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Research Article

THE COMPARISON OF BIOMECHANIC ALTERATION ON CERVICAL ANGLE DURING WALKING WITH AND WITHOUT SMARTPHONE DUAL-TASK TEXTING AMONG SMARTPHONE USERS

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ABSTRACT

Background: The prevalence of smartphone usage continues to rise, becoming deeply embedded in daily routines across all age groups. Young adults are significant users, often engaging in dual-tasking like texting while walking. Such behaviors may lead to biomechanical alterations, especially in cervical posture, increasing the risk of musculoskeletal problems. **Objective:** This study aimed to analyze biomechanical changes in cervical angle during walking with and without dual-task texting among smartphone users. **Method:** A quantitative observational study with a repeated measurement design was conducted involving 30 male participants (aged 21.07 ± 1.05 years). Participants were observed under five conditions: baseline walking and four texting conditions. Cervical angle was measured using video analysis, with anatomical landmarks identified and kinematic data processed through Kinovea software. Adjustments were made for participants wearing hijabs. Statistical analyses included One-Way ANOVA and Post Hoc Bonferroni tests. **Results:** Cervical angle significantly increased during texting conditions compared to baseline walking ($p<0.01$), with angles ranging from 56.67° to 60.03°, compared to 43.51° during baseline walking. The study confirmed that dual-task texting induces notable biomechanical alterations in cervical posture. **Conclusion:** The findings highlight the risks associated with dual-task texting on cervical posture, emphasizing the need for increased awareness among smartphone users. Future studies should explore more complex texting scenarios to develop preventive strategies for cervical spine health.

Keywords: cervical angle, dual-task walking, biomechanic, smartphone, texting

PENDAHULUAN

Smartphone usage has skyrocketed since its 1992 debut, becoming essential across all social classes and age groups, with over two billion users globally by 2017 (Goadrich & Rogers, 2011). Besides communication, smartphones now shape modern lifestyles and trends, offering tools for creativity, entertainment, and even healthcare, while also contributing to an increase in physical complaints (Guyon Jr, Corroon, Ferran, Hollenbach, & Nguyen, 2020; Niederer et al., 2018). However, despite the benefits of smartphones in various aspects of life, negative effects also arise from their use. A large portion of the world's population

spends significant time on smartphones daily (Bertozzi et al., 2021). According to Cevik in 2020, many smartphone users maintain a non-neutral neck position, with the head tilted forward and bent at 20° or more (Çevik, Kaplan, & Katar, 2020). Prolonged and continuous use in such positions can gradually alter the spinal curve, particularly in the cervical vertebrae segment (Betsch et al., 2021; Xie, Szeto, Madeleine, & Tsang, 2018). The posture frequently adopted by smartphone users is forward head posture, a condition where the vertebrae form a forward curve, causing the head to lean more anteriorly (Chun, Kim, & Choi, 2017; Jacquier-Bret & Gorce, 2023).

Dual-tasking is the ability to perform two tasks simultaneously, requiring participants to coordinate their attention without prioritizing one task over the other, unlike multitasking, which shifts focus between tasks (Saraiva, Castro, & Vilas-Boas, 2023). It involves both cognitive components, such as counting, reading, and attention, and motor components, like sitting, standing, and walking. These elements impact posture, gait, and visual focus, especially in activities like walking while using a smartphone, which is a common dual-task scenario. However, this practice can lead to reduced awareness, impaired balance, disrupted gait patterns, and an increased risk of falls and injuries (Agostini, Lo Fermo, Massazza, Knaflitz, & rehabilitation, 2015; Goddard, Remler, Roos, Turchyn, & Sciences, 2018; Susilo, Bovonsunthonchai, & Wattananon, 2022).

A study by Schabrun et al in 2014 found that using a smartphone while walking increases the average neck flexion angle from 29.2° to 31.8° (Schabrun, van den Hoorn, Moorcroft, Greenland, & Hodges, 2014). There is a significant difference between single-task and dual-task smartphone use. However, Lee's study (2015) also found that changes in the cervical vertebrae curve vary depending on the position and activity performed while using the smartphone (Lee, Kang, & Shin, 2015). This suggests that variations in conditions greatly influence research related to the effects of smartphone use on the cervical angle.

To further analyze the biomechanic alteration due to the effects of texting activities on smartphone on cervical angle, the researchers examined and compared the impact of dual-task activities, such as walking only and walking without a smartphone or single-tasking. The researchers hypothesized that there would be significant differences between dual-tasking and single-tasking concerning changes in the cervical angle among smartphone users.

METODE

This research is a quantitative study utilizing an observational study design with five groups of measurement approach, 1) base walking; 2) texting-1; 3) texting-2; 4) texting-3; and 5) texting-4. The study was conducted in January 2023 at the Gymnasium Laboratory, 1st floor of Building D, Physiotherapy Program, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta. The involvement of subjects was approved by the Health Research Ethics Committee of TIK.II 04.05.01 dr. SOEJDONO Hospital under the number 169/EC/I/2023.

The subjects were young adults from Universitas Muhammadiyah Surakarta, recruited through a Google Form distributed via social media. The sample size was determined in advance through calculations using G-Power software version 3.1.9.4, based on by Han et al (Han & Shin, 2019). Sampling was conducted from December 2022 to January 2023. The inclusion criteria for this study were as follows: 1) Aged 18-35 years, 2) Experienced in using a smartphone (touchscreen) for more than 1 year, 3) Using a smartphone for more than 2 hours per day, 4) Able to walk at least 10 meters. Subjects were excluded if they met any of the following exclusion criteria: 1) History of vertebral injury, 2) History of cervical surgery, 3) Obesity, 4) Limb length discrepancy of more than 2 cm, 5) Missing one or more phases of the normal walking cycle. Cervical

angles were measured using video analysis captured from the side at the mid-point of the treadmill. Anatomical landmarks, including the tragus of the ear and the seventh cervical vertebra, were used to calculate cervical angles.

Participants completed five conditions: baseline walking, and four texting conditions where they typed a sentence from flashcards while walking. Each condition was recorded for 30 seconds. The researcher explained the dual-task to the subjects. The dual-task involved walking while typing a descriptive sentence from four different flashcards, which was sent via the WhatsApp application. During the dual-task texting activity, the researcher recorded the cervical angle. The subjects walked on a treadmill with a video recording area of 1 meter. A camera was placed on the side to capture changes in the subject's cervical angle. The video data were then calculated and converted into coordinate data using the Kinovea version 0.9.5.

The collected data were processed using SPSS version 26.0 with a significance value of $p<0.05$. Data analysis included the Shapiro-Wilk Test for data normality, homogeneity test used Levene, the One-Way ANOVA Test for data effectiveness, and the Post Hoc Bonferroni Test for further analysis to determine the detailed effects in each condition.

HASIL

Table 1 presents the characteristics of the subject data and their smartphone usage details. The study included 30 male participants, with ages ranging from 19 to 23 years and an average age of 21.11 ± 1.04 years. Most subjects had owned a smartphone for an average of 6.56 ± 2.05 years, and their average daily usage was 8.42 ± 2.86 hours.

Table 1. Characteristic of respondents

No.	Variable	N / Mean ± SD
1	Genders: • Male, • Female	 30 0
2	Age (years)	21.07 ± 1.05
3	BMI (kg/m²)	22.54 ± 2.19
4	Smartphone owned (years)	6.40 ± 2.14
5	Smartphone usage (hours/day)	8.03 ± 2.34

In this study, the dual-task involving walking and typing was found to have a statistically significant effect on the cervical angle degree of the respondents ($F_{(4,145)} = 32.463$, $p \leq 0.01$). This information is detailed in **Table 2 dan Figure 1.** which shows the comparison of cervical angles under the tested conditions.

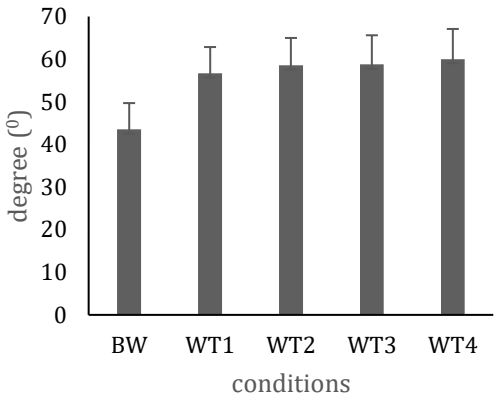

Figure 1. Comparison means of cervical degree

In the follow-up analysis using the post hoc Bonferroni test, a significant difference was found between the baseline walking condition (BW) and the texting walking conditions 1, 2, 3, and 4 respectively ($p \leq 0.001$), while there were no significant differences were observed between the texting walking conditions 1 through 4 ($p > 0.05$) as shown in **Table 3**.

Table 2 Effects of smartphone on cervical angle

Variable	Conditions					*P value
	BW	WT1	WT2	WT3	WT4	

Cervical angle (°)	43.51 ± 6.19	56.67 ± 6.18	58.56 ± 6.42	58.76 ± 6.85	60.03 ± 7.06	**<0.001**

BW: baseline walking, WT1: walking-texting 1, WT2: walking-texting 2 , WT3: walking-texting 3, WT4: walking-texting 4
P value < 0.05 by one way ANOVA

Tabel 3 Pairwise comparison of smartphone usage

Variabel	Tabel Pairwise (*p value)									
	BW-WT1	**BW-WT2**	**BW-WT3**	**BW-WT4**	**WT1-WT2**	**WT1-WT3**	**WT1-WT4**	**WT2-WT3**	**WT2-WT4**	**WT3-WT4**
Cervical angle	**≤ 0.001**	**≤ 0.001**	**≤ 0.001**	**≤ 0.001**	1.000	1.000	0.488	1.000	1.000	1.000

BW: baseline walking, WT1: walking-texting 1, WT2: walking-texting 2 , WT3: walking-texting 3, WT4: walking-texting 4
**p value* by *Post Hoc Bonferonni*, *significant difference p<0.05*

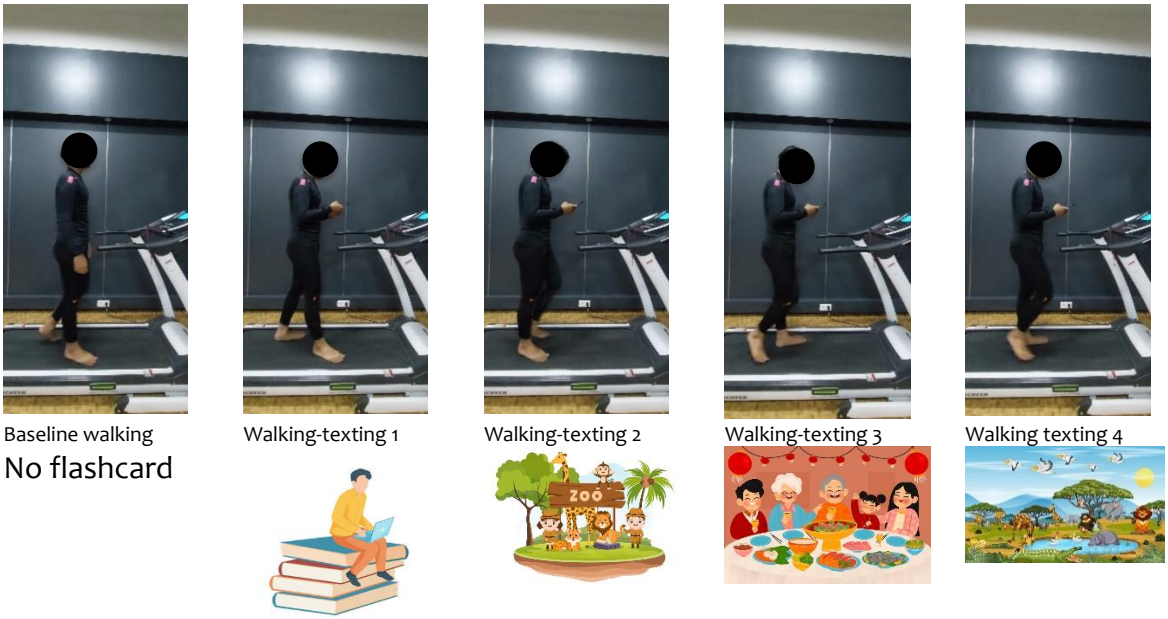

Figure 2. protocol of study

DISCUSION

The findings from this study confirm the hypothesis that dual-task texting has a significant impact on changes in the cervical angle among smartphone users. When using smartphones, subjects tend to focus more on the device, resulting in a greater forward head tilt to better view the screen. Tables 2 and 3 illustrate that there was a significant difference between walking without a smartphone (baseline walking) and walking texting 1, 2, 3, and 4. This finding is similiar with Schabrun's 2014 study, which found that walking with a smartphone increases the cervical angle compared to walking without one. This effect is attributed to the tendency of subjects to process incoming information more easily when their head is tilted downward. The head, body, and hand movements while using a smartphone while walking are aimed at stabilizing the visual focus on the screen (Schabrun et al., 2014).

The increase in cervical angle has been shown to undergo significant changes when comparing single-task walking (without smartphone use) to dual-task walking (with

smartphone use). Figure 1 confirms that there is a change in cervical angle during baseline walking and dual-task texting using flashcards. In Hyeseon Han's 2019 study, it was noted that during natural walking, the human head moves rhythmically in what is known as compensatory motion to stabilize head and visual fixation in response to the cyclic movement of the trunk (Han & Shin, 2019). The study further explained that the variation in the degree of cervical angle and head movement between single-task and dual-task conditions differs greatly due to efforts to minimize head flexion oscillation.

For additional explanation, the complexity of dual-tasking also influences gait patterns. It was observed that subjects showed inconsistencies in walking characteristics such as tempo, step length, step height, and step width. This instability in gait is attributed to the cognitive load on information processing, as noted in Kim's 2020 study, which suggests that such instability causes movements to take longer (Kim, Jung, Shin, Hahm, & Cho, 2020). The changes in information received by receptors can impact gait stability because, during dual-tasking, the ratio between the swing and stance phases shifts, leading to an increase in the time the foot remains in contact with the ground (Crowley, Madeleine, & Vuillerme, 2019).

Dynamic stability is influenced by various components of the body's nervous system, such as the somatosensory system, motor cortex, occipital lobe, and prefrontal cortex, which are responsible for planning, processing information, and instructing the body to maintain balance and posture through muscle movements (Crowley et al., 2019; Yano, Nakamura, Suzuki, Smith, & Nomura, 2024). The previous research also noted the involvement of the thorax and upper limbs in providing stability during dual-task activities (Schabrun et al., 2014). This condition reflects the role of executive function, which is managed by the frontal lobe and involves planning, sequencing, initiating, and managing complex behaviors or activities. The prefrontal cortex receives projections from other neocortical areas, such as the parietal and temporal regions, and then sends these projections to the medial dorsal nuclei, septal nuclei, amygdala, hypothalamus, and basal ganglia, which are connected to other cortical structures before passing the information to efferent nerves (McGarry & Carter, 2017).

This study demonstrates that dual-task texting significantly alters the cervical angle in young adult smartphone users, increasing the risk of developing musculoskeletal issues such as neck pain and poor posture. The consistent forward head tilt observed during dual-tasking activities suggests that smartphone use in such contexts places additional strain on the cervical spine. These findings align with previous research, reinforcing the need for increased awareness of the potential health risks associated with dual-tasking while using smartphones. Further research is encouraged to explore more complex scenarios and their implications on both gait patterns and posture, which could lead to improved clinical practices in preventing and addressing these issues.

CONCLUSION

This study concludes that dual-task texting significantly impacts the cervical angle in young adult smartphone users, with an observed increase in cervical angle from 43.51° during baseline walking to 56.67°-60.03° during texting while walking. This effect is chronic and, if not managed, may lead to neck pain and poor posture. The findings highlight the importance of awareness among users about the risks associated with dual-task texting. Future research should explore more varied and

complex texting scenarios and examine the relationship between gait patterns and posture during dual-task activities.

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