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Effects of TRX Training on the Physical Performance of College Basketball Players

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Abstract

Background: College basketball is an intense sport that demands athletes to possess excellent explosive power, multi-directional agility, and high-intensity metabolic endurance. Common physical training programs often lead to a plateau during a long season. The TRX (Total Resistance Exercise) system offers an alternative. A comprehensive TRX system integrates suspension straps with plyometric boxes, agility ladders, resistance bands, and battle ropes. However, at present, there is a lack of sufficient long-term empirical data to enable an effective comparison between this complex system and conventional basketball training. Methods: Sixty male college basketball players were allocated randomly into a TRX training group (TTG, n = 30) or a conventional control training group (CTG, n = 30). Both groups participated in a 12-week program. The TTG used the complete TRX system, whereas the CTG carried out regular weight lifting and running on the court. The researchers assessed 11 physical performance parameters prior to and after the program. Results: After 12 weeks, the TTG showed considerable progress in all 11 evaluation indices ($p < 0.05$). However, the CTG experienced a decrease in linear sprint speed, dynamic balance, and maximum vertical jump height ($p < 0.05$). The Time × Group interaction effect demonstrated that the TTG had better functional agility, speed, and comprehensive court fitness changes. Conclusion: A 12-week complete TRX exercise program is more effective than conventional techniques in improving the physical ability of college basketball players. Coaches ought to incorporate this multisource system to avoid a reduction in speed and interruption of agility.

Keywords

TRX Training, Physical Performance, Basketball, Unstable Conditioning

1. Introduction

Modern college basketball is distinguished by vigorous intermittent physical exercise (Ziv & Lidor, 2009). In a normal game, the players carry out continuous sprinting, quick changes of position, and powerful jumping (Stojanović et al., 2018). These actions frequently take place with strong defensive opposition and physical collisions. Therefore, the athletes need to have a mixture of neuromuscular strength, agility, and aerobic capacity (Montgomery et al., 2010; Scanlan et al., 2011). Moreover, the basketball movements are not usually executed in a steady and symmetrical posture. The players have to accelerate and decelerate alternately by using single-leg pushing and landing techniques (Gonzalo-Skok et al., 2017; Spiteri et al., 2015).

Traditional strength and conditioning programs usually include weight lifting on stable ground, like heavy barbell squats and bench presses (Simenz et al., 2005), and linear track running as well as endurance running (Taylor, 2004). These common methods are very effective for increasing absolute strength in the initial off-season (Kraemer et al., 2002). However, the athletes often reach a training stoppage by using these methods for a long time. Bilateral resistance training with insufficient high-speed functional transfer may decrease muscle elasticity (Kubo et al., 2007). Consequently, this may result in a lower stretch-shortening cycle (SSC) of the muscles, causing slower linear sprint speeds and reduced vertical jump ability (Cormie et al., 2011).

In recent years, functional conditioning has become popular to overcome these training obstacles. The Total Resistance Exercise (TRX) training method is an illustration of this technique. Modern suspension training has greatly improved. A complete TRX training plan is not only done with simple bodyweight straps now. It also combines suspension exercises with plyometric boxes, agility ladders, resistance bands, and battle ropes.

This training system gives a special physiological effect. The unstable suspension straps make the core muscles stabilize the body when performing pushing and pulling movements (Mok et al., 2015). Meanwhile, the agility ladders and plyometric boxes improve fast footwork and lower limb explosiveness (Markovic, 2007). Furthermore, the exercises with battle ropes and resistance bands keep the muscles in constant tension, thus challenging both the anaerobic and aerobic energy systems at the same time (Chen et al., 2018). All these devices train the whole kinetic chain. This closed-chain, multi-planar method closely resembles the actual physical requirements of a basketball game (Behm et al., 2010).

Although the TRX system has some advantageous theories, there is a shortage of thorough empirical studies to evaluate its long-term effects in comparison with conventional exercises. Little investigation has been done on the influence of a multifunctional TRX system on all-around basketball fitness. Moreover, collegiate basketball players are the main subjects for this kind of research. These athletes participate in fierce competitions and have a heavy practice schedule. However, they usually do not have the individualized training and recovery resources that are provided to professional players.

Consequently, collegiate athletes are highly susceptible to training plateaus, muscle stiffness, and accumulated fatigue over the course of a long season. Identifying a time-efficient, multi-modal conditioning program is essential for their athletic development. Therefore, the primary objective of this study was to compare changes in physical performance among male collegiate basketball players following a 12-week comprehensive TRX training system versus a traditional physical training program. We hypothesized that the TTG would achieve significantly greater improvements across all tested variables. Specifically, we expected the TRX system to prevent the speed and vertical jump detraining effects often seen in traditional long-term programs.

2. Methods

2.1. Participants

Sixty male basketball players from Cangzhou Normal University voluntarily participated in this study. They were randomly assigned to either a TRX training group (TTG, n = 30) or a control training group (CTG, n = 30). The mean age, height, weight, and training years of the TTG were 22.780 ± 1.27 years, 180.883 ± 5.401 cm, 71.627 ± 8.386 kg, and 4.017 ± 0.846 years, respectively. The mean age, height, weight, and training years for the CTG were 20.630 ± 1.22 years, 181.800 ± 5.098 cm, 74.743 ± 6.745 kg, and 4.450 ± 1.086 years, respectively. Inclusion criteria required participants to have at least two years of competitive basketball experience and no history of severe musculoskeletal injuries in the past six months.

Male collegiate athletes were specifically selected for this research. First, these athletes face high-intensity competition schedules. Second, they have limited time for physical training due to heavy academic demands. Third, they generally lack highly individualized recovery resources. Therefore, finding a time-efficient and comprehensive conditioning system is highly practical for this population. Prior to the study, all participants signed an informed consent form.

2.2. Experimental Design and Training Protocol

This study utilized a randomized, pre-test and post-test experimental design. The training intervention lasted for exactly 12 weeks. Each training session lasted approximately 90 to 120 minutes, with rest intervals of 30 to 90 seconds. The TTG completed a comprehensive TRX training program. This multi-modal program included bodyweight suspension straps, medicine balls, plyometric boxes, agility ladders, resistance bands, and battle ropes. The CTG completed a traditional physical training program. This conventional program consisted of stable-ground weightlifting (such as barbell squats and bench presses) as well as straight-line sprints and endurance runs. Both groups performed identical standard warm-up and cool-down routines to isolate the effects of the main conditioning exercises.

Both groups of participants completed their respective exercise programs three times a week. Attendance rates were above 94 percent for both groups, and there were no dropouts. Therefore, all 60 participants were included in the final analysis.

2.3. Measures

Researchers assessed physical performance one week before the intervention (pre-test) and one week after the intervention (post-test). The testing sequence and environmental conditions were identical for all participants. The assessment included 11 specific variables divided into three physical domains:

- **Strength and Power:** Upper-body explosive power was measured using the seated medicine ball throw (SMBT). Core muscular endurance was evaluated using the one-minute sit-ups (OMSU) test. Lower-body power and maximum vertical explosiveness were measured using the standing long jump (SLJ) and the running to touch high (RTTH) test, respectively.
- **Speed, Agility, and Balance:** Linear acceleration was assessed using the 30-meter sprint test (30MST). Multidirectional agility and braking mechanics were measured with the T-type running test (TTRT). Dynamic balance was evaluated for both the left and right legs using the star excursion balance test (SEBTL and SEBTR). Joint flexibility was measured using the seated forward bend (SFB).
- **Basketball-Specific Conditioning:** Metabolic aerobic capacity was evaluated using the Yo-Yo intermittent recovery test level 1 (YYIR1). Comprehensive court fitness was assessed using the full-court dribble layup test (FCDLT). The FCDLT measures a complex combination of speed, endurance, and basketball technique under metabolic fatigue.

2.4. Statistical Analysis

Data analysis was performed using SPSS software (version 27.0.1). The descriptive statistics were expressed as means and standard deviations (SD). An independent-samples t-test was applied to examine differences in baseline demographic variables and physical fitness between the two groups prior to the intervention.

To assess the effectiveness of the training program, we conducted a repeated-measures multivariate analysis of variance (MANOVA). This model evaluated the main effects of time (pre-test and post-test) and group (TTG and CTG), as well as the Time × Group interaction. The partial eta squared (η_p^2) was calculated to report the effect size of the interaction. The statistical significance level was set at $p < 0.05$.

3. Results

3.1. Baseline Characteristics

Prior to the intervention, an independent samples t-test was conducted to verify the equivalence between the TRX training group (TTG) and the control training group (CTG). The baseline demographic and physical performance variables for both groups are shown in Table 1 and Table 2.

Table 1. Baseline characters of demographic characteristics (N = 60).

Variables	TTG (n = 30) Mean (SD)	CTG (n = 30) Mean (SD)	*t*-value	*p*-value
Age (years)	20.78 (1.27)	20.63 (1.22)	0.467	0.642
Height (cm)	180.883 (5.401)	181.800 (5.098)	−0.676	0.502
Weight (kg)	71.627 (8.386)	74.743 (6.745)	−1.586	0.118
Training years (years)	4.017 (0.846)	4.450 (1.086)	−1.725	0.090

Note: $^*p < 0.05$ indicates the significance level; SD: standard deviation; TTG: TRX training group; CTG: control group.

Table 2. Baseline characters of physical performance variables (N = 60).

Variables	TTG (n = 30) Mean (SD)	CTG (n = 30) Mean (SD)	*t*-value	*p*-value
SMBT (cm)	438.550 (48.122)	448.550 (42.385)	−0.854	0.397
OMSU (pcs)	42.530 (6.976)	45.670 (6.562)	−1.792	0.078
SLJ (cm)	268.300 (16.651)	266.817 (14.293)	0.370	0.713
30MST (s)	4.933 (0.371)	4.869 (0.314)	0.714	0.478
YYIR1 (level)	15.397 (0.497)	15.490 (0.453)	−0.761	0.450
TTRT (s)	11.380 (0.745)	11.042 (0.567)	1.977	0.053
SEBTL (cm)	85.959 (7.356)	88.578 (7.756)	−1.342	0.185
SEBTR (cm)	85.438 (7.428)	88.369 (7.241)	−1.548	0.127
SFB (cm)	12.833 (6.020)	14.137 (5.892)	−0.847	0.400
RTTH (cm)	303.900 (12.118)	308.070 (11.549)	−1.363	0.178
FCDLT (s)	61.072 (5.052)	58.299 (5.782)	1.978	0.053

Note: $^*p < 0.05$ indicates the significance level; SD: standard deviation; TTG: TRX training group; CTG: control group; SMBT: seated medicine ball throw; OMSU: one-minute sit-ups; SLJ: standing long jump; 30MST: 30-meter sprint test; YYIR1: Yo-yo intermittent recovery test; TTRT: T-type running test; SEBTL: star excursion balance test (left); SEBTR: star excursion balance test (right); SFB: seated forward bend; RTTH: running to touch high; FCDLT: full-court dribble layup test.

The statistical analysis showed that there were no significant differences between the two groups in all 11 physical performance variables at the beginning ($p > 0.05$). The initial physical performance variables were at the same level in both groups. These results indicate that the randomization procedure was effective. Both groups had the same initial ability, thus allowing us to conclude that any difference in the tests after the treatment is due to the specific training interventions rather than other interference factors.

3.2. Training Adaptations and Between-Group Differences

After the 12-week intervention program, measurements of physical performance revealed significant differences between the two groups in terms of both results and adaptation patterns. Table 3 summarizes the quantitative results for all measured variables, including both descriptive statistics (presented as means and standard deviations) and inferential statistics (highlighting the time × group interaction and its corresponding effect size).

Table 3. Changes in physical performance and time × group interaction effects (N = 60).

Variables	TTG Pre-test Mean (SD)	TTG Post-test Mean (SD)	CTG Pre-test Mean (SD)	CTG Post-test Mean (SD)	Interaction *F*	*p*-value	η_p^2
Strength & Power							
SMBT (cm)	438.550 (48.122)	462.700 (40.009)	448.550 (42.385)	450.550 (40.459)	26.513	< 0.001	0.314
OMSU (pcs)	42.530 (6.976)	46.030 (5.822)	45.670 (6.562)	45.800 (6.980)	13.575	< 0.001	0.190
SLJ (cm)	268.300 (16.651)	275.650 (14.593)	266.817 (14.293)	267.750 (14.279)	39.258	< 0.001	0.404
RTTH (cm)	303.900 (12.118)	307.230 (12.196)	308.070 (11.549)	307.400 (11.560)	67.138	< 0.001	0.537
Speed, Agility & Mobility							
30MST (s)	4.933 (0.371)	4.601 (0.302)	4.869 (0.314)	4.997 (0.412)	60.081	< 0.001	0.509
TTRT (s)	11.414 (0.768)	10.730 (0.779)	11.042 (0.567)	11.040 (0.710)	48.056	< 0.001	0.453
SEBTL (cm)	85.959 (7.356)	89.735 (7.690)	88.578 (7.756)	88.111 (7.735)	42.873	< 0.001	0.425
SEBTR (cm)	85.438 (7.428)	90.106 (7.852)	88.369 (7.241)	88.298 (7.228)	35.751	< 0.001	0.381
SFB (cm)	12.833 (6.020)	15.943 (5.889)	14.137 (5.892)	13.950 (5.287)	43.721	< 0.001	0.430
Specific & Conditioning							
YYIR1	15.363 (0.466)	15.883 (0.505)	15.490 (0.453)	15.550 (0.436)	44.041	< 0.001	0.432
FCDLT (s)	61.072 (5.052)	57.773 (5.146)	58.299 (5.782)	58.139 (5.639)	21.225	< 0.001	0.268

Note: **p* < 0.05 level of significance; TTG = TRX training group; CTG = control training group; Interaction *F*: F-statistic for individual variable main effects; η_p^2 = partial eta squared indicating effect size; SMBT = seated medicine ball throw; OMSU = one-minute sit-ups; SLJ = standing long jump; RTTH = running to touch high; 30MST = 30-meter sprint test; TTRT = T-type running test; SEBTL/R = star excursion balance test (left/right); SFB = seated forward bend; YYIR1 = Yo-Yo intermittent recovery test (Level 1); FCDLT = full-court dribble layup test. For 30MST, TTRT, and FCDLT, a lower numerical value indicates better performance.

The TTG showed significant variations in the above-mentioned tests. As can be seen from Table 2, the upper body power (SMBT) of the TRX athletes was, on average, raised by 24.150 cm, and their core endurance (OMSU) by 3.500 repetitions. They also strengthened their lower body explosiveness, which resulted in an increase of 7.350 cm in their standing long jump (SLJ). Moreover, their times in both the linear 30MST and the multidirectional TTRT were considerably shortened. Their dynamic balance and joint flexibility also improved greatly.

On the contrary, the CTG exhibited a partial and almost unchanged development. The control group only showed slight increases in upper-body and core strength in certain areas. Their functional performance decreased instead. As can be seen from **Figure 1**, the CTG lost lower-body explosiveness, which is indicated by a reduction in the maximum vertical jump (RTTH).

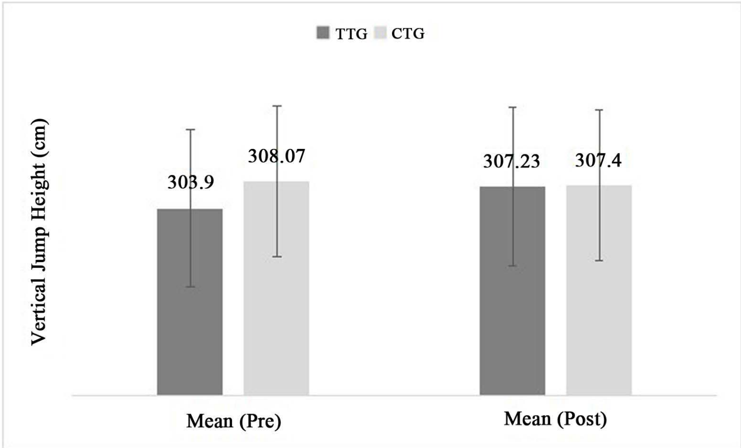

Figure 1. Bar chart for vertical jump.

In addition, their straight-line sprint speed also declined. **Figure 2** shows that the average time for the 30-meter sprint test (30MST) increased from 4.869 seconds to 4.997 seconds. Other key indicators, such as dynamic balance (SEBTL and SEBTR) and flexibility (SFB), not only failed to improve but actually declined slightly.

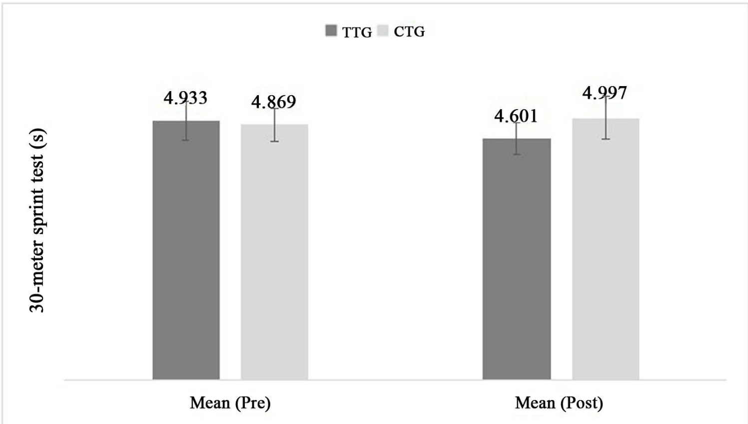

Figure 2. Bar chart for 30-meter sprint test.

The MANOVA analysis revealed a highly significant time × group interaction effect for all 11 variables ($p < 0.05$). This indicates that the TRX training system significantly outperformed the traditional training program in all test measures. This advantage was particularly pronounced in vertical power. The RTTH test exhibited the largest interaction effect size in the study ($F = 67.138$, $\eta_p^2 = 0.537$). Similarly, the TRX intervention was more efficient in improving linear speed (30MST, $F = 60.081$, $\eta_p^2 = 0.509$) and multidirectional agility (TTRT, $F = 48.056$, $\eta_p^2 = 0.453$).

This performance difference also persisted in metabolic adaptation training. The TTG group demonstrated improved aerobic capacity in the YYIR1 test ($F = 44.041$, $\eta_p^2 = 0.432$), whereas the CTG group showed no improvement. This advantage was particularly evident in the overall field fitness index. As shown in Figure 3, in the more demanding FCDLT test, the TTG group's completion time was reduced by an average of 3.299 seconds. In contrast, the CTG group showed no significant change. The interaction effect in the FCDLT test was highly significant ($F = 21.225$, $p < 0.05$, $\eta_p^2 = 0.268$).

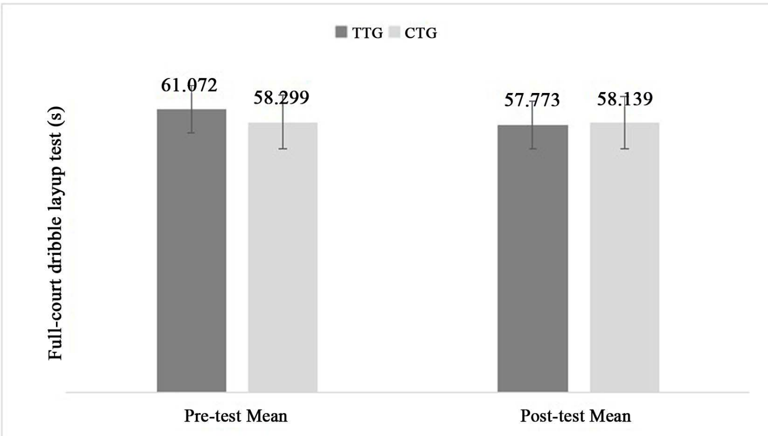

Figure 3. Bar chart for full-court dribble layup test.

Finally, TRX training not only increased initial strength but also transformed this strength into greater on-field speed, multidirectional agility, and metabolic endurance. In contrast, conventional weightlifting and running programs did not improve functional performance and failed to prevent declines in speed and vertical jump ability over the 12-week period.

4. Discussion

The primary objective of this study was to evaluate differences in physical fitness between college basketball players who underwent a TRX training program and those who followed a traditional physical conditioning plan. The results confirmed our initial hypothesis. The TRX training group demonstrated significant improvements across all measured indicators, including explosive power, change-of-direction agility, and metabolic endurance. In contrast, the traditional training group showed only slight improvements in upper-body and core strength, but failed to enhance the athletes' functional performance on the court. During the 12-week training period, this group experienced significant declines in both straight-line sprint speed and maximum vertical jump capacity. These results strongly suggest that for basketball players, multimodal TRX training is a superior method for overcoming training plateaus and preventing performance decline.

The TTG group achieved significant improvements in upper-body strength and core endurance. These changes are primarily attributed to the unique mechanism of action of the suspension straps. Suspension training creates an extremely unstable training environment. This instability prompts the central nervous system to activate deep stabilizing muscle groups to maintain posture (Byrne et al., 2014). Stronger core muscles provide an efficient link, enabling athletes to transfer force from the lower body to the trunk and subsequently to the upper limbs (Shinkle et al., 2012). Consequently, athletes who engage in TRX training have improved functional strength, reflected in enhanced throwing power and core strength.

In addition, TTG demonstrated significant improvements in both sprint (30MST) and agility (TTRT) capabilities. The entire TRX system involves closed-chain movements across different anatomical planes. Athletes must accelerate and decelerate through dynamic bodyweight exercises, which primarily enhance neuromuscular coordination (DiStefano et al., 2013). Besides, the use of plyometric boxes and agility ladders could effectively activate the stretch-shortening cycle (SSC) of the lower limbs. Quick footwork exercises could reduce the ground contact time and enhance the braking mechanism (Young, 2006). Thus, the TRX treatment not only strengthened the individual muscle groups but also efficiently trained the entire kinetic chain to produce force quickly, leading to better functional agility in playing basketball.

The main result of this research is the decrease in CTG performance. The traditional group showed a reduction in the maximum vertical jump height (RTTH) and had slower 30-meter sprint times (30MST). The traditional conditioning mainly depends on the barbell squats, which involve lifting heavy weights at a slow speed. Continuous practice of slow-speed resistance training may cause changes in the firing rate of fast-twitch muscle fibers (Pareja-Blanco et al., 2017). Moreover, lifting heavy weights without proper high-speed functional movements decreases muscle elasticity. This results in a decrease in efficiency in the stretch-shortening cycle (SSC) (Turner & Jeffreys, 2010). Therefore, this physiological change can account for the decline in jumping power.

Furthermore, the former scheme mainly used repeated linear running. The joint stress caused by heavy lifting and linear sprints is quite severe. Throughout a 12-week period, the athletes may gradually experience muscle fatigue in their periphery, which hides the increase in strength. As a result, their explosive ability and sprint speed will decrease (Gabbett, 2016). Thus, the previous program cannot meet the different and high velocity stimulation required for college basketball players.

Fast changes in offense and defense are predominant in present basketball. Such intense game parts often decide the result of the match (Petway et al., 2020). Quick starts and sudden stops are required at the beginning of the court changeovers. In addition, repeated explosive vertical jumps under great metabolic fatigue are also necessary (Delextrat & Cohen, 2008). Hence, the main purpose of any physical training program is to improve performance on the court.

The FCDLT indicates the difficult physiological demands. The TTG has a very high translation rate by greatly reducing the testing time. The TRX athletes take advantage of their enhanced linear sprint speed and multi-directional braking techniques to make quicker position changes on the court. Moreover, their greater maximum vertical jumping ability (RTTH) helps them to do better and more efficient layups close to the basket. The whole TRX training scheme can improve the athletes' core stability and kinematic chain efficiency even when they are tired aerobically (Prieske et al., 2016). In the end, the TTG is able to transform their individual physical strength into the performance of complicated basketball skills.

5. Limitations

This investigation possesses some inherent restrictions. First, the study sample consisted solely of male college basketball players; therefore, the findings cannot be generalized to female athletes, younger athletes, or professional athletes. Second, apart from supervised training sessions, the researchers did not strictly control the participants' daily dietary and sleep patterns. In order to more clearly demonstrate the training impacts, future research should include thorough nutritional examinations. Moreover, the treatment lasted for 12 weeks, which is adequate to detect substantial changes, but the continuous effects of TRX training throughout an entire competitive season are still unclear. Therefore, it is suggested that in subsequent studies, the periodicity of suspension training during the basketball season should be investigated.

6. Conclusion

In conclusion, a 12-week TRX training plan is more beneficial than a general physical fitness program for college basketball players. The TRX multi-functional system can enhance maximal vertical jump, change of direction agility, and specific metabolic endurance on the court. However, a program consisting of ground-stable weight-lifting and straight running may result in a decrease in linear speed and jumping ability. Thus, coaches and physical trainers of basketball should include comprehensive whole-body resistance exercises from various planes in their regular physical training routines. This combined approach is an effective and scientifically proven method to overcome development obstacles and improve playing performance on the court.

Ethical Approval

This project has been approved by the Ethics Committee of Beijing Sport University (Approval No.: 2025578H).

Author Contributions

TH: Designed, collected, analyzed data, wrote, and drafted this article. SS: Revised and finalized the manuscript. AB: Data interpretation. FJW: Copyediting.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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