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# DUAL-MOTOR BALANCE TASKS PROMPTS SLIGHT LOWER LIMB NEUROMUSCULAR ADAPTATIONS IN HEALTHY YOUNG ADULTS

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## ABSTRACT

Previous literature has analyzed muscular recruitment patterns in various populations during complex balance conditions that involve a secondary task. This inquiry seeks to determine whether challenging sensory systems in young adults during single and dual-motor tasks can prompt modifications in neuromuscular patterns at the hip and leg musculature. Our study included twenty-nine healthy young adults (3 males and 25 females) with an average age of 24.3+/-2.4. Electromyography (EMG) electrodes were used to collect EMG data, and the variables of interest include the onset of muscle contraction, the decay of muscle contraction, peak muscle activation, and duration of muscle contraction. Five balance activities were conducted while performing a dual-motor task, while sensory input was altered in each condition. No significant changes in EMG activity were observed in the gastrocnemius (GA) and (TA) muscle activity. However, a tendency was observed in the onset and duration values of the gluteal muscles. Recruitment of the TA and GA remained uniform across variables, but gluteus maximus (GMax) and medius (GMed) activity appeared sooner (onset) and lasted longer (duration). Comparability in muscle recruitment during dual-task balance activities indicates healthy young adults can successfully rely on other sensory systems for balance when one or more networks are altered. Increases in GA and TA activity suggested a greater need for ankle strategies during the condition trials, while increased GMax and GMed activity indicated the same for hip strategies. Further research should examine joint kinematic to discern any adaptations during dual-motor tasks in young, healthy adults.

**Contribution/Originality:** The paper's primary contribution is finding neuromuscular balance adaptations in lower limb muscles to diverse dual-motor standing tasks in healthy young adults. Mainly, this research identified tendencies towards muscle variations that could be associated to the challenge of diverse balance sensory systems in combination to dual motor activities.

## 1. INTRODUCTION

Commonly, proper balance is defined as the ability to retain the center of gravity (CoG) within the region of the base of support (BoS). CoG collapsing outside the BoS will provoke an imminent fall, unless postural adaptations are taken to recover the CoG within the limits of their BoS. The CoG is broader than the BoS for double limb stance, requiring several networks to preserve postural control, such as lower limb musculature (Pollock, Durward, Rowe, & Paul, 2000).

Static and dynamic postural control requires three main domains to balance and adapt to different challenging scenarios: the neuromuscular system, balance sensory systems, and frontal motor cortex interplay (Dual Tasks) (Pollock et al., 2000). The neuromuscular component employs muscle recruitment from several areas throughout the body, for instance proximal trunk muscles and lower limbs, to adapt to various environments (Shumway-Cook & Woollacott, 2007). For example, the body moves like an inverted pendulum during static standing. While the body is swaying in a pendulum, dorsiflexors (tibialis anterior) and plantar flexors (gastrocsoleus) activate to maintain the body upright (Sozzi, Honeine, Do, & Schieppati, 2013). During anterior-posterior sway, neuromuscular activity interplay can be observed between the gastrocnemius (GA) and tibialis anterior (TA) (Giulio Di, Maganaris, Baltzopoulos, & Loram, 2009). Particularly, during movements in an anterior direction, the gastrocnemius muscle peaks in activation. However, the TA counteracts the movement in an opposite direction, posterior sway, reaching its peak activity (Yoon, 2017). This interplay in lower limb musculature is critical for deterring falls in the anterior or posterior directions. In more complex scenarios where the balance system is challenged, leg musculature adapts efficiently, provoking small changes in neuromuscular timing in healthy young adults to preserve postural control (Rosario, Bowman, Vega-Calderon, & Orozco, 2021).

Shumway-Cook and Woollacott (2007) mentioned that the sensory balance system entails the visual, somatosensory, and vestibular. All three systems work together and dynamically to retain postural control. If one of these systems is compromised or adapts to diverse scenarios, the body will rely on the other two systems to preserve balance. When one or more systems are challenged, or impairments are present, sensory re-weighting allows other systems to take over dominance to maintain posture (Shumway-Cook & Woollacott, 2007). In a healthy balance system, as studied by Bowman, Jose, and Rosario (2021) adaptations of visual, proprioceptive, and vestibular networks on postural control to challenging scenarios yield minor modifications to velocity and distance of sway in young adults.

Another component associated with postural control in dual-task can be described as the ability to perform two or more cognitive and motor activities simultaneously while maintaining an upright posture (Shumway-Cook & Woollacott, 2007). Dual tasks are an important component in discharge planning to ensure patients return to their daily activities (ADLs) (Shin & An, 2014). In a healthy population, like Rosario and Jose (2021b) studied, dual cognitive tasks revealed minor neuromuscular corrections during all balance activities in young adults. Authors concluded that the ability to adapt diverse scenarios that engage Ve, Pro and Vi is efficient even with a dual cognitive component (Rosario & Jose, 2021b). On the other hand, in another study, Rosario and Jose (2021a) identified that the normal adaptations were in antero-posterior directions in jerk, velocity, and directions to uphold the standing position in healthy young adults. Researchers further noticed that posture, regardless of the tasks, was achieved by a significant anterior-posterior adaptation compared to medio-lateral movement in dual cognitive tasks (Rosario & Jose, 2021b).

The complexity of dual motor tasks is based on the additional interference that requires central processing to preserve postural stability (Ivanenko & Gurfinkel, 2018). Bowman et al. (2021) postulated that during dual-motor tasks, concurrent challenges to sensory systems would provoke "finer intricacy in sensory processing" due to the specific requirement of attentional resources (for instance, holding a cup of water while standing on foam), making motor-dual tasks demanding to uphold. One of the balance mechanisms is related to changes in neuromuscular patterns in leg musculature (TA and GA) during dual-motor tasks compared to single tasks, as Rosario and Jose (2021a) reported. These postural changes could be credited to learning a new motor skill, accompanied by the interplay of the prefrontal cortex during the different balance activities (Jueptner et al., 1997).

Based on the above interpretation, the role of neuromuscular activation patterns on proximal musculature (gluteus muscles) is unclear during single and dual-motor tasks in conjunction with altered sensory conditions in healthy young adults. Therefore, we hypothesize that neuromuscular activity of distal muscles will be invariable, but shifts in proximal musculature activity will be seen during dual-motor tasks, which require more multitasking efforts. This inquiry aims to identify normal adaptive patterns in the activities above, which will help identify when balance adaptations emerge.

## 2. METHODOLOGY

Participants were obtained via convenient sampling at the Texas Woman's University Dallas campus, where all data collection occurred (Institutional Review Board Approval Number #20092). First, each participant signed an informed consent upon agreement after a research assistant explained the study's objectives. Then participants were screened to obtain demographic data, such as weight, height, age, and foot dominance.

The study criteria included young, healthy adults aged 18-45 years old and in good health. Additionally, the following exclusion factors were established to avoid any confounding factors that could alter EMG activity: 1) unstable postural control for 30 seconds during the Romberg Test, 2) women who are pregnant or think they are pregnant, 3) BMI >40 4) individuals with hypertension, 5) any untreated visual acuity or difficulty reading small prints even while wearing prescription glasses, 6) any surgeries or injuries at the back or lower extremity within the past six months, 7) any use of drugs with side effects of drowsiness that endures more than 24 hours before our study.

### *2.1. Equipment*

Electromyography Equipment: For the electromyography surface electrode system (EMG) (Delsys, Inc. Boston, MA), the current study attended the standardized placement of the electrode protocol on the leg muscles published by Rosario and Jose (2021a). EMG was employed to obtain neuromuscular activity of muscles at 1,000 Hz. The activity of the gastrocnemius (GA), tibialis anterior (TA), gluteus maximus (GMAX), and gluteus medius (GMED) muscles were of interest in this investigation. Before placing the electrodes, the dominant leg for each participant was identified. The strategy to recognize leg dominance was performed similarly to the previously published protocol by Bowman and Rosario (2021). After, when necessary, an electric razor was used to prepare the electrode placement site to circumvent any impedance to EMG data transference.

Neuromuscular Assessment**:** The EMG activity for each balance test was recorded for 15 seconds. In this research, we identify the various time data points (seconds), such as the onset of maximal activity, when the muscle contraction sinks or decays (Decay), peak muscle activation (TP), and duration of muscle contraction (Duration) as our variables of interest.

Balance Protocol: Subjects sustain a static bipedal stance while gazing at a square at eye level 10-feet away. In this study, nine tasks were designed to examine balance and the EMG modifications on leg muscles. One of the tasks was performed on a firm surface as a baseline. The others (eight) were arranged on a foam pad surface (15.5 inches long, 12.5 inches wide, 2.4 inches in height) or a firm surface. Balance assessments consisted of four single and four dual-motor tasks (holding a 12 oz cup filled with water).

The specific single-task balance tests on foam were as follows: 1) eyes open (EO), 2) eyes closed (EC), 3) eyes open with head movements (EOHUD) with a cadence of 60 beats per minute, 4) eyes closed with head movements (ECHUD). The same balance examinations were executed during the dual-motor tasks, although participants were asked to hold a cup filled with water (motor task) while concurrently executing the tests. Table 3 describes the conditions for each balance task, including the systems utilized for sensory re-weighting.

### *2.2. Data Analysis*

EMG data was captured by EMG works and processed by EMG analysis for all musculature. For the data analysis, this study utilized SPSS (version 28) and screened for normality prior, applying a repeated measure ANOVA to compare the onset, TP, decay, and duration of all muscles across the different balance tasks. We consider a p-value of $< 0.01$ statistically significant to accommodate the repeated analysis.

## 3. RESULTS

Participants: Table 1 presents an overview of the demographic data of the subjects included in this study. Individuals were mostly female, young adults, and generally healthy based on height-weight ratio and selected cardiovascular vital signs. Twenty-eight participants (25 females and 3 males) with an average age of 24.3+/- 2.4 years contributed to this study. The dominant leg of each participant was determined (mostly right dominance) for the placement of electromyography (EMG) electrodes.

**Table 1.** Demographic data of all participants.

| Characteristics | Control Participants Average n = 28 |
|---|---|
| Age | 24.3 +/- 2.4 years |
| Gender | Male = 3 Female = 25 |
| Height (in) | 65.7 +/- 3.06 |
| Weight (lb) | 144.9 +/- 25.9 |
| Heart Rate (bpm) | 70.8 +/- 15.5 |
| Systolic BP (mmHg) | 111.4 +/- 14.2 |
| Diastolic BP (mmHg) | 73.2 +/- 6.8 |
| Sat O2 (%) | 98.3 +/- 0.9 |
| Dominant Leg | Right = 20<br>Left = 8 |

Table 2 demonstrates no significant differences in the studied muscles. However, a tendency was observed in the gluteal muscles with an increment of onset and duration of activation. Additionally, results showed a slight difference in the activation of the TA compared to the GA.

## 4. DISCUSSION

Limited studies have compared neuromuscular patterns of lower limb musculature during single and dual-motor tasks, especially in young adult populations. This study aims to identify whether complex balance tasks evoke distinct neuromuscular patterns in GMax, GMed, TA, and GA in young adults. Because effective sensory and motor systems are seen in healthy young adults, we speculate that there will be limited changes in the muscle activity of the distal lower extremities during the balance tasks. However, the complexity of the dual-motor tasks, which require further multitasking efforts, may elicit increased muscle activity in the proximal lower extremities. The results of our query exhibit no significant changes in TA and GA EMG activity, and observed prolonged onset and longer duration for the gluteus muscles; however, not significant. Consequently, we partially support our hypothesis. The various balance tests performed in this study sought to alter different sources of sensory information that contribute to balance, causing participants to rely more heavily on their other intact senses, a term known as sensory re-weighting (Assländer & Peterka, 2014). As a result, balance is achieved with minimal posture changes (Assländer & Peterka, 2014). When more than one sensory system is altered or challenged, and the participant has an unhealthy balance system, obvious changes in posture will emerge (Martin Rosario, 2020; MG Rosario, 2022; Rosario & Jose, 2021b). In the current study, the most common task comparable to the participants' baseline balance is the DL EO FIRM condition. BOS, vision, proprioception, and vestibular are each intact during this task. However, to increase complexity and challenge the diverse system, this inquiry partially follows the published dual-motor balance tasks protocol (Bowman et al., 2021; Rosario et al., 2020). Therefore, in EC HUD FIRM, individuals must rely on their BOS and proprioception to remain balanced. BOS and visual sense are the components challenged in the EO HUD FOAM condition, and lastly, BOS and vestibular sense must compensate for the loss of visual sense and proprioception sense in the EC FOAM condition. The added dual-motor task of holding a cup of water increased the complexity of the balance conditions, further challenging the participants' ability to remain stable.

**Table 2.** Comparisons of EMG timing (seconds) for GMAX, GMed, GA, and TA during various balance task speeds. Results of a Repeated Measures ANOVA were performed during all tasks. The significance level was set at p≤0.05.

| Glut Max | Means and SD | Means and SD | P Value |
|---|---|---|---|
| | Onset DL EO FIRM = 6.9 +/- 4.3 | SL EO FIRM = 5.5 +/- 4.9 | 0.3 |
| | | EC HUD FIRM = 8.3 +/- 4.2 | 0.3 |
| | | EO HUD FOAM = 7.5 +/- 3.7 | 0.65 |
| | | ECFOAM = 7.3 +/- 3.9 | 0.77 |
| | TP DL EO FIRM = 0.4 +/- 0.4 | SL EO FIRM = 0.2 +/- 0.1 | 0.54 |
| | | EC HUD FIRM = 0.6 +/- 0.9 | 0.19 |
| | | EO HUD FOAM = 0.4 +/- 0.3 | 0.92 |
| | | ECFOAM = 0.4 +/- 0.3 | 0.97 |
| | Decay DL EO FIRM = 0.4 +/- 0.3 | SL EO FIRM = 0.4 +/- 0.4 | 0.9 |
| | | EC HUD FIRM = 0.4 +/- 0.3 | 0.97 |
| | | EO HUD FOAM = 0.4 +/- 0.2 | 0.91 |
| | | ECFOAM = 0.4 +/- 0.3 | 0.88 |
| | Duration DL EO FIRM = 0.8 +/- 0.6 | SL EO FIRM = 0.7 +/- 0.5 | 0.92 |
| | | EC HUD FIRM = 19.3 +/- 6.9 | 0.01 |
| | | EO HUD FOAM = 0.8 +/- 0.4 | 0.99 |
| | | ECFOAM = 0.7 +/- 0.5 | 0.98 |
| Glut Med | Means and SD | Means and SD | P Value |
| | Onset DL EO FIRM = 7.7 +/- 4.5 | SL EO FIRM = 5.7 +/- 4.1 | 0.13 |
| | | EC HUD FIRM = 9.3 +/- 3.6 | 0.2 |
| | | EO HUD FOAM = 7.9 +/- 4.3 | 0.84 |
| | | ECFOAM = 7.2 +/- 3.9 | 0.72 |
| | TP DL EO FIRM = 0.4 +/- 0.2 | SL EO FIRM = 0.3 +/- 0.2 | 0.5 |
| | | EC HUD FIRM = 0.4 +/- 0.3 | 0.29 |
| | | EO HUD FOAM = 0.2 +/- 0.1 | 0.14 |
| | | ECFOAM = 0.3 +/- 0.3 | 0.61 |
| | Decay DL EO FIRM = 0.4 +/- 0.3 | SL EO FIRM = 0.3 +/- 0.2 | 0.42 |
| | | EC HUD FIRM = 0.4 +/- 0.3 | 0.3 |
| | | EO HUD FOAM = 0.3 +/- 0.2 | 0.63 |
| | | ECFOAM = 0.3 +/- 0.2 | 0.07 |
| | Duration DL EO FIRM = 0.7+/- 0.4 | SL EO FIRM = 0.6 +/- 0.4 | 0.41 |
| | | EC HUD FIRM = 0.9 +/- 0.6 | 0.24 |
| | | EO HUD FOAM = 0.6 +/- 0.4 | 0.28 |
| | | ECFOAM = 0.6 +/- 0.4 | 0.42 |
| Gastrocnemius | Means and SD | Means and SD | P Value |
| | Onset DL EO FIRM = 7.2 +/- 4.0 | SL EO FIRM = 6.3 +/- 4.0 | 0.48 |
| | | EC HUD FIRM = 8.6 +/- 4.1 | 0.26 |
| | | EO HUD FOAM = 7.3 +/- 3.5 | 0.99 |
| | | ECFOAM = 6.9 +/- 3.8 | 0.26 |
| | TP DL EO FIRM = 0.3 +/- 0.2 | SL EO FIRM = 0.4 +/- 0.2 | 0.15 |
| | | EC HUD FIRM = 0.4 +/- 0.2 | 0.23 |
| | | EO HUD FOAM = 0.4 +/- 0.3 | 0.2 |
| | | ECFOAM = 0.4 +/- 0.3 | 0.07 |
| | Decay DL EO FIRM = 0.3 +/- 0.3 | SL EO FIRM = 0.4 +/- 0.2 | 31 |
| | | EC HUD FIRM = 0.4 +/- 0.2 | 0.26 |
| | | EO HUD FOAM = 0.4 +/- 0.2 | 0.15 |
| | | ECFOAM = 0.5 +/- 0.2 | 0.05 |
| | Duration DL EO FIRM = 0.6 +/- 0.4 | SL EO FIRM = 0.7 +/- 0.4 | 0.15 |
| | | EC HUD FIRM = 0.7 +/- 0.4 | 0.18 |
| | | EO HUD FOAM = 0.8 +/- 0.4 | 0.11 |
| | | ECFOAM = 0.9 +/- 0.4 | 0.05 |
| Tibialis Ant | Means and SD | Means and SD | P Value |
| | Onset DL EO FIRM = 8.5 +/- 3.7 | SL EO FIRM = 4.0 +/- 4.6 | 0.05 |
| | | EC HUD FIRM = 6.8 +/- 4.2 | 0.2 |
| | | EO HUD FOAM = 7.4 +/- 4.0 | 0.43 |
| | | ECFOAM = 6.1 +/- 3.8 | 0.6 |
| | TP DL EO FIRM = 0.4 +/- 0.3 | SL EO FIRM = 0.4 +/- 0.2 | 0.34 |
| | | EC HUD FIRM = 0.3 +/- 0.2 | 0.18 |
| | | EO HUD FOAM = 0.4 +/- 0.2 | 0.8 |

| | | | |
|---|---|---|---|
| | | ECFOAM = 0.3 +/- 0.2 | 0.34 |
| | Decay DL EO FIRM = 0.4 +/- 0.3 | SL EO FIRM = 0.5 +/- 0.2 | 0.84 |
| | | EC HUD FIRM = 0.5 +/- 0.3 | 0.92 |
| | | EO HUD FOAM = 0.5 +/- 0.3 | 0.82 |
| | | ECFOAM = 0.5 +/- 0.4 | 0.37 |
| | Duration DL EO FIRM = 0.9 +/- 0.5 | SL EO FIRM = 0.8 +/- 0.4 | 0.73 |
| | | EC HUD FIRM = 0.8 +/- 0.4 | 0.54 |
| | | EO HUD FOAM = 0.9+/- 0.5 | 0.99 |
| | | ECFOAM = 0.9 +/- 0.5 | 0.93 |

**Note:** BPM = Beats per minute; TP = Time to peak; SL= single limb; DL=double limb, EO=eyes open, EC=eyes closed; HUD=head up and down.

**Table 3.** Description of conditions for balance tasks, including the systems utilized for sensory re-weighting.

| Condition | Altered | Intact |
|---|---|---|
| DL EO FIRM | None - control | BOS, vision, proprioception, vestibular |
| SL EO FIRM | BOS | Vision, proprioception, vestibular |
| EC HUD FIRM | Vision, vestibular | BOS, proprioception |
| EO HUD FOAM | Vestibular, proprioception | Visual, BOS |
| EC FOAM | Visual, proprioception | BOS, vestibular |

Based on the above, the first finding of this study is the comparable neuromuscular activity of the leg muscles (GA and TA) during the tasks, which implies effective postural control mechanisms in young adults. The similarities in muscle activation indicate that muscles across different balance tests in young adults adapt effectively to different postural conditions by modulating sensory and motor systems. Our results are comparable to Rosario et al. (2020) in that GA onset preceded TA activity in standing balance tasks. The activity pattern suggests that GA is the agonist muscle group during quiet stance, and that the TA acts as the antagonist (Rosario et al., 2020). To further our conclusions, the time to GA peak activation (TP) was also longer than the TA, demonstrating an initial posterior sway adaptation.

After the initial adaptation that yielded a quicker TP of the GA, results showed that the decay of the TA exhibited a longer time than the GA, which is contrary to the findings of other studies (Rosario et al., 2020). This lengthy decay of the TA implies an increase in posterior ankle strategy or sway during complex balance trials, increasing TA recruitment. As mentioned above, the duration of the TA was also longer than the GA in this study, which is inconsistent with other cited EMG studies, but furthers the notion that the posterior ankle strategy was utilized during single-leg balance tasks (Rosario et al., 2020). Rosario et al. (2020) reviewed double leg balance, which could explain the difference between studies. The researchers investigated the activation of GA and TA during dual limb tasks, while this inquiry observed muscle activity in a single limb. Thus, the previously stated finding indicates that TA is recruited during single-leg double studies, with the added motor component, due to posterior sway adaptations.

Hip strategy recruitment could be another possible explanation for the posterior sway movement due to TA activity, since most balance tests were on a single limb. Literature has established that lapses in postural stability due to minor balance perturbations can be successfully corrected using ankle strategies. However, hip strategies may be employed when perturbations are stronger, and ankle strategies are no longer successful (Shumway-Cook & Woollacott, 2007). The level of TA recruitment compared to the GA activity in this study can be attributed to an increase in posterior ankle strategy to recover postural stability and hip strategy recruitment. To further understand postural control during dual-motor tasks, future studies should use motion capture systems (such as Vicon) concurrently with EMG during balance tasks to observe the changes in body segment angles related to muscle activity.

The second discovery of this study indicates that gluteal muscles (GMax and GMed) adapt differently than lower leg muscles. The single-limb nature of the tasks could explain the gluteal adaptation. These results suggest increased active hip stability was required with single-limb balance activities. The additional component of holding the cup could have added an extra challenge, resulting in a prolonged onset (time to activation) and longer duration. These results correspond with previous study findings indicating dual tasks' implications on postural stability, such as the aforementioned (Bowman et al., 2021). Increased challenge of balance tasks combined with the split attention of holding a cup of water is related to increased postural sway, according to Bowman et al. (2021). This increased sway could lead to postural adaptation by switching from ankle to hip strategy to maintain an upright posture (Horak, 2006).

Using a hip strategy to maintain balance could be another reason for deferring gluteal muscle activation compared to leg musculature and single-limb tasks that require more gluteal activation for stabilization of the pelvis (Earl, 2005; Prior et al., 2014). Moreover, studies such as Rosario et al. (2021) and Beurskens, Steinberg, Antoniewicz, Wolff, and Granacher (2016) corroborate our findings by identifying changes in postural stability during dual-motor tasks and gait activities in healthy young adults. When specifically looking at the impact of cognitive and motor interference on gait performance, Beurskens et al. (2016) found that motor interference causes more profound gait changes than cognitive interference tasks due to more overlap of the brain networks required for two concurrent motor tasks. A cognitive task may not require the same part of the brain or neural network to be used as the motor task, providing less interference. As most of the gait cycle is a single limb balance activity that requires hip musculature for pelvic stability, postural stability studies with dual tasks can substantiate the results of this research (Kharb, Saini, Jain, Dhiman, & Tech, 2011; Lee, Jung, & Lee, 2013). On the other hand, Rosario et al. (2021) noted similarities in gait activities during dual cognitive tasks in similar musculature within the healthy young adult population (2021). Finally, Small and Neptune's results echoed that dual cognitive tasks have limited effects on balance strategies used to maintain postural stability while walking in healthy adults (2022).

Limitations of this study could include the gender distribution of participants. The current study recruited the participants as a convenient sample, resulting in most subjects being females. Although we do not expect a major difference in balance across genders for this particular methodology, future research could determine whether a more diverse gender distribution renders similar or different results in terms of muscle activation during dual tasks with balance activities. Along with previous research, the results from this study could help form a baseline to compare the effects of dual tasks on muscle activation during balance in other populations. Since holding a cup full of water closely imitates functional activities required for activity of daily living (ADLs) and instrumental ADLs (Edemekong, Bomgaars, Sukumaran, & Levy, 2022), analyzing other populations with known balance issues, such as diabetics and those living with HIV, with a similar design, could help determine fall risk associated with split attention. Furthermore, prospective studies should compare EMG response during dual-cognitive and dual-motor tasks, and the cortical involvement during both tasks.

## 5. CONCLUSION

This study analyzed lower extremity muscle activation during single and motor dual-task balance activities to determine if specific neuromuscular patterns exist within young, healthy adults. In addition, this study indicated the comparability of leg muscle activation during balance and SL stance activities. In this population, co-contraction of GA and TA is typically near-identical, demonstrating that the postural system can adjust during both single and dual motor tasks to maintain balance. Therefore, any variation of activation of GA and TA while performing balance activities could indicate neuromuscular changes. However, EMG data indicated prolonged onset and longer duration of the gluteal muscles (GMax and GMed). These neuromuscular adaptations could be due to the increased requirement for hip stability with single limb tasks, or the use of hip strategy to maintain balance. This research adds to the body of knowledge on typical neuromuscular patterns with dual-motor tasks in young, healthy adults.

Future research can compare neuromuscular signaling within various populations (diabetics or those living with HIV) to determine if the disease impacts muscle activation during dual-motor balance tasks. Moreover, this research topic could be expanded to further explore the distinctions between cognitive and motor interference by comparing lower extremity neuromuscular activation during dual-motor-cognitive activities while performing progressively difficult balance tasks. The clinical significance of this work is to improve understanding of the impact of dual tasks on neuromuscular signaling in the lower extremities. In addition, knowing typical neuromuscular signaling for LE musculature controlling balance in healthy young adults will help characterize changes in other populations that may correlate to increased fall risk. As a final note, neuromuscular adaptations for balance differ from gait. The current study proposes a further investigation into dual-motor during gait and balance tasks in diverse groups to characterize and compare neuromuscular components.

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