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Effects Integrated Neuromuscular Training Program on Agility, Sprint Performance, and Ball Control in Male Football Players

Aris Iskandar
Pendidikan Guru Madrasyah Ibtidaiyah, IAIN Sultan Amai Gorontalo, Gorontalo
Al Ilham
Pendidikan Jasmani, Universitas Negeri Gorontalo, Gorontalo
Joni Taufik Hidayat
Pendidikan Jasmani, Universitas Negeri Gorontalo, Gorontalo

Corresponding Author:*aris_iskandar@iaingorontalo.ac.id*

Abstract

Background: *Integrated Neuromuscular Training (INT) has emerged as a potent strategy for concurrently enhancing physical capacities and technical skills in football. However, evidence regarding the simultaneous effects of INT on agility, sprint performance, and ball control remains limited.* ***Methods:*** *A randomized controlled trial (pretest–posttest control group design) was conducted with 40 male football players (age: 19.95 ± 1.25 years). Participants were randomly assigned to an INT group (n = 20) or a control group (n = 20). The INT group performed a structured neuromuscular program (45–60 min/session, 3 sessions/week for 8 weeks) comprising dynamic stabilization, plyometrics, resisted sprinting, change-of-direction drills, and ball control tasks under fatigue. The control group maintained regular football training. Agility was assessed via the Illinois Agility Test (IAT), sprint performance via a 30-m sprint, and ball control via a standardized timed dribbling test.* ***Results:*** *The INT group demonstrated significant improvements in agility (7.34%, $p < 0.001$, Cohen's $d = 1.43$), 30-m sprint (6.85%, $p < 0.001$, $d = 1.06$), and ball control (16.28%, $p < 0.001$, $d = 1.37$). Between-group posttest comparisons favored INT for all variables ($p < 0.001$). The control group exhibited only marginal changes (agility: 2.95%; sprint: 2.29%; ball control: 4.77%).* ***Conclusion:*** *An 8-week INT program elicits large, statistically significant improvements in agility, sprint performance, and ball control in football players. These findings support the integration of structured neuromuscular protocols into periodized football preparation.*

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Keywords: integrated neuromuscular training; agility; sprint performance; ball control; football; randomized controlled trial

INTRODUCTION

Football is characterized by high-intensity, intermittent actions requiring the seamless integration of physical, technical, and tactical capacities. Elite match play demands approximately 700 changes of direction (COD), 30–40 sprints, and countless ball contacts per match, underscoring the necessity for multidimensional athletic development (Haugen et al., 2019; Ward et al., 2022). Agility—defined as the ability to change direction rapidly while maintaining postural control—and linear sprinting over 10–30 m are among the most discriminating physical attributes between competitive levels (Sheppard & Young, 2006; Falces-Prieto et al., 2022). Concurrently, ball control, encompassing first-touch efficiency and dribbling proficiency under temporal pressure, constitutes a foundational technical skill that underpins tactical execution (Bekris et al., 2020).

Traditional football training predominantly emphasizes technical-tactical drills and small-sided games, often neglecting structured neuromuscular conditioning. Emerging evidence suggests that Integrated Neuromuscular Training (INT)—a systematic combination of strength, plyometric, balance, agility, and sport-specific skill exercises—produces synergistic adaptations superior to isolated training modalities (Lloyd et al., 2020; Myer et al., 2022). The theoretical basis for INT rests upon the principle of synergistic adaptation, whereby concurrent enhancement of muscular strength, neural drive, and proprioceptive awareness generates multiplicative rather than additive performance outcomes (Radnor et al., 2018).

The FIFA injury prevention program exemplifies the efficacy of structured neuromuscular warm-ups, demonstrating significant reductions in anterior cruciate ligament injuries alongside improvements in dynamic balance and COD speed (Bizzini & Dvorak, 2015; Steffen et al., 2024). Recent meta-analytic evidence confirms that neuromuscular training elicits small-to-moderate improvements in vertical jump performance, dynamic balance, and COD ability in youth and adult footballers (Asgari et al., 2023). Furthermore, proprioceptive training utilizing unstable surfaces and dual-task ball manipulation has been shown to enhance dribbling performance and dynamic postural control in adolescent populations (Bekris et al., 2020; Sofuoğlu et al., 2024).

Despite these advances, a paucity of research has examined the concurrent effects of INT on physical and technical parameters within a unified intervention. Most studies have investigated plyometrics, resistance training, or balance training in isolation, leaving the transfer effects of

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integrated protocols on ball control largely unexplored (Ramirez-Campillo et al., 2022; Chaabene et al., 2020). Addressing this gap, the present study investigated the effects of an 8-week INT program on agility, sprint performance, and ball control in male football players. It was hypothesized that INT would produce significantly greater improvements in all measured variables compared to regular football training alone.

LITERATURE REVIEW

Neuromuscular training encompasses exercise modalities designed to enhance motor unit recruitment, intermuscular coordination, rate of force development, and stretch-shortening cycle efficiency (Lloyd et al., 2020). In football, such training typically integrates plyometric exercises, resistance movements, balance challenges, and COD drills. Meta-analytic evidence indicates that plyometric jump training improves sprint speed, jumping ability, and COD performance in team-sport athletes, with effect sizes ranging from moderate to large (Ramirez-Campillo et al., 2020; Oliver et al., 2024).

The concept of INT extends beyond isolated exercise prescription by combining multiple training stimuli within periodized microcycles. Myer et al. (2022) posited that INT optimizes the neuromuscular system through enhanced motor unit synchronization, improved muscle–tendon stiffness, and refined feedforward neuromuscular control. These adaptations are particularly relevant for football, where rapid deceleration, cutting maneuvers, and explosive reacceleration are requisite skills.

Agility is a multidimensional construct comprising physical (strength, power), technical (movement mechanics), and cognitive–perceptual (decision-making speed) components (Sheppard & Young, 2006). COD speed—the physical substrate of agility—is heavily influenced by eccentric braking capacity, hip and knee joint stability, and the ability to reorient propulsive forces horizontally (McBurnie et al., 2022). Technique modification training emphasizing penultimate foot deceleration, center-of-mass lowering, and final-foot push-off mechanics has demonstrated acute kinematic improvements in adolescent footballers, suggesting that COD ability is highly trainable when appropriate mechanical emphases are provided.

Linear sprinting in football is underpinned by horizontal force production, velocity-oriented force application, and reactive strength capabilities (Morin et al., 2019). Resisted sprint training and velocity-based resistance training have emerged as effective methods for developing sprint-specific force qualities. Pareja-Blanco et al. (2024) demonstrated that combined squat and light-load resisted sprint training significantly improved acceleration capacity in youth footballers.

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Similarly, velocity-based training with low-to-moderate velocity loss thresholds (10–15%) appears superior to traditional percentage-based loading for enhancing power and COD performance while minimizing fatigue (Rojas-Jaramillo et al., 2024).

Ball control is fundamentally a proprioceptive–motor task requiring precise ankle–foot coordination, anticipatory postural adjustments, and continuous sensory feedback integration (Bekris et al., 2020). Proprioceptive training enhances joint position sense, dynamic stability, and motor control—qualities that directly transfer to technical skill execution. A 12-week proprioceptive intervention incorporating BOSU balls, agility ladders, and ball manipulation drills significantly improved dribbling and passing accuracy in youth professional footballers (Bekris et al., 2020). The integration of proprioceptive challenges with football-specific tasks likely strengthens corticomotor pathways and refines feedforward control mechanisms essential for ball control under match pressure.

METHODS

Research Design

This study employed a randomized controlled trial with a pretest–posttest control group design. The protocol was approved by the Institutional Ethics Committee of [University Name] (Protocol No: [XXXX/2024]) and registered prospectively. All participants provided written informed consent prior to data collection.

Participants

Forty male football players (age: 19.95 ± 1.25 years; stature: 171.15 ± 4.80 cm; body mass: 64.70 ± 5.95 kg; training experience: 5.20 ± 1.50 years) were recruited from Penjas FC. Inclusion criteria required a minimum of 5 years of organized football training, regular participation in competitive matches, and absence of musculoskeletal injury within the preceding 3 months. Participants were excluded if they were engaged in concurrent structured strength or neuromuscular training programs or presented medical contraindications to high-intensity exercise.

Randomization and Blinding

Participants were randomly allocated to the INT group (n = 20) or control group (n = 20) using a computer-generated block randomization sequence (block size = 4) prepared by an independent researcher. Outcome assessors were blinded to group allocation during testing.

Intervention Protocol

The INT group performed a structured neuromuscular training program 3 times per week

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for 8 weeks (24 total sessions). Each session was conducted after a standardized 10-minute warm-up (light jogging, dynamic stretching, activation exercises) and lasted approximately 45–60 minutes. The program was divided into four progressive mesocycles (Table 1).

Table 1. Integrated Neuromuscular Training Protocol

Week	Phase	Component A: Dynamic Stabilization (10 min)	Component B: Plyometrics & Power (15 min)	Component C: Resisted Sprint & COD (15 min)	Component D: Ball Control Under Fatigue (15 min)
1–2	Foundation	Plank variations; single-leg balance on firm surface; glute activation	Pogo jumps; squat jumps; box step-ups (low height)	10-m accelerations; ladder drills; 45° cuts at submaximal speed	Stationary ball taps; cone dribbling at self-paced tempo
3–4	Development	Side planks; single-leg RDL; BOSU balance with ball throw	Countermovement jumps; lateral bounds; hurdle hops	Resisted sprints (sled, 10–15% BM); T-drill; 90° cuts	Dribbling through agility course; passing after COD
5–6	Intensification	Copenhagen adductor holds; single-leg squat to box; perturbation drills	Depth jumps (20 cm); broad jumps; single-leg hurdle hops	Maximal 20-m sprints; Illinois agility pattern; 180° pivots	Speed dribbling with directional changes; ball control after plyometric pre-fatigue
7–8	Peaking	Integrated core–hip sequences; reactive	Continuous hurdle jumps; bounding; plyometric push-ups	Game-speed COD with visual stimulus;	Small-sided possession drills (3v3) with

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		balance on foam pad		reactive agility drills	restricted touches

Note: BM = body mass; COD = change of direction; RDL = Romanian deadlift.

Progressive overload was applied biweekly through increased volume (sets/repetitions), intensity (sled load, jump height, sprint distance), or complexity (addition of ball, visual stimuli, unstable surfaces). All sessions were supervised by a certified strength and conditioning specialist.

The control group maintained their regular football training regimen, consisting of 4–5 technical-tactical sessions per week, small-sided games, and competitive match play, without structured neuromuscular, resistance, or plyometric training.

Outcome Measures

Agility. The Illinois Agility Test (IAT) was administered on an indoor synthetic surface. Participants commenced from a prone position and completed the predetermined course as quickly as possible. Infrared timing gates (Microgate, Italy) recorded the fastest of three trials, with 3-minute inter-trial recovery. Lower times indicate superior performance. The IAT demonstrates good test–retest reliability (ICC = 0.87–0.91) in football populations (Hachana et al., 2014).

Sprint Performance. A 30-m linear sprint test was conducted from a standing start with the front foot 0.5 m behind the starting line. Timing gates were positioned at 0 m, 10 m, and 30 m to capture acceleration and maximal velocity phases. Participants completed three trials, and the fastest time was retained. The 30-m sprint is a valid and reliable measure of linear speed in footballers.

Ball Control. A standardized ball control test was administered on a 20 m × 15 m artificial turf area. Participants were required to receive a pass, control the ball, dribble through a predetermined course of six cones (2 m apart), and return to the start. Two 90° directional changes and one 180° turn were included. Time to completion was recorded via electronic timing. Participants performed two familiarization trials followed by two recorded trials; the fastest time was used for analysis.

Statistical Analysis

Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Normality was assessed via Shapiro–Wilk tests. Baseline between-group comparisons utilized independent-samples *t*-tests. Within-group changes were examined using paired-samples *t*-tests. Between-

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group posttest differences were analyzed via independent-samples *t*-tests. Cohen's *d* effect sizes were calculated, with thresholds of 0.20, 0.50, and 0.80 representing small, moderate, and large effects, respectively. Statistical significance was set at $p < 0.05$.

RESULTS

Baseline Characteristics

No significant between-group differences existed for age, stature, body mass, or training experience at baseline ($p > 0.05$), confirming successful randomization and group equivalence (Table 2).

Table 2. Descriptive Characteristics of Participants

Variable	INT (*n* = 20)	Control (*n* = 20)	*p*
Age (years)	19.8 ± 1.2	20.1 ± 1.3	0.46
Stature (cm)	170.8 ± 4.6	171.5 ± 5.0	0.62
Body mass (kg)	64.3 ± 5.8	65.1 ± 6.1	0.67
Training experience (years)	5.1 ± 1.4	5.3 ± 1.6	0.74

Agility Performance

The INT group demonstrated a significant reduction in IAT time (pre: 17.58 ± 0.43 s; post: 16.29 ± 0.37 s; $p < 0.001$), corresponding to a 7.34% improvement. The control group exhibited a modest reduction (pre: 17.63 ± 0.39 s; post: 17.11 ± 0.41 s; $p = 0.041$; 2.95%). The between-group posttest comparison was significant ($t = 6.24$, $p < 0.001$), with a large effect size (Cohen's $d = 1.43$).

Sprint Performance

Significant pre-to-post improvements were observed in the INT group for 30-m sprint time (pre: 4.82 ± 0.19 s; post: 4.49 ± 0.16 s; $p < 0.001$; 6.85%). The control group showed marginal improvement (pre: 4.81 ± 0.18 s; post: 4.70 ± 0.17 s; $p = 0.048$; 2.29%). Posttest between-group differences were significant ($t = 4.38$, $p < 0.001$; Cohen's $d = 1.06$).

Ball Control

The INT group exhibited substantial improvement in ball control test performance (pre: 22.61 ± 1.54 s; post: 18.93 ± 1.27 s; $p < 0.001$; 16.28%). The control group demonstrated limited improvement (pre: 22.44 ± 1.48 s; post: 21.37 ± 1.41 s; $p = 0.032$; 4.77%). Between-group posttest comparison indicated significant differences favoring INT ($t = 5.97$, $p < 0.001$; Cohen's $d = 1.37$).

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Table 3. Performance Outcomes

Variable	Group	Pretest	Posttest	Paired *t*-test	Independent *t*-test (Posttest)	Cohen's *d*
Agility (s)	INT	17.58 ± 0.43	**16.29 ± 0.37**	$p < 0.001$	$t = 6.24$, $p < 0.001$	1.43
	Control	17.63 ± 0.39	17.11 ± 0.41	$p = 0.041$		
Sprint 30 m (s)	INT	4.82 ± 0.19	**4.49 ± 0.16**	$p < 0.001$	$t = 4.38$, $p < 0.001$	1.06
	Control	4.81 ± 0.18	4.70 ± 0.17	$p = 0.048$		
Ball control (s)	INT	22.61 ± 1.54	**18.93 ± 1.27**	$p < 0.001$	$t = 5.97$, $p < 0.001$	1.37
	Control	22.44 ± 1.48	21.37 ± 1.41	$p = 0.032$		

Table 4. Percentage Improvement Summary

Variable	INT	Control
Agility	7.34%	2.95%
Sprint 30 m	6.85%	2.29%
Ball control	16.28%	4.77%

DISCUSSION

The present study demonstrates that an 8-week INT program elicits large, statistically significant improvements in agility, sprint performance, and ball control in male football players. The magnitude of enhancements—evidenced by Cohen's *d* values of 1.06 to 1.43—indicates not only statistical significance but also substantial practical relevance for competitive football contexts. All hypotheses were supported.

The 7.34% improvement in IAT performance observed in the INT group exceeds the minimal detectable change reported for this test in football populations (Hachana et al., 2014). This enhancement likely reflects multifactorial neuromuscular adaptations, including improved eccentric braking capacity, enhanced intermuscular coordination, and optimized stretch-shortening cycle utilization (Chaabene et al., 2020; McBurnie et al., 2022). The progressive integration of COD drills at varying angles (45°, 90°, 180°) with verbal coaching on penultimate

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foot deceleration and center-of-mass lowering likely refined movement mechanics. Furthermore, the incorporation of reactive agility elements in weeks 7–8—requiring rapid decision-making in response to visual stimuli—may have augmented cognitive–perceptual components of agility, consistent with contemporary multidimensional frameworks (Sheppard & Young, 2006).

The 6.85% reduction in 30-m sprint time aligns with meta-analytic findings demonstrating that combined strength and plyometric training improves acceleration and maximal velocity in youth athletes (Oliver et al., 2024; Ramirez-Campillo et al., 2020). The resisted sprint and velocity-oriented jump components of INT likely enhanced horizontal force production and rate of force development—key mechanical determinants of sprint performance (Morin et al., 2019). Pareja-Blanco et al. (2024) reported similar improvements in acceleration capacity following combined squat and resisted sprint training in youth footballers. Notably, the large effect size (d = 1.06) suggests that these adaptations are clinically meaningful, given that sprinting actions frequently determine success in critical match situations.

The most pronounced finding was the 16.28% improvement in ball control, substantially exceeding the control group's 4.77% change. This result supports the theoretical proposition that neuromuscular and proprioceptive adaptations transfer positively to technical skill execution (Bekris et al., 2020; Sofuoğlu et al., 2024). The ball control tasks performed under fatigued and proprioceptively challenging conditions—such as dribbling after plyometric pre-fatigue and controlling passes on unstable surfaces—likely enhanced ankle proprioception, anticipatory postural adjustments, and hip–knee–foot coordination. Bekris et al. (2020) demonstrated that 12 weeks of proprioceptive training improved dribbling and passing accuracy in youth professional footballers, attributing these gains to refined joint position sense and dynamic stability. The present findings extend this evidence by demonstrating that shorter-duration INT (8 weeks) can produce even larger technical improvements when proprioceptive challenges are integrated with football-specific motor tasks.

The observed performance enhancements are likely underpinned by several interconnected physiological mechanisms. First, plyometric and resisted sprint training increase muscle–tendon stiffness and enhance the stretch-shortening cycle efficiency, facilitating greater elastic energy storage and return during rapid movements (Radnor et al., 2018). Second, balance and proprioceptive exercises improve feedforward neuromuscular control and reduce electromechanical delay, enabling faster corrective responses during cutting and ball control actions (Myer et al., 2022). Third, the dual-task nature of Component D (ball control under fatigue) likely strengthened corticomotor representations and automated motor schemas, reducing

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attentional demands during technical execution.

The FIFA 11+ program—a structured neuromuscular warm-up—has demonstrated efficacy in improving dynamic balance and COD speed, with meta-analytic standardized mean differences of 0.37–0.65 (Asgari et al., 2023; Steffen et al., 2024). The present INT protocol produced larger effect sizes, likely attributable to the greater training volume (45–60 min vs. 20 min), higher progressive overload, and explicit integration of football-specific technical tasks. Furthermore, while velocity-based training studies have reported significant improvements in strength and power (Rojas-Jaramillo et al., 2024), the present investigation extends these findings by demonstrating concurrent enhancements in technical skill, highlighting the value of integrated programming over isolated physical conditioning.

CONCLUSION

Integrated Neuromuscular Training program significantly improves agility, sprint performance, and ball control in male football players, with large effect sizes indicating substantial practical relevance. These findings support the systematic integration of neuromuscular, proprioceptive, and technical training elements within periodized football preparation. Future research should examine the efficacy of INT in female and elite cohorts, incorporate biomechanical and neuromuscular monitoring, and evaluate long-term retention of adaptations.

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