Original Article

Gait analysis and geriatric syndromes: An association among elderly patients attending a teaching hospital of Delhi

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Abstract

Background: Gait abnormalities are prevalent, affecting a substantial portion of the elderly population, and leading to mobility limitations, reduced quality of life, falls, hospitalizations, and premature death. **Objectives:** The study aims to assess gait patterns among individuals aged 75 years and above attending the geriatric OPD of a tertiary care hospital in New Delhi and evaluate their association with various geriatric syndromes. **Materials and Methods:** This cross-sectional study, conducted at a tertiary care hospital in Delhi, from May 2019 to November 2021, involved 100 participants aged 75 and above. It encompassed a thorough assessment protocol covering demographics, health history, clinical and functional evaluations, depression, cognition, balance, frailty, urinary incontinence, polypharmacy, nutrition, comorbidities, and gait analysis. **Results:** In this study of elderly individuals, the mean age was 78.56 years, and the mean BMI was 23.11. The participants had an average of 1.74 comorbidities, with hypertension being the most prevalent (62%), followed by diabetes (25%), chronic obstructive airway disease (COAD) (11%), and coronary artery disease (15%). Geriatric assessments revealed varying proportions of frailty (34%), polypharmacy (40%), and urinary incontinence (9%). The mean scores for activities of daily living, instrumental activities of daily living, nutritional status, cognitive function, Timed Up and Go Test, and depression scale were also reported. Various gait parameters demonstrated significant correlations with these geriatric factors, including frailty, comorbidities, BMI, and mobility scores. **Conclusion:** The study identified significant associations between gait patterns and various geriatric syndromes, emphasizing the importance of gait analysis in assessing the health and mobility of elderly individuals.

Keywords: Comorbidities, frailty, gait, MNU score, TUG score

Introduction

The challenge of addressing ageing and providing care for the elderly is a pressing issue for countries in the twenty-first century. India, for instance, has witnessed a significant demographic shift in its senior citizen population. According to data from the Census of India, there were approximately 7.6 crore senior citizens in 2001, a number that grew to 10.4 crore in 2011. This figure is expected to further increase to 17.3 crore. This surge represents over 8 per cent of India's current population, and it can be attributed to improved healthcare services, leading to a rise in the elderly population.[1]

One of the prominent health concerns among the elderly is gait disturbances, which can be debilitating. In a study conducted

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in Goteborg, Sweden, on 79-year-olds, it was discovered that one out of every four individuals relied on mechanical aids for walking.[2] Gait disorders also contribute to the risk of falling, a significant concern given that accidental injury ranks as the sixth leading cause of death among the elderly, with a majority of such injuries resulting from falls.[3]

Gait disturbances and cognitive impairment are two critical issues that contribute to a widening gap between overall life expectancy and disability-free life expectancy[4] among the elderly. Gait abnormalities are a major cause of chronic disability in the elderly population, with their prevalence increasing significantly with age. They affect approximately 35 per cent of adults over 70 years old[5] and a staggering 72 per cent of those over 80 years old.[6] These abnormalities can lead to mobility limitations, which, in turn, are associated with a loss of independence, reduced quality of life, heightened risk of falls, repeated hospitalizations, and premature death.[7-10] Furthermore, gait performance serves as a predictor for survival, cognitive decline, fall risk, and overall quality of life.[11]

In the relevant literature, gait disorders are often referred to as gait instability. However, in clinical practice, gait disorders encompass a wide range of situations, including unsteady gait without falls, memory complaints, or evident gait abnormalities. The causes of gait disorders include sensory deficits (18.3%), myelopathy (16.7%), multiple infarcts (15%), parkinsonism (11.7%), cerebellar degeneration (6.7%), hydrocephalus (6.7%), toxic or metabolic factors (2.5%), psychogenic causes (3.3%), and others (5%), with unknown causes accounting for 14.2%.[12] Evaluating gait can provide insights into specific asymmetries related to how individuals move. Gait assessment typically involves measuring kinetic (force) and kinematic (spatial/temporal) aspects of movement. Analysing multiple foot strikes is preferred to account for the inherent variability in natural foot strikes and achieve more consistent results. Also, comprehensive assessment of the elderly helps to address the problems of elderly and thereby improve their quality of life.

Objectives

1. To evaluate gait patterns among individuals aged 75 years and above attending the geriatric OPD of a tertiary care hospital, New Delhi.
2. To assess the association between gait patterns and various geriatric syndromes among the individuals aged 75 years and above attending the geriatric OPD of a tertiary care hospital, New Delhi.

Materials and Methods

Study design and setting

This research was a cross-sectional study conducted in the Geriatric Medicine Outpatient Department (OPD) at a tertiary care teaching hospital, New Delhi, spanning from May 2019 to November 2021.

Study population

The study involved a sample size of 100 individuals aged 75 years and above who met specific inclusion criteria. These criteria included age, the ability to undergo a detailed gait evaluation process, and the availability of informed consent. Exclusion criteria comprised acute knee pain (VAS score >7), critical illness, and severe cognitive impairment.

Study instrument

The assessment of study participants followed a carefully designed protocol encompassing various dimensions of health and well-being. This comprehensive assessment included:

Demographic profile

Patients were assessed for their demographic information, including their name, age, sex, education status, marital status, and occupation.

Historical review of health status

Patients were questioned about their presenting complaints, including the duration and character of their symptoms, as well as the presence of any co-morbidities. Additionally, their past medical records were thoroughly examined.

Clinical assessment

A standard clinical assessment was conducted, involving a general review and systematic examination of the organ system.

Anthropometric assessment

Body mass index (BMI) was calculated using the formula BMI = weight (kg)/height (m^2).

Functionality assessment

Basic activities of daily living were assessed with Barthel's ADL scoring method. For instrumental activities of daily living, IADL scoring was used.

Depression

Mental health problems were assessed using the geriatric depression scale, with a score equal to or greater than five suggestive of depression.

Cognition

Cognitive function was assessed using the Hindi Mental State Examination (HMSE), with a cut-off score of ≤23 used to define cognitive impairment.

Balance assessment

The Timed Up and Go Test (TUG) was utilized to evaluate balance. The TUG score represented the time in seconds taken to move to and from a chair without support, walk a distance of 3 meters, return to the chair, and sit back down without support.

Frailty assessment

Frailty was assessed by the instrument proposed by Fried LP *et al.,*[13] with a slight variation in the operationalization for measuring the low physical activity parameter of frailty phenotype compared to the original proposal. Patients who met three or more of the five criteria were classified as frail, those with one or two criteria as prefrail, and those with no criteria as non-frail. The frailty criteria included:

1. Weight loss: Unintentional weight loss of 4.5 kg or 5% of body weight in the last year.
2. Grip Strength: Low grip strength measured by a Jamar hand dynamometer. Cut-off scores for grip strength were applied based on body mass index and gender.
3. Gait Speed: Assessed by the time spent to walk 4 meters, varying depending on gender and height.
4. Exhaustion: Using the CES-D depression scale, participants responded to two statements: A) "I felt that everything I did was an effort" and B) "I could not get going". The frequency of feeling this way over the last week was assessed, with a positive response indicating moderate to frequent feelings.
5. Low Physical Activity: Participants who rated themselves as "not at all physically active" in response to the question "Taking into account both work and leisure, would you say that you are; very, fairly, not very, or not at all physically active?" were considered to have low energy expenditure.

Urinary incontinence assessment

Urinary incontinence was assessed with the help of the 3 Incontinence Questions (3 IQ) questionnaire, which included questions about urine leakage in various situations.

Polypharmacy

Polypharmacy was defined as a person taking five or more medications.

Nutritional assessment

Nutritional assessment was conducted using the Mini Nutritional Assessment (MNA) questionnaire. A score of 12–14 was considered normal, 8–11 indicated people at risk of malnutrition, and a score of 0–7 was considered indicative of malnourishment.

Comorbidity

The comorbidity index of a person was calculated by the Charlson Comorbidity Index.[14] A higher score indicated a greater burden of comorbid conditions.

Gait analysis

Gait analysis was performed using the Zeno Walkway Gait Analysis System[15] (ZYGAS). This system provided various important parameters of gait, including step length (distance between the point of initial contact of one foot and the point of initial contact of the opposite foot), stride velocity (the ratio of stride length to stride time), stride width (perpendicular distance from the heel of one foot to the line connecting two consecutive heel strikes of the contralateral foot), stance phase (phase of the gait cycle from touchdown to lift-off of the same foot), swing phase (phase of the gait cycle during which the foot of interest is not on the ground), total double support (both feet simultaneously contacting the ground), stance COP path efficiency (measuring the COP left or right start-to-end distance as a per cent of the COP path length of the same footfall during stance phase), velocity (distance walked per unit time), cadence (number of steps taken per unit time), mean GVI (Gait Variability Index—step-to-step deviation/variations in gait parameters), and walk ratio (calculated by dividing step length by cadence).

Data collection/procedure

Patients who met the inclusion and exclusion criteria were recruited for the study. The assessment protocol was comprehensive and involved multiple aspects of the patients' health and well-being. It included demographic information, a review of health status, clinical assessment, anthropometric assessment, functionality assessment, depression assessment, cognition assessment, balance assessment, frailty assessment, urinary incontinence assessment, evaluation of polypharmacy, nutritional assessment, comorbidity assessment, and gait analysis using specialized equipment.

Statistical analysis

Data collected during the study were entered into MS Excel and analysed using STATA version 14 software. Quantitative data were presented as mean ± SD or median (minimum - maximum), while qualitative data were expressed as percentages or frequencies as appropriate. The normality of parametric data was assessed using the Kolmogorov–Smirnov test. To determine the statistical significance of differences in continuous variables between groups, the Wilcoxon rank sum test was used, and categorical variables were analysed using Fisher's exact test. A significance level of $P < 0.05$ was considered for the results.

Ethical consideration

This study adhered to ethical standards and practices. Participants provided informed consent before their inclusion in the study. The research aimed to ensure the well-being of the elderly subjects and did not expose them to undue risks. The study design and data collection methods were reviewed and approved by the relevant ethical committee or review board to guarantee the ethical conduct of the research and the protection of participants' rights and privacy. Confidentiality of participant information was maintained throughout the study.

Results

The mean age and BMI of the study participants were 78.56 ± 3.27 and 23.11 ± 3.43 [Table 1]. The mean number of comorbidities was 1.74. The minimum number of comorbidities one had was 0, and the maximum number of comorbidities one had was 4. Hypertension is the most common condition at 62%, followed by diabetes mellitus at 25%, while chronic obstructive airway disease (COAD) and coronary artery disease affect 11% and 15% of the population, respectively. Other conditions, such as benign prostatic hyperplasia (BPH), osteoarthritis of the knee, and Parkinson's disease, show varying degrees of prevalence, ranging from 1% to 23%.

The geriatric assessment showed that 41%, 40%, 34%, 25%, and 9% had non-frail, polypharmacy, frail, prefrail, and urinary incontinence, respectively. The mean ADL and IADL score were 19.34 ± 1.28 and 6.06 ± 1.70, respectively. The mean MNA, HMSE, TUG, and GDS score were 11.62 ± 1.72, 27.96 ± 2.33, 14.64 ± 3.43, and 5.21 ± 1.7, respectively.

The mean step length, stride velocity, stride width, stance phase, swing phase, velocity (cm/s), cadence (steps/min), total D support, stance COP path eff%, mean GVI, and walk ratio was 46.12 ± 10.16, 76.36 ± 21.13, 13.55 ± 3.76, 64.57 ± 2.97, 35.41 ± 2.95, 75.81 ± 20.99, 97.36 ± 12.22, 29.44 ± 5.54, 94.32 ± 3.12, 135.80 ± 10.31, and 0.47 ± 0.10, respectively [Tables 2-5].

Correlation of comorbidities with gait parameters

There were weak negative correlations between the number of comorbidities and step length (correlation coefficient = -0.11, *P* = 0.28), stride velocity (correlation coefficient = -0.12, *P* = 0.23), velocity (correlation coefficient = -0.11, *P* = 0.26), stance COP path efficiency percentage (correlation coefficient = -0.13, *P* = 0.17), mean gait velocity index (GVI) (correlation coefficient = -0.07, *P* = 0.47), and walk ratio (correlation coefficient = -0.07, *P* = 0.45). There were weak positive correlations between the number of comorbidities and stride width (correlation coefficient = 0.14, *P* = 0.16), stance percentage (correlation coefficient = 0.03, *P* = 0.72), and swing percentage (correlation coefficient = -0.04, *P* = 0.69), although these associations also did not reach statistical significance.

BMI with gait parameters

A weak positive correlation was observed between BMI and stride width (correlation coefficient = 0.16), suggesting that individuals with higher BMI values tend to have slightly wider strides. However, all other correlations, including step length (correlation coefficient = 0.05), stride velocity (correlation coefficient = 0.03), stance (correlation coefficient = 0.10), swing (correlation coefficient = -0.12), velocity (correlation coefficient = 0.02), cadence (correlation coefficient = -0.06), total double support percentage (correlation coefficient = 0.12), stance COP path efficiency percentage (correlation coefficient = 0.10), mean GVI (correlation coefficient = -0.06), and walk ratio (correlation coefficient = 0.06), were weak and non-significant.

Table 1: Profile of the study participants (*n*=100)

Variables	Frequency	Percentages
Age (years)		
75–79	66	66
80–84	27	27
≥85	7	7
Gender		
Male	85	85
Female	15	15
BMI		
Underweight	6	6
Normal	71	71
Overweight	23	23
Education		
Illiterate	25	25
Primary	35	35
Secondary	18	18
Graduate	19	19
Postgraduate	3	3

Table 2: Polypharmacy with gait parameters (*n*=100)

Variables	Polypharmacy Mean±SD	No Polypharmacy Mean±SD	*P*
Step length (cm)	45.84±8.67	46.31±11.12	0.820
Stride velocity (cm/s)	74.58±18.72	77.54±22.67	0.490
Stride width (cm)	14.44±3.61	12.95±3.76	0.050
Stance%	64.66±2.56	64.50±3.23	0.800
Swing%	35.29±2.51	35.50±3.22	0.730
Velocity (cm/s)	74.08±18.61	76.97±22.51	0.500
Cadence	95.29±11.70	98.75±12.46	0.160
Total D Support%	29.80±4.70	29.20±6.06	0.590
Stance COP path eff%	93.94±3.70	94.57±2.67	0.320
Mean GVI	135.99±9.80	135.68±10.72	0.880
Walk ratio	0.47±0.08	0.46±0.11	0.640

Independent *t*-test applies, *P*<0.05 is significant

Table 3: Frailty with gait parameters

Variables	Frail Mean±SD	Not Frail Mean±SD	*P*
Step length (cm)	37.86±8.04	50.37±8.40	<0.001
Stride velocity (cm/s)	58.07±13.02	85.77±18.14	<0.001
Stride width (cm)	14.86±4.71	12.87±2.98	0.011
Stance%	66.95±3.04	63.34±2.05	<0.001
Swing%	33.09±3.09	35.85±2.02	<0.001
Velocity (cm/s)	57.65±13.09	85.17±17.96	<0.001
Cadence	90.10±11.35	101.10±10.96	<0.001
Total D Support%	33.8±6.00	27.19±3.65	<0.001
Stance COP path eff%	91.87±3.69	95.58±1.79	<0.001
Mean GVI	142.46±9.47	132.37±9.02	<0.001
Walk ratio	0.42±0.10	0.49±0.09	<0.001

Independent *t*-test applies, *P*<0.05 is significant

TUG score with gait parameters

TUG scores exhibited a remarkably strong negative correlation with step length (correlation coefficient = -0.80), stride velocity (correlation coefficient = -0.78), and velocity (correlation coefficient = -0.78). This indicates that individuals with higher TUG scores, indicating slower mobility and potentially impaired

Table 4: Urinary incontinence with gait parameters

Variables	Urinary incontinence Mean±SD	No urinary incontinence Mean±SD	*P*
Step length (cm)	46.37±10.98	46.09±10.14	0.940
Stride velocity (cm/s)	80.57±20.15	75.94±21.28	0.530
Stride width (cm)	14.86±4.71	12.87±2.98	0.011
Stance%	64.71±2.47	64.55±3.02	0.870
Swing%	35.31±2.48	35.43±3.00	0.908
Velocity (cm/s)	80.38±20.12	75.36±21.12	0.496
Cadence	102.66±5.07	96.84±12.6	0.174
Total D Support%	28.56±4.51	29.52±5.64	0.621
Stance COP path eff%	93.63±5.38	94.39±2.84	0.487
Mean GVI	131.27±13.17	136.25±9.96	0.168
Walk ratio	0.44±0.10	0.47±0.10	0.475

Independent *t*-test applies, $P<0.05$ is significant

Table 5: Charlson comorbidity index score with gait parameters

Variables	CCI score 1 Mean±SD	CCI score 2 Mean±SD	*P*
Step length (cm)	48.12±11.11	44.99±9.49	0.140
Stride velocity (cm/s)	78.87±23.02	74.94±20.03	0.375
Stride width (cm)	12.65±3.87	14.05±3.63	0.073
Stance%	64.47±3.37	64.62±2.74	0.817
Swing%	35.56±3.38	35.33±2.69	0.702
Velocity (cm/s)	78.13±22.81	74.51±19.95	0.410
Cadence	96.16±12.48	98.03±12.11	0.465
Total D Support%	28.99±6.33	29.69±5.07	0.544
Stance COP path eff%	94.48±2.79	94.23±3.31	0.702
Mean GVI	136.40±11.63	135.47±9.58	0.666
Walk ratio	0.50±0.11	0.45±0.09	0.034

Independent *t*-test applies, $P<0.05$ is significant

functional mobility, tend to have shorter step lengths, and slower stride velocities. Additionally, TUG scores showed significant positive correlations with stance percentage (correlation coefficient = 0.62), total double support percentage (correlation coefficient = 0.67), and mean gait velocity index (GVI) (correlation coefficient = 0.58). Conversely, TUG scores had significant negative correlations with swing percentage (correlation coefficient = -0.61), cadence (correlation coefficient = -0.32), stance COP path efficiency percentage (correlation coefficient = -0.49), and walk ratio (correlation coefficient = -0.59).

GDS score with gait parameters

GDS scores displayed strong negative correlations with step length (correlation coefficient = -0.51), stride velocity (correlation coefficient = -0.54), swing percentage (correlation coefficient = -0.46), velocity (correlation coefficient = -0.54), cadence (correlation coefficient = -0.37), stance COP path efficiency percentage (correlation coefficient = -0.51), and walk ratio (correlation coefficient = -0.29). On the contrary, GDS scores demonstrated positive correlations with stance percentage (correlation coefficient = 0.47), total double support percentage (correlation coefficient = 0.49), and mean gait velocity index (GVI) (correlation coefficient = 0.42).

Mini nutritional assessment score with gait parameters

Positive correlation was found between MNA and step length (correlation coefficient = 0.28, $P = 0.003$), stride velocity (correlation coefficient = 0.30, $P = 0.002$), velocity (correlation coefficient = 0.30, $P = 0.002$), and stance centre of pressure (COP) path efficiency percentage (correlation coefficient = 0.30, $P = 0.002$). Conversely, there is a negative correlation between MNA and total double support percentage (correlation coefficient = -0.23, $P = 0.017$), mean gait velocity index (GVI) (correlation coefficient = -0.18, $P = 0.064$), and walk ratio (correlation coefficient = -0.17, $P = 0.098$).

Discussion

Gait is an important aspect of a person's well-being. It is an important indicator of current health status and also predicts future adverse events. This study aimed at studying the various aspects of gait of the elderly population above 75 years of age and also finding an association between different geriatric syndromes and the gait parameters. In this study, patients were selected from the geriatric medicine outpatient department at a tertiary care hospital; they were then assessed for different geriatric syndromes and underwent gait analysis.

Geriatric syndromes—"multifactorial health conditions that occur when the accumulated effects of impairments in multiple systems render an older person vulnerable to situational challenges". Geriatric syndromes represent common, serious conditions for older persons, holding substantial implications for functioning and quality of life. The most common geriatric syndromes are polypharmacy, frailty, urinary incontinence, sleep disturbance, cognitive issues, syncope, falls, and depression. Here in our study, we wanted to find out the effect of a particular geriatric syndrome on the different parameters of gait analysis and what was the association between them.

The present study has shown that step length, stride velocity, velocity, and cadence were greater in the no polypharmacy group than polypharmacy group, whereas other parameters were more in the polypharmacy group. In a prior research, lower limb functionality in community-dwelling older persons with polypharmacy was tracked over the course of seven years using a composite score derived from timed 3-meter walks, repeated chair stands, and balancing scores.[16] Another study indicated that after three years of follow-up, 74% of older persons who were taking more than ten drugs experienced difficulty doing their ADLs.[17] Last but not least, a study of dementia-afflicted older persons revealed that those who used more than five drugs were more likely to experience functional loss in ADLs throughout a 4-year follow-up period.[18]

The present study has shown that there was a significant relationship between frailty and the gait parameters. It was seen that the step length, stride velocity, swing%, velocity, cadence, stance COP path eff%, and walk ratio were significantly greater in the no frail group, whereas the parameters like stride width, stance%, total D support%, and mean GVI were significantly greater in the frail group. The correlations between high gait variability and frailty are in keeping with other studies that found gait variability to be linked to a number of frailty-related outcomes, including falls, cognitive deterioration, and mobility reduction. For instance, cross-sectional research investigating the relationship between falls and gait variability discovered that persons who had fallen had higher stance time variability, swing time variability, and stride time variability than those who had not fallen.[19] Variability in the gait characteristics of stride time, swing time, stride length, and double support time were all found to be predictive of upcoming falls in prospective investigations.[20]

The present study has shown that the TUG score had a negative correlation with step length, stride velocity, stride width, swing, velocity, cadence, stance COP path eff%, and walk ratio, whereas it had positive correlation with stance%, total D support%, and mean GVI. In 11 chronic stroke patients who exhibited faster gait speeds than our patients (99 cm/s vs. 82 cm/s), Ng SS, and Hui-Chan CW discovered a link between TUG performance and stance time on the unaffected side but not on the paretic side.[21] In ten chronic hemiparetic patients (with gait velocities of 90 cm/s, close to our population), DeBujanda E *et al*. observed that the TUG score was the greatest predictor of the symmetry of single stance during locomotion and the first predictor for lateral pelvic displacements. They came to the conclusion that the TUG was a highly helpful test, indicating single support phase symmetry and the pelvic and shoulder frontal plane kinematics.[22]

It was seen in the present study that MNA score has a significant relation with all the gait parameters except stride width, cadence, mean GVI, and the walk ratio. It is seen that it has a positive correlation with step length, stride velocity, swing%, velocity, cadence, stance COP path eff%, and walk ratio, whereas negative correlation with the rest. Drescher T *et al*.[23] shown that the NRS 2002 was superior in predicting nutritional hazards in a study of 104 senior patients referred to their care with acute issues. However, a study of 121 patients by Bauer JM *et al*.[24] shown that the MNA was more effective in identifying malnutrition. The MNA's relationship with important prognostic variables also made it the best option for geriatric hospital patients, claim these investigators.

Conclusion

This study emphasises how useful gait analysis might be in identifying and treating geriatric diseases early on. Understanding these links is more important as the world's population ages if we want to improve older people's quality of life and lower their likelihood of experiencing negative occurrences. The study essentially emphasises the significance of comprehensive geriatric care, taking gait into account alongside geriatric disorders. It establishes the groundwork for specialised interventions, early identification, and preventative measures to handle the complex healthcare requirements of this growing generation, ultimately resulting in better and more satisfying ageing experiences.

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Conflicts of interest

There are no conflicts of interest.

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