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Research Article

The Effects of TRX-Based Functional Training on Sprint, Agility, and Balance in Youth Football Players: A Controlled Experimental Study

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Abstract: This study aims to investigate the effects of an 8-week TRX-based functional training program on sprint, agility, and dynamic balance in young soccer players. There are 19 participants in total, divided into an experimental group (n=10) and a control group (n=9) (Exp: age 14.0 ± 0.83 years, height 1.62 ± 0.07 m, weight 48.3 ± 7.9 kg, BMI 18.1 ± 2.9; Cont: age 14.9 ± 0.93 years, height 1.65 ± 0.07 m, weight 54.6 ± 14.0 kg, BMI 19.4 ± 3.4). The Arrowhead agility test, 20-meter sprint test, and balance measurements were performed before and after the training program. In the agility test, a significant decrease of 0.10 seconds (1.08%) ($p<0.001$) was observed in the experimental group, while no significant change was found in the control group ($p>0.05$). In the 20-meter sprint test, a significant decrease of 0.12 seconds (2.74%) ($p<0.001$) was observed in the experimental group, while no significant change was detected in the control group ($p>0.05$). In the group comparison, significant differences were found in the Arrowhead test ($p<0.01$) and the 20-meter sprint ($p<0.05$). In the Y-Balance Test, significant increases in reach distances were observed in all directions in the experimental group ($p<0.05$). No significant changes were detected in the control group ($p>0.05$). In the intergroup comparison, a significant difference was found only in the left posteromedial direction ($p<0.05$). Group differences in other directions were not significant ($p>0.05$). In conclusion, the 8-week TRX-based functional training program significantly improved sprint, agility, and dynamic balance performance in young soccer players.

Keywords: TRX, functional training, agility, sprint, balance, football.

1. Introduction

Modern football, especially for athletes in their developmental years, is characterized by a high-tempo structure that requires multidimensional physical performance components such as agility, sprinting ability (Haugen et al., 2014), and dynamic balance (Sannicandro et al., 2024). These physical characteristics not only influence the effective application of technical skills but also directly impact the reduction of injury risk and the sustainability of long-term athletic development (Khan et al., 2025). Therefore, there is growing interest in training models aimed at improving neuromuscular coordination, increasing core stability, and enhancing functional movement quality in young soccer players (Prieske et al., 2016). Additionally, functional training models that support skeletal and muscle development in young athletes during their growth and development stages are gaining increasing importance in youth programs (Bayrakdar & Atıcı, 2025). Functional training models incorporate all types of body movements through specialized exercises. These training methods are recognized as a versatile training tool due to their performance-enhancing effects, which can be applied in various ways in individuals' work life, sports, professional duties, household chores, leisure time, and other activities (Mallmann et al., 2019). While a variety of training modalities such as aerobics, concurrent, and strength training are utilized to enhance physical performance (Silva et al., 2012), functional training has drawn attention due to its focus on improving core stability, postural control, motor coordination, and movement efficiency

(Cook, 2010; Boyle, 2016; Wu et al., 2023). Initially developed for therapeutic purposes, particularly in the rehabilitation of older adults and individuals with specific health conditions, functional training was predominantly used in clinical settings (Cooke et al., 2010; Schwenk et al., 2014). Over time, however, its scope has expanded considerably, becoming a widely applied method in athletic contexts aimed at performance enhancement and reducing injury risk (Chang et al., 2020; Xiao et al., 2021). Among the tools used in functional training, TRX-based systems offer a dynamic platform by facilitating bodyweight exercises that incorporate multi-planar movements. These exercises simultaneously engage balance, flexibility, and muscular strength, setting them apart from traditional strength training, which tends to isolate individual muscle groups (Beckham & Harper, 2010). Functional training, by contrast, addresses integrated movement patterns and promotes global body coordination. It typically progresses from simple foundational movements toward complex, sport-specific actions (Boyle, 2016; Kavanaugh, 2007). The effectiveness of functional training in improving athletic performance across various disciplines. Numerous studies have reported enhancements in key performance parameters such as strength, agility, and balance following functional training interventions (Koźlenia & Domaradzki, 2021; Stepinski et al., 2020; Yıldız et al., 2019; Bodden et al., 2015; Laws, 2017; Bagherian et al., 2019). A systematic review by Xiao et al. (2021) also concluded that this approach yields significant gains in both fitness and athletic capability. Furthermore, specific findings indicate that functional training is particularly effective for soccer players and athletes in similar sports (Koźlenia & Domaradzki, 2021; Yıldız et al., 2019; Laws, 2017; Liao et al., 2022; Sawczyn, 2020), consistently demonstrating a positive relationship between performance improvements and functional training interventions (Stepinski et al., 2020; Yıldız et al., 2019; Kokstejn et al., 2019).

Although the number of studies examining the general effects of functional training has increased in recent years, research specifically addressing the impact of suspension-based systems such as TRX on performance variables like sprinting ability, agility, and dynamic balance in children and youth football players remains limited. TRX suspension training, which utilizes body weight as resistance, is designed to enhance strength, balance, flexibility, and core stability (Gaedtke & Morat, 2015). This method targets the entire body simultaneously and activates multiple muscle groups in a coordinated manner. Due to this multidimensional approach, it is particularly beneficial for athletes who require high levels of coordination and the ability to generate force in various directions (Khorjahani et al., 2021). One of the key advantages of TRX training lies in its emphasis on functional strength and core stability, attributes that are essential for sports involving frequent dynamic and multidirectional actions (Fong et al., 2015). Previous research has also highlighted its positive influence on maintaining balance mechanisms, a critical factor in many athletic movements (Ozdamar et al., 2024). Furthermore, studies have indicated that TRX training may lead to improvements in several essential performance components such as agility, speed, and balance—qualities that are central to success in most sports disciplines (Cardoso Marques et al., 2006; Mugurel et al., 2011; Thuc, 2018; Tinto et al., 2017). The instability inherent in TRX exercises can further stimulate neuromuscular control and coordination, especially in sports that demand complex movement patterns (Nešić et al., 2020). Although existing research on TRX-based training remains somewhat scarce, available findings suggest that this method holds promise as a valuable component of a well-rounded physical preparation program.

Numerous studies conducted on adults have compared suspension training to conventional resistance training performed on stable surfaces, with a primary focus on their respective effects on muscular fitness (Arazi et al., 2018; Kibele & Behm, 2009). For instance, Janot et al. (2013) demonstrated that both TRX and traditional resistance exercises led to significant gains in muscle strength and endurance. However, some evidence suggests that suspension-based exercises may induce greater muscle activation compared to stable-surface training (Cosio-Lima et al., 2013). Although much of the literature centers on adults, research has also extended to younger populations. Studies have explored the effectiveness of unstable surface training, including TRX, in pre-adolescent children as well (Granacher et al., 2015; Marta et al., 2019). Despite these efforts, findings on the outcomes of resistance training conducted on unstable surfaces remain less extensive than those for traditional training methods. Nevertheless, existing research has reported meaningful improvements in physical fitness components—such as power and agility—among pre-adolescent male soccer players following plyometric interventions on both stable and unstable platforms (Negra et al., 2017). While resistance training has been broadly recognized as safe and beneficial for children and youth athletes, the integration of modern tools like TRX can pose practical challenges. In this regard, TRX offers several advantages for developing athletes, including affordability, safety, and ease of transport (Abdul-wahhab & Salih, 2023). Yet, there remains a considerable gap in our understanding of how different resistance training modalities influence physical fitness among child and youth athlete populations. Addressing this gap could provide valuable insights for strength and conditioning coaches, sports scientists, and all professionals involved in the physical development of young athletes. With a similar approach, this study aimed to investigate the effects of a TRX-based functional training program on sprint, agility and dynamic balance in young soccer players. This study, which was structured with a controlled experimental design, aims to provide scientific evidence for improving the functional performance of developmental soccer players. In this direction, it is hypothesized that TRX-based functional training will provide significant improvements in sprint time, agility performance and dynamic balance levels of young soccer players compared to the control group.

2. Materials and Methods

2.1. Research Group

This study includes a research group consisting of young soccer players aged 12–15 who are being trained at a football school in Alanya. There are 19 participants in total, who were randomly assigned to an experimental group (n=10) and a control group (n=9) using a computer-generated randomization program. The average age of the participants was 14.0 ± 0.83 years in the experimental group and 14.9 ± 0.93 years in the control group. The average height was 1.62 ± 0.07 m in the experimental group and 1.65 ± 0.07 m in the control group, while the average body weight was 48.3 ± 7.9 kg in the experimental group and 54.6 ± 14.0 kg in the control group. This demographic information provides an overview of the physical characteristics of the participants and forms an important basis for evaluating the effects of TRX-based functional training.

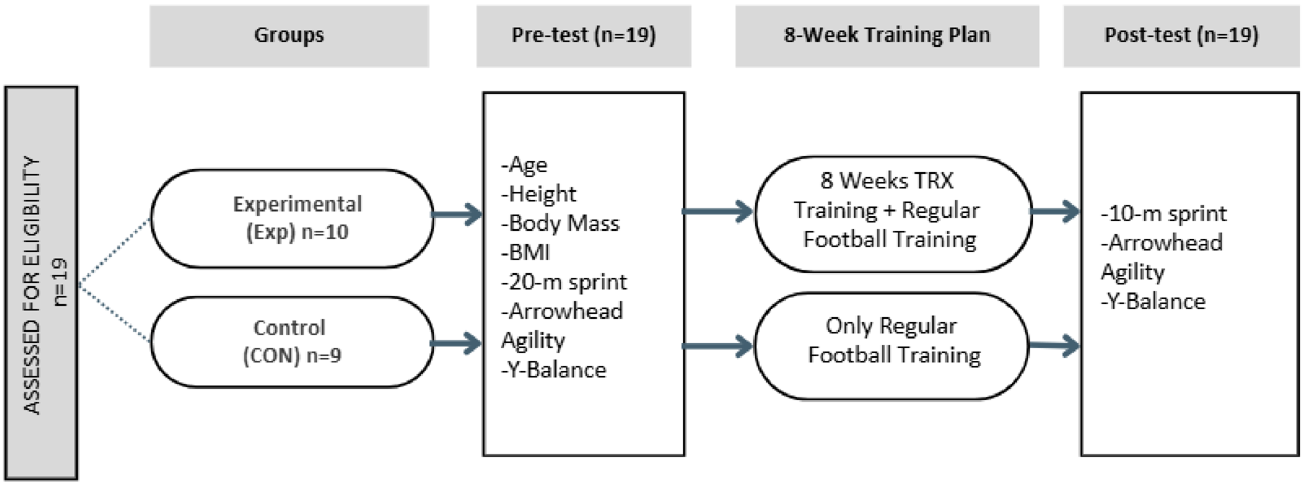


Figure 1. Flow diagram

Table 1. Descriptive Statistics of Demographic and Anthropometric Characteristics of Experimental and Control Groups

Variable	Group	N	$\bar{x} \pm$ SD	Minimum	Maximum
Age (years)	Exp	10	14.0 ± 0.83	13.00	15.00
	Cont	9	14.9 ± 0.93	13.00	15.00
Height (m)	Exp	10	1.62 ± 0.07	1.49	1.67
	Cont	9	1.65 ± 0.07	1.53	1.71
Weight (kg)	Exp	10	48.3 ± 7.9	32.00	61.50
	Cont	9	54.6 ± 14.0	45.00	80.80
BMI (kg/m^2)	Exp	10	18.1 ± 2.9	14.40	22.30
	Cont	9	19.4 ± 3.4	16.70	24.70

Exp; experimental, Cont; Control, $\bar{x}$; mean, sd; standard deviation

In the preliminary power analysis conducted using G*Power, a medium effect size (d = 0.5), a significance level of 0.05, and 80% power were considered. With these parameters, the ideal sample size was determined to be 8 participants for each group. However, the current study was conducted with a smaller sample (experimental group 10, control group 9). This may limit the statistical power of the study and the generalizability of the results.

2.2.Research Model

This study employed a controlled experimental design with pre- and post-test measurements to examine the effects of TRX (Total Resistance Exercise) training on youth soccer players. The TRX program was applied regularly to the athletes in the experimental group for eight weeks, with sessions scheduled three days a week immediately following each soccer training session, a protocol supported by previous studies demonstrating the safety and effectiveness of post-training resistance exercises in youth athletes (Mujika et al., 2009). Each TRX session lasted approximately 30 minutes and was structured considering the children's developmental levels, load tolerance on their musculoskeletal systems, and motor skill development. The program included basic TRX exercises using body weight (TRX row, TRX squat, TRX chest press, TRX hamstring curl, TRX plank, etc.), with intensity gradually increased based on weekly progress. In the initial weeks, movement quality and proper technique were prioritized, while in later weeks, the number of repetitions and duration were increased in a controlled manner. Workouts were conducted in groups under the supervision of a professional trainer, ensuring participants exercised safely and effectively. The program aimed to enhance performance components including core stability, balance, coordination, and muscle endurance.

Table 2. Eight-week TRX training program

Week	Aim	Exercise Content	Sets x Repetitions / Duration	Notes
1	Coordination – Movement learning	TRX Row, TRX Squat, TRX Chest Press, TRX Plank	2 x 10	Correct technique, movement control is paramount
2	Basic Strength - Stabilization	TRX Row, TRX Squat, TRX Chest Press, TRX Hamstring Curl, TRX Plank	2 x 12	Slow tempo, focus on posture and balance
3	Stabilization and endurance	TRX Lunge, TRX Y-Fly, TRX Push-up, TRX Side Plank	2 x 12-15	Variations that disrupt balance are added
4	Dynamic control - Development	TRX Mountain Climber, TRX Single-leg Squat, TRX Pike	3 x 10	30 seconds rest between movements
5	Increased load	TRX Row, TRX Jump Squat, TRX Chest Press, TRX Plank + Shoulder Tap	3 x 12	Functional transitions are included
6	Balance – Core strengthening	TRX T Deltoid Fly, TRX Hamstring Curl, TRX Push-up, TRX Side Plank with Leg Lift	3 x 12-15	Focus on the abdomen and waist area
7	Multifaceted endurance	TRX Atomic Push-up, TRX Squat to Row, TRX Mountain Climber	3 x 15	Less rest time, increased intensity
8	General repetition – Performance test	Performing basic movements with the maximum number of repetitions the participant can do (in test format)	2 set (max)	Can be applied in the final week for evaluation purposes

2.3. Data Collection Tools

2.3.1. Anthropometric measurements

Height measurements were taken in the morning while participants were standing barefoot in an upright position. Participants were positioned so that their heads were parallel to the Frankfort plane, and their heels, hips, backs, and heads were in contact with the measuring device. Measurements were taken using a fixed stadiometer, and results were recorded in centimeters with a precision of 0.1 cm (Lohman et al., 1988). Body weight measurements were taken in the morning, on an empty stomach, and after using the restroom, with individuals wearing light clothing and barefoot. A digital scale with a sensitivity of 0.1 kg was used for measurements, and participants stood in the center of the scale, in an upright position, with their weight evenly distributed on both feet. Weight values were recorded in kilograms (kg) (Norton & Olds, 1996). The Body Mass Index (BMI) was calculated based on the obtained height and body weight data by dividing body weight (kg) by the square of height in meters (kg/m^2). The obtained values were evaluated according to the World Health Organization's classification (WHO, 2000).

2.3.2. Arrowhead test (Agility)

In this study, the Arrowhead Agility Test protocol described by Jalilvand et al. (2015) was used. Performance times were measured using the Brower Speed Trap I Timing System (Brower Timing Systems, Salt Lake City, UT, USA). All participants started the test from a point 1 meter behind the initial photocell gate. At the beginning of the test, the athletes sprinted toward the central cone and then turned around the outside of the cone in their preferred direction (left or right). They then continued by turning around the cone located on the same side and the upper cone. The test concluded with a final sprint toward the finish line photocell gate.

2.3.3. 20-meter sprint test

The 20-meter sprint test was administered to evaluate the anaerobic speed performance of young athletes. The test was conducted on a flat, hard surface in a 30-meter running corridor. Timing was measured using the Brower Speed Trap I Timing System (Brower Timing Systems, Salt Lake City, UT, USA). This system works with dual light sensors placed at the start and finish points and provides measurements with a precision of one thousandth of a second (0.001 s). Young athletes were asked to perform a 10-minute general warm-up (light jogging, dynamic stretching, and a few sprint trials) before starting the test. Before the test began, individuals were positioned at the starting line with their toes not touching the line and were allowed to start running at any time after the "ready" command. This eliminated the reactive time effect from the test. Measurement began when the first photo-cell line was crossed and automatically ended when the second line (20-meter mark) was crossed (Lockie et al., 2003; Brown & Ferrigno, 2005). Each participant was given two attempts, with a full rest period (3–5 minutes) between attempts. The best performance was used in the analysis.

2.3.4. Y-balance test

The Y-Balance Test (YBT) was administered to determine the participants' lower extremity dynamic balance levels. The test was performed using the "Y-Balance Test Kit" (Functional Movement Systems, Chatham, VA, USA). Measurements were taken in a laboratory environment with a flat, non-slip floor. Participants wore athletic shoes during the test and were informed about the protocol prior to the test. During the test, each participant stood on their dominant leg and performed reaching movements in the anterior, posteromedial, and posterolateral directions. Hands were kept fixed at the waist, and the torso was maintained in a stable position. Three trials were performed for each direction, and the longest reach distance was recorded. If the test leg shifted position, the heel of the support leg lifted off the ground, or the participant lost balance during the measurement, the trial was deemed invalid and repeated.

2.4. Data Analysis

Experimental data were analyzed using IBM SPSS statistical software package (version 25.0, Chicago, IL, USA). All data are presented as "mean ± standard deviation" ($\bar{x}$ ± SD). The Shapiro-Wilks test was used to determine whether the data were normally distributed. To examine the effects of agility training on performance, a two-way repeated measures ANOVA (group × factor) was first performed. The dependent variables for each model were the 10-meter sprint test, the Arrowhead agility test, and the Y dynamic balance test. When a significant interaction was observed, the Bonferroni post hoc correction was performed to determine the location of significance. Partial $\eta 2$ was used to assess effect size, and significance was interpreted as follows: <0.06 small, <0.14 moderate, and ≥0.14 large (Cohen, 1988). The significance level was set at $p<0.05$ for all tests. Additionally, within-group changes were calculated proportionally and as percentages using Microsoft Office Excel.

2.5. Ethical Approval

Ethical approval for this study was obtained from the Non-Interventional Clinical Research Ethics Committee of Alanya Alaaddin Keykubat University (Decision No: 2025/05, dated 11.02.2025). The research was carried out in accordance with the ethical principles outlined in the Declaration of Helsinki.

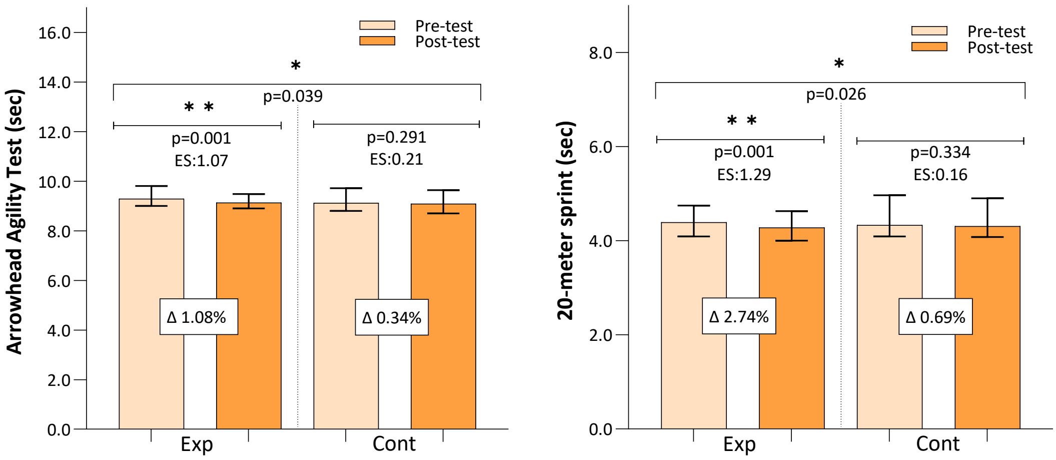
3. Results

Table 3. Comparative Analysis of Agility and Sprint Speed Changes Following Training Intervention

Variable	Group	n	Pre-test x̄±sd	Post-test x̄±sd	Intra-group change Δ (unit)	Intra-group change Δ (%)	t	*p	Cohen's d	F	†p
Arrowhead Test (sec)	Exp	10	9.25 ± 0.25	9.15 ± 0.21	↓0.10	↓1.08%	5,02	0.001*	1,07	4,91	0.039*
	Cont	9	8.97 ± 0.27	8.94 ± 0.26	↓0.03	↓0.34%	1,12	0.292	0,21		
20-m Sprint (sec)	Exp	10	4.38 ± 0.25	4.26 ± 0.25	↓0.12	↓2.74%	5,78	0.000*	1,29	6,02	0.026*
	Cont	9	4.33 ± 0.26	4.30 ± 0.26	↓0.03	↓0.69%	1,02	0.334	0,16		

**p<0,05, Exp; experimental, Cont; Control, ES: Effect size, x; mean, sd; standard deviation, *p; time effect, †p; time × group interaction*

Table 3 presents pre- and post-test performance values, intra-group changes, statistical significance, and effect sizes for the Arrowhead Test and 20-meter sprint. In the experimental group, the Arrowhead Test time decreased from 9.25 ± 0.25 seconds to 9.15 ± 0.21 seconds, reflecting a significant improvement of 0.10 seconds (1.08%) (t=5.02, p=0.001). This change corresponds to a large effect size (Cohen's d = 1.07). The control group showed a minor and statistically non-significant improvement of 0.03 seconds (0.34%) (t=1.12, p=0.292). For the 20-meter sprint, the experimental group improved from 4.38 ± 0.25 seconds to 4.26 ± 0.25 seconds, a statistically significant decrease of 0.12 seconds (2.74%) (t=5.78, p<0.001), with a strong effect size (Cohen's d = 1.29). The control group's decrease of 0.03 seconds (0.69%) was not significant (t=1.02, p=0.334). Between-group analyses revealed significant differences in the Arrowhead Test (F=4.91, p=0.039), and a near-significant difference in the 20-meter sprint (F=6.02, p=0.026). These results indicate that the intervention in the experimental group led to meaningful and substantial improvements in both performance measures.



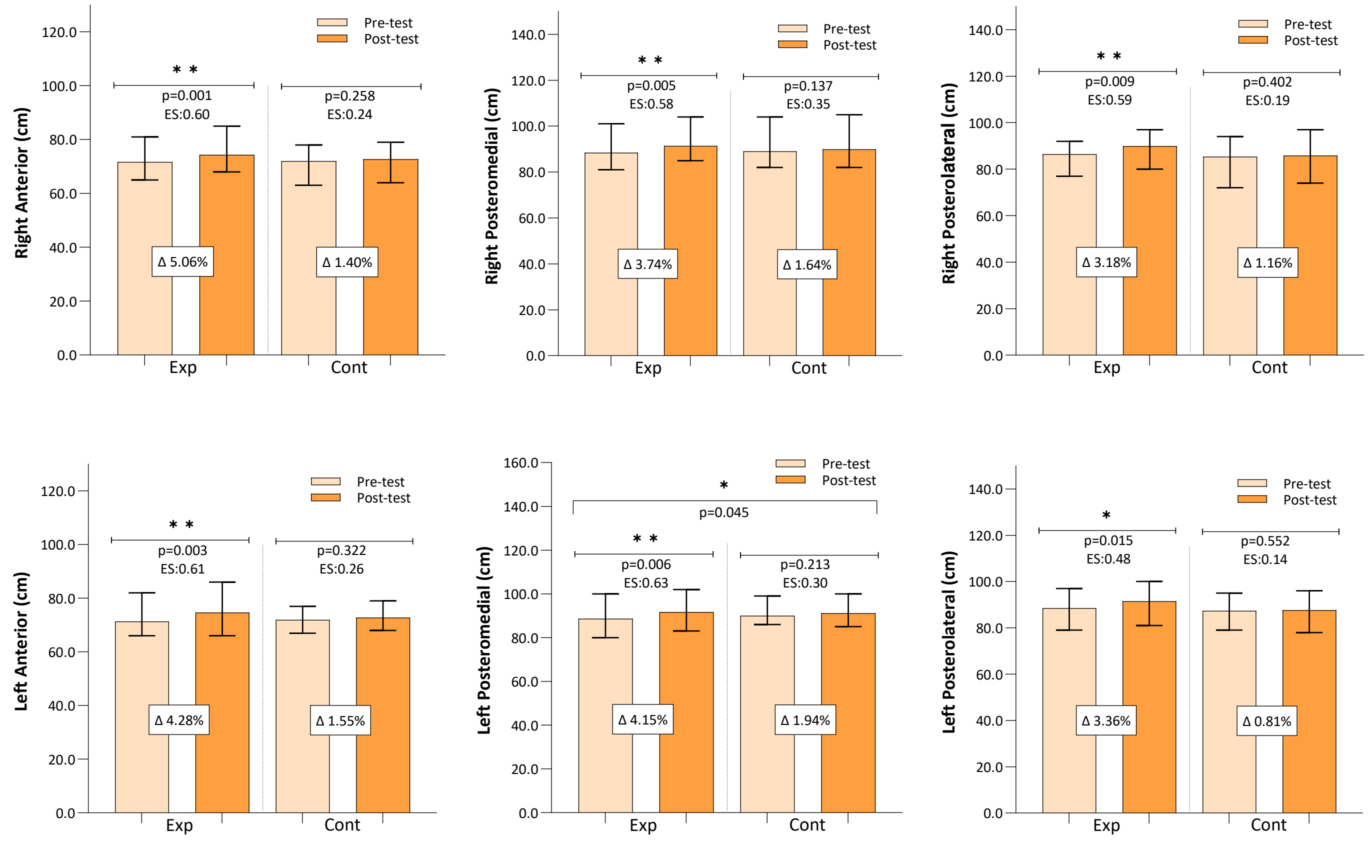
Graph 1. Comparative Analysis of Agility and Sprint Speed Changes Following Training Intervention

Table 4. Effects of intervention on directional reach distances in the y-balance test: pre-post and between-group analysis

Variable	Group	n	Pre-test x̄±sd	Post-test x̄±sd	Intra-group change Δ (unit)	Δ (%)	t	*p	Cohen's d	F	†p
Right Anterior (RA)	Exp	10	73.0±5.1	76.7±6.7	↑3.7	↑5.06%	5.23	0.001*	0.60	3.12	0.092
	Con	9	71.3±4.3	72.3±5.3	↑1.0	↑1.40%	1.21	0.258	0.24		
Right Posteromedial (RPM)	Exp	10	91.2±7.3	95.2±6.2	↑4.0	↑4.39%	3.74	0.005*	0.58	4.01	0.052
	Con	9	87.8±5.5	89.9±6.0	↑2.1	↑2.39%	1.64	0.137	0.35		
Right Posterolateral (RPL)	Exp	10	88.2±4.4	91.0±5.1	↑2.8	↑3.18%	3.28	0.009*	0.59	2.46	0.131
	Con	9	86.3±5.1	87.3±5.4	↑1.0	↑1.16%	0.88	0.402	0.19		
Left Anterior (LA)	Exp	10	72.3±5.1	75.4±5.9	↑3.1	↑4.28%	4.05	0.003*	0.61	2.78	0.108
	Con	9	71.1±4.4	72.2±4.9	↑1.1	↑1.55%	1.05	0.322	0.26		
Left Posteromedial (LPM)	Exp	10	91.6±6.2	95.4±5.4	↑3.8	↑4.15%	3.63	0.006*	0.63	4.34	0.045*
	Con	9	87.6±5.0	89.3±4.5	↑1.7	↑1.94%	1.34	0.213	0.30		
Left Posterolateral (LPL)	Exp	10	89.2±5.8	92.2±6.3	↑3.0	↑3.36%	2.97	0.015*	0.48	1.89	0.181
	Con	9	86.1±5.2	86.8±4.9	↑0.7	↑0.81%	0.62	0.552	0.14		

**p<0,05, Exp; experimental, Cont; Control, ES: Effect size, x; mean, sd; standard deviation, *p; time effect, †p; time × group interaction*

The table 4 presents pre- and post-test values, intra-group changes, statistical significance, effect sizes, and between-group comparisons for different directions of the Y-Balance Test (Right Anterior, Right Posteromedial, Right Posterolateral, Left Anterior, Left Posteromedial, Left Posterolateral) in experimental and control groups. Significant improvements were observed in all directions within the experimental group. For example, the Right Anterior reach increased from 73.0±5.1 to 76.7±6.7, indicating a significant increase of 3.7 units (5.06%) (t=5.23, p=0.001) with a moderate-to-large effect size (Cohen's d=0.60). Similar significant improvements ranging between 3-5% were reported for the other directions. In the control group, increases were smaller and not statistically significant (p>0.05). For instance, in the Right Anterior direction, a 1.0 unit increase corresponding to 1.4% was found (t=1.21, p=0.258). Between-group comparisons revealed a significant difference only in the Left Posteromedial direction (F=4.34, p=0.045), with no significant differences found in other directions (p>0.05). This indicates that the intervention was particularly effective in improving balance in the Left Posteromedial direction compared to controls.



Graph 2. Effects of intervention on directional reach distances in the y-balance test: pre-post and between-group analysis

4. Discussion

In this study, the effects of an 8-week TRX-based functional training program on sprint, agility and dynamic balance in young soccer players aged 12-15 years were investigated. The findings show that the training program caused significant performance increases in the experimental group. The statistical significance and high effect sizes obtained in both intragroup and intergroup comparisons reveal the supportive effect of TRX training on the functional performance of developmental athletes.

In the study, agility performance showed a significant improvement of 0.10 seconds (1.08%) in the experimental group (p=0.001; Cohen's d=1.07). In contrast, no statistically significant change was found in the control group. Similarly, in the 20-meter sprint test, a 2.74% improvement was determined in the experimental group (p<0.001; Cohen's d=1.29) and this finding supported the effect of TRX training on explosive strength and speed development. These results are in line with some previous studies. Fong et al. (2015) and Ozdamar et al. (2024) stated that TRX training can improve agility and speed performance in branches where multi-directional mobility is required in sports. In a study conducted by Valeh et al. (2020), it was stated that 8-week TRX programs were designed to improve physical characteristics such as endurance, strength, balance, flexibility, speed and agility. TRX training improved agility in our participants, likely due to enhanced core, back, and lower extremity muscle function (Usgu et al., 2015). In contrast, Fayazmilani et al. (2022) did not report significant improvements in agility in children, possibly because their program had a shorter duration and lower intensity. These findings align with Keiner et al. (2020), who indicated that traditional strength training may enhance speed more effectively than functional training.

In the literature, it is stated that TRX training programs contribute to the functional characteristics of athletes as well as increasing neuromuscular performance with special exercises applied in various sports branches (Distefano et al., 2013).

In addition, TRX applications are reported to be an effective method for the development of motoric characteristics such as flexibility, balance, strength and coordination (Pancar et al., 2021). The Y-Balance Test results obtained in the study are also striking in this direction. While significant increases were observed in the reaching distances of the participants in the experimental group in all directions, these changes were not statistically significant in the control group. Especially in the left posteromedial direction, there was a significant difference between the experimental and control groups ($F=4.34$, $p=0.045$). This finding supports the potential of imbalance elements in TRX exercises to improve neuromuscular coordination and dynamic balance. Positive effects of TRX training on core stability and postural control mechanisms have been reported by Gaedtke and Morat (2015). Furthermore, Fayazmilani et al. (2022) reported that better balance performance in TRX training was associated with greater muscle strength in children. In addition, some studies have shown that TRX training is also used in preventive physiotherapy applications and contributes to the elimination of musculoskeletal imbalances (Snarr & Esco, 2013). In another study conducted by Erol (2023), it was concluded that eight weeks of high-intensity TRX training significantly increased balance performance in soccer players, while no similar effect was observed in low-intensity TRX applications. In another study conducted on soccer players aged 13–15 years, it was reported that the group participating in the TRX training program showed greater improvement in specific performance parameters, particularly agility, sprint speed, and balance, compared to the control group. However, in the same study, the body weight and agility development of the control group were found to be higher than those of the TRX group (Gürgen & Boz, 2023).

In general, TRX-based functional training has positive effects on balance and agility in young soccer players, whereas traditional strength training may be more effective for sprint performance (Erol, 2023; Gürgen & Boz, 2023; Keiner et al., 2022). However, responses to TRX and traditional strength training may vary with age, and TRX training appears to be particularly advantageous for balance and proprioceptive development in children and adolescents. Therefore, TRX-based functional training is recommended as a complementary component in football training programs to enhance balance, sprint, and agility. In addition to TRX training alone, recent studies have examined the combination of TRX and plyometric exercises, which has been shown to produce synergistic effects, improving both balance and explosive strength. Evaluating such combined programs in future research may provide valuable insights and contribute significantly to the development of athletic performance in young soccer players.

5. Conclusions

The findings suggest that TRX-based functional training can support the multifaceted development of physical performance in developmental soccer players. In particular, significant improvements in Soccer-specific skills such as balance, agility and sprint suggest that this training approach can be considered not only as a supportive but also as a guiding tool. The effects of TRX on core stability, neuromuscular coordination and musculoskeletal adaptation are also noteworthy in terms of athletic health and performance sustainability of young athletes. In this context, it would be beneficial to integrate TRX-based programs, which can be applied with different intensities and durations, into long-term development plans by adapting them to individual needs. In future studies, comparative examination of the effects of TRX applications on different age groups, genders or sports branches will contribute to determine the place of this method in training science more clearly.

Limitations

This study has some limitations. One limitation of the present study is the relatively small sample size, which may restrict the generalizability of the findings to broader populations. Furthermore, some differences were observed between the experimental and control groups in terms of body composition (especially higher weight and BMI values in the control group). These differences may have had a potential impact on performance variables and require caution in interpreting the results. In addition, the study period was limited to 8 weeks, and the long-term effects of TRX training could not be examined. Considering that TRX exercises can be applied at different intensities, the findings of this study should be interpreted only within the context of the training intensity used. In future studies, long-term follow-ups with larger and homogeneous sample groups will provide a more comprehensive and reliable evaluation of the effects of TRX-based training programs on young athletes. In addition, studies considering different age groups, genders and training levels may provide more detailed information on the effects of TRX training on various demographic groups. In this way, it will be possible to individualize training programs and identify sport-specific adaptations.

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Abbreviations

The following abbreviations are used in this manuscript:

TRX	Total Resistance Exercise
BMI	Body Mass Index
Exp	Experimental group
Cont	Control group
SD	Standard Deviation
ES	Effect Size
P	Probability value (significance level)
F	F-test value (ANOVA)
η^2 (eta squared)	Effect size index
YBT	Y-Balance Test

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