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Comparison of The Effect of a Period of TRX and Yoga Versus Traditional Exercises on Balance of Archers

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A B S T R A C T

Archers engage in various exercises to maintain postural stability and balance to achieve peak performance in archery, as balance and fine motor control are critical components of success in this sport. Therefore, the aim of this study was to compare the effect of a period of TRX and yoga versus traditional exercises on the balance of archers. This study is quasi-experimental with a pre-test and post-test design. The present research is applied in nature and was conducted in the field. The statistical population included all male archers in Tehran Province aged 20 to 40 years. From this population, 30 individuals were selected based on inclusion and exclusion criteria through convenience sampling and then randomly assigned to three groups: traditional exercises, yoga, and TRX. In the pre-test, the balance in shooting was measured. After completing the measurements, each group received their respective exercises, and at the end of the last training session, the post-test including the measured variables was repeated. To examine the research hypotheses, initially, the normality of the data was checked using the Shapiro-Wilk test, which revealed that the data were not normally distributed. Therefore, non-parametric statistical tests were used for data analysis. The results of the Wilcoxon test indicated that all three types of traditional exercises, yoga, and TRX led to a significant improvement in balance, hand-arm stability, and performance of the archers. In the intergroup comparison using the Kruskal-Wallis test, it was found that there were significant differences among the three groups in the research variables. Pairwise comparisons using the Mann-Whitney U test revealed that TRX, yoga, and traditional exercises, respectively, had the most significant effects. Based on the obtained results, it is suggested that the training programs used in the present research, with priority given to TRX, yoga, and traditional exercises, be recommended for improving the balance of male archers.

Keywords: *Balance, Archery, TRX Training, Yoga Training*

1. Introduction

High skill in archery is defined as the ability to shoot an arrow at a specified target with precision (1). Achieving high scores in archery requires the ability to maintain the center of gravity, known as "postural control," by overcoming forces that disrupt body balance (2). Postural control and balance are essential for elite archers to reach peak performance. Therefore, archery can be described as a

steady sport that requires balance, fine motor control, appropriate endurance, and upper body strength (3). Archery involves a three-phase movement (standing, drawing the bowstring, and aiming) (4). An archer's skill is evident in their ability to shoot an arrow at a specific target at a precise time. To achieve this, athletes must minimize body movements at each stage to avoid unnecessary movements that can reduce stability, thereby maximizing the chance of hitting the target center. An archer's movements must be as precise as possible and quickly counteract postural instability (5, 6).

Intervention with strength training and respiratory muscle exercises proves that these exercises are effective in reducing hand tremors, as they can overcome muscular fatigue and an archer's anxiety levels. According to Michael Linson, the above findings indicate that an archer's accuracy heavily depends on the ability to stabilize the bow during the full draw, which requires greater muscle strength (7). Different activities require varying degrees of muscular ability; thus, those who engage in specific training throughout the year significantly improve their muscular strength and endurance in that field. Researchers have shown that hand stability does not linearly increase with physical activity but the curve of the relationship between hand tremor and difficulty level accelerates positively (8, 9). Laishram and Kumar (2008) examined the effect of strength training on reducing hand tremors in archers and concluded that the strength training group had the best efficiency in reducing hand tremors. To control the bow during drawing and holding, it is necessary to reduce hand tremors and fatigue; specific resistance training should be a complementary component for preparation, as it directly increases muscular strength and consequently athletic performance. It was found that hand-arm stability can also improve through practice and experience (7). Strength training has many benefits for archers, including stronger muscles to create a more stable foundation, stronger core muscles for greater stability during movements in adverse weather conditions, reduced symptoms of travel fatigue, faster recovery, stress management, achieving similar workloads with less effort, reducing the adverse effects of unilateral sports (using muscles on one side), synchronization of motor unit contraction capacity with minimal delay, synchronization of motor unit recruitment, and intra- and inter-muscular coordination, which all affect not only archery but all sports (10).

Recently, many training methods have been developed for stabilizing the body's core (using body weight), recognized as highly effective for strengthening muscles, improving flexibility, and enhancing balance ability, not only for athletes but also for women and the elderly (11). In addition to traditional training methods, new training methods and modern fitness equipment also exist. These innovative methods are performed on various platforms such as Bosu balls, Pilates balls, and Therabands (11). Additionally, many bodyweight training methods have been created to stabilize the body, one of which is TRX training (11).

The basis of bodyweight training is the core training technique. Core exercises can be performed using only body weight without any equipment. They can also provide good exercise options using various materials. Using materials such as TRX, Bosu balls, Pilates balls, and elastic bands, along with core exercises, allows us to perform core stabilization exercises on stable and unstable surfaces. It can be said that TRX studies are a training priority in sports due to the importance of balance (11). TRX training, as a bodyweight exercise method, uses an auxiliary device to create muscle tension and improve balance and athletic performance. TRX is a training device consisting of simple straps connected to a closed system (11). With this device, athletes can perform bodyweight exercises and adjust the required resistance and tension by changing the body angle in each exercise. TRX exercises are designed based on physiological principles and human motor abilities (11). These exercises include core exercises such as abdominal and back muscles, arm and leg exercises, balance and stability exercises, strength exercises, and sports exercises, including stretching exercises, Taekwondo exercises, and other sports. Using TRX, athletes can perform exercises that are challenging in terms of movement and abilities (11). For example, in TRX exercises, athletes use straps and different body angles to perform exercises that help strengthen core muscles, improve balance and stability, and increase flexibility and body strength. Since TRX exercises are performed with body weight, they can be a suitable option for athletes training in environments with limited tools and space (11). Additionally, TRX exercises are highly suitable

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for athletes seeking challenge and variety in their training due to their diversity and different settings (12). Overall, research has shown that TRX exercises can significantly improve athletic performance, injury prevention, and balance. Pal and colleagues (2021) demonstrated that using TRX exercises can have a positive and significant impact on dynamic balance and core muscle strength (12).

Yoga is defined as a combination of breathing exercises, body postures, and meditation to calm the nervous system and balance the body, mind, and spirit (8{Heidari, 2023 #31234, 13)}. As it has become widespread and introduced to the global community, several yoga schools and organizations have been established over time. Initially, finding a style of yoga that aligns with you can be very challenging. Yoga helps muscles, tendons, and ligaments move through their full range of motion, thereby developing balance and core strength, which is a significant advantage for athletes in their chosen sports. Another essential element in yoga is breath work (Pranayama). Attention to breathing during yoga exercises can be considered one of its most important benefits for athletes. Learning to focus and concentrate through difficult postures by focusing even on inhalation and exhalation helps athletes remain focused during challenging competitions or training sessions (14). The mind-body connection in yoga is crucial for helping athletes develop mental intelligence and concentration. Additionally, yoga helps relax not only tight muscles but also anxious and overly stressed minds. Yoga differs significantly from other types of exercise because it creates movement without pressure and imbalance in the body, making it an ideal complement to other forms of exercise and a significant advantage for any sport (14). Specific yoga exercises target the deep core muscles within the abdomen that connect to the spine, pelvis, and shoulders to help maintain good posture and provide the foundation for all arm and leg movements. More importantly, power derives from the core, and a properly functioning core helps control that power, enabling smoother, more efficient, and coordinated movements in the limbs (14).

Approximately 55% of physiotherapists regularly use yoga as a common alternative strength training method, which may indicate its adaptability for addressing various musculoskeletal issues. Yoga can also be as effective as traditional stretching exercises for trunk and upper limb muscles without a higher risk of side effects than traditional back exercises (8). Ni also stated in 2014 that we examined trunk and pelvic muscle activity levels during 11 commonly used yoga postures. The results supported our hypothesis that different postures cause variations in core muscle activation patterns. These findings can be useful for targeting specific muscles during training and rehabilitation programs designed to strengthen and stabilize the core (11).

Given the presented content regarding training methods such as yoga and TRX on athletes' performance and certain physical fitness factors such as balance during the draw, aiming, and release of the arrow, and considering the common fitness methods among archers, it is clear that modern methods such as TRX and yoga can be used as independent and complementary exercises alongside archery training. Looking at the history of diverse training methods in archery, it appears that these have not been seriously considered by archery coaches and athletes, and previous research on balance and effective training methods on balance in archery has mostly focused on traditional and weight training. Since maintaining balance has a significant share in an archer's performance in real training and competition conditions, to help archers and fill the existing research gap, the present study aims to answer whether there is a significant difference between the effect of a period of TRX, yoga, and traditional exercises on archers' balance.

2. Methods and Materials

2.1. Study Design and Participants

The present study is a semi-experimental study with a pre-test and post-test design. The statistical population of this study includes all adult archery athletes who participated in Iranian archery competitions from 2016 to 2021, aged 20 to 40 years. Based on previous studies, 30 individuals were selected through convenience sampling and randomly assigned to three groups: traditional exercises (10 people), TRX exercises (10 people), and yoga exercises (10 people). Inclusion criteria included male gender, age range 20 to 40 years, no previous experience with yoga and TRX, experience in national competitions, no physical problems such as lower limb injuries, fractures, back injuries, etc., and no acute illnesses. Exclusion criteria included absence for more than one session, unwillingness to continue

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cooperation, and occurrence of any injuries or physical and movement issues during training.

To conduct the study, the proposal was first approved by the Faculty of Physical Education and Sports Sciences at Islamic Azad University, Central Tehran Branch. Then, in coordination with Tehran's archery teams, the necessary preparations for the study were made in a specialized sports hall. Interested participants were invited to fill out consent forms after being informed about the study's benefits, potential risks, and details. Based on the inclusion and exclusion criteria, 30 individuals were randomly selected and divided into three groups.

During the intervention phase, participants in the three groups engaged in their respective training programs for 8 weeks, with three 60-minute sessions per week. The overall program included 24 sessions, with each session consisting of 10 minutes of warm-up, 40 minutes of training, and 10 minutes of cool-down. Traditional training focused on specific weight training for the upper body, shoulder girdle, and core.

2.2. Measures

On the first day, the pre-test involved measuring static balance in archery. Demographic information including height, weight, age, and BMI was also measured for each participant. After the pre-test, participants were randomly assigned to three groups of 10.

At the end of the training period, immediately after the final session, the post-test included the same measurements as the pre-test. Throughout the study, two assistants with expertise in archery collaborated with the primary researcher.

2.3. Interventions

2.3.1. Traditional Exercises

The first group underwent traditional archery training (specific weight training for the upper body, shoulder girdle, and core) (8).

Bench Press: Lie on a bench with your back flat, grip the bar with hands shoulder-width apart, lower the bar to your chest, and press it back up. This exercise primarily targets the pectoralis major, posterior deltoids, and triceps brachii.

Lunges: Step forward with one foot, lowering your hips until both knees are bent at 90-degree angles. Ensure the front knee is directly above the ankle. Push back to the starting position and alternate legs. The primary muscles involved are the quadriceps, hamstrings, and gluteal muscles.

Shoulder Belt (Seated Row): Sit and hold the handles with a close grip. Pull the bar towards your chest using only your arms, then return to the starting position. This exercise targets the rhomboids, trapezius, latissimus dorsi, and deltoids.

Squats: Place a barbell on the upper back, keep the back straight, and bend the hips and knees to lower until the thighs are parallel to the ground. Return to the starting position. The primary muscles worked are the quadriceps, hamstrings, and gluteal muscles.

YTW: Lie on a bench with arms extended. Lift arms to form a 'Y' shape, then move them laterally to form a 'T', and finally pull them back to form a 'W'. This engages the quadriceps, hamstrings, and gluteal muscles.

Triceps Extension: Hold a dumbbell with both hands, lift it overhead, and lower it behind the head while keeping elbows close to the ears. This exercise primarily targets the triceps brachii.

Single-Leg Deadlift: Stand on one leg, hinge at the hips, and lower the torso towards the ground while keeping the back straight. Return to an upright position. This exercise focuses on the gluteal muscles.

Hamstring Curl: Lie face down on a machine with your ankles under the pads, curl your legs to bring your heels towards your glutes, and return to the starting position. This primarily targets the hamstrings.

Plank: Lie face down, support your body on elbows and toes, keeping the body in a straight line from head to heels. Hold for the designated time. This exercise engages the rectus abdominis, transverse abdominis, obliques, and erector spinae.

Isometric Side Rotation: On a Roman chair, place one hip on the pad, align your body in an isometric hold with a weight in hand, and hold for the designated time. This targets the obliques and quadratus lumborum.

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2.3.2. *TRX Exercises*

The TRX group performed suspension training exercises on the upper body, core, and shoulder girdle. The yoga group practiced 10 selected yoga exercises focusing on the upper body, core, and shoulder girdle (8).

TRX Chest Press: Facing away from the anchor point, grip the TRX handles, and angle your body. Bend elbows to lower the body to chest level, then extend elbows to return to the starting position. This primarily targets the pectoralis major, posterior deltoids, and triceps brachii.

TRX Suspended Lunge: Place one foot in both TRX stirrups, bend the weight-bearing knee while keeping the knee behind the toes, then return to the starting position. This exercise involves the quadriceps, hamstrings, and gluteal muscles.

TRX Shoulder Belt: Facing the anchor point, grip both handles with a close grip, angle your body straight. Extend the arms, then pull the body to chest level and return. This targets the rhomboids, trapezius, latissimus dorsi, and deltoids.

TRX Squat: Grip both handles facing the anchor point with a neutral grip, bend knees until thighs are parallel to the ground while using arms for balance, then return to the starting position. This primarily engages the quadriceps, hamstrings, and gluteal muscles.

TRX YTW: Facing the anchor point, grip both handles with arms extended. Perform the 'Y', 'T', and 'W' movements, returning to the starting position after each. This involves the quadriceps, hamstrings, and gluteal muscles.

TRX Triceps Extension: Facing away from the anchor point, grip both handles with arms extended overhead, bend elbows to 90 degrees, then extend back to the starting position. This primarily targets the triceps brachii.

TRX Single-Leg Deadlift: Place the back of one foot in both TRX stirrups, hinge at the hips while keeping the back straight and legs slightly bent, lower the torso, then return to an upright position. This focuses on the gluteal muscles.

TRX Hamstring Curl: Lie on the ground with each heel in a TRX stirrup, lift hips into a bridge position, curl the heels towards the glutes and return. This primarily targets the hamstrings.

TRX Plank: Lie on the ground, support the body on elbows and place the back of the feet in TRX stirrups, maintain a straight line from head to heels, and hold. This exercise engages the rectus abdominis, transverse abdominis, obliques, and erector spinae.

TRX Pallof Press: Stand sideways to the anchor point with both handles held at chest level, extend arms to press the handles outwards and return while keeping the body aligned. This targets the obliques and quadratus lumborum.

2.3.3. *Yoga Exercises*

Static balance was measured using a static balance analyzer, which indirectly measures body stability fluctuations based on the reaction of a static surface to forces caused by changes in the center of gravity. The device provides real-time, visual feedback for various parameters in two dimensions, both with eyes open and closed. The static balance analyzer has dimensions of 44x44 cm, with four sensors at each corner measuring forward, backward, left, and right fluctuations in percentages and centimeters. The device shows the stability of the center of gravity within circles ranging from 5 to 144 percent and other values, including standard deviation from the balance point, the length and width of the balance point in both percentages and centimeters, and the percentage presence of the center of gravity in various quadrants. The reliability and validity of this system are 0.70 and 0.90, respectively (9). To measure static balance, after preparing the device and providing necessary instructions, each participant stood barefoot on the device for 30 seconds, looking at a fixed point on the wall at eye level to prevent eye movement. Each participant was tested three times to increase reliability, with a two-minute rest between tests. The average score of the three trials was recorded as the individual's static balance score (15).

Halfway Lift: Bend forward at a 90-degree angle with straight knees, keeping the spine extended and parallel to the ground. This engages the back muscles and gluteal muscles.

Forward Fold: Bend forward, keeping knees slightly bent, support the upper body with a straight lower back, and slowly fold forward until the abdomen touches the thighs. Shift the hips upward to stretch the legs evenly, touching the ground or holding the ankles. This primarily targets the gluteal muscles, hamstrings, calves, and erector spinae.

Downward Facing Dog: Start on all fours, extend the elbows and relax the upper back, lift the knees off the ground and push the hips back to form an inverted V shape with the

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body. Straighten the legs. This exercise targets the back muscles, hamstrings, and triceps.

Upward Facing Dog: Lie face down, place hands near the waist, and lift the chest and head off the ground while keeping the legs extended and the tops of the feet on the ground. This primarily engages the quadriceps, hamstrings, glutes, trapezius, biceps, and deltoids.

High Plank: Assume a plank position with extended arms and open elbows, maintaining a straight body line from head to heels. This engages the rectus abdominis, transverse abdominis, obliques, and erector spinae.

Low Plank: Assume a plank position with elbows and forearms on the ground, maintaining a straight body line from head to heels. This targets the rectus abdominis, transverse abdominis, obliques, erector spinae, and deltoids.

Chair Pose: Bend knees and hold the upper body at a 45-degree angle, arms extended upwards, with a straight spine. This primarily involves the hamstrings, calves, thighs, latissimus dorsi, back, trapezius, deltoids, arms, and forearms.

Mountain Arms Up: Stand in mountain pose, arms extended upwards towards the sky with a slight back arch, elbows straight, and biceps near the ears. This engages the deep back muscles, abdominals, and lower trapezius.

Mountain With Open Arm Twist: Stand in mountain pose, reach one arm back and the other forward, rotating the chest while keeping hips and knees stable. The twist comes from the mid-body, and the gaze follows the backhand. This targets the deep back muscles, abdominals, and lower trapezius.

Warrior 1: Step one foot forward and the other back, arms extended at shoulder height, bend the front knee while keeping the back leg straight, and rotate the chest forward. This primarily targets the triceps, deltoids, serratus anterior, latissimus dorsi, quadriceps, hamstrings, sartorius, glutes, and calves.

2.4. Data Analysis

Data analysis involved independent t-tests, analysis of variance, and Bonferroni post hoc tests. Statistical analysis was conducted using SPSS version 26, with a significance level of $p \leq 0.05$.

3. Findings and Results

In the traditional exercise group, the age ranged from 23 to 34 years, with a mean age of 26.20 years (SD = 3.32). The height ranged from 176 to 183 cm, with a mean height of 179.50 cm (SD = 2.46). The weight ranged from 76 to 85 kg, with a mean weight of 79.40 kg (SD = 2.67). The BMI ranged from 22.94 to 26.83, with a mean BMI of 24.65 (SD = 1.01).

In the yoga group, the age ranged from 22 to 35 years, with a mean age of 27.10 years (SD = 3.84). The height ranged from 175 to 182 cm, with a mean height of 178.70 cm (SD = 2.21). The weight ranged from 72 to 86 kg, with a mean weight of 79.50 kg (SD = 4.62). The BMI ranged from 21.98 to 27.76, with a mean BMI of 24.92 (SD = 1.83).

In the TRX group, the age ranged from 23 to 37 years, with a mean age of 28.50 years (SD = 4.30). The height ranged from 176 to 183 cm, with a mean height of 179.30 cm (SD = 2.16). The weight ranged from 70 to 89 kg, with a mean weight of 79.20 kg (SD = 5.63). The BMI ranged from 22.34 to 27.47, with a mean BMI of 24.61 (SD = 1.42).

Table 1 presents the mean and standard deviation of the measured balance variables of the subjects, categorized into three groups, at the pre-test and post-test stages.

Table 1

Mean and Standard Deviation of Balance Variables by Research Groups at Pre-Test and Post-Test Stages

Stage	Group	Minimum	Maximum	Mean	Standard Deviation
Pre-Test	Traditional	13	15	14	0.667
	Yoga	12	15	13.90	0.994
	TRX	12	16	14.20	1.13
Post-Test	Traditional	9	13	10.80	1.31
	Yoga	8	12	9.50	1.17
	TRX	7	10	8.40	0.843

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To examine the data distribution, the Shapiro-Wilk test was used. The results indicated that the balance variable was not normally distributed ($P > 0.05$); therefore, non-parametric statistical tests were used for data analysis.

The results of the Wilcoxon statistical test to examine intra-group changes in archers' balance for the traditional exercises group ($Z = -2.687$, $P \leq 0.007$), the yoga group ($Z = -2.831$, $P \leq 0.005$), and the TRX group ($Z = -2.816$, $P \leq 0.001$) showed that a period of traditional, yoga, and TRX exercises significantly affected the balance of male archers.

To investigate the differences between traditional, yoga, and TRX exercises on archers' balance, the Kruskal-Wallis non-parametric equivalent of the ANOVA test was used. The results showed a significant difference in balance among the three groups of male archers ($P \leq 0.05$). Further analysis using the Mann-Whitney U test for pairwise comparison revealed significant differences between the post-test balance means of the traditional exercise group and the yoga and TRX groups; and between the yoga and TRX groups ($P \leq 0.05$). The comparison of means (Table 2) showed that the TRX group ($X = 8.40$), the yoga group ($X = 9.50$), and the traditional exercises group ($X = 10.80$) had the least fluctuation in balance, indicating the highest stability.

Table 2

Pairwise Comparison of Balance Among Different Groups Using the Mann-Whitney U Test

Groups	Traditional	Yoga	TRX
Traditional	----	0.036	0.001
Yoga	----	----	0.030

4. Discussion and Conclusion

The results of comparing the means in the pre-test and post-test stages for the effects of traditional, yoga, and TRX exercises on the balance of male archers indicated that these exercises positively impacted balance. The findings of the present study are consistent with the results of studies by Ni et al. (2014) (Karami et al., 2023) and Haith et al. (2018) (Karami et al., 2023). The results indicated that traditional exercises alone could have significant effects on the balance of male archers. Traditional exercises generally include weight training, balance exercises, and muscle strength training. Balance exercises can help strengthen the core muscles, which play a crucial role in maintaining body balance and stability. These exercises can include balance board training, single-leg balance exercises, and balance exercises using various tools such as balance balls and boards. Traditional training programs are often designed by coaches and fitness experts to meet the primary needs of athletes. As shown in the present study, regular and appropriate training programs can significantly improve the balance of male archers. Balance in archery is critical and plays a vital role in archers' performance. Balance is one of the key factors for achieving accuracy and power in shooting since it directly impacts execution skills, as noted in various studies (16). Body balance not only helps improve the strength of an archer's muscles but also assists in maintaining stability and steadiness while drawing the bow and shooting. With proper balance, an archer can accurately and stably aim and release the arrow (10). In archery, external factors such as wind and light can significantly affect shooting. With proper balance, an archer can best control their body and bow and effectively deal with external factors (10). Therefore, balance in archery plays a crucial role in achieving accuracy, power, stability, and controlling external factors. Through regular and continuous training to improve body balance and using relevant techniques, archers can enhance their performance and achieve better shooting results (17).

Additionally, balance exercises in yoga help archers improve their body consistency and maintain better balance when drawing the bow. As other studies on yoga exercises have shown, regular yoga practice can significantly improve muscle strength, endurance, flexibility, and balance (Boehde et al., 2005). The effectiveness of yoga on balance is due to the increase in muscle flexibility (Ghasemian Moghddam et al., 2022); the stretching during practice helps the body maintain balance in various static and semi-dynamic conditions and resist factors that disrupt balance (3, 18). Another effect of yoga exercises is increased blood

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circulation and oxygenation to the muscles, preparing them fully for contractions to maintain balance, which is very important (4). Yoga exercises include movements such as stretching, holding positions, and performing movements requiring hand and arm strength. Practicing yoga strengthens the hand and arm muscles, improving hand-arm stability when drawing the bow. Stability is a psychomotor phenomenon resulting from a combination of bodily movements and psychological processes; this ability is influenced by motor factors, meaning those who engage in specific training in this area will have higher stability. Researchers have shown that hand stability does not increase linearly with increased physical activity intensity; however, the relationship curve between hand tremor and physical activity difficulty level is positively accelerated (2, 19). This fact indicates that practice, especially exercises that are not solely strength-based like yoga, can lead to balance improvement.

TRX exercises also utilize your body's potential balance. Using TRX straps and cables, you can perform exercises that affect body balance. These exercises include movements such as balance on one foot and balance on the hands. Strengthening body balance through these exercises allows archers to have greater strength and stability when drawing the bow. Regarding TRX's impact on balance from a sensory perspective, it can be stated that since balance control involves the visual, vestibular, and proprioceptive systems, integrated in the brain and resulting in motor responses, and considering that physical activity can enhance balance (12), it can be concluded that TRX exercises improve and affect the input of these senses in maintaining balance (12). Additionally, from a physical perspective, exercises using body weight that improve muscle strength and endurance can contribute to increased balance.

The results of comparing the post-test means for the effects of the three types of exercises—traditional, yoga, and TRX—on the balance of male archers indicated significant differences among the three groups in their impact on balance ($P \leq 0.05$). Further pairwise comparisons revealed significant differences between traditional exercises and yoga and TRX exercises, as well as between yoga and TRX exercises. The comparison of means indicated that the TRX group, followed by the yoga group and the traditional exercises group, had the least fluctuation in balance, indicating the highest stability. Based on the results, it can be concluded that there is a significant difference between traditional, yoga, and TRX exercises in male archers' balance, with the TRX group, yoga group, and traditional exercises group showing the best balance performance. The TRX group, related to exercises performed using the TRX system, includes exercises utilizing TRX ropes and fitness systems. These exercises mainly focus on the body's core muscles but also simultaneously strengthen body balance. The TRX system can help build muscle strength and improve body balance (6, 20). This system challenges and enhances body balance using body weight, rope adjustments, and various training environments. Following TRX exercises, yoga is recognized as a physical and mental system focused on balance and coordination between body and mind. Yoga exercises primarily focus on flexibility, balance, and deep muscle strength. With yoga practice, individuals can increase their focus and improve the connection between body and mind (5). These factors can also help and enhance body balance. Traditional exercises are also effective strategies historically included in athletes' training programs, usually focusing on balance, flexibility, strength, and body coordination. These exercises can help body balance, strengthen muscles, and improve coordination between different body parts. To explain why the TRX group had the best balance performance, it can be stated that TRX exercises specifically target core muscles, including core, back, and lower body muscles. These exercises strengthen muscles, improving body balance. The specific nature of TRX exercises, using resistance bands and body weight targeting particular muscle groups critical for balance, may be a key reason for their effectiveness. Additionally, these exercises often involve balance-demanding movements, such as balancing on one foot or in more complex poses, and include a variety of exercises that impact the body in different ways (21-23). In contrast, yoga exercises generally include flexibility movements that enhance muscle and joint flexibility. Improved flexibility promotes body balance because more flexible muscles can better adapt to body changes and adjustments. Yoga also requires a high degree of mental focus and attention. These exercises can improve balance performance because mental focus and attention to body posture increase coordination between different body parts. Alongside these, traditional exercises involve a variety

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of combined exercises that specifically and generally affect balance and related muscles. In conclusion, all three training groups significantly focus on body balance. TRX exercises include movements requiring body balance and muscle strength. In the yoga group, there is a focus on body and mind balance, with various yoga poses and movements helping to strengthen body balance. Traditional exercises also include exercises that impact body balance and muscle strength. Strengthening core muscles (such as abdominal and back muscles) can improve body balance. Both TRX and yoga exercises often specifically target core muscles. Strong core muscles help prevent falls and promote balanced body strength. TRX and yoga exercises help you become aware of your body and focus on movements and breathing, which can improve balance. The results of the present study showed that TRX, yoga, and traditional exercises, respectively, had the most significant impact on balance.

Authors' Contributions

R.K.Z.V. conceptualized the study, designed the research methodology, and supervised the overall project implementation. Z.E.K., the corresponding author, conducted the data analysis using non-parametric statistical tests, interpreted the results, and led the drafting and revising of the manuscript. M.B. assisted with the recruitment of participants, facilitated the exercise sessions, and contributed to the literature review. S.P. supported the data collection and analysis process and helped in drafting sections of the manuscript. All authors participated in discussing the findings, critically reviewed the manuscript for important intellectual content, and approved the final version for publication.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study placed a high emphasis on ethical considerations. Informed consent obtained from all participants, ensuring they are fully aware of the nature of the study and their role in it. Confidentiality strictly maintained, with data anonymized to protect individual privacy. The study adhered to the ethical guidelines for research with human subjects as outlined in the Declaration of Helsinki.

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