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Article

Effects of mobile phone task engagement on gait and dynamic stability during stair ascent and descent

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Abstract: Mobile devices, including smartphones, have become closely integrated into our daily lives. However, using a phone while walking may lead to falls due to cognitive distraction. In comparison to walking on level ground, stair ambulation represents one of the most challenging and hazardous forms of movement. It is imperative to explore the impact of mobile phone task engagement on walking patterns and stability during stair ascent and descent. Methods: Recruited 16 young participants for our study, where they were required to perform single tasks (ascending and descending stairs) and dual tasks (using a smartphone while ascending and descending stairs). During these activities, we collected data on gait parameters and the range of motion (RoM) of the center of mass (CoM) in the anterior-posterior and medial-lateral directions. Paired-sample t-tests were employed for data analysis. Results: Mobile task engagement resulted in a decrease in walking speed ($p < 0.001$), a decrease in gait cycle ($p < 0.001$), and an increase in task completion time ($p < 0.001$). During stair ascent, there was a reduction in double support ratio ($p = 0.010$) and an increase in single support ratio ($p < 0.001$). The stability of the center of mass (CoM) in the anterior-posterior direction increased during task execution ($p < 0.001$), while the stability in the medial-lateral direction decreased (ascending stairs $p = 0.041$; descending stairs $p = 0.024$). Conclusion: These findings indicate that engaging in mobile tasks affects the gait parameters during stair ascent and descent. However, the impact on dynamic stability is not entirely negative; instead, it has a positive effect on the dynamic stability of the CoM in the anterior-posterior direction. This suggests that healthy young participants may adopt a more stable gait pattern while performing dual tasks.

Keywords: gait stability; mobile; walking; stairs; disturbance

1. Introduction

With the emergence of electronic content easily accessible via smartphones, texting while walking has become a common physical activity, demonstrating widespread prevalence and effectiveness. Stair ambulation represents one of the most challenging and hazardous forms of movement [1], When individuals engage in reasoning or handling objects while navigating stairs, the risk of falls is further heightened [2,3]. Ascending and descending stairs are common functional activities in daily life. During the process of ascending or descending stairs [4], the dual-task paradigm is essential, representing a common scenario in daily life. Simultaneously performing additional tasks often leads to gait pattern changes associated with falls [5]. Dual-tasking involves executing a motor task (such as walking or climbing stairs) while concurrently engaging in cognitive or physical tasks. However, compared to walking on level ground, stair ambulation is more challenging due to its higher demand for body stability [6,7]. The changes in stability during stair ambulation constitute a three-dimensional dynamic process. Falls and injuries related to staircases mostly occur in the sagittal plane (anterior-posterior direction) and coronal plane (medial-lateral direction) [8,9]. Therefore, the exploration of changes in body stability in the anterior-posterior and medial-lateral directions during stair ascent and descent is urgently needed.

When engaging in everyday functional activities such as standing, walking, and rising, individuals often concurrently handle additional cognitive tasks, leading to attentional diversion. The interference of additional tasks can directly impact the control of functional movements and the ability to integrate sensory system information [10], For instance, during posture control, individuals need to efficiently integrate sensory information to adjust the position of the center of mass (CoM) or the size of the base of support (BoS) to maintain balance. Research has found that the introduction of dual tasks has significantly adverse effects on gait, but consensus has not been reached regarding the impact on walking stability. Some studies indicate a deterioration in stability during dual-task execution, while others report the opposite [11–13]. The lack of consistency in results may stem from variations in the selection of stability evaluation indicators. Commonly used metrics to assess body stability in previous research include center of mass (CoM) position [14], center of pressure (CoP) displacement, CoM-CoP difference [15], and margin of stability (MoS) [16–18]. Maintaining dynamic stability during the gait process relies on the ability to control the motion of the CoM. Therefore, changes in CoM range of motion (CoM_{RoM}) in the sagittal plane (anterior-posterior direction, $CoM_{RoM\text{-}AP}$) and coronal plane (medial-lateral direction, $CoM_{RoM\text{-}ML}$) have been widely utilized to detect gait instability [19], albeit mostly in unrestricted level walking conditions [20,21], Currently, there is limited research employing $CoM_{RoM\text{-}AP}$ and $CoM_{RoM\text{-}ML}$ metrics to investigate dynamic stability changes during stair ambulation in the context of dual-task paradigms [22].

Therefore, this study aims to investigate the impact of mobile phone task engagement on the dynamic stability and gait parameters during ascending stairs and descending stairs. The hypotheses of this study are as follows: 1) Compared to single-task conditions, mobile task engagement alters gait parameters; 2) Compared to single-task conditions, mobile task engagement results in a decrease in dynamic stability in both the sagittal plane (anterior-posterior direction) and coronal plane (medial-lateral direction).

2. Methods

2.1. Subjects

Sixteen participants (8 males, 8 females) were recruited from Jeonbuk National University, and the study received approval from the Jeonbuk National University Ethics Committee (JBNU2022-04-008-001). Participants did not have any orthopedic issues that could potentially limit their ability to complete walking tasks or cause gait variations and balance-related issues. Written informed consent was obtained from each participant before the experiment. Prior to their involvement in the study, all participants completed a brief survey regarding their personal information (such as height, weight, and age). The physical characteristics of the participants are presented in **Table 1**:

Table 1. Subject characteristics (n = 16).

	Age (yr)	Height (cm)	Body Mass (kg)	BMI(kg/m^2)	Dominant side
Mean ± SD	26.0 ± 4.0	172.1 ± 7.3	69.6 ± 9.8	23.5 ± 2.2	Right

2.2. Experimental procedure and apparatus

Test data collection: We used a total of 13 infrared cameras (Prime 17W, OptiTrack, Natural Point, Inc., Corvallis, OR, USA), and the cameras captured the motion data of each subject at a sampling rate of 240 Hz. During the course of this test, 14 mm reflective markers were used as marker points for the test, and each subject attached a total of 57 reflective marker points, including tracking and localization points, to the surface of the skin [23]. At the end of each subject's test, the 3D motion data captured during the test were transferred to the software Visual3D (Professional 6.0, C-Motion Inc., Germantown, MD, USA) for data analysis of gait parameters and other features.

2.3. Test procedure

Prior to the formal testing phase, participants were instructed to change into tight-fitting clothing and shoes provided by the laboratory, followed by morphological data measurements. Subsequently, experimenters affixed reflective marker balls to the participants (**Figure 1**). After the preparatory procedures were completed, participants engaged in approximately 5 minutes of warm-up exercises and familiarized themselves with the experimental environment (**Figure 2**). At the commencement of the test, participants waited at an appropriate starting position and, upon hearing the command "start" ascended and descended the stairs one step at a time at their comfortable pace until completion. Participants performed all assigned tasks on the simulated staircase (**Figure 3**).

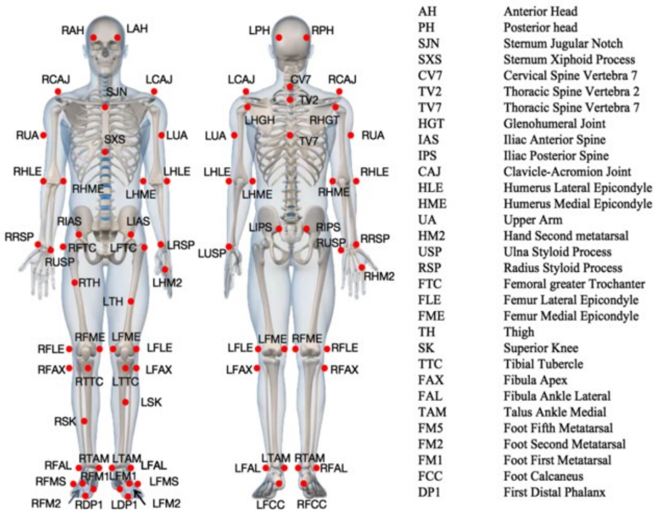

Figure1. The anatomical position of the participant's pelvis and lower extremities for placement of reflex markers [23,24].

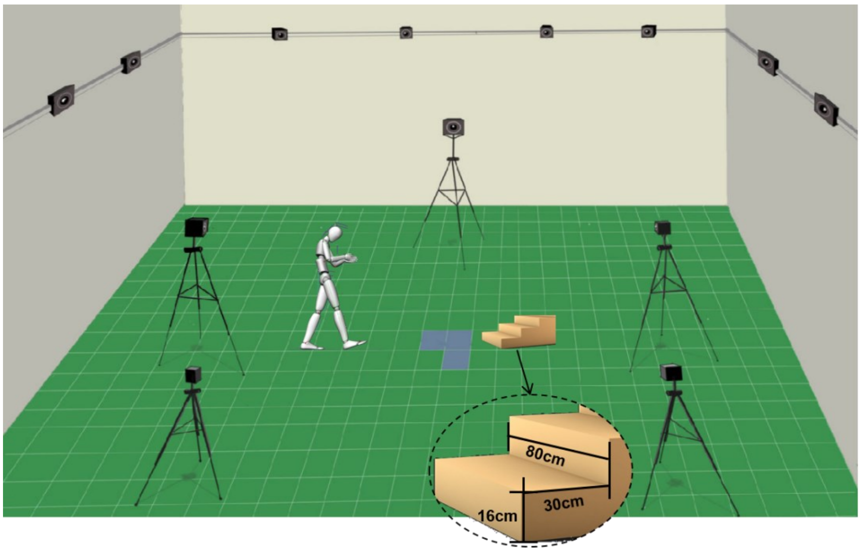

Figure 2. To collect data for this study, we constructed a 3-step simulated staircase (each step with a height of 16 cm, depth of 30 cm, slope ≈ 30°). The parameters of the steps were in accordance with national residential standards.

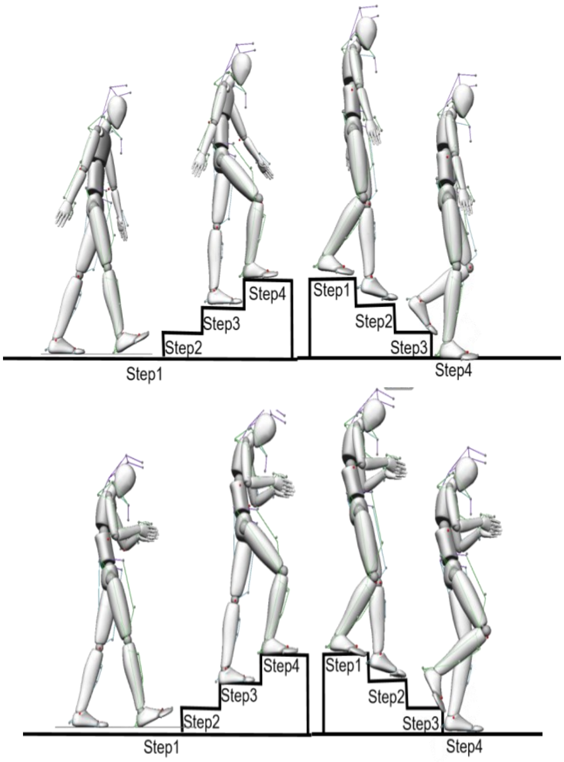

Figure 3. Simulation of staircase and tasks.

In this study, each participant used their own personal phone, and they also used their familiar text input methods during the text editing tasks. This ensured that the participants were very familiar with the operation of their devices. During the testing process, the information provided by the participants was based on random questions posed by the experimenter, as detailed in **Table 2**. Every test featured different questions. These questions displayed in real-time on a screen in front of them appeared in the participants' chat dialogue boxes, and the accuracy of the participants' responses was checked.

The testing experiment comprised two tasks: 1) Single-task: walking up and down the stairs without using a phone; 2) Mobile phone task: participants held a phone in both hands during the stair ascent and descent, simultaneously performing a text editing task. Participants were required to send specified texts during the task, with the text content randomly selected from everyday conversational phrases (**Table 2**). Three valid data collections were conducted for each task condition, with a 30-second rest interval between each test. Throughout the experiment, participants were instructed to ensure that in each trial, the right foot landed on step 1 when ascending the stairs (**Figures 3** and **4**), and when descending, the right foot landed on step 2 (**Figures 3** and **5)**. It was prohibited for both feet to simultaneously occupy a single step during the experiment.

Table 2. Daily conversation content.

① Let's go out for dinner together tonight!	⑤ Where is your hometown?
② I am going to class. What about you?	⑥ What is your favorite movie?
③ The weather forecast says it will snow tomorrow.	⑦ How have you been recently?
④ Do you have any plans for the weekend?	⑧ I like the songs of this band.

2.4. Data analysis

We utilized Visual-3D software for the analysis and processing of the collected three-dimensional kinematic and kinetic data. Both kinematic and kinetic data underwent a fourth-order Butterworth digital low-pass filtering, with cutoff frequencies of 6 Hz [25]. During data analysis, gait parameters and the center of mass (CoM) height were normalized based on the participant's height. Single and double support phases of one gait cycle were extracted for dynamic stability analysis (**Table 3**, **Figures 4** and **5**). The processed data were further analyzed using SPSS software, where the mean values of three valid data sets for each participant were compared and analyzed.

Table 3. The segmentation of the gait cycle in this study.

		Ascending stairs (**Figure 4**)	Descending stairs (**Figure 5**)
Double Support	Right double support	The gait cycle in this study begins at the moment when the right heel makes contact with step 3 and continues until the moment when the left toe leaves step 2.	The gait cycle in this study begins at the moment when the right toe makes contact with step 2 and continues until the moment when the left toe leaves step 1.
	Left double support	The gait cycle in this study starts at the moment when the left heel makes contact with step 2 and continues until the moment when the right toe leaves step 1.	The gait cycle in this study begins at the moment when the left toe makes contact with step 3 and continues until the moment when the right toe leaves step 2.
Single Support	Right single support	The gait cycle in this study starts at the moment when the left toe leaves step 2 and continues until the moment when the left heel makes contact with step 4.	The gait cycle in this study begins at the moment when the left toe leaves step 1 and continues until the moment when the left toe makes contact with step 3.
	Left single support	The gait cycle in this study starts at the moment when the right toe leaves step 1 and continues until the moment when the right heel makes contact with step 3.	The gait cycle in this study begins at the moment when the right toe leaves step 2 and continues until the moment when the right heel makes contact with step 4.

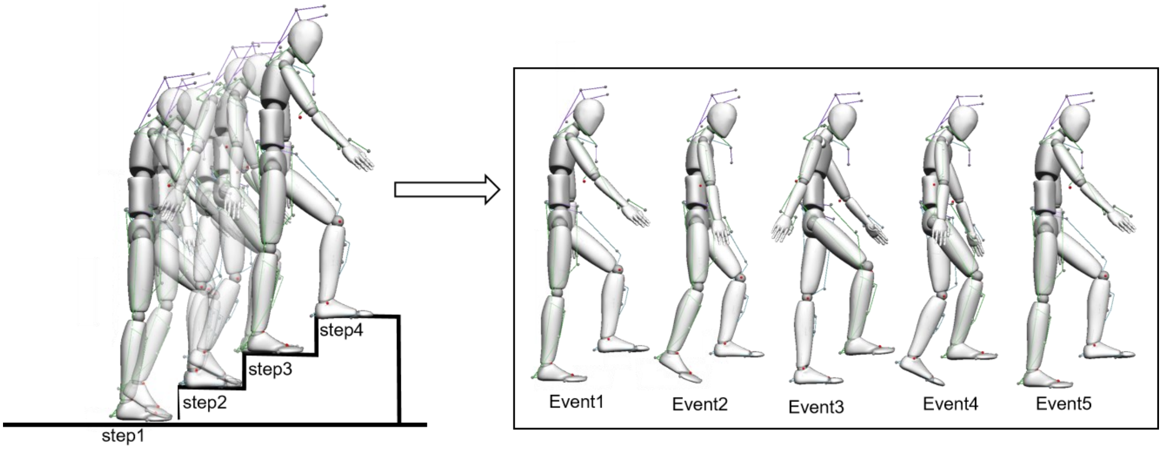

Figure 4. Gait cycle and events when ascending stairs.

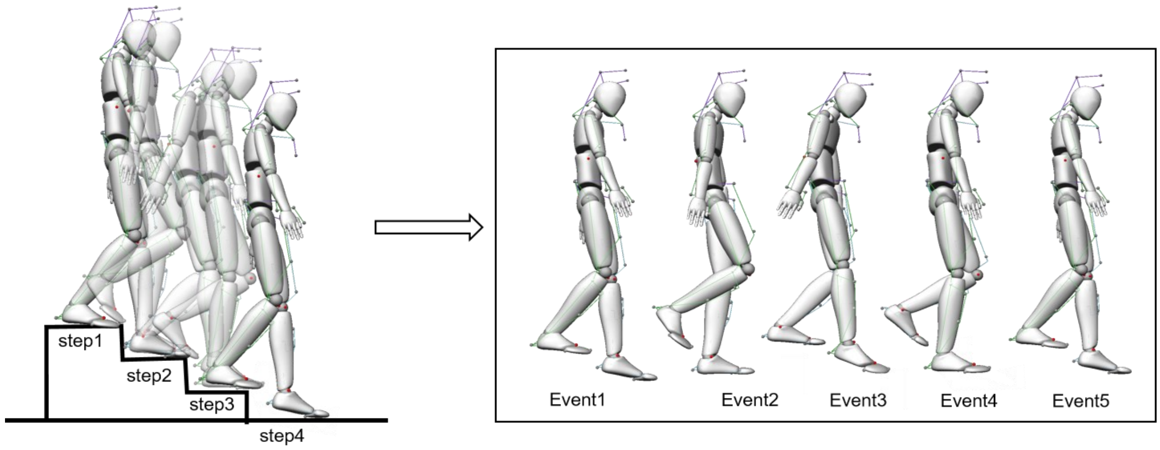

Figure 5. Gait cycle and events when descending stairs.

Step Length (m): The anterior-posterior distance between the Left Heel and Right Heel marker points during the double support phase. Step Width (m): The shortest horizontal distance between the inner edges of the two feet is defined as the step width. Cadence (step/min): The number of steps taken within one minute. Gait speed (m/s): The speed of ascending stairs is defined as the whole body center of mass (CoM) velocity from the moment the left foot makes contact with step 1 until the right foot contacts step 3 (**Figure 4**). The speed of descending stairs is defined as the whole body CoM velocity from the moment the right foot makes contact with step 1 until the left foot contacts the ground (**Figure 5**).

Dynamic Stability CoM_{ML}: The dynamic stability during the gait process is assessed by the range of motion (RoM) of the center of mass (CoM) in the medial-lateral (ML) and anterior-posterior (AP) directions. The calculation method for CoM_{RoM} is:

$$CoM_{RoM} = CoM_{max} - CoM_{min}$$

Here, CoM_{max} is the maximum value reached during the stride length, and CoM_{min} is the minimum value reached during the stride length. The vertical motion amplitude on the stairs is constrained by the dimensions of the stairs' columns and treads. Therefore, in this study, we did not investigate this aspect [26].

2.5. Statistical analysis

We analyzed the data using SPSS 23.0 and a normality analysis was conducted on the participants' data. The analysis indicated that the data followed a normal distribution. Paired-sample *t*-tests were employed to analyze the significance of differences between the two gait tasks (using a phone and not using a phone) in both ascending and descending stairs environments. To achieve a normal distribution and reduce the impact of outliers, the data for cup inclination deviation were log-transformed. Use Shapiro-Wilk test to assess if the log-transformed data are normally distributed. If the normality assumption is met, conduct the paired samples t-test on the log-transformed data. The significance level was set at $p < 0.05$. Interpret the results in terms of the log-transformed data back-transforming.

3. Results

Table 4. Gait Parameters during ascending and descending stairs under two task Conditions

Tasks	Variables	No phone	Watch the phone	*p*
Ascending stairs	Step Length (m)	0.31 ± 0.02	0.31 ± 0.03	0.554
	Step Width (m)	0.13 ± 0.06	0.10 ± 0.08	0.050
	Cadence (step/min)	44.81 ± 5.41	35.95 ± 6.63	<0.001
	Gait Speed (m/s)	0.59 ± 0.07	0.47 ± 0.09	<0.001
	Completion Time (s)	1.82 ± 0.28	2.26 ± 0.35	<0.001
Descending stairs	Step Length (m)	0.46 ± 0.04	0.42 ± 0.04	<0.001
	Step Width (m)	0.11 ± 0.04	0.11 ± 0.04	0.844
	Cadence (step/min)	53.43 ± 4.71	46.86 ± 5.71	<0.001
	Gait Speed (m/s)	0.70 ± 0.08	0.58 ± 0.08	<0.001
	Completion Time (s)	1.63 ± 0.14	1.83 ± 0.21	<0.001

From **Table 4**, it can be observed that the inclusion of the mobile phone task during stair ascent significantly reduced the step frequency and had a very significant impact on both the walking speed and overall task completion time ($p < 0.001$). The effects on step length and step width were not substantial. However, for stair descent with the inclusion of the mobile phone task, there was a very significant impact ($p < 0.001$) on all indicators except step width, including a reduction in step length, decrease in step frequency, decrease in walking speed, and an increase in task completion time.

The inclusion of the mobile phone task had an impact on the proportion of support phases during stair ascent and descent. During stair ascent, the proportion of the right single support phase and left single support phase significantly increases ($p < 0.001$), while the proportion of the double support phase decreases due to the inclusion of the mobile phone task ($p = 0.010$). In the process of descending stairs, the inclusion of the mobile phone task significantly increased the proportion of the right single support phase and left single support phase during stair ascent ($p < 0.001$) but had no significant impact on the proportion of the double support phase (**Figure 6**).

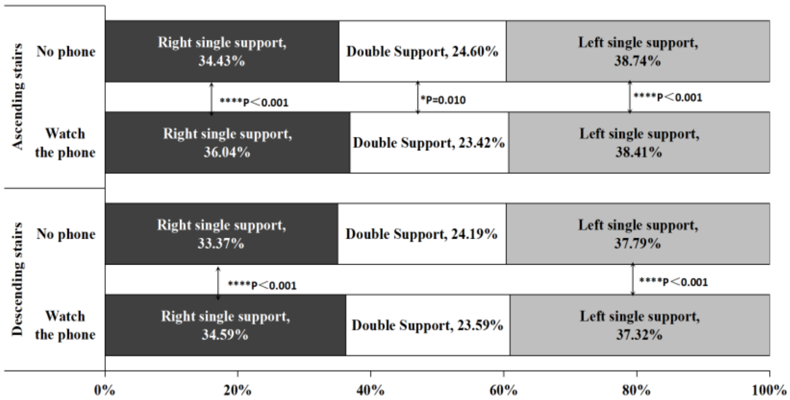

Figure 6. Percentage of each time phase in the gait cycle during ascending and descending stairs.

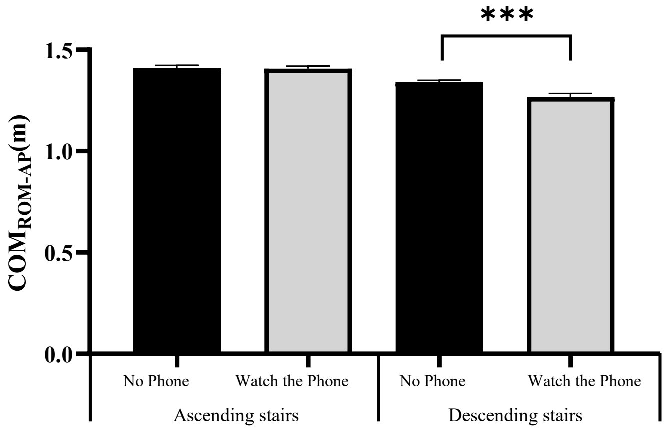

Figure 7. CoM$_{RoM-AP}$ for completing the whole test.

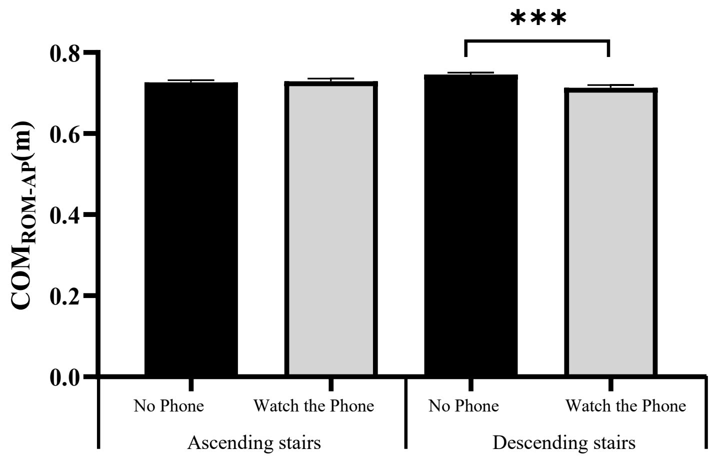

Figure 8. CoM$_{RoM-AP}$ for a gait cycle.

The intervention of the mobile phone task during task completion led to a decrease in the magnitude of CoM$_{RoM-AP}$ changes during stair descent (p = 0.001), while the impact on stair ascent was not significant (**Figure 7**). In one gait cycle, the addition of the mobile phone task similarly reduced the magnitude of CoM$_{RoM-AP}$ changes during stair descent (p = 0.001) (**Figure 8**).

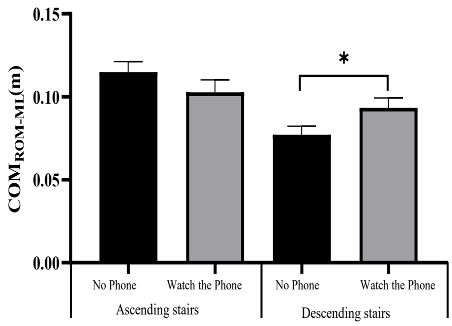

Figure 9. COM_{ROM-ML} for completing the whole test.

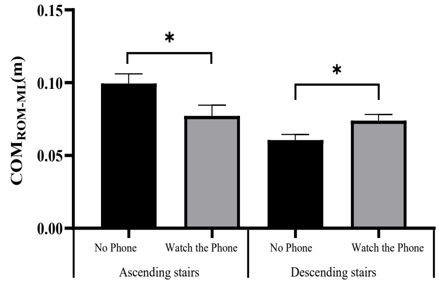

Figure 10. COM_{ROM-ML} for a gait cycle.

During the completion of the stair ascent task, the intervention of the mobile phone task leads to a decrease in the magnitude of CoM_{RoM-ML} changes, while in the process of stair descent, the magnitude of CoM_{RoM-ML} changes increases ($p = 0.041$) (**Figure 9**). We further observed the changes in CoM_{RoM-ML} during one gait cycle and found that the intervention of the mobile phone task reduced the magnitude of CoM_{RoM-ML} changes during stair ascent ($p = 0.027$) but increased the magnitude of CoM_{RoM-ML} changes during stair descent ($p = 0.024$) (**Figure 10**).

Table 5 presents the information on COM_{ROM} during double support and single support phases in each gait cycle test. During the ascending stairs task, there was a significant increase in stability in the medial-lateral direction during the left single support and right double support phases, as well as in the anterior-posterior direction during the right double support phase, due to the mobile phone task ($p < 0.05$). However, the opposite effect was observed in the right single support phase ($p < 0.001$). In the descending stairs task, a significant increase in stability in the anterior-posterior direction was observed during the single support phase($p < 0.05$), while a marked decrease in stability in the medial-lateral direction occurred during the right double support phase due to the mobile phone task ($p = 0.001$).

Table 5. COM $_{ROM}$ for each time phase in the gait cycle during ascending and descending stairs.

	Ascending stairs				**Descending stairs**			
	No phone	**Watch the phone**	***p***	↑/↓	**No phone**	**Watch the phone**	***p***	↑/↓
Left single support								
CoMRoM-AP (cm)	2.12 ± 0.42	2.02 ± 0.36	0.246	↑	0.95 ± 0.14	0.87 ± 0.17	0.033	↑
CoMRoM-ML (cm)	0.20 ± 0.10	0.24 ± 0.11	0.038	↓	0.19 ± 0.09	0.22 ± 0.09	0.137	↓
Right single support								
CoMRoM-AP (cm)	2.77 ± 0.25	2.56 ± 0.32	<0.001	↑	2.29 ± 0.20	2.18 ± 0.26	0.015	↑
CoMRoM-ML (cm)	0.22 ± 0.11	0.21 ± 0.14	0.800	↑	0.20 ± 0.12	0.26 ± 0.13	0.041	↓
Left double support								
CoMRoM-AP (cm)	0.97 ± 0.24	1.02 ± 0.19	0.226	↓	3.40 ± 0.27	3.28 ± 0.40	0.105	↑
CoMRoM-ML (cm)	0.32 ± 0.25	0.35 ± 0.27	0.612	↓	0.25 ± 0.10	0.30 ± 0.16	0.084	↓
Right double support								
CoMRoM-AP (cm)	1.40 ± 0.35	1.69 ± 0.39	<0.001	↓	0.81 ± 0.14	0.78 ± 0.15	0.207	↑
CoMRoM-ML (cm)	0.21 ± 0.16	0.31 ± 0.20	0.009	↓	0.29 ± 0.12	0.38 ± 0.14	0.001	↓

CoM_{RoM-AP}: represents the stability in anterior-posterior direction.
CoM_{RoM-ML}: represents the stability in the medial-lateral direction.
↑/↓: indicates the trend of stability change after the intervention of mobile phone task

4. Discussion

Through our study, we explored the impact of the mobile phone task intervention on gait parameters during task execution, as well as its effects on the entire experimental process, a gait cycle, and four significant phases within a gait cycle in both anterior-posterior and medial-lateral directions during stair ascent and descent. However, contrary to our hypothesis, the intervention of the mobile phone task influenced the gait performance and dynamic stability of participants during stair ascent and descent. Importantly, these effects were not entirely detrimental.

The most noticeable impact in gait performance was on walking speed and step frequency, and the intervention of the mobile phone task had a more pronounced effect on participants' gait performance during stair descent compared to stair ascent. Previous dual-task studies on stair walking and communication with others evaluated dynamic gait stability using the range of motion of the center of mass, showing a decrease in movement speed for young males during dual-task stair ascent/descent processes, which aligns with our initial hypothesis [27], Under dual-task conditions, both young [27] and elderly participants [28,29] exhibit a decrease in gait speed during level walking. The increase in the complexity of the gait task leads to a decrease in gait speed, suggesting an increased movement cost for postural control. However, the slower gait speed reduces the control cost of the movement. Research has also demonstrated that under dual-task conditions, performance in at least one of the two tasks may decrease. This is because attention resources are allocated to each task being executed. Changes in gait under dual-task conditions may result from the allocation of attention resources from gait to the simultaneously executed second task, highlighting the competition between attention demands for gait and the accompanying demands of the second task [27,30].

A considerable amount of research indicates that visual impairment can significantly alter gait patterns [31–33]. They suggest that the main reasons for such changes are cognitive distraction, reduced visual attention to the environment, and changes in body demands during task execution. These factors may also impact trunk stability, aligning with our results. Additionally, we observed a noticeable change in the proportions of different phases during stair ascent and descent, consistent with previous research [34], In both stair ascent and descent tasks, there was a decrease in the proportion of the double support phase, indicating a decrease in body stability [35]. Moreover, similar to the findings of Kim Seong-Min and colleagues [36] the intervention of the mobile phone task led to a significant increase in the proportion of right single support during stair ascent and descent, while the proportion of left single support on the non-dominant side significantly decreased. This differs from previous research and might be because participants prioritize increasing support on the dominant side to better maintain body stability. Therefore, even with the intervention of the mobile phone task during stair ascent and descent, participants were able to achieve a stable state through rapid adjustments (such as reducing walking speed and step frequency).

Dynamic stability of the body refers to the ability of the human body to resist external disturbances and maintain stability during movement [17]. In the research conducted by other scholars, increased displacement of the Center of Mass (CoM), Center of Pressure (CoP), and the deviation of CoM-CoP can all be explained as a decline in dynamic gait stability during walking. As the inclination angle increases, the deviation of CoM-CoP becomes larger, making it more challenging for the body to restore the CoM above the CoP [37]. Similarly, if there is a significant deviation of CoM-CoP, the lower limb joints cannot maintain an upright posture, leading to the occurrence of falls [38]. Research suggests that, under dual-task conditions, measuring the range of movement of the center of mass in the medial-lateral direction can represent the dynamic gait stability of participants [27]. In our study, due to the intervention of the mobile phone task, the stability in the anterior-posterior direction during stair descent significantly decreased in Left single support and Right single support, while stability in the medial-lateral direction improved in Right single support and Right double support.

However, during the task of ascending stairs while looking at the phone, the stability in the anterior-posterior direction improved in Left double support, Right double support, and in the medial-lateral direction, stability improved in Left single support, Right double support, and Right double support. Therefore, some of the research results did not fully support our initial hypothesis. These findings are consistent with previous studies, mostly involving young participants, where the intervention of the mobile phone task resulted in additional enhancement of body stability under dual-task conditions [11,39,40].

Although the intervention of the mobile phone task influenced the magnitude of changes in the Center of Mass Range of Motion (CoM_{RoM}) in the anterior-posterior and medial-lateral directions, none of the participants experienced falls. This is attributed to the fact that CoM_{RoM} consistently remained within a safe range. Other studies have reported that the risk of falls only increases when $CoM_{RoM\text{-}ML}$ exceeds a displacement greater than 6 cm in community-dwelling older adults [41].

Some scholars explain the occurrence of this phenomenon as the integration of postural control and dual-task paradigms. One study found that when participants ascend stairs while holding a cup, they prioritize enhancing their own stability first to keep the glass stable. The additional constraints imposed by the more demanding dual-task interact with the original task of simply descending stairs, thereby increasing overall body stability [32]. During movement, the environmental information provided by the visual system is crucial. When using a mobile phone, reducing head movements to keep the gaze fixed on the phone may alter vestibular and visual sensory signals for balance control. This cautious gait pattern observed when using a mobile phone may reduce the risk of injury when visual obstruction occurs [33,42,43]. Therefore, the improved stability performance of participants in our study during stair ascent and descent tasks is plausible [12]. It is worth considering that a cautious gait strategy might be employed to ensure that participants can edit text accurately rather than solely focusing on fall prevention.

This study has the following limitations:1) It would be preferable to consider dynamic gait stability at different walking speeds during the testing process. However, when participants are required to simultaneously perform a cognitive task, maintaining a faster walking speed becomes challenging. Editing information leads to a noticeable decrease in gait speed, which affects their gait during stair ascent and descent. 2)

During the testing process, participants, especially while ascending and descending stairs, subjects needed increased dynamic stability in order to text accurately,although this also helped prevent falls. In future research, task replacement could be considered.

In future research investigating dual-task interventions during walking, it would be advisable to consider the factor of walking speed to demonstrate whether it has varying effects on the simultaneous execution of dual tasks. The participants selected for this study were healthy young university students. Subsequent research should focus on elderly individuals, as compared to young people, older adults tend to have more experiences of falls [44] and require more attentional resources during stair ascent and descent walking [2].

5. Conclusion

When using a mobile phone while ascending or descending stairs, even young and healthy participants alter their gait and dynamic stability. However, changes in CoM_{RoM} and slower walking speed may represent a compensatory strategy for enhancing dynamic stability and reducing movement control costs in young, healthy participants performing dual tasks. This study suggests that when texting, individuals adopt a more stable gait pattern, such as slowing down walking speed and increasing the duration of single support on the dominant side, to avoid hazards and prevent falls, thereby enabling safe ambulation.

Author contributions: Conceptualization, QQ, CW and SK; methodology, QQ, JZ and SK; software, QQ and CW; validation, JZ and SK; formal analysis, QQ and JZ; investigation, QQ, YX, YL and JZ; resources, YX, CW and SK; data curation, YL and CW; writing—original draft preparation, QQ and CW; writing—review and editing, JZ and SK; visualization, JZ; supervision, SK; project administration, CW. All authors have read and agreed to the published version of the manuscript.

Ethical approval: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Jeonbuk National University Ethics Committee (JBNU2022-04-008-001 and August 2022).

Conflict of interest: The authors declare no conflict of interest.

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