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The Effect of Virtual Reality-Based Multimodal Training Programs on the Balance and Agility Skills of Young Soccer Players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. Young soccer athletes often demonstrate insufficient development of balance and agility, which may limit their overall performance. The integration of structured training programs with virtual reality (VR) technology offers a promising approach to enhancing these physical components.

Objectives. The study aimed to examine the effect of a VR-based multimodal training program integrating the FIFA 11+ protocol on balance and agility in young soccer players.

Materials and Methods. A randomized controlled trial with a pretest–posttest design was conducted involving 20 male soccer players aged 11–13 years. Participants were randomly assigned to an experimental group (VR-based training, n = 10) and a control group (conventional training, n = 10). The intervention lasted 8 weeks (3 sessions per week). Balance was assessed using the Stork Static Balance Test, and agility using the T-Test. Data were analyzed using mixed ANOVA with repeated measures, including evaluation of the Time × Group interaction, and effect sizes (Cohen's d).

Results. A significant Time × Group interaction was observed for balance ($F = 124.35$, $p < 0.001$) and agility ($F = 26.21$, $p < 0.001$). The experimental group demonstrated greater improvements in balance ($\Delta = 4.87$ s; $d = 1.07$) and agility ($\Delta = 0.83$ s; $d = 2.70$) compared to the control group ($\Delta = 1.37$ s; $d = 0.54$ and $\Delta = 0.31$ s; $d = 1.05$, respectively).

Conclusions. The findings indicate that VR-based multimodal training significantly improves balance and agility in young soccer players and can be considered an effective and innovative approach in youth soccer training programs.

Keywords: virtual reality, multimodal training, balance, agility, soccer.

Introduction

An athlete in a multifactorial sport, such as soccer, requires physical fitness, high technical skills, and well-developed tactical competencies. Many studies show that physical fitness has the greatest influence on overall physical performance of soccer players (Luo et al., 2023). Accordingly, athletic performance is largely determined by an athlete's physical, technical, and tactical capacities (Koopmann et al., 2020). In addition, integrating sport-specific exercises, particularly in youth soccer, into this routines can benefit physical performance and long-term physiological adaptation. Athletes who compete regularly require well-developed physical components particularly adolescents aged between 10 and 14 years and boys involved in sports activities that demand repeated jumping and agility movements (such as soccer, basketball, volleyball, and tennis)(Almousa et al., 2024; Chamera et al., 2023). Some studies define agility as rapid whole-body movement

involving changes in speed or direction in response to external stimuli such as ball movement, opponent movement, and teammate movement (Z. Zhao et al., 2026). Soccer players often perform complex maneuvers, such as rapid changes of direction, high-intensity sprints, and precise ball control, which require synchronized effort from both legs (Haddad, 2024). During actions such as kicking, passing, and jumping, players tend to rely predominantly on one leg, which demands well-developed balance capacity (DeLang et al., 2021). Therefore, young soccer players must develop good balance and agility skills to support the systematic development of movement quality.

Observations conducted with coaches at the Soccer School (SSB) in November 2025 revealed that the athletes' physical capacity was not yet optimal. The mean agility ability score measured using the T-Test agility showed 12.5 seconds categorised as low and below the normative profile of competitive young athletes. The mean balance score measured using the Stork Static Balance Test was 27 seconds, below the normative average for most people. Without targeted intervention, young soccer players will continue to experience deficits in physical performance, particularly in balance and agility. Targeted physical performance training is a highly effective intervention in sports training programs. . An increasing number of athletes and teams have adopted physical training programs as an important component of warm-up or exercise routines The goal is to improve the physical performance of young athletes through balance and agility components. FIFA11+ is one of the most eefective training programs to improving athletes' balance and agility (Aouadi et al., 2025). FIFA 11+ is a multimodal exercise programs derived from neuromuscular training principles (Belamjahad et al., 2025). Literature review, it is shown that there is positive evidence regarding the effect of the FIFA 11+ program on physical performance outcomes in young female athletes aged 9 years (Kambitta Valappil et al., 2025). Initially developed as an injury prevention protocol, the FIFA 11+ programs has also been shown to be effective in improving athletes' physical fitness more broadly (Nuhu et al., 2021). The integration of the FIFA 11+ programs with emerging sports technologies such as virtual reality (VR) can provide valuable insights into the true potential of technology-enhanced training compared to traditional methods (K. Zhao & Guo, 2022). VR can be utilized to enhance the performance of individual athletes and serve as a valuable tool for coaches and teams in designing more effective physical and tactical strategies. VR can transform training sessions into engaging and immersive experiences, making practice more enjoyable and motivating for athletes (Richlan et al., 2023). According to Shousha et al., (2021), VR training can improve static and dynamic balance in soccer athletes aged 12-16 years. Virtual reality training has also been shown to be an enjoyable medium that increases agility in adults (Wang, 2023). The benefits of VR in complementing conventional training include the creation of an immersive multisensory environment and the facilitation of faster and more effective motor pattern development.

To date, virtual reality research has largely focused on physical fitness, injury rehabilitation, and education. However, physical performance training programs targeting the balance and agility components of young soccer athletes through FIFA 11+-integrated VR multimodal training have not been studied. This study therefore presents an opportunity to investigate the effects of VR-based multimodal training on young soccer athletes. By targeting the physical components of balance and agility, training interventions can prevent young soccer athletes from failing to reach their developmental potential. This study uses the FIFA 11+ protocol with VR-based multimodal training to improve balance and agility. The VR simulation is interactive, enabling the enhancement of balance and agility in young soccer players. The insights gained will inform the development of balance and agility training strategies through VR-based multimodal exercises for young soccer players.

Materials and Methods

Participants

The participants in this study were young male soccer athletes aged 11 to 13 years. This study was carried out from January to March 2026 at a soccer training center in Indonesia. The sample comprised 20 athletes recruited using random sampling and subsequently allocated at random to one of two groups. The experimental group (n = 10) received VR-based multimodal training, while the control group (n = 10) underwent conventional training without virtual reality. The sample must meet certain inclusion criteria, including having been a registered soccer club athlete for at least one year, being male, and being physically active with a training frequency of three sessions per week. Exclusion criteria included any current illness that could affect physical activity or physical condition at the commencement of the study. Participants were also excluded if they had a history of medical conditions. All participants were first given an explanation of the objectives of the study as well as the initial conditions required to participate in the activity. Written informed consent was obtained from all participants prior to commencing the study. In addition, the testing procedure was explained thoroughly and in detail, with special emphasis on important aspects to minimize the risk of injury during the study.

Study Design

This study uses a quantitative approach with a randomized controlled trial design pretest and posttest. The research was conducted for 8 weeks from January to March 2026. This design is to determine the effect of virtual reality-based multimodal training programs compared to conventional training methods in improving the balance and agility of young soccer athletes (fig. 1).

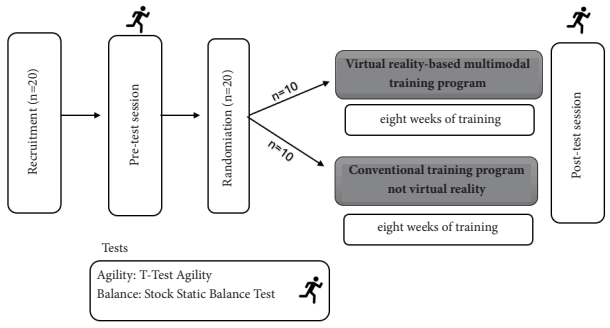

Fig. 1. Experimental Design of the Study

Procedures and Instruments

The procedural sequence consisted of three stages: pre-test, program intervention, and post-test.

Pretest

The measurement test was initiated to measure balance using the Stork Static Balance Test and to measure agility using the T-Test Agility. Measurements were carried out with the same procedure on all subjects to ensure data consistency.

Program Intervention

The training program was carried out 3 times per week for 8 weeks. Virtual Reality ExperimentalGroup: Research subjects performed a VR-based multimodal training programme using the Meta Quest 2 device, integrating the FIFA 11+ protocol for 20 minutes per session, incorporating balance training, core stability, plyometric exercises, and agility drills.

This exercise using virtual reality tools has interactive aspects, security, and affordability of use. In the context of soccer, virtual reality-based multimodal training was developed to replicate the game conditions of the sport of soccer through controlled simulations, including response to visual stimuli, the ability to change direction dynamically, and the integration of movement coordination. This approach allows athletes to adapt to the situational demands of the game in a more specific and measurable way. The control group conventionally had a training program consisting of agility exercises: shuttle run, ladder drill; balance exercises: ladder drill + balance, plyometric exercises: box jump and lateral jump for 30 minutes per session. Conventional training was conducted without virtual reality and was designed for general youth soccer training.

Table 1. FIFA 11+ Virtual Reality-based integrated multimodal training program

Training Unit Components	Movement Name	Description
Part 1 - Running Exercises (6 Movements for 8 minutes)	Running Straight Ahead	Run straight for about 40 m, then run back
	Running Hip Out	Walk/run while rotating the hips outward
	Running Hip In	Walk/run while rotating inward
	Running Circling Partner	Running around a partner (about 2 m)
	Running Shoulder Contact	Run side by side shoulder contact
	Running Quick Forwards & Backwards	Run forward and backward quickly
Part 2 – Strength, Balance & Plyometrics (15 Movements for 10 Minutes)	Level 1 (Beginner)	
	The Bench (Static)	Static plank push-up position
	Sideways Bench (Static)	Static side plank
	Hamstrings (Beginner)	Two-legged bridge, heels on the floor
	Single-Leg Stance	Stand on one foot
	Squats (With Toe Raise)	Squat + lift heels
	Jumping – Vertical Jumps	Vertical jump, soft landing
	Level 2 (Intermediate)	
	The Bench (Alternate Legs)	Plank + alternate leg raises
	Sideways Bench (Raise Lower Hip)	Side plank hip lift
	Hamstrings (Intermediate)	One-legged bridge
	Single-Leg Stance (Throwing Ball)	One foot + throw and catch the ball
	Squat (Walking Lunges)	Forward lunge step
	Jumping – Lateral Jumps	Side jump on one foot
	Level 3 (Advanced)	
	The Bench (One Leg Lift & Hold)	Single-leg plank hold
	Sideways Bench (With Leg Lift)	Side plank + leg lift
	Hamstrings (Advanced)	Nordic hamstring exercise
	Single-Leg Stance (Partner Push)	One foot + partner's push
	Squats (One-Leg Squats)	Single-leg squat
	Jumping-Box Jumps	Jump to the box + controlled landing
Part 3 – Running Exercises (3 Moves for 2 Minutes)	Running Across the Pitch	Sprint across the field
	Running Bounding	Run with explosive long strides
	Running Plant & Cut	Run, stop, change direction sharply

Fig. 2. Virtual reality-based multimodal training

Instruments

Agility: T-Test Agility

Time counting begins when participants cross the start/finish line of the start time counter and stops when they return to the finish line. Three attempts were conducted with a rest interval of 2–3 minutes between each attempt, and the best time was recorded. The T-Test agility test is conducted using the standard version as reported in the literature i.e. forming a distance of 10 × 10 m.

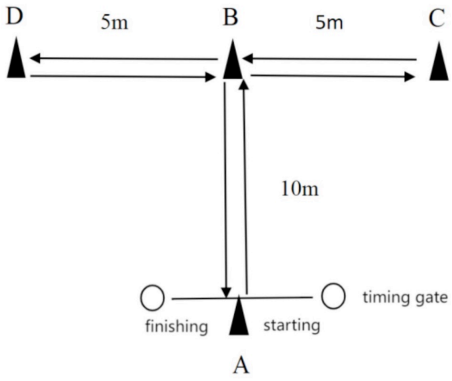

Fig. 3. T-Test Agility

Balance: Stork Static Balance Test

Balance was measured using the Stork Static Balance Test. 'Participants stood upright with both hands on the hips and placed the non-dominant foot against the inner knee of the stance leg, then lifted the heel of the stance foot off the ground on the signal "go". Participants are asked to maintain this position as long as possible. The test ends when the raised heel touches the ground or when the supporting foot moves away from the knee. Tested over 3 trials, the best score is used. The test–retest reliability is 0.86

Post-test

After the intervention was completed over 8 weeks, participants were reassessed using the same instruments as in the pre-test stage. The post-test results were then compared with the initial measurements to determine the level of improvement in balance and agility.

Statistical Analysis

Data were analysed using SPSS version 23, the normality of data distribution was tested using the Shapiro–Wilk test and Levene's test was used to confirm homogeneity of variance. Descriptive statistics were used to determine the basic parameters of the test results in each group (experiment and control) at the initial and final test stages (mean; standard deviation). To test the hypotheses and analyse differences between initial and final test scores within and between groups, a mixed ANOVA with repeated measures was employed to evaluate changes over time and compare subjects' scores from both groups. In all tests, the confidence level used was 0.05. In addition, Cohen's d coefficient was included as an indicator of effect size. The criteria for effect size were set as follows: negligible (<0.20), small (0.20–0.50), medium (0.50–0.80), and large (>0.80).

Results

Description of Research Data

The description of the data shows the average values of balance and agility before and after the intervention in the virtual reality (experimental) group compared with the conventional (control) group.

Based on Table 2 the experimental group (virtual reality) showed significant descriptive results. The mean balance value increased from 35.82 to 40.69 seconds, while agility increased from 12.16 to 11.33. The experimental group recorded significant differences in balance and agility between the pre-test and post-test compared to the control group, which showed small variations as shown in the table above.

Preliminary Assumption Tests

Normality Test

The data normality test used the Shapiro-Wilk method with a significance level of 0.05.

Table 2. Descriptive Statistics of the Experimental Group vs Control Group

Variable	Experimental					Control			
	N	Min	Max	Mean	SD	Min	Max	Mean	SD
PreTest Balance	10	27.86	42.75	35.82	4.80	28.96	36.41	32.40	2.52
PostTest Balance	10	33.82	48.73	40.69	4.82	30.77	38.13	33.77	2.55
PreTest Agility	10	11.68	12.70	12.16	0.34	12.10	13.01	12.60	0.31
PostTest Agility	10	10.97	11.78	11.33	0.27	11.95	12.69	12.30	0.26

Table 3. Normality Test Results

Variable	Sig. Experimental	Sig. Control	Description
Pre-test Balance	0.945	0.787	Normal
Post-test Balance	0.867	0.346	Normal
Pre-test Agility	0.847	0.705	Normal
Post-test Agility	0.676	0.280	Normal

The results of the normality test showed that all pre-test, post-test, balance and agility variables as well as experimental and control had a significance of $p > 0.05$ so that it could be concluded that the data were distributed normally and met the assumptions of parametric analysis.

Homogeneity Test

Table 4. Homogeneity Test Results

Variable	Sig.	Description
Pre-test Balance	0.62	Homogeneous
Post-test Balance	0.85	Homogeneous
Pre-test Agility	0.736	Homogeneous
Post-test Agility	0.872	Homogeneous

The results of the homogeneity test showed that the variance across all groups was homogeneous ($p > 0.05$).

Hypothesis Test

Mixed Anova Test

Hypothesis Test of Virtual Reality-Based Exercise on Balance

Table 5. Summary of Hypothesis Testing of Virtual Reality on Balance

Source	Type III Sum of Square	Df	Mean Square	F	Sig.	ηp^2
Time	97.188	1	97.188	393.044	0.000	0.956
Time*Group	30.748	1	30.748	124.348	0.000	0.874
Error (Time)	4.451	18	0.247			

Based on the results of table 5 on the Time x Group row, the value of $F = 124.348$ ($p<0.05$) means that there is a Time x Group interaction.

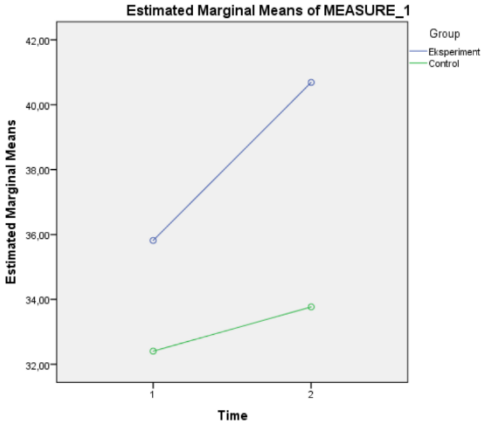

Fig. 3. Plot of the Experimental Group and the Control Group

Figure 3 Shows that there is an interaction between the experimental group and the control group across the pre-test and post-test measurement points.

Hypothesis Test of Virtual Reality-Based Exercise on Agility

Table 6. Summary of Hypothesis Test of Virtual Reality on Agility

Source	Type III Sum of Square	df	Mean Square	F	Sig.	ηp^2
Time	3.336	1	3.226	123.186	0.000	0.873
Time*Group	0.686	1	0.686	26.210	0.000	0.593
Error (Time)	0.471	18	0.026			

Based on the results of Table 6 in the Time x Group row, it shows an F value = 26.210 ($p<0.05$) which means there is a Time x Group interaction.

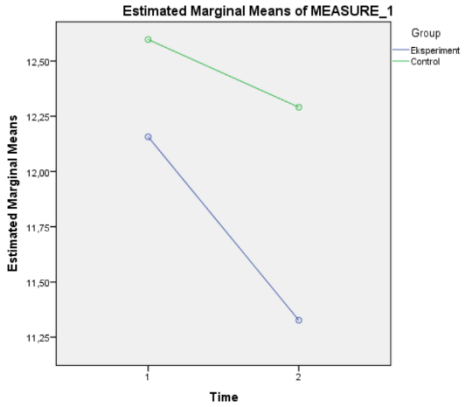

Fig. 4. Plot of the Experimental Group and the Control Group

Figure 4 shows that there is an interaction between the experimental group and the control group during the pre-test and post-test.

Table 7. Effect Size (Cohen' d)

Variable	Group	Δ (Change)	Effect Size (d)	Category
Balance	Experimental	+4.87 seconds	1.07	Large
	Control	+1.37 seconds	0.54	Medium
Agility	Experimental	+0.83 seconds	2.70	Very Large
	Control	+0.31 seconds	1.05	Large

Effect size analysis showed that virtual reality-based interventions had a large impact on balance and a very large impact on agility. The effect size value was very large ($d > 0.80$) in the experimental group (virtual reality) compared to the control group.

Discussion

This study provides evidence that FIFA 11+-integrated VR-based multimodal training has a significant impact on the balance and agility abilities of young soccer athletes. The significant Time × Group interaction indicates meaningful difference in pre-test and post-test scores between the experimental and control groups, as illustrated in Figures

3 and 4. Another study highlights the significant positive impact of the integration of virtual reality technology in improving the physical components of young female soccer players (Makhadmeh & Fayad, 2025). Consistent with these findings, the VR-based experimental intervention produced markedly greater improvements in balance and agility than the conventional control condition. In conventional sports training, motivation and comfort tend to decline as training intensity increases; however, the present study found that intensity and comfort of sports training in the higher intensity phase through VR (Giakoni-Ramírez et al., 2023). These findings should be interpreted with consideration of the specific characteristics of the participants, who are young soccer athletes aged 11 to 13 years. The literature reveals that high-achieving young athletes who start playing earlier in sports involving more specific training demonstrate faster progress than those who begin later (Güllich et al., 2022). This idea supports the theoretical suggestion about the developmental phases of young athletes' talent, one of which is the early enhancement of physical capacity before the secondary specialization period in the form of specialized training. Specialised warm-up training in the form of FIFA 11+ with VR technology improves proprioception and neuromuscular control by providing visual stimulation to users as they perform athletic movements carried out in a safe environment (Pangestuputra & Changestu, 2024). Given that soccer demands a high level of physical conditioning, incorporating training elements such as balance and agility into warm-up routines is particularly important (Barbour et al., 2024). Bukowska et al., (2021) found that body balance improves with an increase in the duration and intensity of exercise. The present study's multimodal training programme incorporates movement components specifically targeting balance and agility. a menu of multimodal training programs contains movements that resemble components for balance and agility.

The multimodal integrative training derived from FIFA 11+ encompasses balance training, core stability work, plyometrics, and agility drills which may be a concern due to potential cumulative effects. However, systematic reviews report that concurrent training is more effective than single-mode plyometric or balance training in improving agility and balance in children and adolescents (Blavt et al., 2023; Sun et al., 2025). Multimodal training has a component of virtual reality-based agility training that can affect athletes' agility. In line with Li et al. (2025) the effectiveness of virtual reality training in improving athletes' physical abilities includes speed, flexibility, and agility. The improvement of balance and agility based on virtual reality is greater than conventional. Similarly, Cariati et al., (2025) revealed that virtual reality training was better than conventional training control groups with regard to the balance of young soccer athletes aged 15 to 16 years.

The present study demonstrates that a training program of three sessions per week over 8 weeks significantly improves agility. Arede et al., (2022) demonstrated that a similar multimodal protocol based on the FIFA 11+ framework, conducted twice weekly over six weeks, improved agility in 11-year-old athletes. Meanwhile, FIFA 11+ using virtual reality shows success in simultaneously improving balance and agility in athletes who trained for 8 weeks (Davidovica et al., 2025; Panchal et al., 2025). Research findings by Demeco et al., (2024) show that VR is superior to other forms of training because it provides more immersive and engaging information, and effectively improves cognitive perceptual skills. This study provides an additional improvement in the performance of young soccer players through a multimodal training program. These findings suggest that VR-based training represents a technologically advanced alternative to conventional training approaches. Although the findings are promising, several limitations should be acknowledged. Future studies are recommended to adopt longitudinal designs with larger and more diverse samples, accounting for gender and age range, over extended study durations..

Conclusions

Based on the findings of this study, it can be concluded that virtual reality-based multimodal training can improve the balance and agility of young soccer athletes. In addition, from the data, the increase statistically has more impact than conventional training. Virtual reality-based training enhances physical performance through an immersive, engaging, and effective training experience. This positions VR-based multimodal training as an innovative method in the field of training technology for modern soccer. Thus, further research is recommended for a longer research time and a wider sample to obtain more detailed data.

Ethics Approval

The research was conducted in accordance with the principles of the code of ethics. The research protocol was reviewed and approved by the Ethics Committee of Universitas Negeri Yogyakarta (No. T/1423.1/UN34.9/PT.01.04/2025).

Data Availability Statement

Open access.

AI Transparency Statement

No AI tools were used in this study.

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Conflicts of Interest

All authors must declare any potential conflicts of interest.

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Вплив мультимодальних програм тренувань на основі віртуальної реальності на показники рівноваги та спритності юних футболістів

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 12 с., 5 табл., 4 рис., 39 джерел.

Обґрунтування. Юні футболісти часто демонструють недостатній рівень розвитку рівноваги та спритності, що може обмежувати їхню загальну результативність у грі. Інтеграція структурованих тренувальних програм із технологіями віртуальної реальності (VR) є перспективним підходом до вдосконалення цих фізичних складових.

Мета дослідження. Метою дослідження було вивчити вплив мультимодальної програми тренувань на основі VR, що інтегрує протокол FIFA 11+, на показники рівноваги та спритності юних футболістів.

Матеріали і методи. Проведено рандомізоване контрольоване дослідження за схемою претест–посттест із залученням 20 футболістів чоловічої статі віком 11–13 років. Учасників було розподілено за методом рандомізації на експериментальну групу (тренування на основі VR, n = 10) та контрольну групу (традиційні тренування, n = 10). Інтервенційна програма тривала 8 тижнів (3 заняття на тиждень). Для оцінювання рівноваги використовували тест статичної рівноваги «Лелека», а спритність вимірювали за допомогою t-критерію Стьюдента. Аналіз даних проведено із застосуванням змішаного двофакторного дисперсійного аналізу з повторними вимірюваннями, включаючи оцінку взаємодії чинників «Час × Група» та розміри ефекту (d Коена).

Результати. Виявлено значущу взаємодію чинників «Час × Група» для показників рівноваги ($F = 124,35$, $p < 0,001$) та спритності ($F = 26,21$, $p < 0,001$). В експериментальній групі зафіксовано суттєвіше покращення рівноваги ($\Delta = 4,87$ с; $d = 1,07$) та спритності ($\Delta = 0,83$ с; $d = 2,70$) порівняно з контрольною групою ($\Delta = 1,37$ с; $d = 0,54$ та $\Delta = 0,31$ с; $d = 1,05$ відповідно).

Висновки. Отримані результати свідчать, що мультимодальні тренування на основі технології VR достовірно покращують рівновагу та спритність юних футболістів, і їх можна розглядати як ефективний та інноваційний підхід у програмах підготовки юнацького футболу.

Ключові слова: віртуальна реальність, мультимодальне тренування, рівновага, спритність, футбол.

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