INVESTIGATION OF BIOMECHANICAL PARAMETERS AND THEIR ASSOCIATION WITH AGE IN THE CASE OF ELDERLY WOMEN

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Gait and balance disorders are common in older adults and they are independent predictors for the functional decline resulting in various degrees of disability and loss of independence. Gait disorders have multiple causes, they have a progressive course and may negatively impact the functional performances. Many gait disorders appear in connection with underlying diseases. The incidence of gait deficiencies is greater in older women. Non-neurological causes are more often identified. Painful joint deformities are common causes of gait disturbances in elderly. The study proposes to identify the influence of age on the walking speed and the support phase during walking. The study included 100 female volunteers, aged between 55 and 87. The subjects participated in the measurement of biomechanical parameters using AMTI's AccuGait System, while speed was determined using a speed measurement system placed above the ground reaction force measuring platform. It was found that there are statistically significant differences among the three age groups in terms of walking speed and support phase.

Keywords: elderly, gait disorders, travel speed, stance time

INTRODUCTION

Walking and the postural balance are fundamental physiologic processes which enable the individual to properly respond to challenges and to integrate in the environment. Both are motor functions of great complexity relying on the anatomic and functional integrity of the musculoskeletal system as the peripheral organs of locomotion, the somatosensory pathways and of the motor cortex and the brain stem control as well.

Gait and balance disorders are common in older adults and they are independent predictors for the functional decline resulting in various degrees of disability and loss of independence. They often involve multiple contributing factors and a comprehensive assessment is essential to determine the targeted intervention. The functional limitations increase with age and the physiologic senescence processes are complicated by underlying medical condition not always attributable to aging itself. Gait disorders have multiple causes, they have a progressive course and may negatively impact the functional performances. Appropriate preventive and rehabilitation interventions are needed in order to avoid loss of independence and limited quality of life (Alexander and Goldberg, 2005).

Early identification of the most appropriate interventions relies on the diagnostic approach of the walking impairments emphasizing on the level of the deficit and the underlying medical condition. The clinical classifications categorize the deficits

according to various criteria (Jahn *et al.*, 2010; Nutt *et al.*, 1993; Nutt, 2001; Thompson, 2007). Clinically oriented classifications are preferred in the current practice.

The classification proposed by Nutt and Marsden (1993), for example, is a three-level classification of the gait and postural balance disorders according to the level of the deficit (Nutt *et al.*, 1993).

1. Higher-level disturbances
   - deficit of the cortical control of gait
   - anxiety-related gait disorders
   - psychogenic gait disorders
2. Intermediate-level disturbances
   - efferent and afferent sensorimotor pathways of the CNS (paresis after stroke, Parkinson's disease - extrapyramidal manifestations, cerebellar dysfunction - incoordination)
3. Lower-level disturbances
   - arthritis
   - myopathy
   - polyneuropathy

The classification above provides valuable information on the level of the deficit. Nevertheless, clinicians often prefer categorizing the impairments strictly based on the clinical observation (Snijders *et al.*, 2007). Clinical evaluation is a sufficient as an initial approach and offer a precise guideline for the next step of the diagnostic approach, in most cases.

Walking deficiencies and balance impairment are frequent in older adults as a consequence of aging itself or as a result of age-related diseases.

Population-based studies review show that gait and balance disorders occur in 14% of individuals aged over 65, about 20% of people aged 80 report difficulties in locomotion and postural balance and the corresponding figure is about 50% beyond 85 years old (Martin and O'Neill, 2004; Sanders *et al.*, 2010).

It was found in one study performed in a family medicine setting that gait and balance disorders had multiple causes in 75% of the older adults. In most of the older patients examined in family settings, the self-reporting walking difficulties appeared in connection with underlying diseases (Hough, cited by Salzman, 2010): painful joints (deformities, arthritis) 37%, orthostatic hypotension 9%, stroke 10%, visual impairment 1%, back pain 5%.

RESEARCH METHODOLOGY

The study used quantitative methodology, and an exploratory and descriptive approach. The research methods which best fit the objective of the study were the biomechanical gait measurement for ground reaction force, the questionnaire-based survey, and observation (Vasilescu *et al.*, 2015; Mihai *et al.*, 2016; Gherman *et al.*, 2016).

The data was collected in Bucharest over a period of three weeks. The ground reaction force was measured using AMTI´s AccuGait System (www.amti.biz). The respondents were also applied a short questionnaire consisting of questions referring to anthropometric and demographic data, mainly enquiring about the respondents' age, height, weight and medical conditions.

The main statistic indicators characterizing the sample are presented in Table 1.

Table 1. Statistic indicators for the main demographic and anthropometric parameters

		Height *(cm)*	Weight *(kg)*	Age *(years)*
N	Valid	100	100	100
	Missing	0	0	0
Mean		161.75	72.96	67.05
Median		163.00	71.00	64.00
Mode		165	80	59
Std. Deviation		6.663	11.414	8.916
Minimum		148	50	55
Maximum		184	112	87

Source: SPSS software

The age of the participants varied between 55 and 87 (Fig. 1), with the eldest female subjects (over 71 years) making up most of the sample (34%), followed by the subjects in the 60-64 (27%) and 55-59 (26%) age groups, respectively). The average height of the subjects of the studied sample was 161.75 cm, the average weight was 73 kg and the average age was 67 years (Deselnicu *et al.*, 2016).

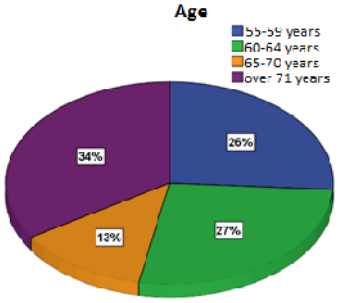

Figure 1. Sample structure by age (Source: SPSS software)

Data Analysis and Results Interpretation

Health Conditions Analysis

Important information correlated with the biomechanical parameters was provided by the answers to the health condition questionnaire. The elderly women participating in the study declared the illnesses that they suffer from.

Age is a very important parameter for the investigated sample. The participants have been divided into three age groups, to further investigate significant differences between the three groups in terms of important parameters. Figure 2 illustrates the differences regarding the declared health conditions across age groups:

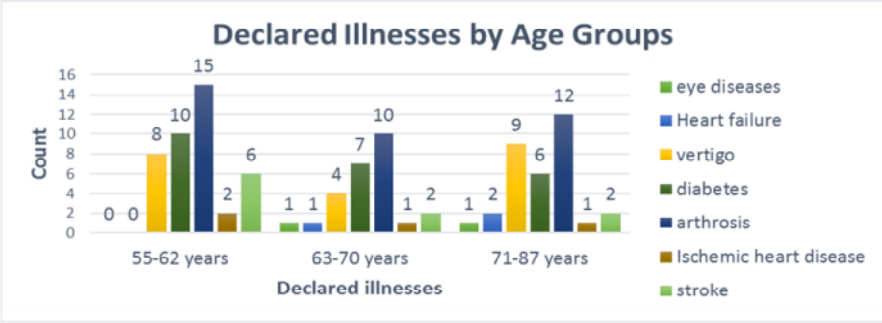

Figure 2. Distribution of declared illnesses by age groups

Data analysis shows that walking and balance disorders have multiple causes: arthrosis, diabetes, vertigo, eye diseases, heart failure, ischemic heart diseases, and stroke. In all three age groups, the most common diseases are: arthrosis, diabetes, and vertigo.

The distribution of the main biomechanical parameters that were investigated with the force platform are presented in Table 2.

Table 2. Biomechanical parameters statistic indicators

		Travel speed (m/s)	Stance time (s)
N	Valid	100	100
	Missing	0	0
Mean		.7004	.89870
Median		.7300	.82250
Mode		.49	.740
Std. Deviation		.18170	.277616

Source: SPSS software

The average support phase period when the foot is in contact with the ground is 0.89870 seconds, and the average walking speed is 0.73 m/s.

Furthermore, the authors investigated if the variance of the main biomechanical parameters which were tested was statistically significant across the three age groups. Two working hypotheses were formulated as follows:

H_1: There are statistically significant differences between the three age groups in terms of the travel speed.

H_0: There are no statistically significant differences between the three age groups in terms of the travel speed.

The analysis was performed using the SPSS software. The results are presented in Table 3.

Table 3. One-Way ANOVA test results for the variance of travel speed across age groups

		Sum of squares	df	Mean Square	F	Sig.
Travel speed	Between Groups	1.697	2	.848	52.362	.000
	Within Groups	1.572	97	.016		
	Total	3.269	99			

Source: SPSS software

The significance level for hypothesis H_1 is 0.000 (p=0.000), which is smaller than the significance level of 0.05 established for this analysis. Hypothesis H_1 was therefore accepted, confirming that there are statistically significant differences between the three age groups in terms of the travel speed. Consequently, the null hypothesis was rejected.

The second working hypothesis tested the variance of the support phase of elderly women across age groups:

H_2: There are statistically significant differences between the three age groups in terms of the support phase.

H_0: There are no statistically significant differences between the three age groups in terms of the support phase.

Table 4. One-Way ANOVA test results for the variance of the support phase across age groups

		Sum of Squares	df	Mean Square	F	Sig.
Support phase	Between Groups	.477	2	.239	3.237	.044
	Within Groups	7.153	97	.074		
	Total	7.630	99			

Source: SPSS software

The significance level of 0.044 (p=0.044) for hypothesis H_2 was calculated, which is smaller than the significance level of 0.05. Hypothesis H_2 was therefore accepted, confirming that there are statistically significant differences between the three age groups of elderly women in the investigated sample in terms of the support phase.

Age is, therefore, an important factor that influences important biomechanical parameters such as the travel speed and support phase in the case of elderly women.

CONCLUSIONS

Data analysis shows that age is an important factor influencing significant biomechanical parameters, such as the support phase and walking speed in the case of elderly women.

Acknowledgements

This work was supported by UEFISCDI Bucharest under the Partnership Programme project “Preventing gait deficiencies and improving biomechanical parameters for the elderly population by designing and developing customized footwear”, acronym MOBILITY, code PN-II-PT-PCCA 2013-4, Contract no. 122/2014.

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