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Effects of visual feedback–guided core stabilization on transversus Abdominis function and sprint performance in elite collegiate sprinters

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Abstract: Sprinting efficiency depends on rapid force production and coordinated transfer of ground reaction forces between the lower limbs and the trunk. The transversus abdominis (TrA) stabilizes the deep core and facilitates segmental control of spinal function and regulation of intra-abdominal pressure. An impairment in the function of this muscle results in inefficient force transfer and performance deficits in sprint athletes. This randomized controlled trial investigated the effects of a visual-feedback–based core stabilization program on TrA function, lower-limb isokinetic strength, and 100-meter sprint performance in elite male collegiate sprinters. Twenty-two athletes were assigned to either a visual-feedback core exercise group or a standard core exercise group, and both groups performed a 12-week intervention consisting of three sessions per week. TrA activation was assessed using surface electromyography, TrA thickness was measured via ultrasound, and quadriceps and hamstring concentric peak torque at 180°/s was evaluated using an isokinetic dynamometer. Sprint performance was judged based on the fastest time across three 100-meter trials. The visual-feedback group showed significantly greater increases in TrA activation and TrA thickness than the standard core exercise group ($p < 0.05$). Both groups demonstrated improvements in quadriceps and hamstring strength, although enhancements were more pronounced in the visual-feedback intervention. Only the visual-feedback group showed a significant reduction in the 100-meter sprint time ($p < 0.05$), indicating effective translation of physiological adaptations to sport-specific performance. These findings suggest that visual-feedback–guided core stabilization may enhance deep trunk function, lower-limb force generation, and competitive sprint performance in elite athletes.

Keywords: *Core stabilization, Elite athletes, Sprint performance, Surface electromyography, Transversus abdominis, Visual biofeedback.*

1. Introduction

Sprinting performance depends on rapid force production and coordinated transfer of ground reaction forces between the lower limbs and trunk. Short-distance sprinting events, such as the 100-meter sprint, require explosive power and precise neuromuscular control, with final race outcomes often determined by hundredths of a second [1, 2]. Trunk stability is essential for maintaining stride mechanics during acceleration and maximal velocity phases, and inadequate proximal control increases energy loss and compromises force transfer [3-5].

The transversus abdominis (TrA) muscle is a key deep core stabilizer that allows segmental spinal control and intra-abdominal pressure regulation [6-8]. Reduced TrA activation destabilizes the trunk, increases pelvic motion, and elevates the risk of injury in speed-power athletes [9-11]. Hamstring strains, lumbar dysfunction, and Achilles tendon disorders are reportedly very common among competitive sprint populations, suggesting a relationship between core impairment and lower-limb pathology [12].

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Training to improve core stabilization enhances neuromuscular coordination and athletic performance; however, conventional programs for elite athletes rely heavily on subjective perception of muscle contraction, making selective TrA activation difficult [13-15]. Visual biofeedback offers real-time information on contraction intensity and timing, facilitating motor learning and improving selective muscle recruitment [16-18]. Although ultrasound and pressure-based biofeedback have been reported to enhance deep trunk activation in clinical populations, evidence in elite sprint athletes remains limited.

This study investigated the effects of visual-feedback–based TrA training on TrA activation, TrA thickness, lower-limb isokinetic strength, and 100-meter sprint performance in elite male collegiate sprinters. We hypothesized that visual feedback would lead to greater improvements in deep core function and sport-specific performance than standard core stabilization training.

2. Materials and Methods

2.1. Study Design

This randomized controlled trial was approved by the Institutional Review Board of Eulji University (IRB NO. EU24-78). A total of 24 elite collegiate male sprinters in their 20s were recruited from the K University of Sport in Seoul, Korea. All participants were officially registered with the Korea Association of Athletics Federations and affiliated with the Korea University Athletics Federation. Elite athletes were defined as sprinters who had competed in at least one national-level competition within the past year and had participated in structured training programs scheduled more than four times per week [19].

Participants were included if they met the following criteria: (1) registered collegiate sprinter, (2) at least 5 years of continuous sprint training experience, (3) no musculoskeletal or cardiovascular disorders that could influence study outcomes, and (4) voluntary participation after receiving full information about the study procedures and signing written informed consent. Exclusion criteria were: (1) orthopedic disease or surgery of the hip or knee joint within the last 6 months [20], (2) ankle surgery within the last 3 months [21], (3) injury occurring during the intervention period [22], and (4) adherence to the intervention protocol below 80% [23].

Simple randomization was used to allocate participants into two groups: the visual-feedback core stabilization exercise group (VF group) and the standard core exercise group (SC group). Group names were prepared in equal numbers, sealed in opaque envelopes, and selected individually by participants to ensure unbiased allocation. Initially, 24 athletes were enrolled (n = 12 per group); however, two athletes sustained injuries unrelated to the intervention and were excluded. Therefore, the final analysis included 22 participants (VF: n = 11; SC: n = 11).

Table 1.
General characteristics of participants in this study.

Variable	VF-Core	ST-Core	*p*
Age (yrs)	21.73± 0.90[a]	21.18± 1.16	0.235
Height (cm)	180.9± 3.2	178.2±5.7	0.373
Weight (kg)	71.45± 3.23	70.64±5.14	0.660
BMI (kg/m²)	22.05 ± 1.31	22.68 ± 1.01	0.423

Note: a mean±SD.
*p<0.05.
VF-Core: Visual Feedback Core Stabilization Group.
ST-Core: Standard Core Exercise Group.

2.2. Measurement Methods and Tools

2.2.1. TrA Activation (Surface Electromyography [EMG]).

TrA activation was assessed using an EMG-based visual feedback system (Blueback Physio EMG, France), which provides real-time information on contraction intensity and timing. TrA activation was evaluated through 13 standardized tasks recommended by the Blueback Physio protocol, including breathing control, static posture tasks, plank variations, and lower-limb functional movements such as squats and lunges. These tasks were designed to assess reflexive activation, voluntary contraction, and muscular endurance under progressive loading. Surface electrodes were placed 2 cm medial and 2 cm inferior to the anterior superior iliac spine (ASIS), with a reference electrode positioned above the iliac crest in accordance with manufacturer guidelines (Fig. 2) [24]. Previous research has demonstrated high criterion validity of this system, showing strong correlations between surface EMG recordings and ultrasound imaging of deep abdominal muscle function [25].

2.2.2. Tra Muscle Thickness (Ultrasound)

TrA thickness was measured using real-time B-mode ultrasound with a linear probe (Philips Healthcare, Netherlands). Participants were assessed in the supine position, with the hips shoulder-width apart, knees flexed to 90°, and abdominal muscles relaxed. The probe was placed transversely on the abdominal wall between the anterior and mid-axillary lines, midway between the twelfth rib and the iliac crest, following established protocols [26]. Images were obtained at the end of a relaxed expiration, and measurements were repeated three times on each side; the mean value was used for analysis [27]. Ultrasound assessment of TrA thickness has yielded excellent intra-rater reliability (ICC = 0.98) and high inter-rater reliability (ICC > 0.90) [28]. It has been widely used as a structural indicator of deep core adaptation associated with improvements in spinal stabilization [16, 29]. Therefore, TrA thickness was selected as a primary structural outcome to evaluate long-term adaptation beyond immediate changes in muscle activation.

2.2.3. Isokinetic Knee Strength Assessment (Cybex HUMAC Norm)

Isokinetic strengths of the quadriceps and hamstrings were assessed using an isokinetic dynamometer (Cybex HUMAC Norm, CSMi, USA). Testing was performed in a seated position, with the trunk, pelvis, and tested thigh stabilized using straps to minimize compensatory movement. Concentric knee extension and flexion of both limbs were evaluated at an angular velocity of 180°/s. Each participant completed three maximal repetitions, and peak torque (Nm) was recorded. Relative strength was calculated by normalizing peak torque to body mass (Nm/kg). The Cybex system has yielded high reliability and validity for quantitative lower-limb strength assessment, particularly when measuring knee flexor and extensor strength (ICC ≈ 0.85) [30]. Accordingly, isokinetic strengths of the quadriceps and hamstrings were selected as primary outcome variables.

2.2.4. 100-Meter Sprint Performance Assessment

Sprint performance was measured using a handheld digital stopwatch with 1/1000 s resolution (CASIO HS-70W, Japan). Participants completed three 100-meter sprint trials on an official outdoor track using their habitual start technique. Timing was initiated at the athlete's first movement, and the fastest record was used for analysis. A trained sprint coach performed all measurements, and adequate rest intervals were provided between trials to minimize fatigue. Manual timing by experienced evaluators has achieved high reliability in 100-meter sprint assessments (ICC ≈ 0.98) [31].

2.3. Interventions

Both groups completed a 12-week core stabilization program, three sessions per week, with each session lasting approximately 50–60 minutes. All sessions began with a common warm-up routine and were supervised by licensed physical therapists with at least 2–5 years of clinical experience in sports physical therapy. The intervention was conducted at the K University sports physical therapy clinic and the university's weight training facility. All sessions were standardized to ensure consistent training conditions. Participants were instructed to refrain from performing any additional core-specific exercises during the intervention period.

2.3.1. Common Exercise Program

The common exercise program used in this study is presented in Table 2. This program was adapted from the lower-extremity strengthening protocol reported by Hammami et al. [32], which demonstrated improvements in agility, maximal lower-limb power, and neuromuscular adaptation in athletes, and from the rehabilitation guidelines provided in *Physical Rehabilitation of the Injured Athlete* [33]. The program was further refined based on the researcher's clinical experience. The common exercise program was applied identically to both groups before the experimental interventions to standardize baseline muscular strength and trunk stability. Implementing a uniform conditioning phase minimized confounding effects arising from differences in initial fitness levels and training experience between participants and allowed the effects of the visual-feedback intervention to be evaluated independently. Therefore, this program served as a critical methodological component for ensuring internal validity and isolating the true impact of the intervention.

Table 2.
Common exercise program.

Warm-up jogging 10 min	
Main exercise	Clamshell / 15 rep 2 set
	Squat / 15 reps, 2 sets
	Squat reach / 15 reps, 2 sets
	Split squat/ 12 rep 2 set

2.3.2. Visual-Feedback Core Stabilization Exercise Program

The visual-feedback core stabilization program was implemented using the Blueback Physio EMG system, which enabled participants to observe real-time TrA activation during exercise. Three electrodes were attached to the abdominal region, and athletes performed core stabilization tasks while continuously monitoring TrA contraction level, onset timing, and duration through the application. The program emphasized selective activation of the deep abdominal musculature rather than superficial abdominal bracing, and verbal cues were provided to avoid compensatory lumbar extension or pelvic rotation. Training progressed over 12 weeks, with three sessions per week, including the common warm-up program. During weeks 1–4, participants performed low-intensity stabilization exercises focused on selective TrA activation in supine and quadruped positions; during weeks 5–8, static core stabilization tasks and controlled limb movements were introduced; and during weeks 9–12, functional multi-joint exercises were performed while maintaining TrA activation. Each session lasted approximately 50–60 minutes and incorporated a standardized rest period of 1 minute between sets. If superficial abdominal dominance or altered trunk mechanics were observed, corrective feedback was provided immediately to ensure proper TrA recruitment.

2.3.3. Standard Core Exercise Program

Athletes in the standard core exercise group performed a conventional core stabilization training program without visual feedback, developed based on previous evidence demonstrating improvements in lower-limb balance and athletic performance following core training in elite soccer players [34] and the effects of an 8-week core program on agility and balance in track athletes [35]. The researcher's clinical experience also supplemented the program. The intervention was conducted for 12 weeks, with three sessions per week, and each session lasted approximately 50–60 minutes, including the common exercise routine. Training intensity followed a progressive structure: during weeks 1–4, participants performed foundational core stabilization and low-intensity strengthening exercises targeting basic control of the TrA and rectus abdominis; weeks 5–8 focused on dynamic stabilization and core endurance through exercises such as modified planks, bird-dog variations, and multi-segment coordination tasks; and weeks 9–12 incorporated high-intensity core exercises, including rotational strengthening, unilateral loading (e.g., single-leg deadlifts), and functional movements designed to enhance trunk rotational control and whole-body integration. Rest intervals between sets were standardized to 1 minute. Improper movement patterns such as excessive trunk flexion, pelvic tilt, or compensatory lower-limb strategies were corrected immediately to maintain accurate activation of the target musculature. This program was implemented without surface EMG or visual monitoring and served as a conventional control condition to compare the effects of visual feedback-based core stabilization.

2.4. Data Analysis

All statistical analyses were performed using SPSS version 27.0 for Windows (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed with the Shapiro–Wilk test, and all major outcome variables met the assumption of normality ($p > 0.05$). Descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to summarize the participants' general characteristics. Because normality assumptions were met, within-group pre–post changes were analyzed using paired t-tests, and between-group differences in change values were examined using independent t-tests. Along with p-values, effect sizes were calculated to evaluate the magnitude of differences. Cohen's d was reported for t-tests and interpreted as small ($d = 0.2$), medium ($d = 0.5$), and large ($d \geq 0.8$). Statistical significance was set at $\alpha = 0.05$.

3. Results

3.1. Pre- and Post-Intervention Changes in TrA Activation

To compare pre- and post-intervention changes in TrA activation within each exercise group, paired t-tests were conducted (Table 3).

3.1.1. Visual-Feedback Core Exercise Group (VF-Core Group)

In the VF-Core group, TrA activation significantly increased from 40.55 ± 13.5 at baseline to 75.18 ± 9.13 after the intervention, and the change in score of 34.63 was statistically significant ($p < 0.05$).

3.1.2. Standard Core Exercise Group (ST-Core group)

In the ST-Core group, TrA activation increased from 37.55 ± 23.2 at baseline to 54.27 ± 18.1 after the intervention; however, the change in score of 16.72 was not statistically significant ($p > 0.05$).

3.1.3. Post-intervention comparison of TrA activation between the experimental groups

An independent t-test was used to compare pre- and post-intervention changes in TrA activation between the exercise groups. There was a significant difference in TrA activation between the two groups ($p < .05$), and the increase was significantly greater in the VF-Core group.

Table 3.
Changes in transversus abdominis activation by group.

Group	Pre (%MVIC)	Post (%MVIC)	t	*p*	*Cohen's d*
VF-Core	40.55 ± 13.51[a]	75.18 ± 9.13	-5.10	0.001***	2.1
ST-Core	37.55 ± 23.2	54.27 ± 18.19	-1.94	0.082	0.8
t	0.37	3.40			
p	0.716	0.003*			1.9

Note: * $p < 0.05$, *** $p < 0.001$
a mean ± SD
VF-Core: Visual Feedback Core Stabilization Group, ST-Core: Standard Core Exercise Group

3.2. Comparison of Pre- and Postintervention TrA Thickness

3.2.1. VF-Core Group

There was a significant increase in TrA thickness in the VF-Core group after the intervention (pre: 3.35 ± 0.54 mm; post: 4.36 ± 0.31 mm; $p < 0.05$). The change in thickness ($\Delta = 1.01 \pm 0.412$ mm) was statistically significant ($p < 0.05$; Table 4).

3.2.2. ST-Core Group

The ST-Core group also demonstrated a significant increase in TrA thickness (pre: 3.25 ± 0.58 mm; post: 3.65 ± 0.43 mm; $p < 0.05$). The change in thickness (Δ = 0.40 ± 0.478 mm) was statistically significant ($p < 0.05$).

3.2.3. Between-Group Comparison of TrA Thickness Changes

A significant difference in TrA thickness was observed between the two groups ($p < 0.05$); The increase in TrA thickness was greater in the VF-Core group than in the ST-Core group.

Table 4.
Changes in transversus abdominis thickness by group

Group	Pre (mm)	Post (mm)	t	*p*	*Cohen's d*
VF-Core	3.35 ± 0.54[a]	4.36 ± 0.31	-8.29	0.001***	2.2
ST-Core	3.25 ± 0.58	3.65 ± 0.43	-4.08	0.002*	0.7
t	0.41	4.54			
p	0.682	0.001***			1.8

Note: * $p < 0.05$, *** $p < 0.001$
a mean ± SD
VF-Core: Visual Feedback Core Stabilization Group, ST-Core: Standard Core Exercise Group

3.3. Changes in Quadriceps and Hamstring Isokinetic Strength

3.3.1. Quadriceps Strength

3.3.1.1. Peak Torque

Both groups demonstrated significant increases in quadriceps peak torque at 180°/s following the intervention ($p < 0.05$). The VF-Core group showed significant improvements in both limbs, but the change in the ST-Core group was not statistically significant in the left limb. Post-intervention comparisons revealed no significant differences between groups, although the left limb showed a trend favoring the VF-Core group (Table 5).

3.3.1.2. Relative Strength (PT%BW)

Quadriceps strength relative to body weight significantly increased bilaterally in both groups ($p < 0.05$). Postintervention comparisons did not reveal significant differences between groups.

3.3.2. Hamstring Strength

3.3.2.1. Peak Torque

Hamstring peak torque significantly increased in both groups for the right limb ($p < 0.05$). For the left limb, only the VF-Core group demonstrated a significant improvement. Postintervention values were significantly higher in the VF-Core group than in the ST-Core group for the left limb ($p < 0.05$; Table 6).

3.3.2.2. Relative Strength (PT%BW)

Relative hamstring strength significantly increased bilaterally in both groups ($p < 0.05$). No significant post-intervention differences were seen between the groups.

Table 5.
Changes in quadriceps strength (peak torque and body weight–relative) at 180°/s.

Group	Limb	Pre PT (Nm)	Post PT (Nm)	*p*	*Cohen's d*	Pre PT%BW (%)	Post PT%BW (%)	p	*Cohen's d*
VF-Core	Right	168.06 ± 8.40	184.71 ± 9.24	0.001***	1.3	238.54 ± 11.93	259.05 ± 12.95	0.001***	1.1
ST-Core	Right	168.73 ± 8.44	180.08 ± 9.00	0.001***	0.2	239.85 ± 11.99	255.85 ± 12.79	0.001***	0.4
t		-0.2	1.16			-0.46	4.54		
p		0.84	0.28		0.5	0.532	0.648		0.2
VF-Core	Left	165.63 ± 8.28	182.88 ± 9.14	0.001***	1.1	232.16 ± 11.61	255.81 ± 12.79	0.001***	1.2
ST-Core	Left	166.90 ± 8.35	172.80 ± 8.64	0.13	0.2	220.15 ± 11.01	247.24 ± 12.36	0.001***	0.2
t		-0.39	1.79			1.92	1.13		
p		0.7	0.09		0.9	0.068	0.27		0.5

Note: * p < 0.05, *** p < 0.001
a Mean ± SD
VF-Core: Visual Feedback Core Stabilization Group, ST-Core: Standard Core Exercise Group.

Table 6.
Changes in hamstring strength (peak torque and body weight–relative) at 180°/s.

Group	Limb	Pre PT (Nm)	Post PT (Nm)	p	*Cohen's d*	Pre PT%BW (%)	Post PT%BW (%)	p	*Cohen's d*
VF-Core	Right	96.53 ± 4.83	112.14 ± 5.61	0.001***	1.7	135.40 ± 6.77	157.27 ± 7.86	0.001***	1.4
ST-Core	Right	96.09 ± 4.80	106.77 ± 5.34	0.001***	0.4	136.62 ± 6.83	154.69 ± 7.73	0.001***	0.4
t		0.58	0.96			-0.33	0.42		
p		0.56	0.35		0.4	0.73	0.67		0.1
VF-Core	Left	94.02 ± 4.70	110.44 ± 5.52	0.001***	1.4	131.66 ± 6.58	154.93 ± 7.75	0.001***	1.1
ST-Core	Left	93.97 ± 4.70	100.12 ± 5.01	0.001***	0.4	133.64 ± 6.68	149.36 ± 7.47	0.001***	0.3
t		0.15	2.12			-0.47	1.24		
p		0.95	0.04*		1.1	0.64	0.22		0.5

Note: * p < 0.05, *** p < 0.001
a mean ± SD
VF-Core: Visual Feedback Core Stabilization Group, ST-Core: Standard Core Exercise Group.

3.4. Changes in 100-meter Sprint Performance
3.4.1. Within-Group Comparison

The 100-meter sprint time significantly reduced in the VF-Core group after the intervention ($p < 0.05$). In contrast, the time did not significantly change from baseline to post-intervention in the ST-Core group ($p > 0.05$; Table 7).

3.4.2. Between-Group Comparison

Post-intervention sprint performance was significantly better in the VF-Core group than in the ST-Core group ($p < 0.05$), indicating a superior improvement in sprint time with the visual-feedback intervention.

Table 7.
Changes in the 100-meter sprint performance by group.

Group	Pre (s)	Post (s)	t	*p*	*Cohen's d*
VF-Core	11.26 ± 0.29[a]	10.85 ± 0.24	5.092	0.001***	-1.5
ST-Core	11.30 ± 0.21	11.12 ± 0.25	-0.923	0.40	- 0.7
t	- 0.301	-2.63			
p	0.767	0.016*			- 1.4

Note: * $p < 0.05$, *** $p < 0.001$
a mean ± SD
VF-Core: Visual Feedback Core Stabilization Group, ST-Core: Standard Core Exercise Group.

4. Discussion

This study investigated the effects of a visual-feedback–based core stabilization program on TrA function, lower-limb isokinetic strength, and 100-meter sprint performance in elite collegiate sprinters. After 12 weeks, the visual-feedback group demonstrated substantially greater improvements in TrA activation and thickness, lower-limb strength, and sprint performance than in the standard core exercise group. These findings indicate that real-time EMG feedback may enhance deep core control and improve sport-specific performance in high-intensity sprint athletes.

The TrA is important for maintaining segmental spinal stability, regulating intra-abdominal pressure, and ensuring efficient force transmission during dynamic locomotor tasks [10-15]. Visual biofeedback facilitates selective activation of deep trunk muscles by improving motor awareness and contraction precision [36-39]. Similarly, in the present study, significant increases were noted in both TrA activation and structural thickness only in the visual-feedback group. These results support the notion that repeated, visually guided contractions enhance neuromuscular recruitment and promote structural adaptation of the deep core musculature. From a motor learning perspective, extrinsic knowledge-of-performance feedback accelerates error correction and stabilizes activation patterns in the early stages of skill acquisition [36]. Thus, real-time visualization of TrA activity may have allowed participants to more effectively fine-tune their contraction intensity and onset timing, leading to more consistent and efficient core engagement.

The visual-feedback group also exhibited more pronounced improvements in quadriceps and hamstring isokinetic strength. Core stability is a prerequisite for efficient limb force production because it minimizes compensatory muscle activity and reduces energy loss during dynamic movement [40-42]. When trunk stability is compromised, distal musculature must compensate, increasing fatigue and limiting the potential for strength development [43-45]. The superior strength gains in the visual-feedback group suggest that enhanced trunk stability created a more favorable biomechanical environment for lower-limb loading. This interpretation is consistent with previous research demonstrating that core training improves joint stability, neuromuscular control, and force generation capacity during athletic tasks [5, 46-49].

A key finding of this study is that only the visual-feedback group demonstrated a significant improvement in the 100-meter sprint time. In elite sprinting events, where performance outcomes are determined by minimal temporal margins, even small improvements reflect meaningful physiological adaptations. The enhanced sprint performance observed in this study likely resulted from the combined effects of improved TrA activation, increased trunk stability, and greater lower-limb strength. A stable trunk enhances the transmission efficiency of ground reaction forces, reduces unnecessary trunk sway, and allows a higher proportion of force to be translated into forward propulsion [5, 50]. Previous studies across various populations have shown that improved core stability enhances movement efficiency and running performance [51, 52]. The present results extend these findings to short-distance sprinting and demonstrate the added value of EMG-based feedback for deep core activation.

This study has several strengths, including the use of objective and complementary measures of TrA activation and structural thickness, standardized isokinetic strength testing, and evaluation of an ecologically valid performance outcome (100-meter sprint performance). Training volume and frequency were matched between groups, allowing the specific effects of visual feedback to be isolated and minimizing confounders. Nevertheless, several limitations should be acknowledged. The sample consisted exclusively of male collegiate sprinters, limiting generalizability to female athletes or other performance levels. Sport-specific training outside the intervention could not be completely controlled, and the absence of long-term follow-up limits insight into the persistence of training effects. Future studies should examine diverse athletic populations, explore extended training durations, and compare different biofeedback modalities to determine optimal strategies for enhancing performance and preventing injury.

In summary, visual-feedback–based core stabilization significantly improved deep trunk muscle function, lower-limb strength, and sprint performance in elite sprinters. Integrating EMG-based feedback into training may offer a practical, effective approach to optimizing core activation, improving neuromuscular efficiency, and supporting performance enhancement in high-intensity athletic environments.

5. Conclusion

This study demonstrated that a visual-feedback–based core stabilization program is effective in enhancing deep trunk function and sprint-related performance in elite collegiate sprinters. Compared with standard core training, the visual-feedback group exhibited significantly greater improvements in TrA activation and a larger increase in TrA thickness, indicating superior neuromuscular control and structural adaptation of the deep core musculature. Furthermore, the intervention led to bilateral strength gains in the quadriceps and hamstrings, suggesting that improved trunk stability may facilitate more efficient lower-limb force production. Notably, only the visual-feedback group showed a meaningful reduction in the 100-meter sprint time, demonstrating that these neuromuscular benefits translated into enhanced sport-specific performance.

These findings highlight the potential value of integrating EMG-based visual feedback into athletic training programs, particularly for sports requiring rapid force transmission and high trunk control. However, the study was limited to male collegiate sprinters and included a 12-week intervention without long-term follow-up. Future research should examine broader athletic populations, assess the durability of training effects, and compare different biofeedback modalities to determine optimal strategies for performance enhancement and injury prevention.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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