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DUAL COGNITIVE TASKS PROVOKE TEMPORO-SPATIAL GAIT AND ANTICIPATORY POSTURAL ADJUSTMENTS IN HEALTHY YOUNG ADULTS

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ABSTRACT

Usually, dual cognitive tasks require additional attention to maintain postural control during standing and walking. In certain pathologies or injuries, dual cognitive tasks, such as walking and speaking, can challenge the balance system, making certain gait deficiencies more apparent. The issue is identifying normal gait changes compared to gait impairments to understand better the impact cognitive tasks have on gait mechanics. Purpose: To identify changes in temporospatial gait parameters in healthy young adults while walking and performing a cognitive task. Methods: Thirty-four healthy young adults participated in this study. We collected gait parameters with six gyroscopes and accelerometers (distributed on all limbs and trunk) during the 7-meter walk test. Two trials were performed with just walking at a self-selected pace (single task). Then, the participant was asked to perform a cognitive task by counting backward by three from 100 while walking for 7m for two more trials (dual cognitive task). Results: Dual cognitive tasks provoked significant adaptations ($p<.05$) in gait parameters, such as increased double limb support time and stance phase with a reduction in single limb support time and swing phase. Increase the length of the walking cycle by decreasing the cadence and speed of walking speed. In addition, an increase in mediolateral postural sway, first-step initiation time, and trunk range of motion was observed. Conclusion: Dual cognitive tasks can cause normal alterations in the gait's dynamic component and variations in walking initiation. We recommend studying neuromuscular modification, such as changes in muscle activation, during dual cognitive tasks.

Contribution/Originality: The paper's primary contribution is finding gait and postural adaptations to dual cognitive tasks in healthy young adults. Specifically, this study identified anticipatory postural adaptations that could be used as a foundation to assess and create treatment interventions in those with balance impairments.

1. INTRODUCTION

According to the World Health Organization (WHO), falls are a major health issue. Falls can be life-threatening and are among the top two risk factors for death worldwide. The risk of falling increases with age, with the highest percentage of falls among adults aged 60 years and over (www.WHO.org).

One of the primary reasons people suffer from falls is the inability to sustain the center of gravity (CoG) within the area of the base of support (BoS) while walking or standing. In humans, when the CoG moves outside the BoS, several postural control mechanisms are required to preserve equilibrium (Pollock, Durward, Rowe, & Paul, 2000). Injuries to the visual, proprioceptive, vestibular, or musculoskeletal systems can displace the GoG outside of the BoS, resulting in falls.

Postural mechanisms are necessary for static and dynamic balance and to prevent falls. These postural techniques include ankle, hip, and step strategies that involve muscles of the lower extremities and trunk. The chosen mechanism depends on the scale of disturbance. The ankle strategy is adequate for small-amplitude disturbances.

The step method is utilized for more large-amplitude disruptions in movements. Each balance strategy recruits specific muscle groups to maintain balance (Shumway-Cook & Woollacott, 2007).

The interplay of the visual, somatosensory, and vestibular systems comprises a balance system. Dynamic systems theory (DST) explains the interplay between these sensory networks to preserve balance. DST suggests that the three balance networks must integrate sensory information synchronously to maintain postural control, particularly when balance is significantly challenged (Shumway-Cook & Woollacott, 2007) by a perturbation such as a change in the surface.

When this collaboration occurs, individuals can prevent falls while navigating various surfaces by utilizing sensory modification or sensory reweighting. However, sensory reweighting fails when one or more balance systems are impaired, requiring the body to rely on the remaining sensory information to maintain balance (Shumway-Cook & Woollacott, 2007).

The problem is that transitions in the balance system or postural strategies are often unnoticeable for some time, making it challenging to identify gait or balance impairments and prevent falls. One way to identify these impairments is by challenging the patient to perform dual tasks. Dual tasks are the individual's ability to perform two or more cognitive and motor activities simultaneously while maintaining an upright posture, for example, walking and talking.

During ambulation, dual tasking requires increased demands on cognition, resulting in the need for a higher degree of attention, balance, and executive function compared to single tasks (Leland et al., 2017). Leland et al. discovered that when individuals walked at self-selected speed and were asked to recall five sets of sequences, gait speed decreased with reduced attention spans. Consequently, studies have shown that reduced gait speed can be correlated with an increased risk of falls (Kyrdalen, Thingstad, Sandvik, & Ormstad, 2019).

Therefore, dual tasks can make gait and balance impairments appear more evident, making this assessment valuable in clinical settings. Much attention has been paid to spatiotemporal gait parameters such as gait speed, cadence, stride length, and single-limb support time to assess fall risk or mobility impairments in clinical settings. These gait parameters can be utilized to evaluate the impact of ground reaction forces on the body's ability to utilize internal moments or forces to overcome external moments placed on the body (Bonnefoy & Armand, 2015). Additionally, prior research has thoroughly investigated the link between age-related changes in older adults to decreased gait velocity, decreased step and stride length, increased double support time, shorter swing durations, and increased variability across all parameters (Pijnappels, Bobbert, & van Dieën, 2001).

The fact remains, during dual tasks, both younger and older adults can exhibit gait modifications such as a decrease in gait velocity during dual-task conditions; however, older adults presented with an additional 20% decrease in gait velocity (Vieira et al., 2015).

Evidence suggests that an increased attentional load placed on the brain with dual tasks during gait and balance in community-dwelling older adults will modify postural control (Lee, 2017). Prior research has neglected to thoroughly identify the impact of dual tasks on healthy young adults; therefore, this study attempted to discern adaptations in temporospatial gait parameters during dual cognitive tasks in healthy young adults. This study aims to characterize adaptations in temporospatial parameters during dual tasks in healthy young adults.

2. METHODS

2.1. Participants

A total of 34 participants, nine males, and 25 females, were recruited via word of mouth for this study. Subjects were recruited from Texas Woman's University (TWU) and the surrounding community. The inclusion criteria were as follows: 1) participants must be of reasonable health with no current metabolic syndrome and 2) between the ages of 18-65 years to avoid common age-related differences in balance and posture frequently seen in older adults.

The exclusion criteria were developed to avoid any confounding characteristics that could skew the results were as follows: 1) the inability to balance in double limb support without upper extremity assistance; 2) untreated severe visual acuity; 3) body mass index (BMI) > 40, classified as morbidly obese under the BMI classification Table 4) hypertension; 5) trunk or lower extremity surgeries or trauma within the prior six months; 6) drugs that induce drowsiness 24 hours before participating in the study; 7) women who were pregnant or thought they may be pregnant; and 8) an inability to ambulate.

2.2. Procedures

All participants signed the informed consent document before testing and screening. Demographic information and baseline vitals, including blood pressure, oxygen saturation, and pulse, were collected before testing. If subjects needed to wear corrective lenses or contacts during the testing, they were identified during the demographic intake stages. The participant's total time commitment was 40 minutes from start to finish to screen and perform testing protocols.

The dominant leg was identified by asking participants to stand facing away from the tester while the tester gave a slight perturbation along the participants' shoulders' anterior surface. This perturbation caused participants to employ a stepping strategy to regain balance. Thus, whichever foot was initiated, the stepping strategy was determined to be the dominant leg. Data was collected using MobilityLab APDM (APDM Inc., http://apdm.com). MobilityLab is a portable gait and balance laboratory used for motion analysis. The system utilizes accelerometer and gyroscope movement sensors placed on the body using straps to estimate spatial and temporal gait and balance parameters.

The tool's purpose is to quantify the kinematics of the trunk, lower, and upper extremities. In this study, all six sensors were used: bilateral arms, bilateral legs, one lumbar sensor, and one thoracic sensor. Each sensor collected data on medial-lateral (ML) and anterior-posterior (AP) sway velocity, direction, and distance. Participants wore all the sensors for the entire duration of the protocol.

2.3. Gait Protocol

1) Participants were instructed to begin in static standing behind the green line until they heard a computerized tone which signaled them to start walking at a self-selected walking pace.
2) Participants were instructed to walk between the green line and the cone for a total of 7m.
3) Upon reaching the cone, participants were instructed to walk around the cone.
4) They continued the path as described until they heard a second computerized tone, signaling them to stop.
5) A second walking trial was performed the same way as the first.

Participants performed two trials of a single task: a 7-meter walk at a self-selected pace. Subjects were then asked to complete the dual walking tasks, which were the same distance and protocol as the single tasks with the addition of counting. The dual-task was introduced by asking the participants to count backward from 100 (by 3s) while walking at a self-selected walking pace.

2.4. Data Analysis

The kinematic data was placed into the SPSS Data Analysis 25 system for ANOVA analysis comparing single tasks versus dual tasks gait parameters.

The variables of interest gathered and compared were stride length, stride velocity, cadence, gait cycle time, percentage of double limb support, stance-swing phase, range of motion of the shank/leg, peak trunk and shank velocity, and anticipatory postural adjustments and turns. A p-value of ≤ .05 was accepted as significant in this study.

3. RESULTS

Table 1 presents the descriptive data for all participants in the current study. Thirty-four subjects, 9 males and 25 females (age 24.88 ± 5.13) from TWU and surrounding communities participated in this study. Participants had an average height of 23.46 ± 2.87 (in.), the weight of 145.39 ± 23.86 (lbs), and body mass index (BMI) of 23.56 ± 2.87 (kg/m^2). Of the above participants, five were left leg dominant, and 29 were right leg dominant. Six participants wore glasses or contact during the test administration.

Additionally, vitals were systolic blood pressure (BP) of 118.82 ± 15.75 (mmHg), diastolic BP of 76.27 ± 9.09 (mmHg), resting heart rate of 69.82 ± 11.58 (bpm), and resting oxygen saturation of 97.97 ± 2.23.

Table-1. Demographic data of all participants.

Characteristics	Participant Data
Age	24.88 +/- 5.13
Gender	Male= 9 Female = 25
Height (in)	65.85 +/- 3.27
Weight (lb)	145.39 +/- 23.86
BMI (kg/m^2)	23.46 +/- 2.87
Heart Rate (bpm)	69.82 +/- 11.58
Systolic BP (mmHg)	118.82 +/- 15.75
Diastolic BP (mmHg)	76.27 +/- 9.09
Sat O2 (%)	97.97 +/- 2.23
Leg Dominance	R = 29 L = 5
Glasses	Glasses = 6 No glasses = 28

Table 2 illustrates the gait variables during single and dual cognitive tasks. Dual Cognitive provokes significant gait modifications ($p \leq 0.05$), resulting in temporospatial adaptations such as 1) increased gait cycle duration with a reduction in cadence and gait speed, 2) increased stance time with a decrease in time spent in swing phase, 3) reduced single limb support with an increase in double limb support, and 4) a decrease in toe angle and trunk range of motion in the mediolateral direction.

Table 3 shows anticipatory postural adjustments (APA) during single and dual cognitive tasks. Dual cognitive tasks prompt anticipatory postural adjustments related to an increase in first step duration (s) and range of motion ($p<.05$) before the start of a 7-meter walking trial.

Table 4 depicts the posture and turn outcomes during single and dual cognitive tasks. This study found that performing a dual cognitive task while walking on an even surface walkway did not affect turning or create postural adaptations ($p>.05$). Although our results showed a reduction in the number of turns ($p<.05$), this can be expected secondary to decreased gait speed.

Table-2. Comparisons of gait variables among tasks. Results of repeated measure ANOVA were performed comparing single and dual. Significance level set at $p \leq 0.05$.

	Single Tasks	Dual Tasks	P-value
	Means and SD	Means and SD	
Cadence L (steps/min)	110.20 ± 6.59	105.92± 8.99	0.005
Cadence R (steps/min)	110.08 ± 6.58	105.92 ± 8.98	0.05
Cadence Asymmetry (% diff)	-0.13 ± 0.43	-0.00 ± 0.34	0.9
Double Support L (%GCT)	19.26 ± 2.42	20.98 ± 3.30	0.01
Double Support R (%GCT)	19.38 ± 2.38	21.02 ± 3.29	0.01
Double Support Asymmetry (%Diff)	0.64 ± 0.95	0.24 ± 0.62	0.05
Elevation at Midswing L (cm)	1.00 ± 0.52	0.92 ± 0.48	0.38
Elevation at Midswing R (cm)	0.86 ± 0.51	0.89 ± 0.45	0.74
Elevation at Midswing Asymmetry (%Diff)	-12.67 ± 61.09	2.30 ± 52.40	0.16
Gait Cycle Duration L (s)	1.09 ± 0.07	1.14 ± 0.10	0.05
Gait Cycle Duration R (s)	1.10 ± 0.07	1.14 ± 0.10	0.05
Gait Cycle Duration Asymmetry (%Diff)	0.12 ± 0.44	-0.01	0.09
Gait Speed L (m/s)	1.16 ± 0.12	1.08 ± 0.13	0.01
Gait Speed R (m/s)	1.14 ± 0.11	1.07 ± 0.13	0.01
Gait Speed Asymmetry (%Diff)	-1.17 ± 1.90	-0.96 ± 1.98	0.57
Lateral Step Variability L (cm)	3.83 ± 0.90	4.05 ± 1.28	0.31
Lateral Step Variability R (cm)	3.60 ± 1.07	3.57 ± 1.17	0.93
Lateral Step Variability Asymmetry (%Diff)	-7.78 ± 22.57	-12.55 ± 28.18	0.32
Circumduction L (cm)	3.66 ± 1.20	3.87 ± 1.48	.41
Circumduction R (cm)	3.57 ± 1.16	3.74 ± 1.43	.50
Circumduction Asymmetry (%Diff)	-3.87 ± 25.08	-3.90 ± 30.12	.99
Lower Limb-N (#)	15.96 ± 1.97	15.69 ± 2.03	.47
Foot Strike Angle L (degrees)	26.98 ± 4.49	26.80 ± 4.07	.82
Foot Strike Angle R (degrees)	26.43 ± 3.33	26.43 ± 3.19	.99
Foot Strike Angle Asymmetry (%Diff)	-1.84 ± 12.23	-1.18 ± 10.82	.76
Toe Off Angle L (degrees)	38.03 ± 3.13	36.70 ± 3.81	0.05
Toe Off Angle R (degrees)	37.91 ± 3.43	36.65 ± 3.32	0.05
Toe Off Angle Asymmetry (%Diff)	-0.56 ± 8.12	0.04 ± 10.08	0.73
Single Limb Support L (%GCT)	40.39 ± 1.30	39.64 ± 1.75	0.01
Single Limb Support R (%GCT)	40.30 ± 1.30	39.38 ± 1.77	0.01
Single Limb Support Asymmetry (%Diff)	-0.24 ± 2.57	-0.65 ± 2.97	0.43
Stance L (%GCT)	59.65 ± 1.33	60.61 ± 1.74	0.001
Stance R (%GCT)	59.68 ± 1.31	60.41 ± 1.73	0.1
Stance Asymmetry (%Diff)	0.05 ± 1.77	-0.35 ± 1.87	0.24
Step Duration L (s)	0.55 ± 0.04	0.57 ± 0.05	0.01
Step Duration R (s)	0.55 ± 0.03	0.57 ± 0.05	0.01
Step Duration Asymmetry (%Diff)	-0.56 ± 2.81	-0.18 ± 2.62	0.46
Stride Length L (m)	1.26 ± 0.10	1.22 ± 0.11	0.10
Stride Length R (m)	1.24 ± 0.10	1.21 ± 0.10	0.09
Stride Length Asymmetry (%Diff)	-1.09 ± 2.05	-0.92 ± 1.78	0.64
Swing L (%GCT)	40.35 ± 1.33	39.38 ± 1.74	0.001
Swing R (%GCT)	40.32 ± 1.31	39.59 ± 1.73	0.1
Swing Asymmetry (%Diff)	-0.09 ± 2.66	0.53 ± 2.88	0.23
Terminal Double Support L (%GCT)	9.84 ± 1.39	10.67 ± 1.93	0.01
Terminal Double Support R (%GCT)	9.56 ± 1.22	10.36 ± 1.51	0.01
Terminal Double Support Asymmetry (%Diff)	-2.68 ± 12.12	-2.28 ± 10.85	0.85
Toe Out Angle L (degrees)	5.12 ± 5.48	6.26 ± 6.73	0.33
Toe Out Angle R (degrees)	11.06 ± 6.36	11.16 ± 6.50	0.94
Lumbar Range of Motion (Coronal) (degrees)	7.34 ± 1.99	7.39 ± 1.71	0.88
Lumbar Range of Motion (Sagittal) (degrees)	5.03 ± 1.49	5.17 ± 1.75	0.65
Lumbar Range of Motion (Transverse) (degrees)	10.10 ± 3.56	10.50 ± 3.51	0.55
Trunk Range of Motion (Coronal) (degrees)	5.30 ± 2.16	6.22 ± 2.21	0.05
Arm Swing Velocity L (degrees/s)	237.85 ± 62.43	267.34 ± 82.17	0.05
Arm Swing Velocity R (degrees/s)	207.53 ± 59.21	226.77 ± 85.52	0.17
Arm Range of Motion L (degrees)	57.78 ± 17.33	63.41 ± 19.20	0.10
Arm Range of Motion R (degrees)	54.05 ± 15.36	56.03 ± 18.72	0.54

Table-3. Comparisons of Anticipatory Postural Adjustments among tasks. Results of repeated measure ANOVA were performed comparing single and dual. Significance level set at p≤0.05.

	Single tasks mean and SD	Dual tasks mean and SD	P-value
Anticipatory Postural Adjustment - APA Duration (s)	0.39 ± 0.26	0.49± 0.31	0.6
Anticipatory Postural Adjustment - First Step Duration (s)	0.51 ± 0.06	0.54 ± 0.07	0.05
Anticipatory Postural Adjustment - First Step Range of Motion (degrees)	32.20 ± 8.56	37.84 ± 9.53	0.001
Anticipatory Postural Adjustment - Forward APA Peak (m/s2)	0.50 ± 0.24	0.59 ± 0.31	0.10
Anticipatory Postural Adjustment - Lateral APA Peak (m/s2)	0.55 ± 0.23	0.50 ± 0.19	0.19

Table-4. Comparisons of Posture and Turns among tasks. Results of repeated measure ANOVA were performed comparing single and dual. Significance level set at p≤0.05.

	Single Tasks Means and SD	Dual Tasks Means and SD	P-value
Postural-Sway-Acc-Sway Area (m2/s4)	17.50 ± 6.71	17.53 ± 6.03	0.98
Postural-Sway-Acc-Jerk (Coronal) (m2/s5)	2601.94 ± 3242.96	2267.22 ± 2314.67	0.53
Postural-Sway-Acc-Jerk (Sagittal) (m2/s5)	6288.39 ± 2201.43	6703.63 ± 2480.74	0.35
Postural Sway-Acc-Mean Velocity (Sagittal) (m/s)	0.52 ± 0.18	0.54 ± 0.17	0.49
Postural Sway-Acc-Mean Velocity (Coronal) (m/s)	0.29 ± 0.10	0.26 ± 0.10	0.15
Postural Sway-Acc-Path Length (Coronal) (m/s2)	222.61 ± 108.62	209.13 ± 96.37	0.48
Postural Sway-Acc-Path Length (Sagittal) (m/s2)	383.50 ± 73.06	389.48 ± 77.74	0.67
Turns-Angle (degrees)	179.72 ± 9.46	178.99 ± 13.69	0.74
Turns-Duration (s)	2.22 ± 0.42	2.31 ± 0.46	0.30
Turns-N (#)	2.86 ± 0.52	2.62 ± 0.62	0.05
Turns-Turn velocity (degrees/s)	197.81 ± 40.90	193.64 ± 42.11	0.59
Turns-Steps in Turn (#)	3.94 ± 0.74	3.91 ± 0.88	0.82

4. DISCUSSION

This study attempted to determine whether dual cognitive tasks influence temporospatial gait parameters while walking on an even surface walkway in healthy young adults. Additionally, we wanted to examine whether dual-tasking can lead to changes in single-and double-limb support times during level-ground walking. To our knowledge, few studies have compared single and dual cognitive tasks and patterns of temporospatial gait parameters such as gait speed, cadence, stride length, and single limb support (SLS) time during ambulation on even surfaces in healthy young adults. The current study identified two main findings that are worth highlighting.

Our first finding indicates that dual cognitive tasks provoke gait modifications, seen as an increased gait cycle duration, causing a reduction in cadence and decreased gait speed. We also discovered that with dual tasking, stance time increased with a consequent decrease in swing phase duration, and single limb support (SLS) times decreased with an increase in double limb support (DLS) times. Furthermore, we observed kinematic changes with a reduced toe angle and increased trunk range of motion (ROM) in the mediolateral (M-L) direction.

These findings indicate that cognitive interplay provides the need to modify some gait variables in young adults. For example, we believe that individuals with an affected SLS or DLS might find modifications needed for cognitive interplay to be more challenging to execute. Based on these results, we suggest paying closer attention to individuals with known balance deficits since modifications required during a dual-task decrease dynamic stability and linearly increase the risk for falls. To solidify our last remark, LaRoche, Greenleaf, Croce, and McGaughy (2014) conducted a study on community-dwelling older adults with ages ranging from 50 to 80 years old. Researchers evaluated dual-task walking at a self-selected pace on an instrumented treadmill. Temporo-spatial parameters were recorded during three different cognitive tasks: 1) no cognitive load, 2) subtraction from 100 by 1s, and 3) subtraction from 100 by 3s. Similar to our findings, the authors found that subjects in their 70s had increased difficulty with the most challenging dual-task (subtraction from 100 by 3s), as evident by an increase in stride length with a linear increase in double limb support time and increased in M-L instability. The authors did not find any significant differences between participants in the 50s-60s age range, suggesting younger participants do not experience such temporospatial changes, unlike the significance of our discoveries. Findings from our study bring into question the importance of evaluating a diverse population across the lifespan in future studies.

In addition to the above outcomes, we established that walking performance on even surfaces combined with dual cognitive tasks does not influence turning or requires postural adaptations while walking. However, our results revealed a decreased number of turns attributed to reduced gait speed with dual cognitive tasks. Similar to our study, Beurskens, Steinberg, Antoniewicz, Wolff, and Granacher (2016) investigated the effects of dual tasks on cognitive and motor interference in healthy young adults. The authors found reduced walking speed and stride length with increased stride times during dual cognitive tasks but found a more noticeable decrease in these parameters with motor interference tasks.

The differences in adaptations in motor and cognitive interference tasks can be linked to a theory known as the brain's central attentional capacity, a term that describes when attentional demands of the brain outweigh the resources available (Künstler et al., 2018). For example, in level-ground walking with dual cognitive tasks, the central capacity is likely to become overwhelmed, causing an imbalance in the distribution of attention between tasks, resulting in an inability to adapt appropriately to walking and posture. We suggest assessing the impact of dual motor tasks in healthy young adults to establish baseline gait adaptations.

Although the cognitive load placed on healthy young participants did not challenge the central attentional capacity enough to provoke adaptations during turns and dynamic balance, the same load can affect individuals with a diminished cognitive reserve due to various pathologies. For example, in individuals with Huntington's disease (HD), the motor, cognitive, and psychiatric areas of the brain exhibit progressive dysfunction and a decrease in automaticity of motor plans requiring a necessary increase in attentional resources, otherwise not needed in the past for more straightforward tasks such as walking (Purcell et al., 2020). In a study by Purcell et al. in 2020, individuals with HD were instructed to walk at a self-selected walking speed and faster walking speed while simultaneously performing a verbal fluency task of naming animals without repeats. Researchers have found that cognitive interference increases the amount of time and number of steps needed to complete turns in patients with HD than in healthy controls during the gait cycle. This adaptation differs from our findings in healthy young adults but can be attributed to pathologies such as HD, which affect the neurological system's ability to function. People with neurological dysfunction will have more pronounced adaptations during gait and turn explicitly in response to the increased cognitive loads required for separate tasks because of the overall diminished cognitive reserve to complete concurrent activities (Montero-Odasso et al., 2014). Our study results demonstrate the importance of identifying gait issues and neurological impairments before introducing dual cognitive tasks to avert the increased risk of falls.

Our second finding showed that dual cognition also prompts anticipatory postural adjustments, such as increased first-step duration and range of motion. Similar to the potential necessity for stepping and postural adjustments when completing turns, the central nervous system (CNS) can utilize either anticipatory postural adjustments (APA) or central postural adjustments (CPA) to maintain and recover balance after perturbations. APA processes incoming perturbations to the CNS and modifies muscle activity accordingly to minimize balance disruptions, otherwise referred to as a feed-forward control mechanism (Kanekar & Aruin, 2014). APA can be enacted either due to an individual's perception of an external perturbation or upcoming self-initiated movement, such as walking initiation from a static standing position after hearing the tone, as in our study. Conversely, CPAs are feedback-based postural control mechanisms that respond to balance disparities only after a perturbation occurs (Santos, Kanekar, & Aruin, 2010).

Interestingly, we found that dual cognitive tasks prompt APA adaptations, such as an increased initial step duration and ROM during the 2-meter walking task on level ground in our study. Previous studies, such as Wang, Asaka, and Watanabe (2013), mentioned that healthy young adults and elderly adults were studied to compare muscle synergies during the preparatory phases before step initiation. Although this study had a different cognitive task than ours, researchers found that elderly subjects exhibited a delayed APA with gait initiation (Wang et al., 2013), highlighting the importance of assessing APA regardless of the population. We speculate that any other pathology affecting gait performing cognitive tasks during walking can show further alterations in APA, such as the duration of their first step initiation. This concept is important for clinicians to consider when working with elderly patients or individuals with altered postural adaptations while performing a dual cognitive task. Their chance of falling will be greatest at the initiation of a cognitive task while walking. We recognize the need to delve into this concept in future endeavors with other known diseases affecting gait, such as HIV and diabetes, to solidify the inference.

5. CONCLUSION

The current study aimed to identify gait adaptations during a dual cognitive task in healthy young adults. Two major adaptations in gait parameters were discovered during a dual cognitive task while walking on an even surface walkway. During gait, single limb support and gait speed were modified to adapt to the cognitive tasks. Further, the first step's critical adaptation, initiating gait, also changed with dual cognitive tasks. These modifications suggest that dual cognitive tasks can require adaptations in a young and healthy balance system to sustain postural control at the initiation of gait or during movement. This study aimed to identify normal variations during dual cognitive tasks exhibited in gait parameters and APA in young, healthy adults.

Based on our outcomes, we infer that the adaptations mentioned above could be implicated in various pathologies and populations. Therefore, we recommend assessing gait in all patients using the variables highlighted in this report. We also suggest that future investigations delve into neuromuscular activation during dual tasks. Research has established that muscle fatigue can affect APA (Silva, Struber, Daniel, & Nougier, 2021); therefore, we propose exploring the neuromuscular adaptation related to APA to understand this modification fully. Finally, APA is a sensitive measure that shows various modifications even in injuries such as chronic low back pain in the older population (Garcez et al., 2021). Therefore, future studies should also examine how these gait variables change in diverse pathologies that can lead to gait disturbances such as low back, peripheral neuropathy, and chronic pain.

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