RESEARCH ARTICLE
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REVISTA RIICS
Investigación e innovación en ciencias de la salud

Smartphone Use Affects Spatio-Temporal Gait Parameters but Not Gait Symmetry in Young Adults Walking Outdoors

El uso de smartphones afecta los parámetros espaciotemporales de la marcha, pero no la simetría, en adultos jóvenes que caminan al aire libre

Martín Suárez[1], **María Casablanca**[1], **Melisa Frisoli**[2], **Pablo Luciano Querubín Pereyra**[1], **Juan Grigolatto**[1], **Daniel Zapata**[1], **Paola Catalfamo Formento**[2]

[1] *School of Engineering; National University of Entre Rios; Oro Verde; Argentina.*

[2] *Human Movement Research Laboratory; School of Engineering; National University of Entre Rios; Oro Verde; Argentina.*

Correspondence
Paola Catalfamo Formento.
Email: pcatalfamo@ingenieria.uner.edu.ar

Editor
Fraidy-Alonso Alzate-Pamplona, MSc.

Declaration of interests
The authors declare no conflicts of interest.

Funding
The authors received no specific funding for this work.

Ethics statement
This study was approved by the Ethics and Experimental Work Safety Committee of the Scientific and Technological Research Center CONICET - Santa Fe, under the code CEYSTE-CES-01302/2024. All participants provided written informed consent.

Abstract

Introduction. Smartphones have become essential tools in daily life. Research has shown that some spatio-temporal parameters of gait are affected when using smartphones. However, most of the research has been conducted indoors, in controlled environments.

Objective. To study the impact of smartphone use on gait spatio-temporal parameters and symmetry in young adults walking outdoors.

Method. Videos of 35 healthy young adults (14 women, aged 18–28 years) were recorded in an outdoor pathway under two walking conditions: habitual walking and walking while texting on a smartphone using both hands. The videos were analyzed to calculate spatio-temporal parameters and symmetry.

Results. The results showed that during walking while texting, participants walked at a lower speed ($P < 0.0001$), with a longer cycle time ($P < 0.0001$), step time ($P < 0.0001$), and stance time ($P < 0.0001$) compared to habitual walking. However, the symmetry between lower limbs showed no differences for any of the analyzed parameters ($P > 0.05$).

Conclusion. Smartphone use while walking affects gait spatio-temporal parameters, leading to reduced walking speed and adjusted temporal variables. However, gait symmetry between lower limbs is preserved. These changes might aim to enhance stability and balance, improving pedestrian safety under divided attention.

Data availability
All data supporting the findings of this study are available within the article. For additional details, please contact the corresponding author.

Author Contributions
Martín Suárez: Conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing – original draft, writing – review & editing.
María Casablanca: Conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing – original draft, writing – review & editing.
Melisa Frisoli: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – riginal draft, writing – review & editing.
Pablo Luciano Querubín Pereyra: Conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing – original draft, writing – review & editing.
Juan Grigolatto: Conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing – original draft, writing – review & editing.
Daniel Zapata: Conceptualization, formal analysis, funding acquisition, methodology, supervision, validation, writing – review & editing.
Paola Catalfamo Formento: Conceptualization, formal analysis, funding acquisition, investigation, project administration, resources, software, supervision, validation, visualization, writing – original draft, writing – review & editing.

Generative AI declaration
The authors declare that no generative AI tools were used in the writing, editing, data analysis, or any other part of the preparation of this manuscript.

Cite this article
Suárez M, Casablanca M, Frisoli M, Querubín Pereyra PL, Grigolatto J, Zapata D, Catalfamo Formento P. Smartphone use affects spatio-temporal gait parameters but not gait symmetry in young adults walking outdoors. Revista de Investigación e Innovación en Ciencias de la Salud. 2025;7(2):1-17. e-v7n2a392. https://doi.org/10.46634/riics.392

Received: 12/19/2024
Revised: 03/20/2025
Accepted: 05/19/2025
Published: 06/18/2025

Keywords

Videography; walking speed; stance time; swing time; dual-task; texting while walking.

Resumen

Introducción. Los smartphones son esenciales en la vida diaria. Sin embargo, se ha reportado que algunos parámetros espacio-temporales de la marcha cambian cuando se utiliza un smartphone en espacios interiores y controlados.

Objetivo. Estudiar el impacto del smartphone sobre los parámetros espaciotemporales y simetría de la marcha en adultos jóvenes, caminando al aire libre.

Método. Videos de 35 adultos jóvenes sanos (14 mujeres, rango de edad de edad de 18 a 28 años) fueron registrados en un pasillo exterior bajo dos condiciones de marcha: caminata habitual y caminata escribiendo en un smartphone con ambas manos. Los videos fueron analizados para el cálculo de parámetros y simetría.

Resultados. Los resultados mostraron que, durante la caminata con el uso del smartphone, los sujetos caminaron a una menor velocidad ($P< 0.0001$), con un mayor tiempo del ciclo ($P< 0,0001$), tiempo de paso ($P< 0,0001$) y tiempo de apoyo ($P< 0,0001$), en comparación con la caminata habitual. Sin embargo, la simetría en los tiempos no mostró diferencias para ninguno de los parámetros analizados ($P>0.05$).

Conclusión. El uso de smartphone mientras se camina afecta los parámetros espacio-temporales de la marcha, adoptando una disminución de la velocidad de marcha y adecuando los tiempos consecuentemente, pero la marcha mantiene la simetría entre miembros inferiores. Es posible que estos cambios tengan el objetivo de aumentar la estabilidad y la capacidad de equilibrio y así mejorar la seguridad de las personas cuando caminan con atención dividida.

Palabras clave

Videografía; velocidad de marcha; tiempo de apoyo; tiempo de vuelo; tarea dual.

Introduction

Smartphones have become essential tools in daily life worldwide. According to the Pew Research Center, 90% of adults and teenagers in the United States now own a smartphone [1]. However, their rapid proliferation has brought various challenges [2–4].

A significant concern is that smartphone use while walking can reduce concentration, divert attention, and impair memory [5,6], negatively affecting visual information processing and motor control responses [7]. This decline in functionality while performing two tasks simultaneously may diminish the efficiency and safety of walking. In fact, authors agree that human gait is not an automatic process, but rather one that requires executive function and attention [8]. Cognitive processes then play a crucial role in enabling a person to perform more than one task at a time. This often involves processing and responding to multiple stimuli simultaneously—a concept known as divided attention [9,10]. In particular, performing a cognitive task, such as reading or texting on a smartphone —while walking— is considered a dual task walking scenario [9–14]. In this context, attentional resources are divided, creating a competition between the efficiency on the smartphone task and gait function. Theoretical frameworks explaining this interference are based on the idea that attentional

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resources are limited; therefore, when the two tasks are performed simultaneously, either walking or the co-occurring task may exhibit a decrease in performance [15].

Injuries caused by the use of smartphones while walking have increased significantly [11], suggesting that dividing attention between navigating public spaces and using a smartphone can compromise pedestrian safety. Research conducted at 20 street intersections in Seattle, Washington —identified as high-risk areas for pedestrian accidents—, revealed that nearly 30% of pedestrians use smartphones while crossing busy intersections, with 7% actively texting while crossing [16]. The authors also reported that texting while walking results in decreased situational awareness and increased risky behaviors while crossing intersections [16].

Walking involves a cyclical process that enables the body to maintain balance while moving forward [17,18]. A gait cycle is typically defined as the time interval between two successive contacts of the same foot with the ground [17,18]. For each gait cycle, various temporal and spatial parameters such as stance time, swing time, and walking speed can be measured; these are referred to as spatio-temporal parameters (STP) [17,18]. Gait symmetry represents the degree of synchronization in the motion of the right and left limbs [19] and can be assessed using STP. For example, stance phase symmetry reflects the similarity in duration of the stance phase between the right and left legs. Some spatio-temporal gait parameters, such as speed, stride length, and swing time, have shown a tendency to change under dual-task walking conditions [20,21]. In contrast, the effects of dual-tasking on gait symmetry appear to depend on both the population and the nature of the task. For example, a longitudinal study in older adults found that reduced gait symmetry during cognitive dual-task walking was associated with an increased risk of future falls [22]. However, another study involving older adults with depression reported no significant changes in gait symmetry when participants performed a cognitive task (counting backwards) while walking [21]. These findings suggest that, although dual-tasking seems to influence spatio-temporal parameters, its effect on symmetry is more variable. It may depend on individual characteristics, health status, and the complexity of the secondary task. In particular, tasks that place greater demands on attentional resources may lead individuals to prioritize the cognitive task over walking efficiency, thereby influencing gait patterns [15]. If present, the effect of dual-tasking on gait symmetry may be explained by the limited attentional or motor resources available to manage both tasks simultaneously. Additionally, the impact on symmetry may occur indirectly—for example, through changes in walking speed, which itself can influence symmetry between legs [23,24].

STP and lower limbs symmetry are often used to assess changes in gait patterns, for instance, after rehabilitation interventions [25–30]. Thus, they are appealing for evaluating the changes in gait patterns due to dual-task walking.

In fact, several studies have focused on evaluating STP for the dual task of walking while using a smartphone [6,7,31,32]. A recent literature review [31], found that 20 out of 22 studies investigating gait STP, measured them for participants walking indoor. Only the remaining two studies measured a limited set of parameters outdoor [32,33].

Krasovsky et al. [33] studied the effects of age and environment (indoors vs. outdoors) on gait while using a smartphone (texting). They evaluated 30 young participants (aged 18–40 years) and 20 older participants (aged 60–80 years) walking in two settings: indoors (a quiet university corridor) and outdoors (a covered walkway).

During the walking task, participants were instructed to type short three-word sentences, such as "I ate pizza" or "It's cold today." Gait speed, cycle time, and stride length were measured under this dual-task condition. The results showed a significant decrease in walking speed in the older group compared to the younger group, primarily due to shorter stride lengths, but not shorter cycle time. Across all participants, the dual-task condition (texting while walking) resulted in reduced walking speed, shorter stride length, and longer cycle time compared to single-task walking. Additionally, an interaction effect was observed between environment and age for both gait speed and stride length: while younger participants walked faster and with longer strides outdoors compared to indoors while texting, older participants walked more slowly and took shorter strides outdoors than indoors.

In turn, with a similar objective Prupetkaew et al. [32] studied 12 young (mean age 22.7 (1.8)) and 12 older (mean age 73.5 (5.6)) participants while walking indoors (in a quiet research lab) and outdoors (in a busy walkway outside the laboratory) and texting using a smartphone. The study also included other conditions, such as standing and holding the smartphone. During the walking trials, participants were asked to respond in writing to questions posed by the researchers, such as "What are your favorite books?" Gait speed, step time, step length, and cadence were measured during the dual-task condition. The results showed no significant effects of the environment on any of the gait parameters. However, walking while texting led to a decrease in walking speed, which was accompanied by increased step time, decreased step length, and reduced cadence compared to single-task walking. The study also reported differences in gait patterns between younger and older participants, highlighting the role of age in dual-task walking performance.

Interestingly, while Krasovsky et al. [33] found that gait parameters varied between indoor and outdoor settings, Prupetkaew et al. [32] reported no such differences. Differences in data collection methodologies (including the co-occuring task, or the actual differences between outdoors and indoors environments and the distance travelled in one and the other) could account for the observed discrepancies in results. Since walking outdoors typically requires greater attentional resources than walking indoors, due to factors such as increased noise, the need to navigate around obstacles or other pedestrians, and potentially uneven terrain, it may represent a more cognitively demanding task. Indeed, previous studies have reported gait differences between outdoor and indoor dual-task walking (where the cognitive tasks did not involve smartphone use) [13,14].

While these STP may be responsive to changes in gait pattern, a complete set of STP and their symmetry should be studied on participants walking outdoor to provide comprehensive information about the changes in gait cycle due to dual-task walking.

Then the objective of this study was to evaluate the effect of smartphone use on gait STP and their symmetry in young adults walking outdoors. Two hypotheses were evaluated in this study: a) Spatio-temporal parameters (STP) of gait will change during the dual-task condition of using a smartphone while walking, compared to the single-task condition in young adults walking outdoors; b) The symmetry of STP will not be affected by the dual-task condition in these participants.

The information obtained in this study could contribute to a better understanding of the extent to which dual-tasking affects gait parameters. By highlighting how cognitive load influences walking patterns, these findings help clarify the challenges individuals may face when navigating environments while engaged in concurrent tasks. This knowledge, in turn, may support the development of preventive measures or interventions aimed at improving safety in hazardous environments, where divided attention could increase the risk of accidents.

Methods

Participants

Young adults from the academic community at the School of Engineering, Universidad Nacional de Entre Ríos (UNER), were invited to participate in this study. Inclusion criteria required participants to be between 18 and 30 years old and proficient in typing on a smartphone using both hands simultaneously. Exclusion criteria included visual, auditory, musculoskeletal, and/or neurological impairments, as well as the consumption of psychotropic substances within 12 hours prior to the study. Participants were also required to wear comfortable clothing, appropriate footwear, and glasses if necessary.

Required sample size was calculated using the software G*Power (version 3.1.9), considering alpha = 0.05 and effect size = 0.8. The required minimum sample size was 25. The final sample included 35 participants aged 18 to 28 years (21 men and 14 women). The study was approved by the Ethics and Experimental Work Safety Committee of the Scientific and Technological Research Center CONICET - Santa Fe, under the code CEYSTE-CES-01302/2024. Each participant received an informational brochure and signed an informed consent form if they agreed to participate.

Data Collection and Analysis Protocol

A straight, level ground pathway commonly used for pedestrian transit between buildings in the School´s courtyard was selected for the study. The 1.25 m wide and 10 m long pathway had cemented floor, and included clearly marked start and finish lines for the single and dual-task activities. The distance between the start and finish lines was 4 m long.

Participants were instructed to walk at a self-selected speed under two different conditions:

1. Habitual walking (HW): Participants walked the entire 10-meter corridor without using a smartphone (Figure 1).

Figure 1. Habitual walking (HW) performed by a participant along the 10-meter pathway.

2. Texting While Walking (TWW): Participants walked normally up to the start line. Then, they typed at least six randomly generated numbers on a smartphone using both hands. If participants failed to input six numbers before reaching the finish line, the walk was repeated (Figure 2).

Figure 2. Participant texting on a smartphone with both hands while walking (TWW), typing at least six randomly generated numbers.

Each participant first performed the single task (HW condition) followed by the dual task (TWW condition).

The random number sequence was obtained from the website www.randomization.com and sent to participants via text message. This sequence ensured similar level of difficulty for all participants [34].

To study the STP, a software developed at the Human Movement Research Laboratory of FI-UNER was used. This software, the Spatio-Temporal Parameter Acquisition Tool (HAPET), extracts STP from video recordings [35,36], using techniques previously validated [28,37–40].

For video recording, the recommendations outlined in the "Protocol for Acquiring Videographic Records of Gait Suitable for Calculating Spatio-Temporal Parameters Using HAPET" [35,41] were followed. The protocol specifies, among other considerations, that the participant's entire body should be visible in the sagittal plane, and that sufficient illumination and adequate contrast between the lower limbs and the surroundings (floors and walls) must be ensured.

A Samsung Galaxy S21 FE smartphone camera (1920x1080 resolution, 60 FPS) was used for video recording. The camera was mounted on a stand approximately 70 cm above the ground and positioned 4 meters away from the pathway, aligned with its center.

Once the videos were recorded, they were processed using the HAPET software. This software performs an automatic calculation of STP based on the manual selection of two gait events: the time of the Initial Contact of the foot with the floor and the time with the foot breaks contact with the floor or Foot-Off [28,37–40]. One of the researchers made the selection of the events manually.

For parameter calculations, the software uses definitions based on Whittle [17], which are temporally related to the different phases of the gait cycle (see Figure 3).

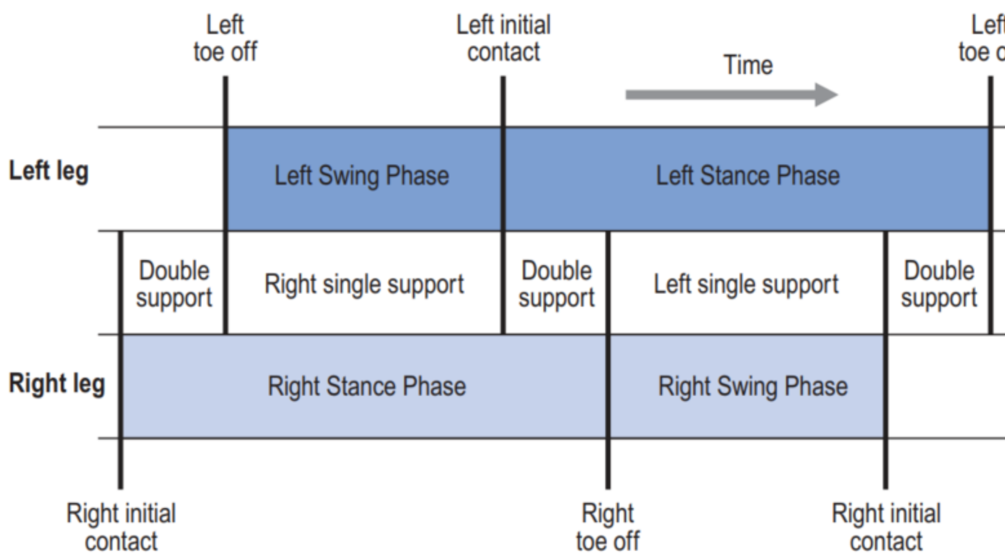


Figure 3. Phases of the gait cycle from which spatio-temporal parameters (STP) are derived [17]. Cycle time is calculated as the time elapsed from Initial Contact to the following Initial Contact of the ipsilateral foot. Stance time as the time elapsed from Initial Contact to Foot-Off.. Swing time as the time elapsed from Foot-Off to the following Initial Contact. And Step Time as the time elapsed from Initial Contact of one foot until Initial Contact of the contralateral foot.

The calculated parameters and their definitions are:

Cycle Time: it is the time elapsed from the Initial Contact of the foot with the floor until the following Initial Contact of the same foot.

Stance Time: represents the time elapsed from the Initial Contact of the foot with the floor until the Foot-Off of the same foot.

Swing Time: represents the time elapsed from the Foot-Off of the foot with the floor until the Initial Contact of the same foot.

Step Time: represents the time elapsed from the Initial Contact of one foot with the floor until the Initial Contact of the contralateral foot.

Walking speed: is the distance covered per unit time.

The Cycle Time, Stance Time, Swing Time and Step time were all calculated for the left and the right foot and initially expressed in ms. Stance and swing times were then normalized to the gait cycle time [42].

Then symmetry values for Stance, Swing, Cycle and Step times were calculated as the percentage differences between the legs. To calculate these values, the software uses the equation proposed by Marinakis [43]:

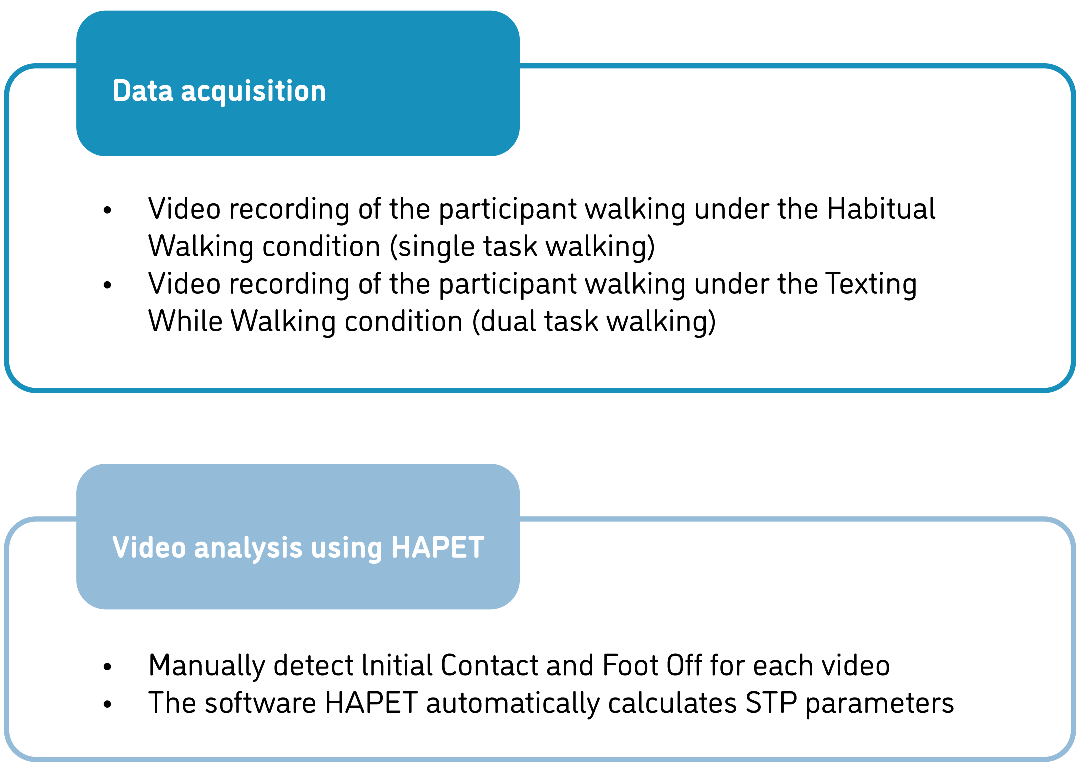
$$S.I. = \frac{\min(R\ \ , P\ \ )}{\max(R\ \ , P\ \ )} * 100$$

Where S.I. is the Symmetry Index, PR is the parameter for the right leg and PL is the parameter for the left leg.

For data analysis, STP values from three gait cycles for each participant were averaged. Then the parameter values for the 35 participants, for both conditions (HW and TWW) were averaged. Finally, for each condition (HW and TWW), mean values and standard deviations were obtained for the following parameters: Right Swing Time, Left Swing Time, Right Stance Time, Left Stance Time, Right Cycle Time, Left Cycle Time, Step Time Right-to-Left, Step Time Left-to-Right, Stance Symmetry, Swing Symmetry, Cycle Symmetry, and Step Symmetry.

The normality of the dataset was evaluated using the Shapiro-Wilk test, which determined that the data were not normally distributed. Subsequently, a non-parametric paired-sample test, the Wilcoxon rank-sum test, was applied to evaluate differences between the habitual walking and smartphone walking conditions for each parameter. IBM SPSS v.25 software was used for the statistical analysis.

A summary of the methodological procedure applied in this study is shown in Figure 4.



Data analysis

- Average for each parameter and each condition was calculated
- Symmetry values were calculated and averaged for each condition
- Statistical analysis was applied to the data

Figure 4. Flow diagram of the methodological procedure used in this study.

Results

Table 1 presents the mean and standard deviation values obtained for walking speed (expressed in m/s), swing and stance time (expressed in ms) during habitual walking and walking while using a smartphone. Figure 5 shows the mean values and standard deviations of cycle time and step time for right and left legs. Figure 6 shows the mean values and standard deviations of swing and stance times (normalized to cycle time) for both legs. Figure 7 shows the mean values and standard deviations of symmetry between limbs.

Table 1. Mean Values, Standard Deviations, and Statistical Results (P) for Spatiotemporal Parameters during Habitual walking and Texting while Walking.

STP	Habitual walking	Texting while Walking	*P*
Walking Speed [m/s]	1.44 (0.18)	1.01 (0.16)	**< 0,001**
Left Cycle Time [ms]	1048,7 (10.4)	1202,7 (23.8)	**< 0,001**
Right Cycle Time [ms]	1049,8 (10.2)	1202,5 (24.6)	**< 0,001**
Step Time Left-to-Right [ms]	520,3 (5.4)	596,1 (12.7)	**< 0,001**
Step Time Right-to-Left [ms]	525,7 (5.1)	602,8 (12.2)	**< 0,001**
Left Swing Time [ms]	388,7 (4.5)	418,5 (8.9)	**< 0,001**
Right Swing Time [ms]	389,1 (3.5)	413,9 (10)	**0,001**
Left Stance Time [ms]	658,7 (9.4)	785,1 (16.6)	**< 0,001**
Right Stance Time [ms]	665,8 (8.9)	791,3 (16.9)	**< 0,001**

Note. Mean values (standard deviation) obtained for each evaluated spatiotemporal parameter under both walking conditions: habitual walking and texting while walking. Values are expressed in milliseconds [ms]. Statistical differences are expressed as P-values.

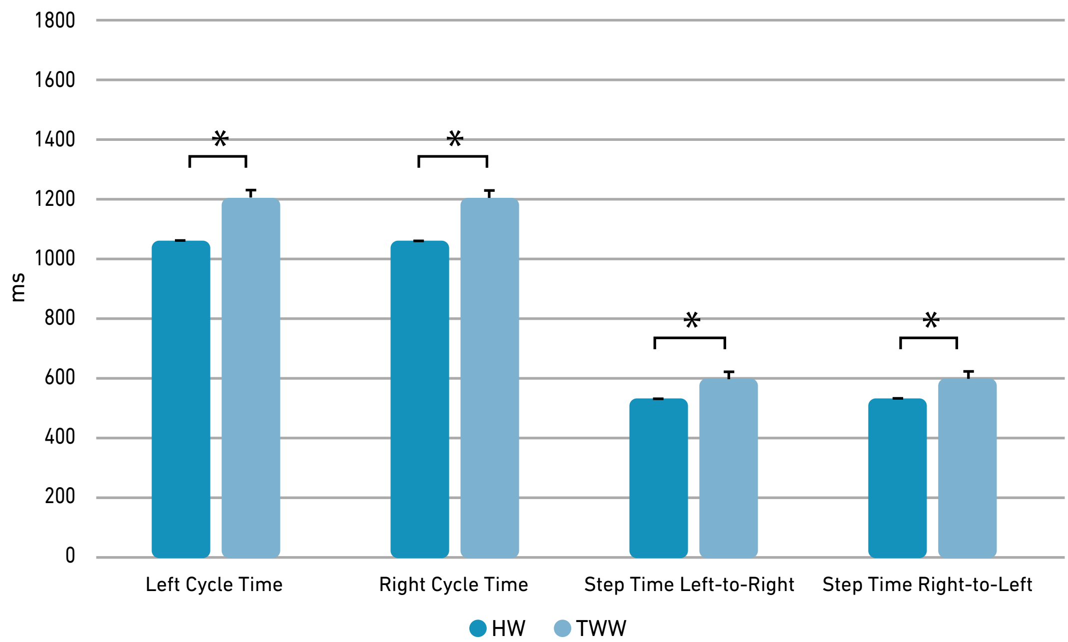


Figure 5. Mean values of the STP: left cycle time, right cycle time, step time left-to-right, step time right-to-left. The error bar represents one standard deviation. * indicates significant differences between the habitual walking (HW) and texting while walking (TWW) conditions.

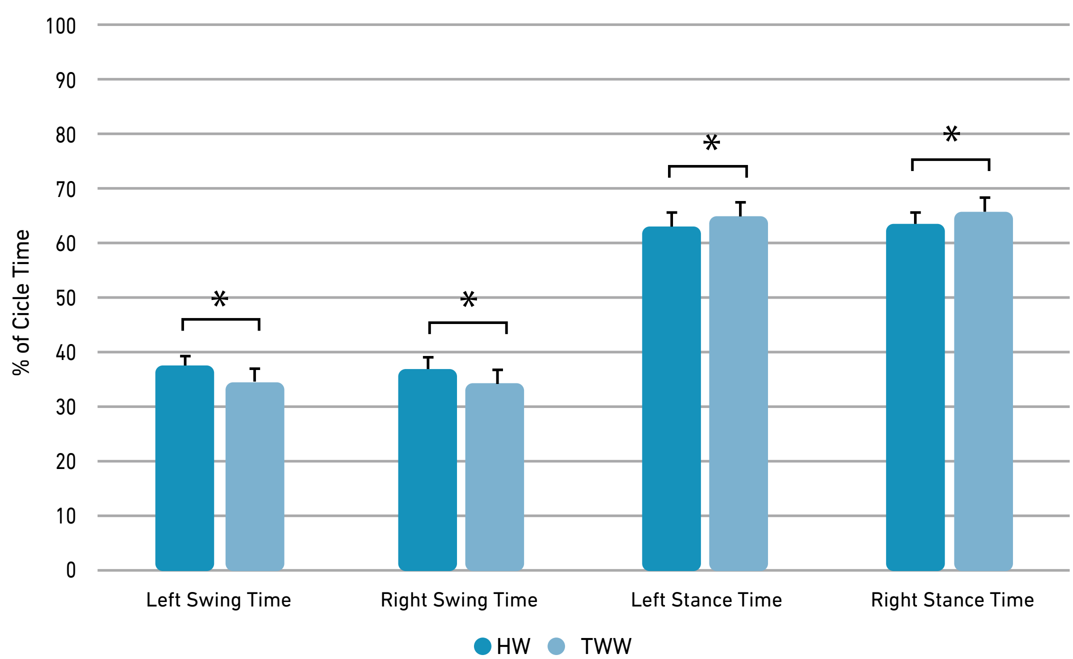


Figure 6. Mean values of the STP: left swing time, right swing time, left stance time, and right stance time. The error bar represents one standard deviation. * indicates significant differences between the habitual walking (HW) and texting while walking (TWW) conditions.

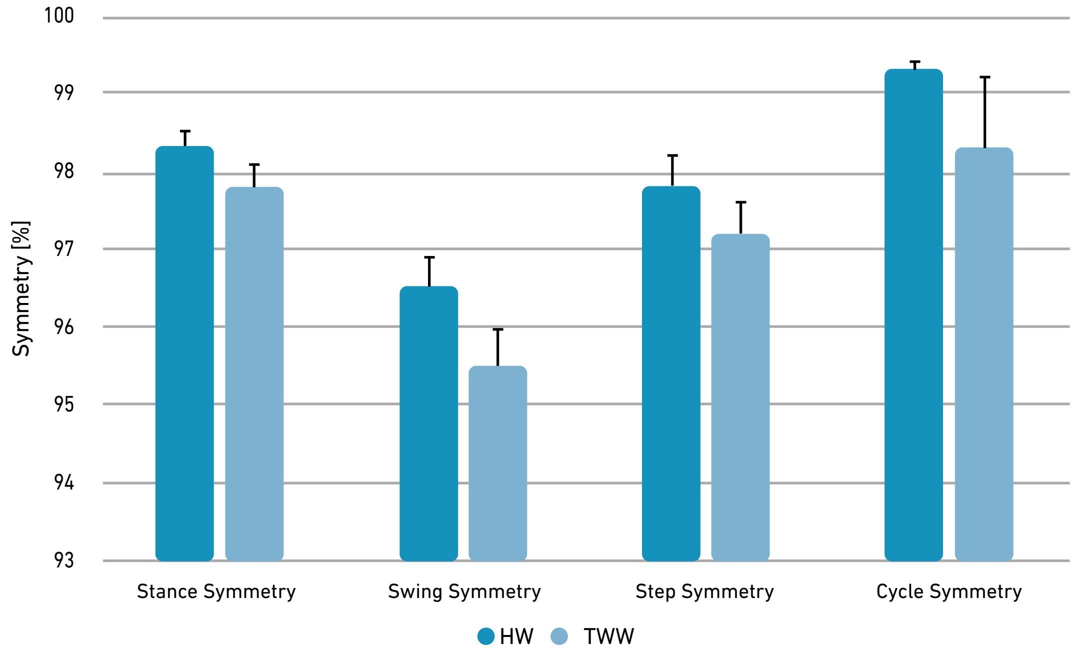


Figure 7. Symmetry values for stance, swing, step, and cycle between right and left lower limbs for both walking conditions (HW and TWW). The error bar indicates one standard deviation.

Results show statistically significant differences between the habitual walking and the texting while walking conditions for all STP analysed: walking speed, cycle time, step time, swing time and stance time. Moreover, these differences were consistent in both the normalized (expressed as a percentage of cycle time) and non-normalized parameters. Since normalization to the gait cycle diminishes the inter-subject variability due to physical characteristics of participants [42], the analyses or normalized parameters more specifically highlights the differences between walking conditions. The results reveal a decrease in walking speed and an increase in cycle and step times when walking while texting. Additionally, stance time increased and swing time decreased in the walking while texting condition.

The results for symmetry did not show statistically significant differences between conditions for any of the parameters analysed: cycle time, step time, stance time and swing time. Although there is a tendency for symmetry to be lower for the texting while walking condition, values are higher than 95% for both conditions.

Discussion

The results obtained in this outdoor study confirmed the first hypothesis presented: STP of gait changed during the dual-task condition of using a smartphone while walking, compared to the single-task condition of walking, in young adults walking outdoors. These results agree with previous studies conducted indoors in laboratory settings [7,9,11].

Also two studies evaluated a limited number of STP both in laboratory settings and outdoors, in areas commonly used by pedestrians [32,33]. Krasovsky et al. [33] studied the effect of smartphone use (texting) and their results showed a decrease in walking speed and a consequent increase in cycle time during the dual-task when compared with the single task. In turn, Prupetkaew et al. [32] showed a decrease in walking speed, leading to an increase in step time and a decrease in step length and cadence.

In this study, a significant decrease in walking speed was observed when participants used a smartphone. As a consequence, cycle time and step time increased, meaning that participants took longer to complete each gait cycle and each step while covering the same distance. These results are consistent with studies conducted in similar populations (young adults) in indoor laboratories [6,44,45] as well as studies conducted outdoors [32,33,45].

Additionally, an increase in stance time and a decrease in swing time were observed for the dual task condition. This result may be a direct consequence of the decrease in walking speed but thy could also indicate that participants adopted a more cautious gait pattern to reduce the risk of trips and falls [46]. And this, in turn, may be due to inadequate or limited peripheral visual information for navigation, as attention is directed toward the smartphone rather than the surrounding environment [32].

It is also possible that the decrease in walking speed, which results in a greater stance time, is a compensatory mechanism to the reduction in functionality caused by performing two tasks simultaneously, and aims at increasing stability and balance [17]. Although this change in gait pattern may serve as a precautionary measure, previous research has shown that it may not be sufficient to ensure safety in daily activities such as pedestrian crossing [47,48]. In fact, studies have shown that when using smartphones, pedestrians decreased their crossing speed but simultaneously increased the risk of accidents compared to those who do not use them [47,48].

An important finding of this study, which has not been reported in previous publications, is that gait symmetry between groups, including cycle time symmetry, step symmetry, stance symmetry, and swing symmetry, remained unchanged between conditions. Although there is a tendency for symmetry to be lower for the texting while walking condition, values are higher than 95% for both, consistent with symmetry values found in the literature [49]. Given that participants were healthy young adults, with no neurological or musculoskeletal impairments, it is possible that any gait adaptations triggered by the dual task occurred symmetrically, i.e. affecting both limbs in a coordinated manner to preserve overall gait efficiency. These findings suggest that, in this population, divided attention during smartphone use does not compromise spatio-temporal gait symmetry, thereby supporting our second hypothesis.

It is important to note that both the tool used in this study, the Gait Parameter Analysis Tool (HAPET), and the protocol used to extract parameters from video recordings were suitable for the extraction of parameters in outdoor settings. These tools make the research more representative of real-world contexts. Furthermore, they offer the advantages of being relatively accessible in terms of cost and simplicity, compared to equipment used in gait laboratories, and do not interfere with the participants' movement.

The results of this study indicate that smartphone use while walking has a significant impact on spatio-temporal gait parameters but does not affect symmetry between lower limbs in young, healthy adults. The findings indicate changes in gait parameters that appear to reflect the adoption of a more cautious walking strategy, likely aimed at maintaining stability while managing competing cognitive demands. However, in complex or hazardous environments —such as busy intersections— these adaptive changes may not be sufficient to prevent accidents [47,48]. Reduced gait speed or increased attentional load could delay reaction times or impair situational awareness.

The information obtained in this study could contribute to a better understanding of the extent to which dual-tasking affects gait parameters. By highlighting how cognitive load influences walking patterns, these findings help clarify the challenges individuals may face when navigating environments while engaged in concurrent tasks. This knowledge, in turn, may support the development of preventive measures or interventions aimed at improving safety in hazardous environments, where divided attention could increase the risk of accidents. A possible application of these findings is the development of safety guidelines tailored for pedestrians. By considering how dual-tasking affects gait and attention, such guidelines could help reduce the risk of accidents in environments where cognitive distractions are common and situational awareness is critical.

Future research should evaluate the impact of the use of smartphones on participants with reduced motor or cognitive function.

Conclusion

To conclude, smartphone use while walking affects gait spatio-temporal parameters (STP) but not limb symmetry. Specifically, a decrease in walking speed was observed, along with an increase in cycle time, step time, and stance time. These changes may be aimed at enhancing stability and balance, thereby preserving the safety of individuals walking under divided attention. Interestingly, symmetry was maintained across conditions, suggesting that healthy young adults may adapt their gait in a coordinated manner when faced with dual-task demands. Future research should investigate whether this symmetry is preserved in populations with reduced motor or cognitive function, where the capacity to adapt symmetrically may be compromised.

References

1. Gelles-Watnick R. Americans' Use of Mobile Technology and Home Broadband [Internet]. Washington DC: Pew Research Center; c2025 [updated 2024 Jan 31]; [about 6 screens]. Available from: https://www.pewresearch.org/internet/2024/01/31/americans-use-of-mobile-technology-and-home-broadband/

2. Lee U, Lee PH. Editorial: Adverse health consequences of excessive smartphone usage, volume II. Front Public Health [Internet]. 2022;10:984398. doi: https://doi.org/10.3389/fpubh.2022.984398

3. Lam WK, Liu RT, Chen B, Huang XZ, Yi J, Wong DWC. Health Risks and Musculoskeletal Problems of Elite Mobile Esports Players: a Cross-Sectional Descriptive Study. Sports Med Open [Internet]. 2022;8(1):65. doi: https://doi.org/10.1186/s40798-022-00458-3

4. Adamczewska-Chmiel K, Dudzic K, Chmiela T, Gorzkowska A. Smartphones, the Epidemic of the 21st Century: A Possible Source of Addictions and Neuropsychiatric Consequences. Int J Environ Res Public Health [Internet]. 2022;19(9):5152. doi: https://doi.org/10.3390/ijerph19095152

5. Lim J, Amado A, Sheehan L, Van Emmerik REA. Dual task interference during walking: The effects of texting on situational awareness and gait stability. Gait Posture [Internet]. 2015;42(4):466-71. doi: http://dx.doi.org/10.1016/j.gaitpost.2015.07.060

6. Strubhar AJ, Peterson ML, Aschwege J, Ganske J, Kelley J, Schulte H. The effect of text messaging on reactive balance and the temporal and spatial characteristics of gait. Gait Posture [Internet]. 2015;42(4):580-3. doi: http://dx.doi.org/10.1016/j.gaitpost.2015.09.007

7. Tandon R, Javid P, Di Giulio I. Mobile phone use is detrimental for gait stability in young adults. Gait Posture [Internet]. 2021;88:37-41. doi: https://doi.org/10.1016/j.gaitpost.2021.05.001

8. Mirelman A, Shema S, Maidan I, Hausdorff JM. Chapter 7 - Gait. Handb Clin Neurol [Internet]. 2018;159:119-34. doi: https://doi.org/10.1016/B978-0-444-63916-5.00007-0

9. Gandolfi M, Fiorio M, Geroin C, Torneri P, Menaspà Z, Smania N, et al. Dual tasking affects gait performance but not automaticity in functional gait disorders: A new diagnostic biomarker. Parkisonism Relat Disord [Internet]. 2023;108:105291. doi: https://doi.org/10.1016/j.parkreldis.2023.105291

10. Smeeton NJ, Wrightson J, Varga M, Cowan R, Schafer L. Coordination between motor and cognitive tasks in dual task gait. Gait Posture [Internet]. 2021;85:138-44. doi: https://doi.org/10.1016/j.gaitpost.2021.01.012

11. Brennan AC, Breloff SP. The effect of various cell phone related activities on gait kinematics. J Musculoskelet Res [Internet]. 2019;22(3-4). doi: https://doi.org/10.1142/S0218957719500118

12. Martín-Martínez JP, Villafaina S, Collado-Mateo D, Fuentes-García JP, Pérez-Gómez J, Gusi N. Impact of cognitive tasks on biomechanical and kinematic parameters of gait in women with fibromyalgia: A cross-sectional study. Physiol Behav [Internet]. 2020;227:113171. doi: https://doi.org/10.1016/j.physbeh.2020.113171

13. Hennah C, Doumas M. Dual-task walking on real-world surfaces: Adaptive changes in walking speed, step width and step height in young and older adults. Exp Gerontol [Internet]. 2023;177:112200. doi: https://doi.org/10.1016/j.exger.2023.112200

14. Almajid R, Appiah-Kubi KO, Cipriani D, Goel R. Dual-tasking interference is exacerbated outdoors: A pilot study. Front Sport Act Living [Internet]. 2023;5:1077362. doi: https://doi.org/10.3389/fspor.2023.1077362

15. Vanderhoof HR, Chavez EA, Eggleston JD. Gait Symmetry Is Unaffected When Completing a Motor Dexterity Task While Using a Walking Workstation in Healthy, Young Adults. Biomechanics [Internet]. 2022;2(3):431-40. doi: https://doi.org/10.3390/biomechanics2030033

16. Thompson LL, Rivara FP, Ayyagari RC, Ebel BE. Impact of social and technological distraction on pedestrian crossing behaviour: an observational study. Inj Prev [Internet]. 2013;19(4):232-7. doi: https://doi.org/10.1136/injuryprev-2012-040601

17. Whittle MW. Gait Analysis - An Introduction [Internet]. 4th ed. Amsterdam: Elsevier; 2007. doi: https://doi.org/10.1016/B978-0-7506-8883-3.X5001-6

18. Baker R, Esquenazi A, Benedetti MG, Desloovere K. Gait analysis: clinical facts. Eur J Phys Rehabil Med [Internet]. 2016;52(4):560-74. Available from: https://www.minervamedica.it/en/journals/europa-medicophysica/article.php?cod=R33Y2016N04A0560

19. Arauz PG, Garcia MG, Chiriboga P, Okushiro V, Vinueza B, Fierro K, et al. In-vivo 3-dimensional spine and lower body gait symmetry analysis in healthy individuals. Heliyon [Internet]. 2024;10(7):e28345. doi: https://doi.org/10.1016/j.heliyon.2024.e28345

20. Smith E, Cusack T, Cunningham C, Blake C. The influence of a cognitive dual task on the gait parameters of healthy older adults: A systematic review and meta-analysis. J Aging Phys Act [Internet]. 2017;25(4):671-86. doi: https://doi.org/10.1123/japa.2016-0265

21. Jungen P, Batista JP, Kirchner M, Habel U, Bollheimer LC, Huppertz C. Variability and symmetry of gait kinematics under dual-task performance of older patients with depression. Aging Clin Exp Res [Internet]. 2023;35(2):283-91. doi: https://doi.org/10.1007/s40520-022-02295-6

22. Gillain S, Boutaayamou M, Schwartz C, Dardenne N, Bruyère O, Brüls O, et al. Gait symmetry in the dual task condition as a predictor of future falls among independent older adults: a 2-year longitudinal study. Aging Clin Exp Res [Internet]. 2019;31(8):1057-67. doi: https://doi.org/10.1007/s40520-019-01210-w

23. Plotnik M, Bartsch RP, Zeev A, Giladi N, Hausdorff JM. Effects of walking speed on asymmetry and bilateral coordination of gait. Gait Posture [Internet]. 2013;38(4):864-9. doi: https://doi.org/10.1016/j.gaitpost.2013.04.011

24. Goble DJ, Marino GW, Potvin JR. The influence of horizontal velocity on interlimb symmetry in normal walking. Hum Mov Sci [Internet]. 2003;22(3):271-83. doi: https://doi.org/10.1016/S0167-9457(03)00047-2

25. Castro-Medina KG. Effects of Visual Feedback on Walking Speed for Stroke Patients: Single-case Design. Rev Investig Innov Cienc Salud [Internet]. 2023;5(1):127-43. doi: https://doi.org/10.46634/riics.153

26. Duré CI, Savio J, Marengo B, Perotti G, Formento PC, Bonell CE. Protocol for the Functional Evaluation of Patients with Knee Injury Treated in a Local Rehabilitation Centre. IFMBE Proceedings [Internet]. 2020;75:907-12. doi: https://doi.org/10.1007/978-3-030-30648-9_117

27. Bertot A, Barrera V, Dutto CI, Bernal C, Catalfamo Formento PA. Análisis de marcha en amputados: prueba piloto. Ortesis, Prótesis y Movilidad. 2019;2(1):34-7.

28. Bertot A, Dutto CI, Barrera V, Bernal C, Bonell C, Catalfamo Formento P. Análisis del movimiento clínico. In Mercante S, editor. 2019 Iberdiscap. X Congreso Iberoamericano de Tecnologías de Apoyo a la Discapacidad. Buenos Aires 20 21 y 22 de noviembre; 2019 Nov 20 – Nov 23; Centro Cultural de la Ciencia, Argentina. General San Martín: Instituto Nacional de Tecnología Industrial; 2020. p. 84-85. Available from: https://thegardenofcuriosity.untref.edu.ar/img/18_c3d/PDF_C3D_Publicacio%CC%81n-IBERDISCAP_01.pdf

29. Riveras M, Ravera E, Shaheen AFF, Ewins D, Catalfamo-Formento P, Catalfamo Formento P. Spatio temporal parameters and symmetry in subjects ascending and descending a ramp, using three different prosthetic feet. Journal of mechanical science and technology [Internet]. 2020;34:955-61. doi: https://doi.org/10.1007/s12206-020-0145-0

30. Riveras M, Ravera E, Shaheen AFF, Ewins D, Catalfamo Formento P. Spatio Temporal Parameters and Symmetry Index in Transtibial Amputees Wearing Prosthetic Feet with and without Adaptive Ankles. In: Leija Salas L, editor. 2019 Global Medical Engineering Physics Exchanges/ Pan American Health Care Exchanges (GMEPE/PAHCE) [Internet]. 2019 March 26-31. Buenos Aires, Argentina: GMEPE/PAHCE; 2019. p. 1-6. doi: https://doi.org/10.1109/GMEPE-PAHCE.2019.8717362

31. Zhang X, Li Q, Gao P, Zhu J, Tuo H, Lin Q, et al. The effect of mobile phone task and age on gait: A systematic review and meta-analysis. Front Physiol [Internet]. 2023;14:1163655. doi: https://doi.org/10.3389/fphys.2023.1163655

32. Prupetkaew P, Lugade V, Kamnardsiri T, Silsupadol P. Cognitive and visual demands, but not gross motor demand, of concurrent smartphone use affect laboratory and free-living gait among young and older adults. Gait Posture [Internet]. 2019;68:30-6. doi: https://doi.org/10.1016/j.gaitpost.2018.11.003

33. Krasovsky T, Weiss P, Kizony R. Older adults pay an additional cost when texting and walking: effects of age, environment and use of mixed reality on dual-task performance. Phys Ther [Internet]. 2018;98(7):549-59. doi: https://doi.org/10.1093/ptj/pzy047

34. Llanga Vargas EF, Logacho G, Molina L. La memoria y su importancia en los procesos cognitivos en el estudiante. Cuadernos de Educación y Desarrollo [Internet]. 2019;(8). Available from: https://www.eumed.net/rev/atlante/2019/08/memoria-importancia-estudiante.html

35. Frisoli M, Poux S, Deris M, Catalfamo-Formento P, García-Añino E. Documentation Tools Development for Rehabilitation Technology Implementation. IFMBE Proceedings [Internet]. 2024;105:305-14. doi: https://doi.org/10.1007/978-3-031-51723-5_38

36. Primosich CV, Molaro Battisti MA, Catalfamo-Formento P, Valotto VO, Bonell CE. Functional Design of Sofware to Obtain Spatio-Temporal Parameters of Human Gait. In: IFMBE Proceedings 105 [Internet]. 2024;105:85-92 [Internet] , https://doi.org/10.1007/978-3-031-51723-5_10

37. Peterson M V, Ewins D, Shaheen A, Catalfamo Formento PA. Evaluation of Methods Based on Conventional Videography for Detection of Gait Events. IFMBE Proceedings [Internet]. 2015;49:234-7. doi: https://doi.org/10.1007/978-3-319-13117-7_61

38. Arcila Cano A, Ewins D, Shaheen A, Catalfamo Formento P. Evaluation of methods based on conventional videography for detection of gait events. IFMBE Proceedings [Internet]. 2017;60:181-4. doi: https://doi.org/10.1007/978-981-10-4086-3_46

39. De Grucci C, Ewins D, Shaheen A, Catalfamo Formento P. Evaluation of a visual method to calculate temporal parameters. In: 2016 IEEE Biennial Congress of Argentina (ARGENCON) [Internet]. 2016 Jun 15-17. Buenos Aires, Argentina: IEEE ARGENCON. p. 1-6. doi: https://doi.org/10.1109/ARGENCON.2016.7585312

40. De Grucci C, Bonell CE, Dutto CI, Barrera V, Bernal C, Catalfamo Formento PA. Gait Analysis through a visual method to calculate temporal parameters: comparison of performance between the gait laboratory and the clinical setting. Revista Argentina de Bioingeniería [Internet]. 2019;23(2):3-8. Available from: https://ri.conicet.gov.ar/handle/11336/107371

41. Deris M, Poux S, García-Añino E, Frisoli M. Desarrollo de herramientas documentales para la obtención de variables de la marcha humana mediante el uso del software HAPET [First Degree Thesis]. Universidad Nacional de Entre Ríos; 2022 . 130 p.

42. Cámara Tobalina J. Análisis de la marcha: sus fases y variables espacio-temporales. Entramado [Internet]. 2011;7(1):160-73. Available from: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1900-38032011000100011&lng=en&nrm=iso&tlng=es

43. Marinakis GNS. Interlimb symmetry of traumatic unilateral transtibial amputees wearing two different prosthetic feet in the early rehabilitation stage. J Rehabil Res Dev [Internet]. 2004;41(4):581-90. doi: https://doi.org/10.1682/JRRD.2003.04.0049

44. Kim SH, Jung JH, Shin HJ, Hahm SC, Cho HY. The impact of smartphone use on gait in young adults: Cognitive load vs posture of texting. PLoS One [Internet]. 2020;15(10):e0240118. doi: http://dx.doi.org/10.1371/journal.pone.0240118

45. Krasovsky T, Weiss PL, Kizony R. A narrative review of texting as a visually-dependent cognitive-motor secondary task during locomotion. Gait Posture [Internet]. 2017;52:354-62. doi: http://dx.doi.org/10.1016/j.gaitpost.2016.12.027

46. Seymour KM, Higginson CI, DeGoede KM, Bifano MK, Orr R, Higginson JS. Cellular Telephone Dialing Influences Kinematic and Spatiotemporal Gait Parameters in Healthy Adults. J Mot Behav [internet]. 2016;48(6):535-41. doi: https://doi.org/10.1080/00222895.2016.1152226

47. Zhang H, Zhang C, Chen F, Wei Y. Effects of mobile phone use on pedestrian crossing behavior and safety at unsignalized intersections. Canadian Journal of Civil Engineering [Internet]. 2019;46(5):381-8. doi: https://doi.org/10.1139/cjce-2017-0649

48. Zhou Z, Liu S, Xu W, Pu Z, Zhang S, Zhou Y. Impacts of mobile phone distractions on pedestrian crossing behavior at signalized intersections: An observational study in China. Advances in Mechanical Engineering [Internet]. 2019;11(4):1-8. doi: https://doi.org/10.1177/1687814019841838

49. Błazkiewicz M, Wiszomirska I, Wit A. Comparison of four methods of calculating the symmetry of spatial-temporal parameters of gait. Acta Bioeng Biomech. 2014;16(1):29-35.