Original Research Article

Gait and/or Balance Impairments in Geriatric Populations: An Etiological Study

ABSTRACT

Background: Elderly was applied to individuals aged 60 years and above. Falls are a significant problem because they result in substantial morbidity and mortality. Several factors increase the risk of falling in older people, such as muscle weakness, gait and balance impairment, neurological dysfunctions, and cognitive decline. This work aimed to study the gait and balance impairments in geriatrics regarding possible etiologies, clinical and radiological approach for diagnosis, as well as their effect on quality of life. **Methods**: The current study was an observational cross-sectional study carried out on 60 subjects aged > 61 years and 40 subjects aged ≤60 years, who were relatives of outpatient clinic patients. Studied individuals were subjected to clinical and digital gait analysis and brain as well as cervical DTI. **Results**: The age of included geriatrics was 61-79 years and 88.3% were males. There was a significant change in AADLs, the SARC-F scale, the MoCA scale, and the DGI scale in older adults. Instrumental gait assessment revealed a significant decrease in gait speed, cadence, swing phase, and stride length, and a significant increase in stride time, contact phase, and double support phase. There was a significant correlation between gait speed and age as well as the degree of sarcopenia. **Conclusion**: Gait speed in the elderly had an inverse correlation with age and sarcopenia and a significant relation with diabetes mellitus, cardiovascular diseases, and sex. Sex and sarcopenia were risk factors for slow gait speed in the elderly.

Keywords: Gait Speed, Geriatrics, Sarcopenia, Gait Analysis, Falls.

1. INTRODUCTION

The term "elderly" refers to those who are 60 or older, and they represent the fastest-growing demographic globally. The increase in the elderly population is more pronounced in developing countries than in developed ones [1]. Gait refers to the rhythmic movement involving the hands and feet during walking. [2]

The gait cycle is defined as the period between two consecutive instances of the heel striking the ground with the same foot (step) and is alternatively termed a stride [3]. It comprises two main phases: stance and swing. The stance phase in walking is further divided into five sub-phases, while the swing phase consists of three sub-phases [4].

Older individuals' gait typically changes with age, even without specific health conditions. These alterations are often measured by assessing changes in gait cycle variables. Spatiotemporal parameters such as stride length, speed, and cadence commonly decrease with age. Additionally, examining factors like gait regularity, symmetry, coordination, dynamic balance, and foot movement during walking can provide insights into potential, even subtle, gait dysfunctions.[5].

Falls represent a considerable concern due to their substantial impact on morbidity and mortality rates. They pose significant public health challenges as they endanger the independence of older individuals and lead to socioeconomic repercussions [6]. Various factors contribute to an increased risk of falling among older individuals, including muscular weakness, vestibular issues, impaired balance and gait, neurological disorders, vision and hearing impairments, cognitive deterioration, and orthostatic hypotension. Additionally, depression, polypharmacy, and environmental factors play roles as co-factors, particularly in older adults [7].

This work aimed to study the gait and balance impairments in geriatrics regarding possible etiologies, clinical and radiological approach for diagnosis as well as their effect on quality of life.

2. SUBJECTS AND METHODS

This observational cross-sectional study was carried out in the Neuropsychiatry and Radiology departments at Tanta University Hospitals in the period from January 2020 to June 2021.

2.1 Participants

Forty middle-aged and 60 over 61 years old subjects, both sexes. They were relatives of patients attending the outpatient clinic of the Tanta Neuropsychiatry Department at Tanta University Hospitals. Exclusion criteria were subjects with a well-known cause of gait and balance disorders as a history of stroke, cognitive impairment, trauma, parkinsonism, orthopedic problems, or other neurological disorders as well as those with MRI contraindications. Figure (1)
Subjects were divided into two groups: Group A comprised 60 subjects >61 years, and Group B included 40 subjects ≤60 years.

2.2 Methods

After obtaining the needed permissions from the research ethics committee and obtaining written consent from participants, each participant was subjected to the following:

2.2.1 Clinical assessment which included the following items

History taking, neurological examination, strength, assistance in walking, rising from a chair, climbing stairs, and falls (SARC-F) scale [8], the advanced activities of daily living scale (AADLs) [9, 10], and Montreal Cognitive Assessment Scale (MoCA) Arabic Version[11].

2.2.2 MRI studies

Brain MRI images were performed to diagnose and grade WMHs using the Fazekas scale [12]. Diffusion tensor tractography (DTT) and 3D microstructural orientation of the corticospinal tract (CST) at the cerebral peduncle, internal capsule, and cervical spine. MRI was acquired using 1.5–Tesla, General Electric Scanner with quadrature 8 channels head coil, GE Healthcare, Milwaukee, WI, USA Diffusion tensor tractography (DTT) uses data acquired through diffusion tensor imaging (DTI) to reconstruct a 3D macroscopic orientation of the white matter fibers. It was assessed by single-shot spin echo–planar imaging with TR 8830 msec., TE 80 msec., acquisition matrix 112 x110 mm, acquisition voxel 2.00/2.03/2.00 mm, field of view; right–left 224 mm, anteroposterior 224 mm and feet–head 120 mm, voxel size; right–left 2 mm, anteroposterior 2 mm and slice thickness 2 mm, reconstruction voxel size 1.75 mm, gradient direction 32, b-value 1000 mm/s and number of slices was 60 with total scan time 9:51 minutes.

- **Data Processing and Analysis**

The DTIs were transferred to the workstation (advantage window 4.7), where they were converted to color coded map images automatically by the loaded program depending on mapping images by three or more colors commonly red, blue, and green mainly and sometimes a mixture between them. Each color denotes the direction of the fiber tract, red is used to show fibers running in a transverse direction or from the right to the left, green for the fibers running from anterior to posterior, and blue for fibers running vertically from head to feet. The region of interest drawing strategies were done according to the fiber assignment by continuous tracking (FACT) method which performs a straightforward linear propagation algorithm. In this method, multiple regions of interest at least two are drowned in a known anatomical point in the course of specific tracts, it is an accurate method as it ensures the exclusion of other tracts that may pass through the same pixel with the targeted tract or decussate with it at the site of the lesion [13,14].

2.2.3 gait analysis

Clinical gait and balance assessment using the dynamic gait index (DGI) [15]. Quantitative (Instrumental) gait assessment was done using a PODO-Smart insole device (Digitsole SAS, Nancy, France). The following parameters were measured: gait symmetry, cadence, speed, stride length and duration, and phases of the walking cycle. PODOSmart system consists of pairs of insoles (weighted a mere 66 g each and comes in six different sizes from 36 to 47 in FR shoe size chart (5.5 to 12.5 US shoe size-chart, 3 to 11.5 UK shoe size-chart) to fit all adult populations connected to Bluetooth connection box. The PODOSmart® smart insole is rechargeable via USB for continuous 33 hours with active use. Although PODOSmart® smart insoles are capable of long-lasting recordings, PODOSmart® artificial intelligence algorithms allow short-term recordings lasting less than a minute. PODOSmart® device allows to measurement of walking and running parameters of users, in real-life conditions. Each PODOSmart® insole has an inertial platform that records each foot's walking steps, running strides, and orientations in space with a sampling frequency of 208 Hz for walk analysis. The Bluetooth connection box retrieves the collected data by the smart insoles. Then, those data are processed by proprietary artificial intelligence algorithms to calculate the spatiotemporal, kinematic, and biomechanical parameters, displayed in a graphical interface, and processed into clinically usable data. [16].

2.3 Statistical Analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing an unpaired Student's t-test. Qualitative variables were presented as frequency and percentage (%) and analyzed using the Chi-square or Fisher's exact test when appropriate. A correlation between various variables was done using the Pearson moment correlation equation. Univariate regression was used to estimate the relationship between a dependent variable and one independent variable. Multivariate regression was also used to estimate the relationship between a dependent variable and more independent variables. A two-tailed P value < 0.05 was considered statistically significant.

3. RESULTS

This study showed that the age of included geriatrics ranged from 61 to 79 years and 88.3% were males. Twenty-three (38%) subjects complained of hypertension, while eighteen (30%) subjects had type II diabetes mellitus. Five (8%) subjects had ischemic heart disease. Thirty-one (51.6%) subjects were taking different medications. Body mass index (BMI), single and dual tasks of DGI, stride duration, contact phase, double support phase, and SARC-F scale were significantly higher in older than younger age groups (P<0.05). AADLs, MoCA, gait symmetry, gait speed, and cadence, swing phase were significantly lower in group A than in group B. Table 1

There was a significant increase in white matter hyperintensity in older than younger age groups (P <0.001). Fractional anisotropy and fiber thickness of the corticospinal tract were significantly decreased in the elderly (P<0.001). Table 2

This study showed a significant inverse correlation between gait speed and age as well as sarcopenia. On the other hand, gait speed revealed no correlation with BMI, AADLs, MoCA scale, DGI scale single and dual-task, and Fractional anisotropy (FA) of the corticospinal tract. Table 3

Sex, DM, and cardiovascular disorders had a significant relation with gait speed. In addition, there was no relationship between gait speed and medications, the Fazekas scale, and HTN. Table 4
The current study showed that sex and sarcopenia were good predictors of gait speed slowness in geriatrics. Table 5

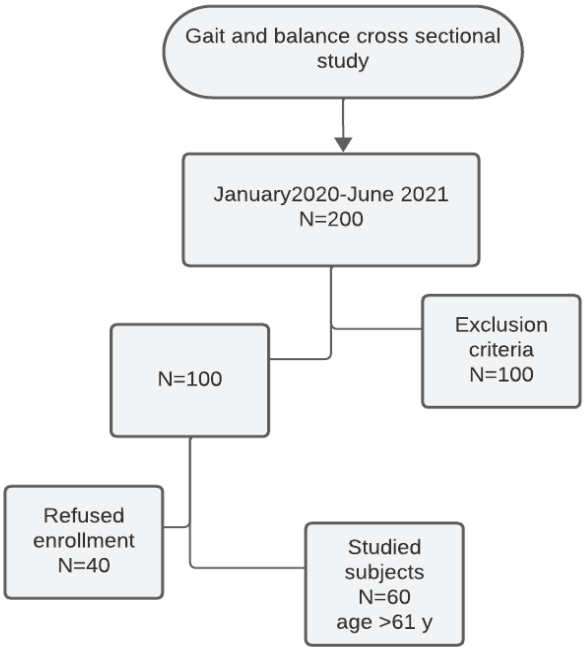


Figure 1: Flow chart of included geriatrics

Table 1. Comparison between the two studied groups according to BMI, DGI scale, AADLs, MoCA scale, SARC-F scale, and instrumental gait analysis

		Group A (n = 60)	Group B (n = 40)	P
BMI (kg/m2)		**29.57 ± 3.47**	**28.02 ± 3.48**	**0.031***
DGI scale	**Single task**	**22.80 ± 0.94**	**21.15 ± 2.01**	**<0.001***
	Dual- task	**22.05 ± 0.93**	**20.17 ± 1.66**	**<0.001***
AADLs		**27.17 ± 1.57**	**27.82 ± 1.28**	**0.024***
MoCA scale		**24.33 ± 1.45**	**27.65 ± 1.21**	**<0.001***
SARC-F scale		**5.37 ± 1.60**	**1.35 ± 1.37**	**<0.001***
Instrumental Gait Analysis				
(%)Symmetry		**90.93 ± 4.37**	**94.15 ± 2.67**	**<0.001***
Speed (m/s)		**0.70 ± 0.17**	**0.86 ± 0.32**	**0.035***
Cadence (step/ min)		**87.02 ± 12.63**	**92.30 ± 8.87**	**0.024***
Stride duration (ms)	**Right**	**1513.3 ± 146.9**	**1353.9 ± 99.82**	**<0.001***
	Left	**1455.0 ± 155.8**	**1362.8 ± 101.9**	**0.001***
Stride length (cm)	**Right**	**68.97 ± 10.99**	**97.30 ± 12.36**	**<0.001***
	Left	**71.50 ± 8.91**	**90.15 ± 11.26**	**<0.001***
Contact phase (%)	**Right**	**65.79 ± 2.27**	**64.36 ± 2.99**	**0.012***
	Left	**66.86 ± 2.63**	**64.91 ± 4.61**	**0.018***
Swing phase (%)	**Right**	**34.26 ± 2.26**	**35.33 ± 2.42**	**0.027***
	Left	**33.13 ± 2.67**	**35.16 ± 4.64**	**0.016***
Double support phase (%)		**13.37 ± 3.69**	**10.45 ± 3.88**	**<0.001***

Data are presented as mean ± SD or frequency (%). * Significant p-value <0.05, Group A: age >61years, Group B: age ≤ 60 years, BMI: body mass index, DGI: dynamic gait index, AADLs: advanced activity of daily living scale, MoCA: Montreal Cognitive Assessment, SARC-F: strength, assistance in walking, rise from a chair, climb stairs, and falls.

Table 2. Comparison between the two studied groups according to white matter hyperintensity, corticospinal tract fractional anisotropy (FA), and corticospinal tract fiber thickness

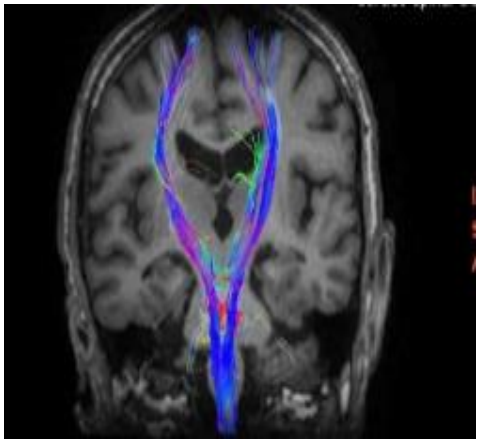
		Group A (n = 60)	Group B (n = 40)	P
Fazekas scale				
Periventricular	**Grade 0**	**3(5.0%)**	**26(65.0%)**	**<0.001***
	Grade I	**21(35.0%)**	**14(35.0%)**	
	Grade II	**20(33.3%)**	**0(0.0%)**	
	Grade III	**16(26.7%)**	**0(0.0%)**	
Deep white matter	**Grade 0**	**8(13.3%)**	**26(65.0%)**	**MCp**
	Grade I	**16(26.7%)**	**14(35.0%)**	**<0.001***
	Grade II	**19(31.7%)**	**0(0.0%)**	
	Grade III	**17(28.3%)**	**0(0.0%)**	
FA				
Cerebral peduncle	**Right**	**0.57 ± 0.11**	**0.73 ± 0.06**	**<0.001***
	Left	**0.57 ± 0.09**	**0.66 ± 0.10**	**<0.001***
Internal capsule	**Right**	**0.52 ± 0.07**	**0.70 ± 0.12**	**<0.001***
	Left	**0.52 ± 0.07**	**0.66 ± 0.10**	**<0.001***
Cervical spine		**0.06 ± 0.07**	**0.13 ± 0.07**	**<0.001***
Fiber thickness				
Cerebral peduncle	**Right**	**89.22 ± 25.33**	**131.6 ± 5.09**	**<0.001***
	Left	**73.10 ± 15.76**	**130.9 ± 4.46**	**<0.001***
Internal capsule	**Right**	**95.42 ± 22.25**	**130.6 ± 7.22**	**<0.001***
	Left	**79.17 ± 14.88**	**132.3 ± 6.60**	**<0.001***
Cervical spine		**93.35 ± 22.31**	**129.9 ± 4.17**	**<0.001***

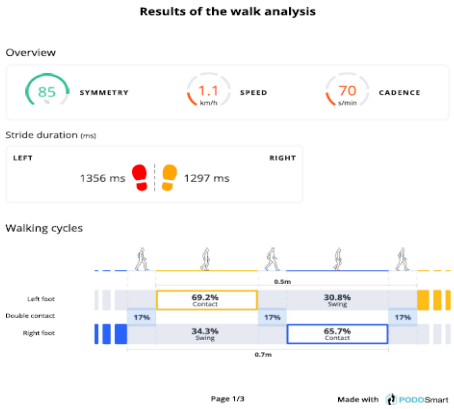
*Data are presented as mean ± SD or frequency (%). * Significant p value <0.05. MC: Monte Carlo, Group A: age > 61 years, Group B: age ≤ 60 years, FA: fractional anisotropy*.

Table 3. Correlation between gait speed and different parameters in group A

		Speed (m/s)	
		rs	**P**
Age (years)		**-0.266**	**0.040***
BMI (kg/m2)		**0.021**	**0.876**
SARC-F scale		**-0.305**	**0.018***
AADLs		**-0.102**	**0.436**
MoCA scale		**0.026**	**0.844**
Fractional anisotropy	**Right cerebral peduncle**	**0.029**	**0.828**
	Left cerebral peduncle	**0.036**	**0.786**
	Right internal capsule	**0.129**	**0.325**
	Left internal capsule	**0.144**	**0.271**
	Cervical spine	**0.001**	**0.995**
Fiber thickness	**Right cerebral peduncle**	**0.283**	**0.028***
	Left cerebral peduncle	**0.169**	**0.196**
	Right internal capsule	**0.176**	**0.179**
	Left internal capsule	**0.060**	**0.650**
	Cervical spine	**0.105**	**0.423**
DGI scale	**Single task**	**0.065**	**0.620**
	Dual task	**0.100**	**0.446**

rs: Spearman coefficient, *: Statistically significant at p ≤ 0.05, MoCA: Montreal cognitive assessment scale DGI: Dynamic gait index, AADLS: Advanced activity of daily living scale.





(a) **(b)**

Figure (2): 63 years male, presented with unsteadiness to the left side of the body. DGI single and dual tasks were 20 and 19, respectively. AADLs 28, MoCA 24, SARC-F scale 4, Fazekas scale G2 periventricular, G1 deep white matter. Diagnosed with mild normal pressure hydrocephalus (a); DTI brain showing bilateral attenuation of the corticospinal tract more on the right side. (b): Instrumental gait analysis showed decreased speed and cadence and increased contact and double support phases.

Table 4. Relation between gait speed and different parameters in group A

		N	Gait speed (m/s)	P
Sex	**Male**	**53**	**0.68 ± 0.17**	**0.010***
	Female	**7**	**0.86 ± 0.12**	
HTN		**23**	**0.72 ± 0.17**	**0.647**
DM		**18**	**0.62 ± 0.16**	**0.014***
Medications		**29**	**0.71 ± 0.17**	**0.859**
Cardiovascular disorders		**5**	**0.56 ± 0.10**	**0.042***
Fazekas scale				
Periventricular	**Grade 0**	**3**	**0.58 ± 0.14**	**0.414**
	Grade I	**21**	**0.68 ± 0.19**	
	Grade II	**20**	**0.73 ± 0.15**	
	Grade III	**16**	**0.73 ± 0.18**	
Deep white matter	**Grade 0**	**8**	**0.61 ± 0.12**	**0.202**
	Grade I	**31**	**0.69 ± 0.18**	
	Grade II	**19**	**0.76 ± 0.16**	
	Grade III	**2**	**0.81 ± 0.00**	

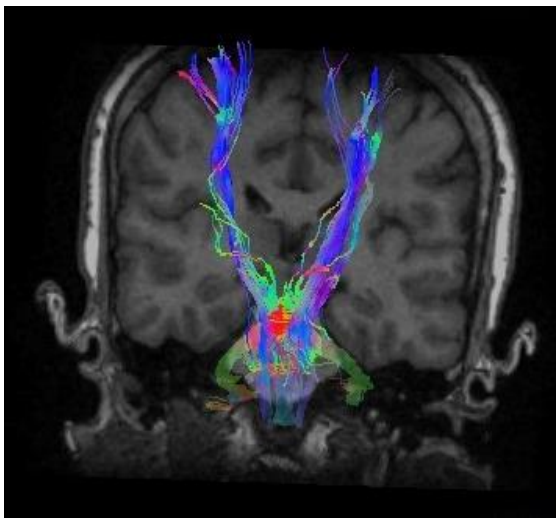
*Data are presented as mean ± SD. * Significant p value <0.05. Group A: age >61years, #: Excluded from the comparison due to small number of cases (n =1), HTN: hypertension, DM: diabetes mellitus*

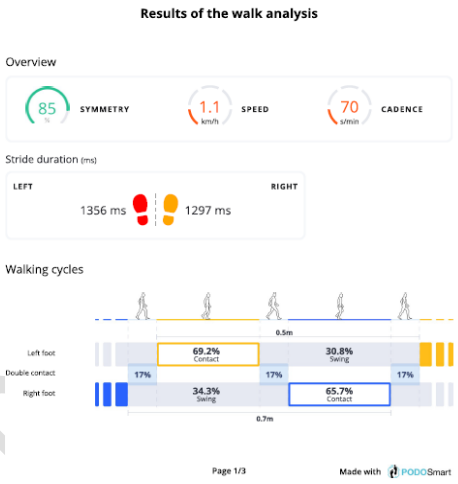
Table 5. Univariate and multivariate linear regression analysis for the parameters affecting gait speed in group A

Gait speed (step/min)	**Univariate**		**#Multivariate**	
	P	**B (LL – UL 95%C. I)**	**P**	**B (LL – UL 95%C. I)**
Sex	0.008*	0.178(0.047 – 0.308)	0.005*	0.164(0.053 – 0.274)
Age	0.028*	-0.009(-0.017–-0.001)	0.070	-0.006(-0.012– 0.001)

SARC-F scale	0.034*	-0.029(-0.056–-0.002)	0.014*	-0.029(-0.052–-0.006)
DM	0.010*	-0.122(-0.214–-0.030)	0.305	-0.044(-0.130–0.041)
Cardiovascular diseases	0.041*	-0.162(-0.317–-0.007)	0.188	-0.084(0.210–0.042)

**: Statistically significant at p ≤ 0.05, #: All variables with p<0.05 were included in the multivariate, B: Unstandardized Coefficients, C.I: Confidence interval, LL: Lower limit, UL: Upper Limit, SARC-F: Strength, Assistance in walking, Rise from a chair, Climb stairs, and Falls, DM: diabetes mellitus.*





(a) **(b)**

Figure (3): 70 years old male, presented with mild gait changes. DGI single task 20 and dual-task 18, AADLs 26, MoCA 22, SARC-F 5, Fazekas scale G1 periventricular, G1 deep white matter. He was diagnosed with mild cognitive impairment (MCI) (a): DTI brain of the corticospinal tract showed mild attenuation of the corticospinal tract on the right side. (b): Instrumental gait analysis showed decreased speed and cadence and increased contact phase and double support phases.

4. DISCUSSION

According to the current study, the average age of the participants was 69.57 ± 5.34 and 11.7% were females. That was agreed with Valkanova et al. [17] study. The current study found that gait speed decreased in older age groups compared to younger ones, which aligns with the findings of Boyer et al. [18].

The current work revealed that the activities of daily living showed a significant reduction in older than younger adults. This was agreed with Sánchez-Rodríguez et al. [19] and Elhassanien et al. [20] studies. As society ages, the occurrence of both decreased walking ability and impaired cognitive function is projected to increase significantly. There is a connection between the impairments in both [17]. Jiang and Wu [21] study found a MoCA range (24-28) that was in line with the current study (22-26).
The current work showed a significant negative correlation between gait speed and age. That was similar to Latorre Román et al. [22] study. The present study found a significant correlation between SARC-F scale and gait speed (P= 0.018). This was agreed with Areco et al. [23] work.
The present study found no association between gait speed and hypertension, BMI, medications, and the Fazekas scale. On the other hand, Monteiro et al. [24] the study found that polypharmacy was cross-sectionally associated with poor gait performance. This difference was attributed to differences in selection criteria and the small sample size of the present study.
While the current study found no correlation between gait speed and MoCA score, Jongki Choia [25] study found that the total MoCA-K score was significantly correlated with walking speed. This incongruence was attributed to different selection criteria as Jongki Choia et al [25] study was done on patients with cognitive impairment. Párraga-Montilla et al. [26] study found no correlation between MoCA score and gait speed.
The current study found no correlation between activities of daily living and gait speed. That was disagreed with Wollesen et al. [27] study. This

was due to different selection criteria as it was done on nursing home residents.

The current study showed no correlation between DTI white matter alterations and gait velocity, In Wu et al. [28] study, a significant correlation existed between FA values, and gait speed in multiple white matter tracts.

The current study found a significant correlation between gait speed and diabetes mellitus that was similar to Chung et al. [29] study that found slower gait speed in diabetic patients.

Gait speed is often used in clinical practice to assess the physical performance and functional ability of those with different cardiovascular diseases (CVDs). It serves as an indication of the overall health and functional status of individuals with CVD [30]. The correlation between decreasing gait speed and incident CVD is reported in Veronese et al. [31] that was similar to the current study.

The present study found no correlation between gait speed and hypertension which disagreed with Ahasn et al., [32]. This could be explained by the different ages of subjects involved in the current work and the presence of more than risk factors that could affect gait speed.

According to Zukowski et al. [33] study, hypertension could be used as a factor in risk assessment and fall screening for community-dwelling older people. While, age, was not identified as a stratifying variable in the decision tree models. This was agreed with the present study in which sex, diabetes mellitus, and sarcopenia were risk factors for gait impairments. While age was not identified as a risk factor for gait impairment in geriatrics.

5. CONCLUSION

DGI showed a significant affection in single and dual tasks in the elderly. The elderly showed a significant reduction in gait symmetry, gait speed, cadence, stride length, and swing phase, in comparison to the younger age group. Geriatrics showed a significant increase in stride duration, gait variability, contact phase, and double support phase in comparison to younger adults. Gait speed in the elderly had an inverse correlation with age and sarcopenia and a significant relation with diabetes mellitus, cardiovascular diseases, and sex. On the other hand, there was no correlation between gait speed and AADLs, MoCA scale, HTN, and medications. Sex and sarcopenia were risk factors for slow gait speed in the elderly.

ETHICAL APPROVAL

As per international standard or university standard, a written ethical approval has been collected and preserved by the authors.

CONSENT

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

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