2	3	12	15 sec.	30sec.	Red	Blue	Black

sec: seconds, Red, Blue, Black: Indicates the hardness level of the resistance band used in the load. 5 kg = Red, 6kg = Blue, 7 kg = Black.

Analysis of Data

SPSS 23 (SPSS. Chicago. IL. US) package program was used in the statistical analysis of the study. The mean and standard deviations of the data were calculated with descriptive statistics. The normality of the distributions was determined by the Shapiro-Wilk test. Height, Weight, Fat Percentage and Body Mass Index data were accepted as confounders. The interaction between all measurements and confounders was evaluated using a multilevel mixed effect linear regression model. To evaluate the effect of confounders, simple regression model was used without any adjustments and then data were obtained by adding relevant independent variables to see if the regression coefficients changed. In addition, independent variables were accepted as confounders if the regression coefficient changed by more than 10%. To determine whether the main effect and main effect group interactions between the repeated measurement strength results obtained at two separate time points in dependent groups caused a difference or not, two-way ANOVA test was used in repeated directions in those showing normal distribution. Additionally, for multiple comparisons, the Bonferroni correction was applied to control for Type I errors. The minimum (min.) number of participants required was determined with G-Power analysis version 3.1.9.6 (Dusseldorf, Germany) and was calculated by marking two-sided hypothesis test (effect size: 0.35) for minimum 80% power and 0.05 error level and the total number of participants (sample) was found to be 30. In addition, the training groups of the participants included in the study were determined by the double block randomization method.

FINDINGS

The differences in the pre-measurement demographic information of the resistance band group and the control group are shown in Table 2. According to the pre-measurement findings, no statistical difference was observed between the groups in terms of height, body weight, body fat percentage and body mass index (p>0.05). No confounding effect of gender, BMI or age was observed. Therefore, comparisons were made without any confounding effect. In addition, no difference was observed between the pre-test measurements of height, body weight and body mass index of the randomly assigned groups (Table 3).

Table 3. Baseline measurement data of participants (Pre-Test Results)

Variables	Group	Mean ± sd.	p
Height (cm)	DBG	149.4 ± 8.8	.243
	CG	147.0 ± 8.47	
Weight (kg)	DBG	43.92 ± 8.73	.661
	CG	42.46 ± 9.21	
Body Fat Percentage (%)	DBG	16.04 ± 5.53	.354
	CG	17.82 ± 4.78	
Body Mass Index (kg/m^2)	DBG	19.03 ± 2.43	.968
	CG	19.07 ± 2.80	

* p ≤ 0.05, Data are shown as mean ± standard deviation; DBG= Resistance Band Group; CG= Control Group; mean= mean, sd= standard deviation

A two-way repeated measures analysis of variance (ANOVA) was conducted to examine the effects of time (pre-test and post-test) and group (experimental vs. control) on explosive strength, as measured through long jump, vertical jump, and backward medicine ball throw (Table 4). The results revealed a significant main effect of time, indicating an improvement in explosive strength over time across all measures. Standing long jump: F= 96.711, $p < .001$, $\eta^2 = .775$; Vertical Jump: F= 147.523, $p < .001$, $\eta^2 = .840$; Backward Medicine Ball Throw: F= 43.017, $p = .001$, $\eta^2 = .606$. The effect of group was not significant, suggesting that performance improvements were similar across both groups ($p > .05$). However, the time × group interaction was significant, indicating that the effect of time varied between groups. Long Jump: F= 45.220, $p = .001$, $\eta^2 = .618$; Vertical Jump: F= 69.892, $p = .010$, $\eta^2 = .714$; Medicine Ball Throw: F = 21.383, $p = .001$, $\eta^2 = .433$. Post-hoc comparisons revealed that the experimental group demonstrated a greater improvement in performance compared to the control group, respectively: Vertical long jump: +9.99% (experimental) vs. +1.85% (control); Vertical Jump: +31.97% (experimental) vs. +6.08% (control); Medicine Ball Throw: +12.21% (experimental) vs. +2.05% (control). These findings indicate that, while both groups demonstrated improvement over time, the experimental group exhibits a significantly greater increase in explosive strength compared to the control group.

Table 4. Analysis of explosive strength performance

Test	Group	Test	n	Mean	sd.	Time	Group	Time ×Group
Standing Long Jump (cm)	RBG	Pre-Test	15	142.13	17.01	F=96.711 p= 0.001** η2=0.775	F=0.502 p= 0.485 η2=0.775	F= 45.220 p=0.001** n2= 0.618
		Post-Test	15	156.33	13.94			
	CG	Pre-Test	15	144.00	14.91			
		Post-Test	15	146.66	15.00			
Vertical Jump (cm)	RBG	Pre-Test	15	20.33	5.15	F=147.523 p= 0.001** η2=0.840	F=3.665 p= 0.066 η2=0.116	F= 69.892 p= 0.010** η2=0.714
		Post-Test	15	26.83	5.21			
	CG	Pre-Test	15	19.73	4.18			
		Post-Test	15	20.93	4.26			
Medicine Ball Throwing (cm)	RBG	Pre-Test	15	719.00	145.55	F=43.017 p= 0.001** η2=0.606	F=0.601 p= 0.066 η2=0.116	F=21.383 p=0.001** η2= 0.433
		Post-Test	15	806.86	145.91			
	CG	Pre-Test	15	741.40	167.72			
		Post-Test	15	756.60	166.49			

*p ≤ 0.05, ** p ≤ 0.01; Data are shown as mean ± standard deviation; RBG = Resistance Band Group; CG= Control Group; mean= mean, sd= standard deviation

The isometric strength, upper body, and core strength endurance of the subjects were assessed through a series of isometric tests, including the leg extension, push-up, sit-up, and plank tests (Table 5). The analysis revealed a significant main effect of time, indicating a general increase in strength performance; Leg Strength: $F = 85.556$, $p < .001$, $\eta^2 = .753$, Push-up: $F = 53.385$, $p < .001$, $\eta^2 = .656$, Sit-up: $F = 980.803$, $p < .001$, $\eta^2 = .743$ and Plank: $F= 39.802$, $p < .001$, $\eta^2 = .587$. These results indicate that both training interventions led to a significant improvement in strength performance over time. The effect of group was significant difference between groups was observed in push-up performance ($p < .05$), whereas other strength measures showed no significant group differences ($p>0.05$). The time × group interaction was significant, indicating that the effect of time on strength performance differed between groups. Leg Extension $F = 31.506$, $p < .001$, $\eta^2 = .6529$, Push-up: $F= 23.867$, $p < .001$, $\eta^2 = .460$, Sit-up: $F = 15.808$, $p < .001$, $\eta^2 = .361$, Plank: $F = 21.581$, $p < .001$, $\eta^2 = .435$. Post-hoc comparisons revealed that the experimental group demonstrated greater improvement in strength performance compared to the control group: Leg Extension: +34.39% (experimental) vs. +9.84% (control), Push-up: +52.80% (experimental) vs. +9.67% (control), Sit-up: +32.34% (experimental) vs. +11.53% (control), Plank: +43.22% (experimental) vs. +4.64% (control). These findings suggest that while both groups demonstrated improvement over time, the resistance band exercise program was more effective in enhancing isometric strength compared to the control condition.

Table 5. Analysis of isometric strength, upper body strength, and core strength endurance

Test	Group	Test	n	Mean	sd.	Time	Group	Time ×Group
Leg Extension (kg)	RBG	Pre-Test	15	54.66	19.16	F=85.556 p= 0.01** η2= 0.753	F=6.507 p= 0.016** η2=0.189	F=31.506 p=0.001** η2= 0.529
		Post-Test	15	73.46	15.79			
	CG	Pre-Test	15	46.73	14.86			
		Post-Test	15	51.33	15.88			
Push-Up (rep.)	RBG	Pre-Test	15	17.80	4.72	F=53.385 p= 0.001** η2= 0.656	F=0.601 p= 0.066 η2=0.116	F= 23.867 p= 0.001** η2= 0.460
		Post-Test	15	27.20	7.52			
	CG	Pre-Test	15	19.33	5.58			
		Post-Test	15	21.20	5.03			
Sit-Up (rep.)	RBG	Pre-Test	15	15.46	3.13	F=80.803 p= 0.001** η2= 0.743	F=0.051 p= 0.823 η2=0.002	F= 15.808 p= 0.001** η2= 0.361
		Post-Test	15	20.46	3.54			
	CG	Pre-Test	15	16.73	3.82			
		Post-Test	15	18.66	3.03			
Plank (sec.)	RBG	Pre-Test	15	142.20	96.81	F=39.802 p= 0.001** η2= 0.587	F=0.530 p= 0.473 η2=0.019	F= 21.581 p= 0.000** η2= 0.435
		Post-Test	15	203.66	133.14			
	CG	Pre-Test	15	201.00	131.07			
		Post-Test	15	210.33	131.69			

*p ≤ 0.05, ** p ≤ 0.01; Data are shown as mean ± standard deviation; RBG = Resistance Band Group; CG= Control Group; mean= mean, sd= standard deviation

The present study was conducted with the objective of examining the effects of time (pre-test vs. post-test) and group (experimental vs. control) on anaerobic power and capacity (Table 6). The assessment of these variables was conducted through the use of the pediatric RAST test, which provides a measurement of Peak Power, Average Power, and Fatigue Index. The results of the study indicated a significant main effect of time, suggesting that anaerobic performance improved over time across all variables. Specifically, the results showed that Peak Power: $F = 45.582$, $p < .001$, $\eta^2 = .619$; Average Power: $F = 31.248$, $p < .001$, $\eta^2 = .527$; Fatigue Index: $F = 19.993$, $p < .001$, $\eta^2 = .416$. These findings indicate that both training interventions resulted in a substantial improvement in anaerobic performance over time. The effect of group was not significant ($p > .05$), suggesting that there was no statistically significant difference in anaerobic performance between the experimental and control groups. Furthermore, the interaction between time and group was not statistically significant ($p > .05$), indicating that both training programs exhibited comparable effects on enhancing anaerobic performance. Over the course of the 6-week training period, both groups demonstrated comparable improvements in anaerobic performance: Peak Power: +18.23% (experimental) vs. +15.46% (control); Average Power: +17.80% (experimental) vs. +11.66% (control); Fatigue Index: +37.57% (experimental) vs. +37.20% (control). These findings indicate that both training interventions were equally effective in enhancing anaerobic power and capacity.

Table 6. Analysis of anaerobic power and capacity

Test	Group	Test	n	Mean	sd.	Time	Group	Time × Group
PRAST Peak Power (w)	RBG	Pre-Test	15	310.57	75.85	F=45.582 p= 0.001** η2= 0.619	F=0.006 p= 0.940 η2=0.000	F= 0.291 p= 0.594 η2= 0.010
		Post-Test	15	367.20	112.36			
	CG	Pre-Test	15	312.08	93.66			
		Post-Test	15	360.34	107.49			
PRAST Mean Power (w)	RBG	Pre-Test	15	274.12	58.83	F=31.248 p= 0.001** η2= 0.527	F=0.194 p= 0.663 η2=0.007	F= 1.458 p= 0.237 η2= 0.049
		Post-Test	15	322.91	96.34			
	CG	Pre-Test	15	269.68	81.78			
		Post-Test	15	301.14	93.32			
PRAST Fatigue Index (%)	RBG	Pre-Test	15	3.47	1.94	F=19.933 p= 0.001** η2= 0.416	F=0.194 p= 0.663 η2=0.007	F= 0.172 p= 0.682 η2= 0.006
		Post-Test	15	4.22	2.03			
	CG	Pre-Test	15	4.77	2.71			
		Post-Test	15	5.79	2.64			

*p ≤ 0.05, ** p ≤ 0.01; Data are shown as mean ± standard deviation; RBG = Resistance Band Group; CG= Control Group; mean= mean, sd= standard deviation

DISCUSSION and CONCLUSION

The most important finding of this study is that 6-week resistance training of 11–12-year-old boys playing Football is a method that causes improvement in isometric strength and also in the development of strength endurance and explosive strength. In particular, the findings obtained in isometric strength tests are considered significant, with the group difference being 24.55% higher than the mean change. Moreover, a notable finding was that the degree of change in explosive strength and strength endurance over time exhibited a higher positive development in comparison to the control group. It has been recognized that resistance band exercises play an important role in increasing explosive power in young athletes through various physiological and neuromuscular adaptations. In contemporary athletic training, the dynamics of resistance band exercises among young competitors can be classified into three categories: muscle fiber responses, neuromuscular adaptations, and coordination improvements. As athletes use resistance bands, muscle fibers respond uniquely to exercise demands. The neuromuscular system adapts significantly, enhancing movement efficiency and efficacy. Additionally, coordination becomes crucial, promoting agility for competition and the integration of movements. This multifaceted training approach highlights the importance of resistance band exercises, boosting young athletes' performance and establishing a strong foundation for future endeavours.

In contemporary athletic training, resistance band exercises are a key strategy for enhancing isometric strength, especially in youth and adolescents (Legerlotz, 2018). Young football players integrating isometric exercises see significant increases in maximal voluntary contractions and strength development (Häkkinen et al., 2011). A systematic review by Peitz et al. (2018) analyzed 75 studies with 5,138 participants aged 6 to 18, finding that resistance band programs effectively boost muscle strength and power in young athletes. Additionally, Mor et al. (2022) reported substantial improvements in balance, vertical leap, agility, and speed from these exercises. Canlı (2019) conducted a controlled study comparing standard basketball training with a strength regimen using resistance bands, highlighting the benefits of integrated training approaches.

As a result of the application, it was observed that the study group's standing long jump, vertical jump, medicine ball throw, and push-up test results increased more than the post-test results of the research group compared to the control group. The improvements in these performance parameters can be associated with an increase in isometric strength. In another study, Selçuk (2013) found that children who did swimming and strength training together improved their standing long jump, push-ups and sit-ups performances more than children who did only swimming training. In the study conducted by Ergener (2021) on judo athletes, only judo training was applied to the control group 6 days a week, and judo training was applied to the resistance band group 6 days a week and resistance band training was applied 3 days a week. As a result of the program, when the pre- and post-test values of the resistance band group were examined, it was determined that there was a significant difference in the standing long jump, backward medicine ball throw, and 30-second push-up test performances. In the study conducted by Gül (2019), while the control group received 90-minute tennis training 6 days a week, the resistance band group also received resistance band exercises 3 days a week at the end of their tennis training. In the realm of physical fitness, a meticulous examination of the variances observed in final assessments between the control group and the resistance band cohort unveiled a noteworthy and statistically significant advantage for the latter. This distinction was particularly evident in the metrics of standing long jump, vertical jump, and the rigorous 30-second push-up evaluations. The research conducted by Bayrakdaroğlu et al. (2021) introduced a regimen of resistance band exercises in conjunction with football training for the experimental group, encompassing a demanding schedule of no less than seven hours weekly over an extensive eight-week timeframe. Conversely, the control group remained solely immersed in football training throughout the study's entirety. A thorough analysis of the pre-test and post-test scores elucidated that the resistance band group exhibited a markedly greater improvement in both standing long jump and sit-up performance when juxtaposed with their control counterparts.

In the investigation by Saravan and Kannan (2019), 24 middle school students engaged in resistance band exercises for 6 weeks, performing routines thrice weekly for upper and lower extremities. This approach significantly improved push-up performance in the resistance band group, highlighting the effectiveness of this training. Similarly, Coşkun's (2013) study involved strength exercises combining body weight with resistance bands over 6 weeks. Various assessments, including push-ups, sit-ups, leg strength, and bar hanging tests, showed that the group using only body weight improved less than those incorporating resistance bands. Prieske et al. (2016) incorporated resistance band elements into core strengthening exercises in young Football players. It was found that resistance band exercises caused increases in trunk muscle activity and led to significant performance improvements. The results of this study show that resistance band training can effectively improve core stability and contribute to overall athletic performance. In addition, it can be said that the strength parameters of the applied resistance band program, explosive strength, isometric strength and muscular endurance results support literature. Contrary to the findings of the reviewed studies, the results of our study did not show any statistically significant differences in sprints and calculated anaerobic performance results compared to the control group.

In their study, Kafa et al. (2020) included 13 male adult basketball players in a core training program consisting of 7 stations, 3 days a week, 40 minutes a day for 6 weeks, and including Bosu ball and resistance band exercises. In the study, pre-test and post-test data were evaluated within the scope of anaerobic power Running-Based Anaerobic Sprint. According to the results of the research, it was observed that the 6-week training had a statistically significant difference on the RAST test. Le Scouarnec et al. (2022) conducted a study to examine the effect of repeated sprint training with progressive elastic resistance on sprint performance and anterior-posterior force production in elite youth football players. In the context of the research conducted, it was observed that the cohort engaging in elastic resistance training exhibited noteworthy enhancements in both sprint performance and force generation, contrasting sharply with the control group, which failed to demonstrate any significant progress. Such findings indicate that the inclusion of elastic resistance within sprint training regimens can substantially elevate the sprinting capabilities of young football athletes. However, it must be noted that the six-week duration of the exercise protocol employed in this investigation may have been insufficient for the participants to achieve optimal adaptation. Conversely, a separate study undertaken by Aktaş et al. (2011) highlighted that the group utilizing resistance bands not only engaged in strength training but also participated in tennis drills over an extended period of eight weeks, whereas the control group was limited to tennis training alone. As a result of the study, it was stated that the strength training applied for 8 weeks did not cause a change in anaerobic power in male tennis players aged 12-14. In this sense, there is a need for information in the literature regarding repeated sprint and anaerobic power outputs in this age group.

In our study, the results obtained from the standing long jump, vertical jump and backward medicine ball throw tests are significantly similar to the research findings examined in literature. As a result of the explosive strength development standing long jump, vertical jump and backward medicine ball throw tests, it is seen that there is a significant difference between the pre-test and post-test in the resistance band group. According to this result, the 6-week training application improved the standing long jump, vertical jump and backward medicine ball throw results of the participants. Within the scope of the research results, it can be said that the explosive strength capacity increased more in football players who had resistance band exercises.

When the participants' back and leg strength test results were examined in our study, it was stated that there was a statistically significant difference. As a result of the study, it was stated that the back and leg strength test results of the participants who took part in the 6-week training application improved. When evaluated as a percentage, the back and leg strength test increase was 34.39% in the resistance band group and 9.84% in the control group. When the literature is examined, it is seen that resistance band training performed additionally to strength training performance has a positive effect on maximal strength. When the push-up test, sit-up test and plank test results including the results of our research were examined, a statistically significant difference was determined. As a result of the research, the push-up test, sit-up test and plank test results of the participants who participated in the 6-week resistance band training improved. According to the push-up test results, 52.80% improvement was observed in the resistance band group and 9.67% in the control group; according to the sit-up test results, 32.34% improvement was observed in the resistance band group and 11.53% improvement was observed in the control group; according to the plank test results, 43.22% improvement was observed in the resistance band group and 4.64% improvement was observed in the control group. When the average results of the PRAST maximum strength test were examined, 18.23% improvement was observed in the resistance band group and 15.46% improvement was observed in the control group. The anaerobic power performance findings obtained as a result of our study are parallel to the literature findings. When compared with the literature, it was not observed that resistance band exercises positively affected anaerobic power capacity. As a result of the study, it was stated that muscle strength increases in 11–12-year-old football players were mostly due to neurological adaptations (Bompa & Haff, 2017). While no increase in muscle mass is seen in children during and before puberty, strength gain is seen. During this process, strength training programs stimulate the muscle and activate the central nervous system. It can be stated that this development can be understood when children perform movements related to strength and power efficiently. For this reason, with strength training, many muscles learn to move together, synchronization of movements and communication between muscles can be established. Finally, the inclusion of resistance bands in training affects core stability and kinetic chain efficiency, which are very important for athletic performance. Exercises such as throwing a medicine ball with resistance bands help improve the connection between hip rotation, core stability and upper body power output (Palmer & McCabe, 2023). It is thought that this integrated approach will allow the athlete to effectively redirect force from the ground through the body, maximizing explosive movements that are essential in various sports.

As a result, this study found that a 6-week elastic band training program significantly improved explosive strength, strength endurance, and maximal strength in 11–12-year-old male football players. While no significant improvements were observed in anaerobic power, the resistance band group showed greater gains in strength-related parameters compared to the control group. The findings suggest that resistance band exercises are a practical and effective method for enhancing performance in young athletes. Incorporating such exercises into regular football training may support physical development during the pubertal period. The lack of a statistically significant improvement in anaerobic power may be explained by the specific characteristics and intensity of the elastic band exercises employed. The program primarily focused on resistance and strength-based movements, which may not have provided sufficient metabolic stress or high-intensity stimulus required to elicit adaptations in anaerobic power. Furthermore, the short duration and low frequency (two sessions per week) of the intervention might have been inadequate to produce measurable changes in anaerobic capacity within such a young population.

One of the limitations of this study is the relatively short duration of the intervention, which may not have been sufficient to observe the long-term effects of elastic band training, particularly on certain performance parameters. Moreover, the study did not include a follow-up period to assess the sustainability of the improvements observed post-intervention. External variables such as nutrition, sleep quality, and additional physical activities outside of the structured training sessions were not controlled, which could have influenced the athletes' performance outcomes. Lastly, the training protocol focused mainly on general strength development and may not have been specifically optimized for all performance domains assessed.

Suggestions

- More studies can be done on the effect of resistance band exercises on the strength parameters of 11–12-year-old football players.
- The development process can be examined by applying resistance band exercises on the strength parameters of 11–12-year-old football players for a period shorter or longer than 6 weeks.
- Resistance band exercises can be applied with a larger study group to determine the differences between the groups more clearly.

- The effects of resistance band exercises on female football players can be examined by including female athletes.

- The effects of resistance band exercises on athletes can be examined by including different branches.

- Resistance band exercises can be studied with professional football players and athletes from other branches.

- Muscle activation movements can be examined by means of an EMG device during the application of resistance band exercises.

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