ASSOCIATION BETWEEN THE WALKING SPEED, CADENCE, CYCLE LENGTH WITH WORDS PER MINUTE AND ANTHROPOMETRIC PARAMETERS

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ABSTRACT

Introduction: *Recent studies have revealed that the usage of mobile phones while walking has a negative impact on its quality, directly influencing the length of the step and the angle of the foot. This implies that smartphone users have a weaker cycle of walking compared to those who do not use smartphones, and their speed is relatively low because of the impact of texting while walking. Thus these studies analyze the impact of smartphone use on walking quality.*

Material and methods: *The experimental method used was designed under three conditions: walking, reading, and texting while walking, with participants required to walk in a 15 meters corridor with no barriers while using their mobile phone in three phases. The experiment was conducted using PODOSMART technology. The data used from this technology were the length of the walking cycle, cadence, speed and the symmetry of legs.*

Results: *Significant results (p<0.001) were observed when comparing the speed of walking without and while using a smart phone to read or type. Additionally, a high correlation was found between body height and cycle length in three assessed conditions (walking, walking while reading and walking while typing). Higher speed, lower cycle length and higher BMI were the best predictors to the increase of steps per minute.*

Conclusion: *The usage of smartphones to read or type while walking significantly impacts the quality of walking, thus decreasing the length, speed of the step, and cadence. Furthermore, it affects the dynamic stability of the active population that can be a serious concern for their future's walking balance, as well as a potential increased risk for the development of disability and morbidity.*

Keywords: *Gait analysis, mobile phones, typing, walking cycle.*

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Introduction

The increased use of smartphones has increased the necessity of research on their impact on quality of life in the general population, particularly in the younger populations due to their higher tendency for usage(1). The use of smartphones is rapidly increasing(2). The evolution of technology and the need to combine walking with mobile phones pose a global challenge(3). It has been suggested that walking and using smartphones simultaneously reduces walking quality(2), thus raising questions for serious implications on the matter. The use of mobile phones while walking may cause slipping, tripping, or falling(4, 5). Based on Shaikh & Shah(4), reading or typing generally affect walking performance. The use of mobile phones while walking is a distraction factor(6, 7), which changes the ability of a person to walk, causing abnormalities(8). Pedestrians who use mobile phones while walking are at risk of accidents(9) and death(10); they slow the pace of walking and are at risk of traffic while using their mobile phones(9). Recent studies have as well revealed that the use of smartphones while walking has a negative impact on the quality of walking, directly affecting the length of the step[4, 11] and the angle of the foot[4], implying that the smart phone users have a weaker cycle of walking in comparison to those who do not use smartphones[12], and their speed of walking is relatively low because of the impact of texting while walking[3]. It should be noted that if walking without a smartphone, the muscle strength increases or decreases depending on the increase or decrease in walking speed[13]. In addition, texting while walking lowers the speed in both genders, without exception[14].

Having these in mind, and the potential implication and consequences of smartphone on walking process in general, this study aimed to determine the impact of smartphone use on walking quality by following assessments in three different conditions. Furthermore, we intend to estimate the best predictors and influencing factors on the number of steps per minute.

Methodology

Experimental design and participants

The whole data collection process was conducted between January and June 2021 in the department of Physiotherapy, Faculty of Medicine, University of Prishtina "Hasan Prishtina", Prishtina, Kosovo. The experimental method was designed following a specific order, with the same tester performing the same assessments. Informed consent and personal data were collected at the entrance, followed by anthropometrics (height and weight) and concluded by length of the walking cycle, cadence, speed, symmetry of legs, and activity of pelvic muscles and calves while walking.

Total 83 participants (56 females and 27 males) aged between 18 to 22 years were involved. The inclusion criteria involved belonging to the set age, as well as having a personal mobile phone that the individual had been using for more than six months. The exclusion criteria involved presenting any healthcare or musculoskeletal problem, neurological disorder, or any other problem that would interfere with the walking process and other related final outcomes.

Anthropometrics and walking analysis

For measuring the anthropometric traits, International Standards for Anthropometric Assessment were followed[15]. Assessments were performed in the morning on the subjects that were wearing light indoor clothes. The process started with the measurement of height through stadiometer (Seca, Hamburg, Germany) using the stretch stature method, while being followed by weight as measured by a digital scale (Seca, Hamburg, Germany).

For assessing the length of the walking cycle, cadence, speed, symmetry of legs, and activity of pelvic muscles and calves while walking, PODOSMART technology (Digitsole, Nancy, France) was used, as a validated appropriate tool to analyze walking according to the gold Vicon standards[16, 17]. The test was performed with the participant instructed to walk ahead and back on a regular walking gait speed within a 15 meters shuttle track (equipped with sufficient light and no barriers) for 1 minute. Test was performed on three phases: phase one – participant walked the normal / regular speed with no distractions; phase two - participant walked while reading a standardized text on their mobile phones; phase three – participant walked while typing a standardized text. Tester stood next, observing and supervising the process, as well as being available for any potential help provision (if needed). The used data from this technology are the length of the walking cycle, cadence, speed, symmetry of legs, and activity of pelvic muscles and calves while walking. The walking track was equipped with sufficient light, wearing light indoor clothes with a duration of more than 1 min until PODSMART technology received the data. All the data were provided within the participants' card as received by the online software of PODOSMAT, taken from Bluetooth insoles connected to a web application.

Informed consent was obtained from every participant, with the whole research process being conducted in accordance with the Declaration of Helsinki. The ethical permit was obtained from the Faculty Ethics Council, Faculty of Medicine, University of Prishtina, Kosovo (22/11/2019, protocol number: 12078).

Statistical analysis

All statistical calculations were processed using the SPSS statistical package (version 27). Since the normal distribution was observed to be violated in many parameters, data were expressed as medians and interquartile ranges (75th to 25th percentile) for the continuous variables and as absolute numbers or percentages for the frequencies of categorical variables. Differences between two groups were assessed using the non-parametric Mann–Whitney U test, whereas differences between the three genotypes were assessed using Kruskal–Wallis 1-way ANOVA. The statistical significance threshold was set at below 0.05. 2 tailed Pearson correlation coefficient was assessed in order to estimate the correlation between parameters.

Multiple regression analysis were performed to predict the influence of walking speed, cycle length and BMI on cadence, as well as number of words per minute (as an outcome) from various other covariates (BMI, walking speed, cadence, cycle length and symmetry) following the stepwise method. Durbin-Watson statistic was used to assess the independence of residuals, whereas R^2 (coefficient of determination) and ΔR^2 (adjusted R^2) were used to assess the overall model fit.

Results

Descriptive characteristics including age, weight, height, BMI, words per minute, as well as speed, cadence, cycle length and symmetry while walking, reading and writing on the smartphone in total participants as well as in genders separately are provided in Table 1. Gender differences were found only in weight, height (p<0.001), BMI, words / min (p<0.01).

The differences between three stages of testing (walking, reading, and writing) for speed, cadence, and cycle are shown in Table 2. As observed, differences between group are obviously seen in all parameters.

	Walking	Reading while walking	Typing while walking	p-value
Speed (km/h)	5.1 (4.8–5.5)	4.6 (4.2-4.8)	4.3 (4.0-4.6)	<0.001
Cadence (steps/min)	113 (109-117)	109 (103-111)	106 (100-109)	<0.001
Cycle length (cm)	1.5 (1.5–1.6)	1.4 (1.3-1.5)	1.4 (1.3-1.4)	<0.001

Table 2: Differences between three stages of testing (walking, reading and writing) for speed, cadence, and cycle.

*Notes: Data are expressed as medians (25th–75th percentile), absolute numbers (percentages). Differences between genotypes were determined by Kruskal-Wallis 1-way ANOVA. Abbreviations: Kg = kilogram; m = meter; cm = centimeter; no = number; min = minute; BMI = body mass index. *p<0.05, **p<0.01, ***p<0.001.*

Table 3 describes the correlation between anthropometric parameters (age, weight, height, BMI) together with the number of words per minute, with walking, reading and writing speed, cadence, cycle length and the symmetry between two sites. This correlation was observed between body height and walking speed in three assessments

	Total (n=83)	Female (n=56)	Male (n=27)	p-value
Age (years)	21.0 (20.0 – 21.0)	21.0 (20.0 – 21.0)	21.0 (20.0 – 21.0)	0.749
Weight (kg)	65.0 (55.0 – 72.0)	60.0 (52.3 – 66.0)	72.0 (65.0 – 86.0)	<0.001*
Height (m)	1.72 (1.65 – 1.76)	1.67 (1.64 – 1.74)	1.78 (1.73 – 1.83)	<0.001*
BMI (kg/cm²)	21.71 (19.82 – 24.24)	20.8 (19.0 – 23.3)	24.2 (21.1 – 26.3)	0.001*
Words / min (no)	27 (23 - 34)	26 (21 - 33)	32 (27 - 38)	0.008*
Walking speed (km/h)	5.1 (4.8 – 5.5)	5.1 (4.8 – 5.5)	5.2 (4.9 – 5.6)	0.209
Walking cadence (steps/min)	113 (109 - 117)	112 (109 - 116)	115 (108 - 118)	0.184
Walking cycle length (cm)	1.5 (1.5 – 1.6)	1.5 (1.5 – 1.6)	1.5 (1.5 – 1.6)	0.404
Walking symmetry (%)	97.0 (96.0 – 99.0)	97 (95 - 99)	97 (97 - 98)	0.772
Reading speed (km/h)	4.6 (4.2 – 4.8)	4.5 (4.2 – 4.8)	4.6 (4.3 – 4.8)	0.217
Reading cadence (steps/min)	109 (103 - 111)	108 (102 - 110)	110 (106 - 112)	0.056
Reading cycle length (cm)	1.4 (1.3 – 1.5)	1.4 (1.3 - 1.5)	1.4 (1.3 – 1.5	0.431
Reading symmetry (%)	97.0 (96.0 – 99.0)	97.0 (96.0 – 99.0)	98.0 (96.0 - 100)	0.374
Writing speed (km/h)	4.3 (4.0 – 4.6)	4.2 (4.0 – 4.6)	4.4 (4.2 – 4.7)	0.224
Writing cadence (steps/min)	106 (100 - 109)	104 (100 - 108)	107 (104 – 112)	0.066
Writing cycle length (cm)	1.4 (1.3 – 1.4)	1.4 (1.3 – 1.4)	1.4 (1.3 – 1.4)	0.188
Writing symmetry (%)	97.0 (96.0 – 98.0)	97.0 (96.0 – 98.0)	98.0 (95.0 – 99.0)	0.821

Table 1: Descriptive characteristics.

*Notes: Data are expressed as medians (25th–75th percentile), absolute numbers (percentages). Differences between genotypes were determined by Mann–Whitney U test. Abbreviations: Kg = kilogram; m = meter; cm = centimeter; no = number; min = minute; BMI = body mass index. *p<0.05, **p<0.01, ***p<0.001.*

(walking ($p<0.05$), walking while reading ($p<0.01$) and walking while typing ($p<0.05$)), body height and cycle length (walking ($p<0.001$), walking while reading ($p<0.001$) and walking while typing ($p<0.01$)). Other correlations were observed between words per minute and walking speed, walking cycle length, reading speed, reading cycle length and writing cycle length ($p<0.01$).

(BMI, walking speed, cadence, cycle length and symmetry). Cycle length was the only variable adding statistically significantly to the prediction F (1,81)=12.416, $p<0.01$, adj. R^2=0.122. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.047. R^2 for the overall model was 13.3% with an adjusted R^2 of 12.2% (data not included in the Tables).

	WS (km/h)	WC (steps/min)	WCL (cm)	WSY (%)	RS (km/h)	RC (steps/min)	RCL (cm)	RAY	WRS (km/h)	WRC (steps/min)	WRC (cm)	WRSY (%)
Age (years)	0.517	0.890	0.278	0.088	0.673	0.995	0.318	0.971	0.862	0.712	0.578	0.830
Weight (kg)	0.384	0.488	0.215	0.820	0.150	0.087	0.440	0.209	0.796	0.375	0.168	0.065
Height (m)	0.018*	0.382	0.000***	0.550	0.008**	0.794	0.000***	0.820	0.013*	0.668	0.001**	0.396
BMI (kg/cm²)	0.819	0.176	0.453	0.685	0.741	0.50	0.260	0.258	0.365	0.351	0.960	0.116
Words/min (no)	0.003**	0.504	0.001**	0.954	0.006**	0.276	0.003**	0.641	0.007**	0.314	0.003**	0.701

Table 3: Correlations.
Abbreviations: WS = walking speed; WC = walking cadence; WCL = walking cycle length; WS = walking symmetry; RS = reading speed; RC = reading cadence; RCL = reading cycle length; RSY = reading symmetry; WRS = writing speed; WRC = writing cadence; WRCL = writing cycle length; WRS = writing symmetry; kg = kilogram; m = meter; cm = centimeter; no = number; min = minute; BMI = body mass index. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

Table 4 shows the prediction of cadence (steps per minute) from various other covariates (BMI, walking speed, cycle length, symmetry and words per minute). The walking speed, cycle length and BMI were the variables adding statistically significantly to the prediction F (3,79)=152.391, $p<0.001$, adj. R^2=0.847.

There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.219. R^2 for the overall model was 85.3% with an adjusted R^2 of 84.7%.

Chair stand	B	95% CI		SE B	B	R²	ΔR²
		LL	UL				
Model						0.853	0.847***
Constant	92.296	84.658	99.934	3.837			
Speed	17.452***	15.779	19.126	0.841	1.429***		
Cycle length	-47.860***	-54.758	-40.963	3.465	-0.954***		
BMI	0.176*	0.034	0.319	0.072	0.107*		

Table 4: Influence of walking speed, cycle length and BMI on cadence.
Model = "Stepwise" method in SPSS Statistics; B = unstandardized regression coefficient; CI = confidence interval; LL = lower limit; UL = upper limit; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

Another multiple regression was performed to predict the number of words per minute (as an outcome) from various other covariates

Discussion

This cross sectional study analyzed the interaction between phone usage and walking, including the potential influence of other factors (either internal of external) such as age, weight, height, body mass index (BMI), number of words and steps per minute, speed, length cycle and the symmetry. Up to date, few studies have shown that the using the phones while walking, impacts negatively the quality of walking, directly affecting the length of the step[11, 18] and the angle of the foot[18], implying that the smartphone users have a weaker cycle of walking in comparison to those who do not use smartphones[12], and their speed of walking is relatively low because of the impact of texting while walking[19]. If we walk without a mobile phone, the muscle strength increases or decreases depending on the increase or decrease in walking speed[13]. In addition, texting while walking lowers the speed in both genders[14]. To the best of our knowledge, no data on the issue could be observed within the studied population, notwithstanding the efforts to provide test-retest reliability of certain physical performance parameters including the gait speed test in both normal and fast pace[20].

In our research, significant results ($p<0.001$) were obtained by comparing the speed of walking without a mobile phone and while using a mobile phone to read or type. Therefore, the use of mobile phones while walking decreases the walking speed.

Similar results as in our experiment were obtained by Crowley and colleagues in 2019 and 2022[5, 21]. Whereas Zhou et al.[22] in their research obtained the results of the impact of typing while walking at a low speed in comparison to walking without a mobile phone. In relation to cadence, in our research, we obtained a significant p-value <0.01 for steps per minute by provoking walking in three situations: walking without a mobile phone, reading while walking, and typing while walking. Similar results were obtained from a previous study[5]. In our research, our results showed a significant data (p<0.01) that using the mobile phone during the walking decreases the length of steps, thus interfering with the quality of gait. Several authors have reported that the use of mobile phones while walking directly affects the distance walked[5, 23].

In this research, the median value of cycle length (cm) while walking was 1.54 (cm), in comparison to during reading while walking 1.40 (cm) and typing while walking 1.37 (cm), and the results were statistically significant (p<0.01). Another interesting finding that caught our attention was the high correlation found in between body height and cycle length in three assessed conditions (walking, walking while reading and walking while typing). This should be explained based on the ability to gain more ground due to the size (and vice versa). Likewise, the number of words per minute was as well shown to be correlated to the three assessed conditions, while having in mind the specifics of each of the later. A final outcome observed was the influence of different parameters on the number of steps per minute (cadence). As anticipated, it was seen that higher speed is the best predictor on the increase of steps per minute, as followed by lower cycle length and higher BMI. For both speed and cycle length, there are certain techniques (e.g. exercises) and modalities (e.g. footwear) where the potential to intervene exists to certain level(s).

However, with respect to the influence of higher BMI, we believe it should be related to the generally higher body lean mass and muscle mass that comes along with higher BMI. In this context, the importance of these findings lay on both clinical and practical values that cadence might have as a physical activity intensity marker[24] and as an important path for potential intervention strategies.

In conclusion to what was written above, the usage of smartphones to read or type while walking significantly impacts the quality of walking. These actions decrease the length of the step, speed of the step, and cadence. It affects the dynamic stability of the active population that can be a serious concern for their future's walking balance, as well as a potential increased risk for the development of disability and morbidity. These findings should be useful for research and clinical purposes for both regular and pathological gait analysis, as well as the general human wellbeing, thus highlighting that the locomotor system of human organism is affected by inappropriate postural positioning.

Furthermore, it adds more depth towards the already existing voices that using smartphones during walking might provide future's balance-disorder. It is a common understanding that the usage of smartphones facilitates life (which is undeniably true), though the potential implication on the quality of life should not be underestimated. In this context, a future longitudinal study would be necessary to further clarify these outcomes, to estimate the time-dependent effects, as well as to know whether to establish or reject the findings.

Even though performing to the best of our knowledge, certain limitations are observable within this study, while being out of our reach. A distinctive limitation was the fact that this study comprised only by a young population, whereas the mature and older adults were not involved. Thus future studies are encouraged to involve other age groups as well, as a necessity to be more representative and all-inclusive.

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