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Article

Cognition and Postural Balance in Young Healthy Adults: A Cross-Sectional Study

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Abstract: (1) Background: It remains unclear whether cognition influences postural balance in young adults or if stability is primarily maintained through automated motor skills. While previous studies have explored cognition-balance links in older adults and athletes, research on healthy young adults is limited. (2) Methods: This study investigated the relationship between cognitive functions (processing speed, working memory, and inhibition) and postural balance (static and dynamic) in 62 healthy adults (18–50 years). Static balance was assessed using the Sway Medical app, while dynamic balance was measured with the Y Balance Test (YBT). Correlation and regression analyses were performed. (3) Results: No significant associations were found between cognitive function and balance performance, suggesting that postural stability in young adults relies more on automated motor processes than cognition. However, the body mass index (BMI) significantly correlated with YBT performance, highlighting the influence of physical attributes on balance control. (4) Conclusions: These findings challenge assumptions regarding cognitive involvement in balance among young adults in routine tasks. Future research should examine whether cognitive demands play a more significant role under increased task complexity, fatigue, or external perturbations. Mobile-based assessments may aid in the early detection of balance deficits, improving interventions in sports and rehabilitation.

Keywords: executive function; cognitive domains; Y Balance Test; Timed Up and Go Test; cognitive training; postural balance

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1. Introduction

Maintaining balance is a complex process requiring the integration of multiple sensory, motor, and cognitive systems (Nashner, 2014; Nazrien et al., 2024). Executive function, a domain of cognition, encompasses goal-oriented behaviours, decision-making, and response inhibition, while processing speed relates to the rapid detection and response to stimuli, both of which can play a role in stabilizing posture during activities (Chantanachai et al., 2022; Muir-Hunter et al., 2014).

The majority of studies linking cognition and balance have focused on older adults (Divandari et al., 2023; Gatto et al., 2020; Heaw et al., 2022; Li et al., 2018). However, this raises a critical question: are these associations a direct reflection of the interplay between cognitive and sensorimotor systems, or are they merely a consequence of concurrent declines due to aging? Investigating the relationship between cognition and balance in young adults, who have yet to experience significant age-related cognitive or sensorimotor decline, seems essential. Previous studies on young athletes have suggested that cognitive processes such as reaction time and executive control are correlated with sport-specific motor skills (Furley, 2023; Kalén et al., 2021; Porter et al., 2022). That could indicate that

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cognition may be critical for maintaining proper balance However, the extent to which baseline cognitive functions influence balance in non-athletic, healthy young adults remains unclear.

Previous research has demonstrated that performing a cognitive and balance task simultaneously (dual tasking) tends to affect dynamic postural stability (Talarico et al., 2017; Westwood et al., 2020). While these findings underscore the influence of cognitive processes on balance, focusing solely on dual-task performance may overlook important insights into how baseline cognitive abilities contribute to maintaining stability in everyday situations.

Additionally, research shows the association between cognition and sports performance among athletes (Kalén et al., 2021; Trecroci et al., 2021) who often benefit from extensive training that optimizes their cognitive and motor skills (Gutiérrez-Capote et al., 2024). However, this focus limits our ability to generalize findings to the broader young adult population. Studying non-athletic, healthy young adults allows us to better understand the natural, untrained relationship between cognition and dynamic balance.

Understanding this relationship has important implications for clinical practice and preventative strategies. Identifying cognitive domains that correlate with balance in young adults could serve as biomarkers, offering valuable insights into their ability to predict balance performance. This understanding could facilitate the early identification of balance-related issues, leading to the development of targeted interventions and training programs to improve stability across the lifespan. If cognitive domains are confirmed to play a crucial role in maintaining balance during youth, early cognitive training could be a proactive strategy to prevent future balance impairments and promote long-term physical well-being.

The primary aims of this study are: 1. to examine the potential association between different cognitive domains and dynamic balance in young non-athletic people; 2. To determine which cognitive domain significantly predicts dynamic balance after accounting for confounding factors; 3. To investigate the correlation between common confounders and cognitive and balance functions.

2. Materials and Methods

Participants

This observational, cross-sectional study involved 62 healthy young adults aged 18- to 50-year-old. A physiotherapist conducted the data collection over a 90-minute session. Participants were excluded if they had any neurological, psychological, orthopedic, or cardiorespiratory issues, or experienced pain that might affect their ability to stand or walk. This study was conducted in accordance with the Declaration of Helsinki and received ethical approval from Monash University and University of Tasmania, and informed consent was obtained from all participants following a comprehensive explanation of the study procedures. Participation was entirely voluntary, with participants having the freedom to withdraw at any point. A total of 67 individuals expressed interest. After the initial screening, 63 met the eligibility criteria and one person declined to participate.

Measurements

Firstly, demographic information such as age, gender, education level, and history of falls or injuries was recorded (see Table 1). Body Mass Index (BMI) was measured using bioelectrical impedance technology (Seca 804 Flat Scale with Chromed Electrodes).

Secondly, cognitive assessments were completed before the balance tests, with the sequence of cognitive tests being randomized. Participants selected a random number between 1 and 4 to determine the starting point, and this process was repeated for each cognitive test that followed. After completing all cognitive assessments, the balance tests were then conducted in a randomised order. Dominant leg was determined by asking participants which leg they would use to kick a ball—a commonly used method in balance research.

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Table 1. Characteristics of participants.

Variables	Number (%)	Mean (ranging)
Education		
High school	27 (43.5%)	
Diploma	10 (16.1%)	
Bachelor	10 (16.1%)	
Master/PhD	15 (24.2 %)	
Sex		
Female	37(60%)	
Male	25(40%)	
Age		35.5 (18-50)
BMI		26.65 (19.4-40.9)

Cognitive Tests

PsyToolkit was used for conducting domain-specific cognitive tests (Kim et al., 2019; Stoet, 2010). This is a freely accessible, web-based platform which is highly effective for conducting both general and psycholinguistic experiments (Stoet, 2017). It is an effective approach for conducting both general and psycholinguistic experiments involving complex reaction time tasks, with findings consistently replicating for both response selection and reaction time (Kim et al., 2019). Tests are as follows:

Deary-Liewald reaction time task: The Deary-Liewald reaction time task evaluated reaction time by displaying four white squares on a computer screen, each corresponding to a specific key: 'z,' 'x,' 'comma,' and 'period (Deary et al., 2011). Participants were instructed to promptly press the corresponding key whenever a cross appeared in one of the squares, which would cause the cross to vanish and trigger the appearance of the next one (Figure 1, A). The median reaction times, measured in milliseconds, were used for subsequent data analysis (Deary et al., 2011). The Deary-Liewald Reaction Time Task is a valid and reliable measure of processing speed, demonstrating high test-retest reliability and strong correlations with established reaction time tasks (Deary et al., 2011; Ferreira et al., 2021)

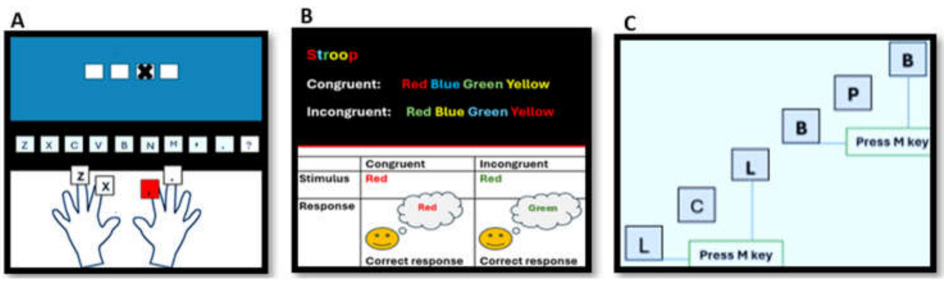

Figure 1. A: Deary- Liewald test B: Stroop test, C: N-back test.

Stroop Color–Word Test: This test assesses the capacity to inhibit cognitive interference (Stroop, 1935). Participants were asked to quickly name the colour of words displayed on a computer screen. The test presented both congruent (matching) and incongruent (non-matching) conditions (Figure 1, B). Reaction times during the incongruent conditions were analysed to assess interference effects (Periáñez et al., 2020). The Stroop Color-Word Test is a widely used measure of cognitive inhibition, which has shown high test-retest reliability and good internal consistency (Jensen & Rohwer Jr, 1966; Siegrist, 1995; Strauss et al., 2005).

N-Back Test: The N-Back Test assesses working memory function (Kirchner, 1958). During the test, participants are presented with a sequence of letters and must determine whether the current

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letter matches the one shown in three positions earlier (Figure 1C). The rate of correct responses is recorded and analysed (Gajewski et al., 2018). The N-back task is a widely used measure of working memory. Previous research has reported moderate test-retest reliability for accuracy scores, particularly in more difficult task levels (Hockey & Geffen, 2004). N-2 back task was used to assess working memory, as previous research suggests that more difficult working memory tasks show higher test-retest reliability (Dai et al., 2019).

Balance Tests

The Y Balance Test (YBT) is a valid and reliable tool for assessing dynamic balance (Plisky et al., 2009; Sipe et al., 2019). The reliability and validity of this test were already checked among young in a systematic review (Powden et al., 2019). Participants stood barefoot on a central footplate with their hands resting on their hips, using their dominant leg to push a block in three specific directions: anterior, posteromedial, and posterolateral, while balancing on their non-dominant leg. Each direction was tested three times, and the average reach distance was calculated for each direction (Sipe et al., 2019). Reach distances were measured to the nearest 0.5 cm, following a consistent sequence: dominant-leg anterior (Figure 2A), posteromedial (Figure 2B), and posterolateral (Figure 2, C). Trials were considered invalid if participants failed to return to the starting position, pushed the block with additional kicks, or stepped on the indicator (Sipe et al., 2019). To calculate the normalized score, the sum of the three reach distances is divided by three times the limb length and multiplied by 100. The YBT composite score is the average of these normalized scores (Sipe et al., 2019). Limb length is measured from the anterosuperior iliac spine to the medial malleolus while the participant lies supine (Sipe et al., 2019)

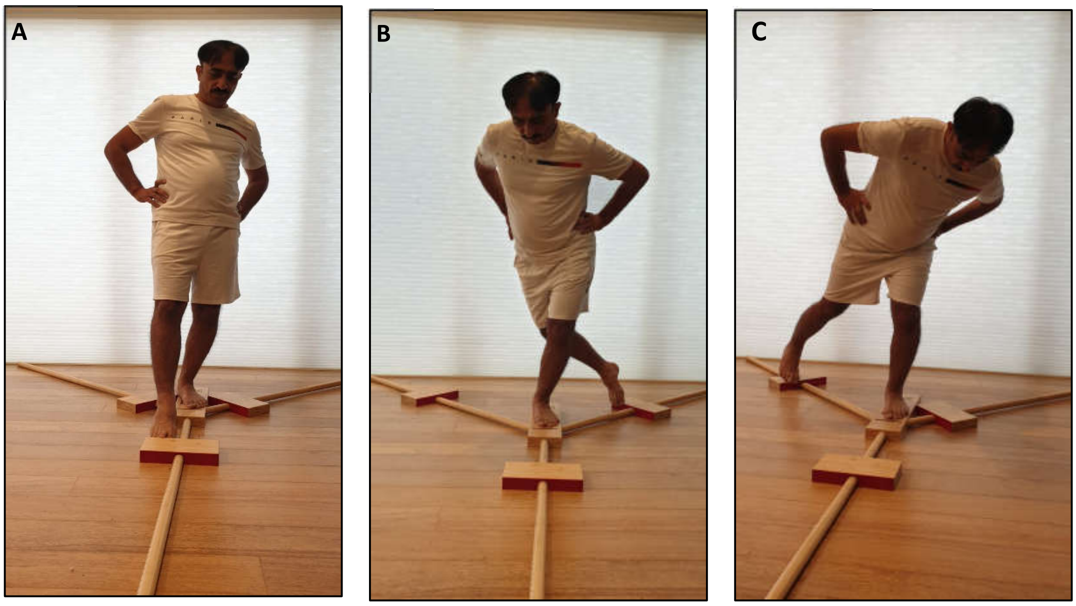

Figure 2. Y Balance test. A: Anterior, B: Posteromedial, C: Posterolateral.

The static balance test was conducted using the Sway Balance Mobile Application (SWAY; Sway Medical, Tulsa, OK) (Vincenzo et al., 2016). This FDA-approved, reliable, and validated method assesses postural stability through accelerometers (Jeremy et al., 2014). Its validity and reliability were tested in the previous studies (R. Amick et al., 2015; Burghart et al., 2017; Dunn et al., 2016). Participants held the device at their sternum, and the accelerometers recorded movement during single-leg stance (SLS) (Figure 2A) and tandem stance (Tandem) (Figure 2B), both with eyes open and closed (EO and EC). The app converted the data into balance scores ranging from 0 to 100, with lower scores reflecting poorer balance (Figure 2C and 2D) (Amick et al., 2013). Each test comprised a practice trial and three repetitions, with the average score calculated. Positions were timed for 10 seconds with a 3-second countdown. (Vincenzo et al., 2016).

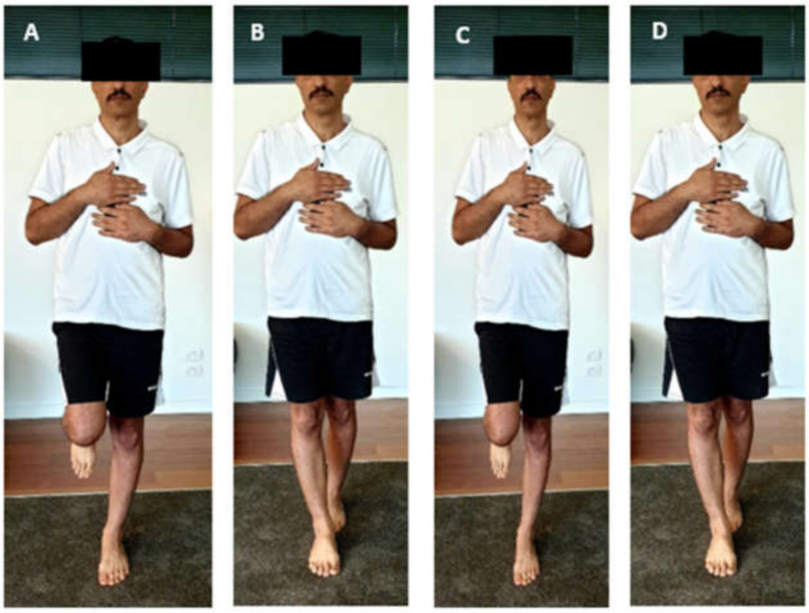

Figure 3. Assessment of static balance using the SWAY Balance mobile application. The participant held the mobile device firmly against the chest throughout each test conditions. A: Single leg stance (SLS) left leg, eyes open (EO), B: Tandem stance left leg, eyes open (EO). C: Single leg stance (SLS) left leg, eyes closed (EC), D: Tandem stance left leg, eyes closed (EC).

Data Management and Analysis

Initially, a descriptive analysis was performed on the demographic data of all participants. Normality of quantitative variables was assessed, which helped determine the appropriate statistical tests (parametric or nonparametric) to be applied. To evaluate the size and direction of linear relationships between variables, bivariate correlations were conducted for each pair of variables (Gatto et al., 2020). Before conducting these correlations, the assumptions of normality, linearity, and homoscedasticity were assessed to ensure the validity of the analysis (Tabachnick, 2019). A confidence level of 95% was used for all analyses, with statistical significance set at $p < 0.05$. All statistical analyses were conducted using the IBM SPSS statistical package (version 24.0). All data with the exception of Stroop incongruent time was normally distributed (Gatto et al., 2020) (Table 2). BMI and age were identified as a potential confounder for inclusion in the regression models for YBT and gender as a potential confounder for static balance tests, as it showed significant correlations with balance variable compared to other variables. Therefore, partial correlation was conducted to check the relationship between cognitive domains and balance tests controlled for those confounders. To make sure that cognition significantly does not contribute to the variance in balance beyond the effect of those confounders, hierarchical multiple regression analysis (MRA) was performed ($p<0.05$, 0.01, & 0.001) (Tabachnick, 2019). The analysis comprised three models, with the process repeated for each cognitive domain in relation to the balance tests. In the first step, confounders were entered as a predictor. In the second step, individual cognitive domains were added to assess whether that cognitive domain can significantly increase the explained variance (indicated by a significant change in R^2) of the model (Tabachnick, 2019). Before interpreting the MRA results, various assumptions were tested. Stem-and-leaf plots and boxplots were utilized to check for normal distribution and the absence of univariate outliers among the regression variables. Normal probability plots of standardized residuals and scatterplots of standardized residuals versus standardized predicted values were examined to ensure the assumptions of normality, linearity, and homoscedasticity of

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residuals were met (Tabachnick, 2019). The required sample size was calculated using G*Power (Faul et al., 2007). A power analysis was conducted using G*Power 3.1 for hierarchical multiple regression (fixed model, R^2 increase), testing the contribution of one cognitive variable after controlling for BMI. Parameters were set to detect a medium effect size ($f^2 = 0.15$), with $\alpha = 0.05$ and power = 0.80. The required sample size for 2 predictors was between 55. To account for potential exclusions and incomplete data, a total of 62 participants were recruited.

Table 2. Pearson correlation coefficients between demographic variables and cognitive performance and balance outcomes

Variables	Age	Gender	BMI	Education
1- YBT. Ave	-0.228	0.278*	-0.514**	0.114
2- YBT. Ant	-0.189	0.161	-0.333**	0.100
3- YBT. PM	-0.295*	0.264*	-0.332**	0.106
4- YBT. PL	-0.119	0.245	-0.478**	0.206
5- SLS. EO	0.135	-0.197	0.037	0.148
6- Tandem. EO	0.015	-0.526**	0.034	-0.012
7- Tandem.EC	0.046	-0.227	-0.087	0.106
8- SLS.EC	0.075	-0.381**	0.011	0.206
9- Deary-L	0.499**	-0.052	-0.055	0.373**
10- Stroop	0.307*	0.280*	0.085	0.051
11- N-back.	-0.093	-0.093	0.020	0.012

Stroop: Stroop color word test; Deary-L: Deary-Liewald test; YBT. Ave: Y Balance Test. Average; YBT. Ant: Y Balance Test. Anterior; YBT.PM: Y Balance Test. Posteromedial; YBT.PL: Y Balance Test. Posterolateral. SLS. EO: Single leg stance, eyes open; SLS. EC: Single leg stance, eyes closed; Tandem. EO: Tandem stance, eyes open; Tandem. EC: Tandem stance, eyes closed.

3. Results

3.1. Participants:

The sample consisted of 62 participants with a median age of 35.5 years (ranging from 18-50) and a median BMI of 2 (ranging from 19.4-40.9). The sample was 60 % female, and 56.5% had tertiary education (Table 1). Baseline cognitive and balance test results are detailed in Table 2.

3.2. Association of Demographic Information with Cognitive and Balance Measures

The correlation analysis revealed significant associations between BMI and the YBT in all three directions, though no significant associations were observed with cognitive domains. Age demonstrated a significant association with processing speed and inhibition, but no significant associations were found with working memory or the YBT, except for the YBT Posteromedial (PM) direction. Education level did not show any significant association with the YBT across any direction

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or average score; however, a significant association was noted with processing speed, with no associations observed for inhibition or working memory. Gender was significantly associated with the average YBT score and the YBT in the posteromedial direction, as well as with inhibition, while no associations were found with other measures (Table 2). The correlation analysis shows that static balance measures (SLS EC, Tandem EO, Tandem EC) have varying relationships with demographic information. Gender is significantly associated with Tandem EO and SLS EC, while age and BMI show no significant correlations with these measures.

3.3. Association Between Cognition and Balance Measures

All cognitive measures including inhibition, working memory, and processing speed showed no significant association with none of static or dynamic balance tests. Descriptive statistics for cognitive domains and balance test results and their correlations with cognitive domains are provided in Table 3 and 4.

Table 3. Descriptive statistics for cognitive and dynamic balance measures (N=62) and correlations between cognitive domains and dynamic balance.

Variables	Mean	SD	1	2	3	4	5	6	7
1- YBT. Ave	80.12	14.26	1						
2- YBT. Ant	61.67	13.38	**0.573****	1					
3- YBT.PM	91.30	16.80	**0.777****	0.149	**1**				
4- YBT.PL	86.71	23.66	**0.919****	**0.377****	**0.615****	1			
5- Deary-L	523.48	103.44	0.031	-0.019	-0.020	-0.067	1		
6- Stroop	1030.45	168.61	-0.128	-0.087	-0.126	-0.055	0.207	1	
7- N-back.	70.77	18.94	0.128	0.042	0.125	0.100	**-0.327***	0.207	1

Table 4. Descriptive statistics for cognitive and dynamic balance measures (N=62) and correlations between cognitive domains and static balance.

Variables	Mean	SD	1	2	3	4	5	6	7
1- SLS. EO	96.26	06.10	1						
2- Tandem. EO	98.16	02.47	**0.573****	1					
3- SLS.EC	61.85	27.41	**0.777****	0.149	**1**				
4- Tandem. EC	86.34	16.54	**0.919****	**0.377****	**0.615****	1			
5- Deary-L	523.48	103.44	0.031	-0.019	-0.020	-0.067	1		
6- Stroop	1030.4	168.61	-0.128	-0.087	-0.126	-0.055	0.207	1	
7- N-back.	70.77	18.94	0.128	0.042	0.125	0.100	**-0.327***	0.207	1

BMI and cognitive domains are predictors. β: standardized regression coefficient; R^2: The coefficient of determination; R^2 change improvement in R-square when the second predictor is added, * P<0.05, ** P<0. 01. SLS.

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EO: Single leg stance, eyes open; SLS. EC: Single leg stance, eyes closed; Tandem. EO: Tandem stance, eyes open; Tandem. EC: Tandem stance, eyes closed.

3.4. Cognitive Domains Predicting Postural Balance

Simple associations alone are not sufficient evidence for functional relationships (Rabbitt et al., 2006). To establish a functional relationship and determine which cognitive domain significantly contributes to the variance in dynamic balance beyond the effect of BMI hierarchical multiple regression analyses (MRA) were conducted. First, MRA was performed to predict balance scores based on BMI, calculating the initial R^2 values. Next, cognitive scores were added to each model to compute new R^2 values. The significance of the changes in R^2 was assessed to determine whether cognitive scores accounted for additional variance in balance test scores. In the first step of the hierarchical MRA, BMI accounted for a significant variance in compliance. In the second step, none of the cognitive domains contributed significant additional variance for none of our balance tests, a part of the results is reported in Table 5.

Table 5. Hierarchical regression results for cognitive domains predicting balance.

Model 1		**Model 2**		**Model 3**	
Independent Variables	**YBT. Ave**	**Independent Variables**	**YBT. Ave**	**Independent Variables**	**YBT. Ave**
Step 1: Background variables		Step 1: Background variables		Step 1: Background variables	
BMI	β: -.393**	BMI	β: .393***	BMI	β: -.393**
Step 2: Cognitive variable		Step 2: Cognitive variable		Step 2: Cognitive variable	
BMI	β: -.391**	BMI	β: -.404**	BMI	β: -.393**
Inhibition	β: -.010	Processing Speed	β:.018	Working memory	β:.075
R^2 step 1 (Age)	0.154	R^2 step 1 (BMI)	.154	R^2 step 1 (Ag)	.154
R^2 step 2 (BMI+ Inhibition)	.154	R^2 step 2 (BMI+ Processing speed)	.167	R^2 step 2 (BMI+ Working Memory)	.160
R^2 change	0	R^2 change	.012	R^2 change	.006

4. Discussion

This study aimed to explore the associations of cognitive domains, inhibition, working memory, and processing speed with dynamic and static postural balance among young adults. We also aimed to determine which cognitive domain contributes significantly to the variance in postural balance beyond the effect of confounders. Contrary to findings often seen in older adults, the results indicated no significant association between these cognitive domains and postural balance measures in the younger adults.

The lack of a detectable correlation between cognitive functions and balance in young adults aligns with the findings of Stuhr and colleagues, who also observed no significant associations between any of their cognitive domain tasks, including processing speed, inhibition, and working memory, and the Star Excursion Balance Test among young adults. This similarity in results further supports the notion that, in young adults, postural balance may be maintained through mechanisms

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less reliant on higher-order cognitive processes (Stuhr et al., 2020). The results may be attributable to the high level of motor skill automation observed in this age group. Automation refers to the ability to perform skilled tasks without conscious executive control, a process that reduces cognitive load and allows for efficient movement control (Poldrack et al., 2005).

In young adults, sensorimotor performance is probably highly automated, which enhances the specificity of movement control while minimizing the need for cognitive resources (Schedler et al., 2021; Stuhr et al., 2020). This high level of automaticity suggests that young adults rely less on top-down cognitive processes to maintain balance compared to older adults. Previous studies have shown the association of balance and cognition among older adults (Divandari et al., 2023). Older adults have greater difficulty achieving automaticity (Rogers et al., 1994), which can lead to increased reliance on cognitive resources for balance tasks. Individuals with more automatic and efficient movement control such as young adults, rely less on higher-order cognitive processes for balance maintenance (Schedler et al., 2021). This could explain why older adults demonstrate stronger associations between cognitive domains and balance, whereas young adults do not. The ability to automate sensorimotor tasks reduces the cognitive load required for balance, potentially leading to a diminished influence of cognitive domains on dynamic balance performance (Sakamoto & Iguchi, 2018). The lack of significant associations between cognitive measures and balance in young adults suggests that their ability to maintain balance relies more on automated motor responses rather than on higher-order cognitive processing. This supports the idea that cognitive-motor performance in young adults is largely automatized, reducing the need for top-down cognitive control in this age group (Stuhr et al., 2020). Motor performance has been shown to progress from early childhood to early adulthood, involving both qualitative (efficient movement pattern) and quantitative (greater smoothness, faster time to peak velocity, and better motor planning) advancements (Stöckel & Hughes, 2015). Similarly, executive functions mature from childhood through adolescence and into early adulthood, primarily due to the maturation of the frontal lobes and other critical brain areas, as well as increased volumes of cortical white and grey matter (Huizinga et al., 2006).

Interestingly, the absence of a discernible relationship between cognitive functions and postural balance in young adults can also be contextualized through the lens of task complexity. As noted by Vuillerme and Nougier (2004), attentional demands for postural control intensify with increasing task difficulty, suggesting that balance tasks require more cognitive input when complexity escalates (Lajoie et al., 1993). For example, it has been shown that if the balance task becomes more challenging, the reaction time obtained while maintaining the equilibrium becomes longer (Vuillerme & Nougier, 2004). Aging necessitates allocating a greater share of attentional resources to meet the balance demands of postural tasks (Lajoie et al., 1996). However, given the typically higher level of motor skill automation in young adults, these tasks may not impose sufficient cognitive strain to reveal meaningful associations between cognitive functions and balance. Therefore, the reason for relatively easy performing dynamic balance tasks by young adults stems from their ability to execute movements with minimal conscious effort, thereby reducing the need for higher-order cognitive involvement (Schedler et al., 2021).

The correlation analysis demonstrated significant associations between BMI and performance on the YBT in all three directions. This result is consistent with findings from other studies, which have reported that young adults with overweight or obesity tend to exhibit poorer dynamic balance performance compared to their normal-weight peers (Alice et al., 2022; Do Nascimento et al., 2017). Weight gain can alter body shape and posture, shifting the center of gravity anteriorly relative to the base of support, making balance maintenance more challenging (Porto et al., 2012). As BMI increases, changes in body structure impact balance, with excessive fat accumulation often leading to impaired equilibrium (Alice et al., 2022). Mocano and colleagues found no significant differences between the overweight student group and the normal weight group in terms of balance performance. However, they proposed that these results might be affected by factors like the students' field of study, regular participation in physical activities, and involvement in academic or recreational programs, all of which could contribute to improved balance performance in overweight students (Mocanu et al.,

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2022). This underscores the importance of accounting for physical health factors—such as BMI—when assessing balance performance, since a higher BMI can compromise an individual's stability by affecting biomechanics and reducing mobility.

Gender differences also emerged in the current findings, with significant associations noted between gender and YBT and also static balance in SLS. EO, SLS. EC, Tandem. EO and Tandem. EC, which is aligned with findings of the recent meta-analysis (Plisky et al., 2021). This may indicate that other factors, such as differences in physical strength, flexibility, or habitual activity levels, could be more influential on postural balance within this population. Moreover, the association between gender and inhibition could be reflective of inherent differences in response inhibition capabilities, which warrants further exploration.

The findings in this study should be interpreted considering the following limitations. Firstly, while we examined the correlation of sex, age, BMI, education, falls or injury history, and body fat mass on the cognitive and balance functions of young adults, there are other factors that may affect cognition and balance that were not accounted for, such as flat foot (Febriyanti et al., 2024), decreased foot arch, and arthritis changes in lower limbs (John et al., 2024). Secondly, the tests may not be challenging enough to show the relationship between cognitive domains and balance among young adults. While the study incorporated multiple cognitive tests, Stroop test, and N-back test, it did not account for other potentially influential factors, such as sensory deficits, muscle strength, or unreported medical conditions, which could also affect dynamic balance. Future studies should employ longitudinal designs and include a broader range of physiological and environmental factors and use highly challenging tests to better understand the interplay between cognition and balance.

This study needs to be conducted among a larger sample size and also consider more challenging balance tasks for young adults. It is suggested for future studies longitudinal designs to be employed to establish causal relationships between cognition and balance while expanding to diverse populations, including athletes and young individuals with cognitive impairments, and those with varying health conditions. The absence of a cognitive-balance association in young adults may be due to their highly automated motor skills, which allow them to perform balance tasks with minimal cognitive effort. This study did not demonstrate evidence of a ceiling effect, with participants showing a wide distribution of scores on both the YBT and SWAY app measures. These findings suggest that the selected balance assessments were appropriately sensitive for the study population. Nonetheless, in research involving healthy young adults, task difficulty remains an important consideration, as performance may approach optimal levels in some individuals. Future studies may consider incorporating more complex or demanding balance tasks—such as dual-task paradigms or unstable surfaces—to further enhance sensitivity and explore more nuanced differences in postural control. By addressing these factors, future research can better elucidate the complex interplay between cognition and balance and inform more effective interventions.

5. Conclusions

This study highlights the minimal role of cognitive processes in balance maintenance among young adults, emphasizing the dominance of automated motor skills. Balance interventions might focus on more challenging, task-specific exercises that engage cognitive contributions, such as dual-task or perturbation-based activities. The significant association between BMI and dynamic balance underscores the importance of incorporating physical health factors like weight management and core stability into training. Gender-specific differences in inhibition and balance measures suggest tailored approaches to training, addressing distinct neuromuscular characteristics. While these findings provide valuable insights, future research should further investigate the contributions of sensory and motor systems, the role of cognitive-motor integration in challenging tasks, and the implications for proactive balance training and injury prevention. These areas could refine training protocols to improve outcomes and build resilience against age-related declines in balance.

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Abbreviations

The following abbreviations are used in this manuscript:

YBT	Y Balance Test
SLS	Single Leg Stance
EO	Eyes Open
EC	Eyes Closed
BMI	Body Mass Index
Ant	Anterior
PL	Posterolateral
PM	Posteromedial

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