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Research Article

Relationship of Balance with Agility and Change of Direction Speed in Young Athletes

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ABSTRACT

The primary objective of the present observational study was designed to examine the interrelationship between static balance, dynamic balance, agility, and change of direction speed (CODS) in young athletes aged 12–18 years. Pre and post evaluation was performed on 60 participants using the Stork Stand Test, “Y” shape, Hexagon Agility Test, T-test. The findings demonstrated that dynamic balance, particularly the posteromedial and posterolateral reach components of the Y-Balance Test, showed the strongest associations with both agility and COD performance. Static balance showed moderate but significant relationships with agility and CODS.

Keywords: Static Balance, Dynamic Balance, Agility, and Change of Direction Speed (CODS), Athletes.

INTRODUCTION

In youth populations, where motor skills are still developing and neuromuscular systems are highly adaptable, these abilities become even more critical. Children and adolescents experience rapid physical changes as they progress through growth spurts, hormonal shifts, and increases in training exposure (1). These developmental phases bring both opportunities and vulnerabilities. On the one hand, the neuromuscular system is highly receptive to training stimuli, allowing balance, agility, and speed-related qualities to improve significantly with structured practice. On the other hand, immature coordination, evolving musculoskeletal structures, and fluctuating strength levels make young athletes more susceptible to movement inefficiencies and sport-related injuries(2).

Dynamic balance represents a higher-order neuromuscular skill that extends beyond simple postural control during stillness. It refers to an athlete’s ability to maintain or quickly regain stability while the body is in motion, particularly during tasks involving landing, pivoting, cutting, decelerating, accelerating, jumping, or changing direction. Because nearly every sport involves constant movement transitions, dynamic balance has emerged as one of the most crucial determinants of athletic performance, movement efficiency, and injury resilience(3).

Agility represents one of the most critical physical qualities in modern sports performance, especially in dynamic and fast-paced environments where athletes must respond quickly to unpredictable situations. Traditionally, agility was narrowly defined as the ability to change direction rapidly. However, contemporary sports science recognizes agility as a multidimensional skill that integrates physical, cognitive, perceptual, and reactive components. This means that agility is not only about how fast an athlete can move but also how fast they can think, perceive, decide, and execute movements under pressure(4).

Change of direction speed (CODS) is another essential physical quality that significantly influences athletic performance, particularly in sports that require quick, pre-planned movement transitions. CODS refers to the athlete’s ability to rapidly decelerate, change direction, and accelerate again along a predetermined path. Unlike agility—which incorporates reactive and perceptual decision-making—CODS tests the athlete’s pure physical capacity to execute planned directional changes efficiently.

CODS is considered a direct measure of neuromuscular power, eccentric strength, coordination, and mechanical efficiency during directional transitions. Because athletes must slow down, lower their center of gravity, stabilize the joints, and reorient their body before accelerating again, CODS reflects the quality of their movement mechanics and lower-limb strength(5,6,7).

The development of athletic performance in youth is a complex process shaped by the interplay of neuromuscular control, biomechanical efficiency, motor coordination, and physical maturation. Among the many components that contribute to successful performance, static balance, dynamic balance, agility, and change of direction speed (CODS) stand out as fundamental determinants of movement quality and sport-specific capability(8,9,10). Despite their importance, these attributes are often inadequately assessed or insufficiently trained in early stages of athletic development, especially within school- and community-level sports programs(11,12).

Youth athletes today participate in increasingly competitive and physically demanding sports environments, where rapid movements, high-speed transitions, and quick decision-making are essential for performance. In this context, fundamental neuromuscular attributes—particularly static balance, dynamic balance, agility, and change of direction speed (CODS)—play critical roles in ensuring that young athletes can perform safely and effectively. However, despite their well-recognized importance, these components are often under-assessed, underdeveloped, or overlooked during early athletic training.

A growing body of scientific evidence suggests that deficits in balance and neuromuscular control are among the primary contributors to performance limitations, inefficient movement mechanics, and sports-related injuries in adolescents. Many youth athletes exhibit poor postural stability, delayed neuromuscular responses, or inadequate movement strategies during high-demand tasks such as cutting, landing, pivoting, and sprint transitions. These limitations not only compromise performance but also place excessive biomechanical stress on vulnerable joints—especially the knee and ankle—making them more susceptible to injuries such as patellofemoral pain, ankle sprains, and ACL tears.

At the same time, agility and CODS, which are essential for success in most field and court sports, are influenced heavily by foundational abilities such as balance, proprioception, and motor coordination. Yet, training programs for young athletes frequently emphasize endurance, strength, or skill drills without systematically addressing the underlying neuromuscular qualities that make agile movement possible. This gap leads to inconsistent skill development, uneven performance progression, and an increased risk of injury during growth spurts, when neuromuscular coordination is naturally unstable.

Despite the interdependence of balance, agility, and CODS, there is limited research that examines these components together within the youth athletic population, particularly in the Indian context, where sports participation is rapidly increasing but scientific monitoring of athletic development remains limited. Existing studies often investigate these variables independently or focus on adult athletes, leaving a critical gap in understanding how these attributes co-develop during adolescence, a period characterized by significant physical and neuromuscular changes.

Additionally, most school- and academy-level training programs lack evidence-based guidelines on how to evaluate balance and agility or how to integrate them effectively into long-term athlete development (LTAD) models. Without scientific insight into how these factors interact, coaches and trainers may be unable to identify weaknesses early, customize training, or design interventions that target the specific needs of young athletes.

Therefore, the core problem addressed by this study is the insufficient understanding of how static balance, dynamic balance, agility, and CODS influence one another in young athletes, and how these relationships affect overall athletic performance. By investigating these components together, this study seeks to fill a crucial knowledge gap and provide scientifically grounded evidence that can inform better training strategies, improve performance outcomes, and enhance injury prevention efforts in youth sports.

Aim & Objectives of the Study

The primary aim of this study is to analyze the impact of static balance, dynamic balance, agility, and change of direction speed (CODS) on overall athletic performance in young athletes. By examining the interrelationships among these neuromuscular components, the study seeks to understand how foundational balance abilities influence an athlete's capacity to perform rapid, complex, and sport-specific movements that are critical for competitive success and injury prevention.

MATERIALS AND METHODOLOGY

The cross sectional research design was used in study. A cross sectional study is a sort of observational research in which data is collected at a single moment in time to evaluate the relationship between variables. The study used Convenience Sampling as its sample design and 60 Recreational and competitive athletes are participated who are involved in the sports with agility and balance (for example, badminton, football, basketball, and athletics) for at least 3 days per week during the last 6 months were selected and assessed for the pre-test parameter.

Paper and pencil for data recording, chair for participants to sit on during assessment and procedure, assessment form, consent form, towel for comfort or support were all used in the study.

Inclusion Criteria

1. **Age Range:** Young athletes aged 12 to 18 years.
2. **Gender**: Both male and female participants.
3. **Activity Level:** Recreational and competitive athletes who are involved in the sports with agility and balance (for example, badminton, football, basketball, and athletics) for at least 3 days per week during the last 6 months.
4. **Health Status:** Clinically healthy people who currently do not suffer from musculoskeletal, neurological or cardiopulmonary impairments.
5. **Consent**: Voluntary participation (e.g., ability to give written informed consent (or assent with written parent/guardian consent in the case of a minor)).

Exclusion Criteria

1. **History of Recent Injury:** Any lower limb and/or spine injury that occurred in the last 6 months which may impede performance in agility or balance tests.
2. **Neurological Disorders**: Neurological disorders that have been identified (e.g., cerebral palsy, multiple sclerosis, stroke), which interfere with balance or movement.
3. **Orthopaedic Surgeries**: History of orthopedic surgery in the last year.
4. **Visual or Vestibular Impairments**: Well-known visual, vestibular, or proprioceptive deficits.
5. **Medication Use:** Use of drugs that may possibly mess up with balance, coordination or reaction times.
6. **Lack of Compliance:** Participants who are unwilling and unable to follow instructions and go through the testing procedures.

Sample Size and Study Duration

For this study the sample size was 60 people the individual were chosen at random from the research population to ensure representativeness and adequate data for analysis. The Study was carried out for 4 months; All participants were provided with a sports-specific training environment throughout the study. Before the intervention, each participant completed a standardized warm-up session, followed by the prescribed exercise program as outlined in the study protocol. This approach ensured that the intervention was performed under conditions that closely resembled the functional demands of their sporting activities in sports centre ,(PMCH) pacific medical university (Udaipur), after obtaining ethical committee approval dated 11-09-2025, PMU/IEC/MPT/2025/65. All participants completed information and consent form at recruitment. Each session was scheduled for 40-45 minutes. This period was set aside to ensure the participants had enough time to execute the procedure correctly.

Procedure

Permission for conduct Study is taken from the institutional ethical committee of PMCH (**Protocol no. PMU/IEC/MPT/2025/65**), Pacific medical university bhilo ka bedla Udaipur(RAJ).

Athletes initially assessed for the inclusion or exclusion criteria. Prior to the procedure, all participants were informed about the purpose, procedures, potential benefits, and possible risks of the study. Written informed consent was obtained from each participant prior to enrollment.

Participants will proceed to the testing site, fill in a demographic and screening form.

There will be a prescribed 10-minute warm up.

Jogging – light jog around the gym or track for 5 min to elevate heart and prepare muscles

Arm/Leg swings

Dynamic Stretches: example includes walking lunges, high knees, butt kicks, and hip circles- each for around 30 seconds

Main Exercises

Balance Exercises

1. Single-leg stands (stable and unstable surfaces)
2. BOSU Ball Squats
3. Y-Balance Reach Drill

Agility Drills

1. Ladder Drills
2. Cone Drills (Shuttle Runs)
3. Plyometric Hops and Zig-Zag Jumps

Change of Direction (COD) Training

1. 5-10-5 Drill (Pro Agility Drill)

Set three cones in a straight line, 5 yards apart. Start at the middle cone, sprint 5 yards to the right cone, touch the line, sprint 10 yards to the far left cone, then return to the middle.

Focus on quick direction changes and low center of gravity.

2. Box Drill

Arrange four cones in a square (5x5 meters). Sprint forward, shuffle laterally, backpedal, and shuffle again to complete the box.

Repeat in both clockwise and counterclockwise directions.

3. T-Drill Practice

COOL DOWN (5 minutes)

Static Stretching

Hamstrings: Sit with legs straight, reach for toes.

Quadriceps: Pull one foot behind to stretch the front thigh.

Calves: Lean against a wall with one leg extended back.

Hold each stretch for 20–30 seconds.

Breathing Exercises

The following assessments will come in such order: Stork Stand Test, "Y" shape, Hexagon Agility Test, T-test (Three trials occur and a time spent the best is recorded)

Data will be keyed in a master sheet to be analyzed statistically.

RESULT

A total of 60 participants were included in the study, 25 females and 35 males. In the 12–13 years age group 10 participants, 14–15 years age group, 18 participants, 16–17 years age group, 22 participants, 18 years age group, 10 participants were participated.

Table 1: BMI Classification of Participants

BMI Category	BMI Range (kg/m²)	Frequency (n)	Percentage (%)
Underweight	<18.5	8	13.3%
Normal Weight	18.5–24.9	40	66.7%
Overweight	25–29.9	10	16.7%
Obese	≥30	2	3.3%
Total		60	100%

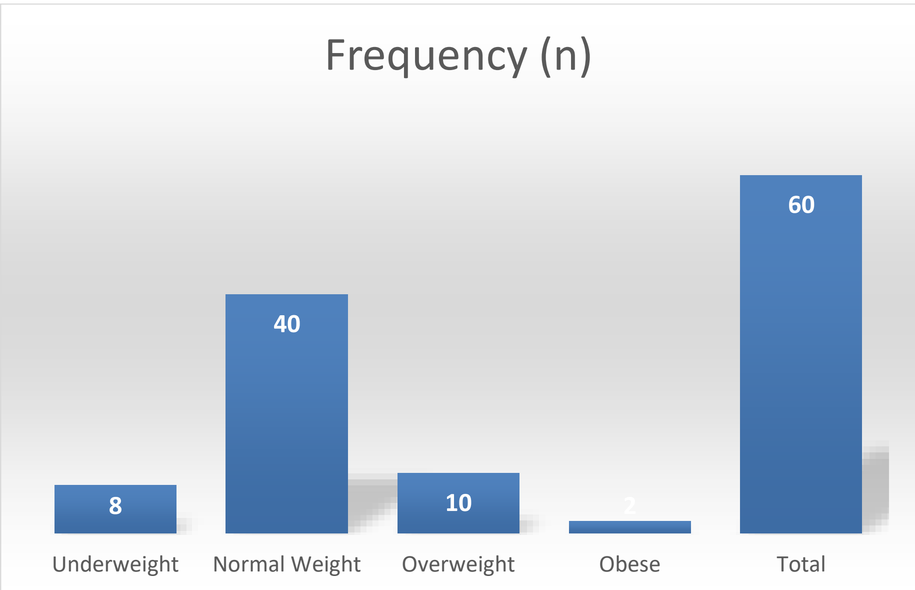
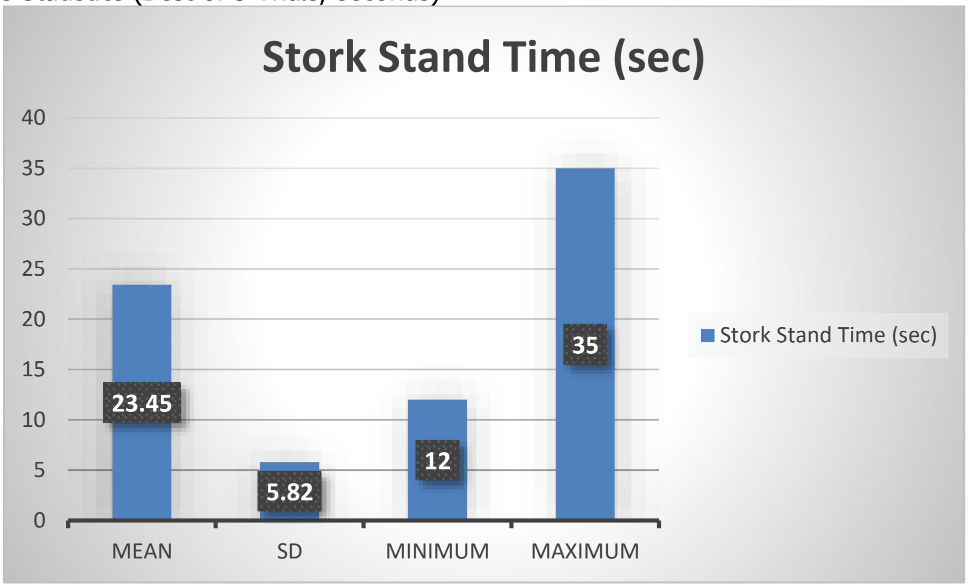


Table 2: Stork Stand Test (Static Balance)

Variable	Mean	SD	Minimum	Maximum
Stork Stand Time (sec)	**23.45**	**5.82**	**12**	**35**

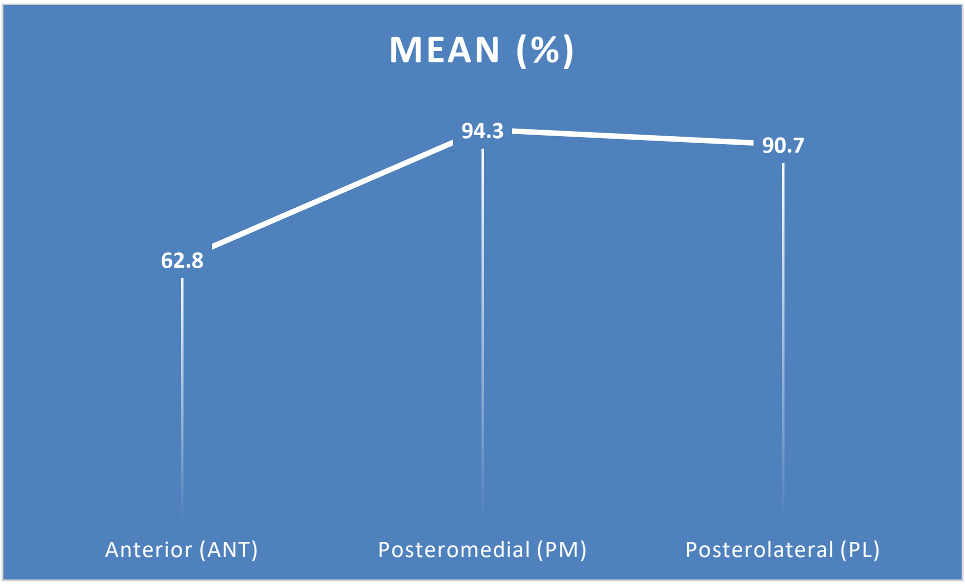
Descriptive Statistics (Best of 3 Trials, seconds)



Reach Distance (Normalized to Leg Length %) Based on 3 Directions

Table 3: Y-Balance Test (Dynamic Balance)

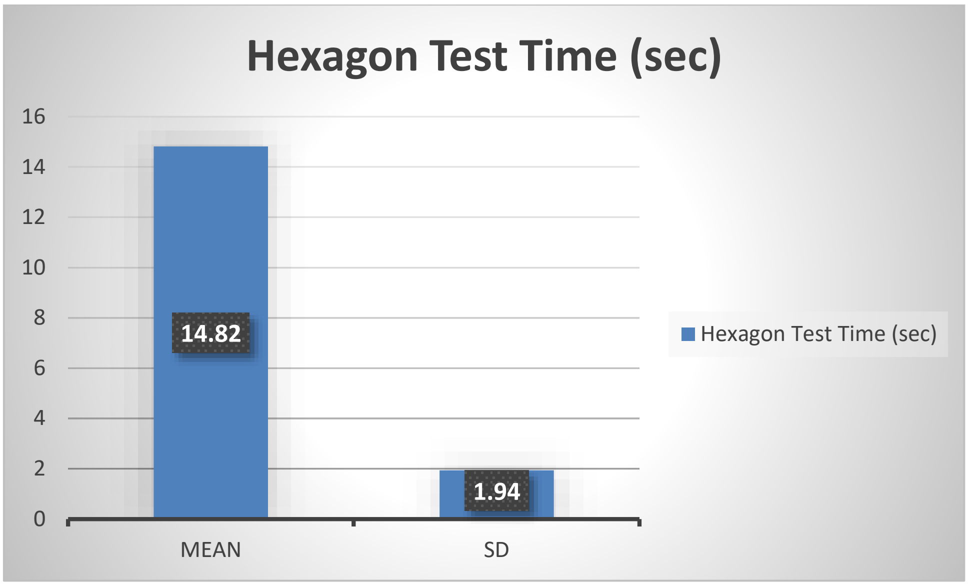
Direction	Mean (%)	SD (%)	Minimum (%)	Maximum (%)
Anterior (ANT)	62.8	4.9	52	74
Posteromedial (PM)	94.3	7.1	78	110
Posterolateral (PL)	90.7	6.5	75	108



Agility Performance (seconds)

Table 3: Hexagon Agility Test

Variable	Mean	SD	Range (Min–Max)
Hexagon Test Time (sec)	14.82	1.94	11.2 – 18.9



COD Performance (seconds)

Table 4: T-Test (Change of Direction Speed)

Variable	Mean	SD	Range (Min–Max)
T-Test Time (sec)	11.52	1.28	9.4 – 14.8

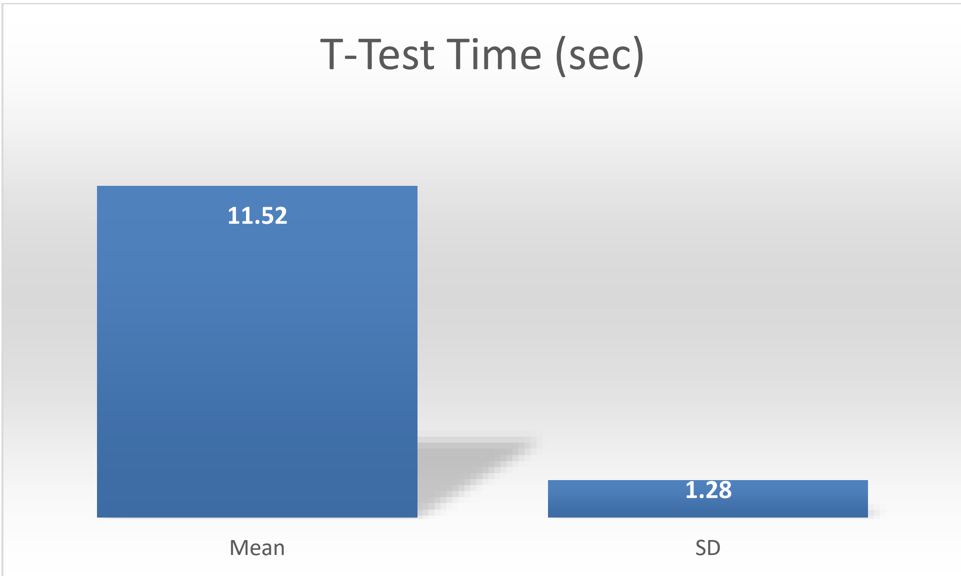


Table 5: Correlation Analysis

Correlation Pair	r-value	p-value	Interpretation
BMI vs Static Balance	-0.42	0.002*	Higher BMI = poorer static balance
BMI vs Dynamic Balance (ANT)	-0.31	0.015*	Higher BMI limits forward reach stability
BMI vs Agility (Hexagon Test)	0.28	0.03*	Higher BMI = slower agility
BMI vs COD (T-Test)	0.34	0.01*	Higher BMI reduces acceleration & change-of-direction speed
Age vs Static Balance	0.22	0.08	Mild improvement with age (NS)
Age vs Dynamic Balance (PM)	0.33	0.01*	Older athletes show better dynamic stability
Age vs Agility	-0.36	0.008*	Older athletes perform faster

Age vs COD	-0.31	0.02*	Older athletes are quicker at COD
Static Balance vs Hexagon Agility	-0.48	<0.001*	Better static balance = faster agility
Static Balance vs COD	-0.40	0.003*	Good stability improves COD performance
Dynamic Balance (ANT) vs Hexagon	-0.44	0.001*	Forward reach stability improves agility
Dynamic Balance (PM) vs Hexagon	-0.49	<0.001*	PM reach is a strong predictor of agility
Dynamic Balance (PL) vs Hexagon	-0.46	<0.001*	PL reach linked with lateral agility
Dynamic Balance (ANT) vs COD	-0.38	0.005*	Better dynamic control improves COD
Dynamic Balance (PM) vs COD	-0.51	<0.001*	PM reach is the BEST predictor of COD
Dynamic Balance (PL) vs COD	-0.47	<0.001*	Strong lateral dynamic control = faster COD
Agility (Hexagon) vs COD	0.63	<0.001*	Elite agility strongly predicts COD performance

*Significant at $p < 0.05$

Table 5 presents the correlation analysis examining the relationships between age, BMI, balance (static and dynamic), agility, and change of direction speed (COD) in young athletes. The correlation coefficient (r-value) indicates the strength and direction of the relationship, while the p-value shows whether the relationship is statistically significant. A negative r-value means that as one variable increases, the other decreases, whereas a positive r-value means both variables increase together. Relationships with $p < 0.05$ are considered statistically significant.

The analysis shows a moderate negative correlation between BMI and static balance ($r = -0.42$, $p = 0.002$), indicating that athletes with a higher BMI tended to have poorer static balance performance. Similarly, BMI showed a negative association with dynamic balance in the anterior direction ($r = -0.31$, $p = 0.015$), suggesting that increased body mass limits forward reach stability. In addition, BMI demonstrated a positive correlation with agility time ($r = 0.28$, $p = 0.03$) and COD time ($r = 0.34$, $p = 0.01$). Since higher times represent poorer performance, this finding indicates that athletes with higher BMI generally performed slower during agility and change-of-direction tasks.

Age-related correlations revealed that age had a mild positive relationship with static balance ($r = 0.22$, $p = 0.08$); however, this relationship was not statistically significant, suggesting that static balance improves slightly with age but not consistently. In contrast, age showed a significant positive correlation with dynamic balance in the posteromedial direction ($r = 0.33$, $p = 0.01$), indicating that older athletes demonstrated better dynamic stability. Age also showed moderate negative correlations with agility ($r = -0.36$, $p = 0.008$) and COD performance ($r = -0.31$, $p = 0.02$), meaning that as age increased, athletes were able to complete agility and COD tasks faster. This reflects improvements in neuromuscular coordination and movement efficiency with maturation.

Strong relationships were observed between balance and performance variables. Static balance showed a moderate negative correlation with agility ($r = -0.48$, $p < 0.001$) and COD ($r = -0.40$, $p = 0.003$), indicating that athletes who could maintain better postural stability performed faster during agility and directional changes. Dynamic balance showed even stronger associations. Anterior reach demonstrated significant negative correlations with agility ($r = -0.44$, $p = 0.001$) and COD ($r = -0.38$, $p = 0.005$). Posteromedial reach showed the strongest relationship with both agility ($r = -0.49$, $p < 0.001$) and COD ($r = -0.51$, $p < 0.001$), identifying it as the best predictor of high-level movement performance. Posterolateral reach also showed strong negative correlations with agility ($r = -0.46$, $p < 0.001$) and COD ($r = -0.47$, $p < 0.001$), emphasizing the importance of lateral stability in sports performance.

Finally, agility and COD were found to be strongly positively correlated ($r = 0.63$, $p < 0.001$), meaning athletes who performed well in agility tasks also demonstrated faster change-of-direction speed. This strong relationship highlights that agility and COD are closely linked motor qualities, relying on similar neuromuscular, balance, and coordination demands.

DISCUSSION

The present observational study was designed to examine the interrelationship between static balance, dynamic balance, agility, and change of direction speed (CODS) in young athletes aged 12–18 years. A total of 60 recreational and competitive athletes from multiple sports were assessed using validated field-based tests, including the Stork Stand Test, Y-Balance Test, Hexagon Agility Test, and T-Test. The findings demonstrated that dynamic balance, particularly the posteromedial and posterolateral reach components of the Y-Balance Test, showed the strongest associations with both agility and COD performance. Static balance showed moderate but significant relationships with agility and CODS, while age demonstrated positive associations with dynamic balance and faster agility and COD performance. Higher BMI was associated with poorer balance and slower movement performance. Overall, the results indicate that balance - especially dynamic balance - plays a critical role in efficient multidirectional movement and neuromuscular performance during adolescence.

When these findings are critically compared with existing literature, strong agreement is observed with multiple contemporary studies that identify dynamic balance as a key determinant of agility and COD performance. Falces-Prieto et al. (2022) reported moderate correlations between dynamic balance-related hopping tasks and COD speed in youth football players, supporting the present finding that dynamic balance contributes significantly to efficient directional changes. Similarly, Wang et al. (2025), in a systematic review of basketball players, concluded that balance training—particularly dynamic balance—improves agility and stability more consistently than static balance training. These findings directly support the present study’s observation that dynamic balance demonstrates stronger predictive value for agility and CODS than static balance.

The strong association found between posteromedial reach and COD performance is also supported by Chen et al. (2024), who demonstrated greater COD improvements when balance training was performed on unstable surfaces. Duchene et al. (2023) further reinforced this biomechanical relevance by showing that athletes with better neuromuscular control and core stability exhibit more efficient sidestepping mechanics and reduced joint loading during COD tasks. Collectively, these studies support the present thesis that dynamic, multi-directional stability is a critical neuromuscular prerequisite for effective agility and directional speed.

The present study supports the growing consensus that dynamic balance is a central determinant of agility and change of direction performance in young athletes, while static balance serves as a supportive but less performance-sensitive component. Although some discrepancies exist in the literature - particularly regarding the relationship between agility and COD and the influence of anthropometric factors - these differences can largely be explained by variations in age, maturity status, task demands, and competitive level. By examining static balance, dynamic balance, agility, and CODS collectively within the same cohort, this study contributes meaningful evidence to youth sports science and reinforces the need for integrated neuromuscular assessment and training models during adolescence.

CONCLUSION

This observational study was conducted to examine the relationship between static balance, dynamic balance, agility, and change of direction speed (CODS) in young athletes aged 12–18 years. Sixty recreational and competitive athletes from various sports were assessed using standardized field-based tests. The findings of this study clearly demonstrate that balance—particularly dynamic balance—is a key neuromuscular factor influencing athletic performance during adolescence.The results showed that athletes with better dynamic balance, especially in the posteromedial and posterolateral directions of the Y-Balance Test, performed significantly better in agility and COD tasks. This indicates that the ability to control body position during movement, single-leg stability, and effective weight transfer are essential for fast and efficient directional changes. Static balance also showed a significant relationship with agility and COD performance, but its influence was weaker compared to dynamic balance. This suggests that static balance provides a basic foundation for postural control, whereas dynamic balance is more critical for sport-specific movements.

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