Variance of foot biomechanical parameters across age groups for the elderly people in Romania

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Abstract. The paper presents the results of a fieldwork study conducted in order to analyze major causal factors that influence the foot deformities and pathologies of elderly women in Romania. The study has an exploratory and descriptive nature and uses quantitative methodology. The sample consisted of 100 elderly women from Romania, ranging from 55 to over 75 years of age. The collected data was analyzed on multiple dimensions using a statistic analysis software program. The analysis of variance demonstrated significant differences across age groups in terms of several biomechanical parameters such as travel speed, toe off phase and support phase in the case of elderly women.

1. Introduction

From a mechanical point of view, the human locomotor apparatus represents a complex system of levers acted upon by a force field. The biomechanics studies reveal the nature of these forces, their actions, as well as the loads acting upon the foot and, through it, on the footwear components [5]. These studies are used for offering information for the rational footwear manufacturing [6], in particular, the shape of the insole, sole or heel. Since footwear represents a necessity nowadays [7], the constructive parameters of the pattern of the footwear product are very important [8].

Due to their unique characteristics, elderly people require customized products. Especially, they have special needs in terms of footwear; very often they cannot use the mass products available on the market. Despite their specific needs, old people are currently constrained to accept the mass footwear that they are offered. Because of their foot deformities, their biomechanical characteristics are different than the rest of the population [1] and constitute important indicators for a better understanding and analysis of their particular footwear necessities [2, 3]. The elderly people, with a lot of illnesses caused by age, are mainly disposed to osteopathy [4]. In the World Health Organization list of preventive activities, the major place is taken by the relevant orthopedic means, among them choosing and processing the correcting means for the normalization of the deformations of footwear and foot pathologies.

2. Research methodology

The study used the 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.
2.1. Data collection
The data was collected in Bucharest, Romania over a period of 3 weeks. The ground reaction force was measured using AMTI’s AccuGait System [9], with NetForce and NetForce/ BioAnalysis components. The respondents also answered to a short questionnaire consisting of questions referring to anthropometric and demographic data, enquiring about their age, height, weight and medical conditions.

2.2. Research sample
The sample was composed of 100 elderly women. 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                | 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 to 87 years, with the eldest female subjects (over 71 years) making the most of the sample (34%), followed by the subjects of the 60 – 64 years (27%) and 55 – 59 years (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.

3. Data analysis and interpretation of research results
Statistical processing of collected data used the statistical software SPSS for Windows, version 19.0, and descriptive and inferential statistical analysis was conducted in the following stages: the statistic summary of relevant information and the analysis of variance.

3.1. 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 (Figure 1):

Figure 1. Declared illnesses for the whole sample.
It can be observed that the most frequent disease is arthrosis, affecting 37% of the investigated sample, followed by diabetes (23%) and vertigo (21%). To a lower extent, the elderly women declared they suffer from stroke (10%), ischemic heart disease (4%), heart failure (3%) and eye diseases (2%).

In order to further investigate the significant variance of the investigated variables, the participants have been divided into three age groups, as age is a very important parameter. Table 2 illustrates the differences regarding the declared health conditions across age groups:

Table 2. Declared illnesses distribution across age groups.

| Age          | Declared illnesses | Frequency | Percent | Valid Percent | Cumulative Percent |
|--------------|--------------------|-----------|---------|---------------|-------------------|
| 55-62 years  | Valid              | Vertigo   | 8       | 19,5          | 19,5              |
|              |                    | Diabetes  | 10      | 24,4          | 43,9              |
|              |                    | Arthrosis | 15      | 36,6          | 80,5              |
|              |                    | Ischemic heart disease | 2   | 4,9      | 85,4              |
|              |                    | Stroke    | 6       | 14,6          | 100,0             |
|              | **Total**          |           | **41**  | **100,0**     | **100,0**         |

| 63-70 years  | Valid              | Eye diseases | 1     | 3,8      | 3,8               |
|              |                    | Heart failure | 1     | 3,8      | 7,7               |
|              |                    | Vertigo      | 4     | 15,4     | 23,1              |
|              |                    | Diabetes     | 7     | 26,9     | 50,0              |
|              |                    | Arthrosis    | 10    | 38,5     | 88,5              |
|              |                    | Ischemic heart disease | 1   | 3,8      | 92,3              |
|              |                    | Stroke       | 2     | 7,7      | 100,0             |
|              | **Total**          |           | **26**  | **100,0** | **100,0**         |

| 71-87 years  | Valid              | Eye diseases | 1     | 3,0      | 3,0               |
|              |                    | Heart failure | 2     | 6,1      | 9,1               |
|              |                    | Vertigo      | 9     | 27,3     | 36,4              |
|              |                    | Diabetes     | 6     | 18,2     | 54,5              |
|              |                    | Arthrosis    | 12    | 36,4     | 90,9              |
|              |                    | Ischemic heart disease | 1   | 3,0      | 93,9              |
|              |                    | Stroke       | 2     | 6,1      | 100,0             |
|              | **Total**          |           | **33**  | **100,0** | **100,0**         |

Source: SPSS software

The distribution of declared illnesses across age groups surprisingly shows an increase of the occurrence of diseases in the first age group (55-62 years), followed by the most elderly age group (71-87 years), with the women in the middle age group (63-70 years) reporting the fewest illnesses.

It can be concluded that the age of 55-62 years is a critical age in terms of the health conditions of elderly women, followed by a period of relative stationary health condition for the next 7 years, while the old age (71-87 years) brings the worsening of the health situation.
3.2. Biomechanical Parameters Analysis

Biomechanical parameters are indirect indicators of pathologies and foot deformities. The distribution of the main biomechanical parameters that were investigated using the force platform are presented (Table 3):

| Travel speed | Heel strike | Toe off phase | Support phase |
|--------------|-------------|---------------|---------------|
| N            | 100         | 100           | 100           | 100           |
| Mean         | 0.7004      | 0.99440       | 0.993100      | 0.89870       |
| Median       | 0.7300      | 0.99500       | 0.917500      | 0.82250       |
| Mode         | 0.49        | 0.095         | 0.8300        | 0.740         |
| Std. Deviation | 0.18170 | 0.004938      | 0.2773675     | 0.277616      |

Source: SPSS software

It can be observed that given the low standard deviation, the sample is relatively homogeneous in terms of the investigated biomechanical parameters.

3.3. The Analysis of Variance

In order to analyze the variance of the declared illnesses of elderly women across age groups, the following research hypothesis was formulated:

$H_1$: There are statistically significant differences between the three age groups in terms of declared illnesses.

$H_0$: There are no differences between the three age groups in terms of declared illnesses.

The most appropriate testing method was considered the One-Way ANOVA. It was performed using the SPSS software. The results of the analysis are presented in Table 4:

| Sum of Squares | df  | Mean Square | F     | Sig.  |
|----------------|-----|-------------|-------|-------|
| Between Groups | 6,472 | 2           | 3,236 | 1,848 | .163 |
| Within Groups  | 169,888 | 97          | 1,751 |       |      |
| Total          | 176,360 | 99          |       |       |      |

Source: SPSS software

As observed, the significance level is 0.163 ($p = 0.163$), which is greater than the confidence level of 0.05 established for this analysis. Consequently, the alternative hypothesis $H_1$ has to be rejected, therefore the null hypothesis has to be accepted: there are no statistically significant differences between the three age groups of elderly women in the investigated sample in terms of the declared illnesses.

Furthermore, the authors investigated if the variance of the main biomechanical parameters which were tested was statistically significant across the three age groups. Four more working hypotheses were formulated as follows ($H_2 - H_5$):

$H_2$: There are statistically significant differences between the three age groups in terms of the travel speed.

$H_3$: There are statistically significant differences between the three age groups in terms of the heel strike.

$H_4$: There are statistically significant differences between the three age groups in terms of the toe-off phase.
H₃: There are statistically significant differences between the three age groups in terms of the support phase.

The null hypotheses stated that there are no differences between the three age groups in terms of these biomechanical parameters. The same statistical test was applied, and the results can be consulted in Table 5:

**Table 5.** One-Way ANOVA test results for the variance of biomechanical parameters across age groups.

| Parameter     | 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 |             |       |       |
| Heel strike   |                |    |             |       |       |
| Between Groups| .000           | 2  | .000        | .769  | .466  |
| Within Groups | .002           | 97 | .000        |       |       |
| Total         | .002           | 99 |             |       |       |
| Toe off phase |                |    |             |       |       |
| Between Groups| .477           | 2  | .238        | 3.237 | .044  |
| Within Groups | 7,140          | 97 | .074        |       |       |
| Total         | 7,616          | 99 |             |       |       |
| 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 for Hypothesis H₂ is 0.000 (p= 0.000), which is smaller than the significance level of 0.05 established for this analysis. Hypothesis H₂ 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.

As the significance level is 0.466 (p= 0.466) which is greater than the significance level of 0.05 established for this analysis, hypothesis H₃ was rejected. Therefore, the null hypothesis was accepted, stating that there are no statistically significant differences between the three age groups of elderly women in the investigated sample in terms of heel strike.

The significance level for Hypothesis H₄ is 0.044 (p= 0.044) smaller than the significance level of 0.05 established for the analysis. This recommends that the working hypothesis H₄ should be accepted, confirming that there are statistically significant differences between the three age groups of elderly women in the investigated sample in terms of the toe-off phase.

The same significance level of 0.044 (p= 0.044) for Hypothesis H₅ was calculated, which is smaller than the significance level of 0.05. Hypothesis H₅ 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, toe off phase and support phase in the case of elderly women.

4. Conclusions

In this research, the authors conducted a study in order to investigate major causal factors influencing foot pathologies and deformities of the elderly women. As observed, the most frequent disease among
the investigated participants is arthrosis, affecting 37% of the female respondents, followed by diabetes (23%) and vertigo (21%). To a lower extent, the elderly women declared they suffer from stroke (10%), ischemic heart disease (4%), heart failure (3%) and eye diseases (2%). Another important finding is that the range of 55-62 years is a critical age in terms of the health conditions of elderly women, followed by a period of relative stationary health condition for the next 7 years, while the old age (71-87 years) brings the worsening of the health situation.

Hypothesis H₁ was rejected, showing that there are no statistically significant differences between the three age groups of elderly women in the investigated sample in terms of the declared illnesses. Hypothesis H₂ was also accepted, confirming that there are statistically significant differences between the three age groups in terms of the travel speed, which decreases with age. Hypothesis H₃ was rejected, showing that there are no statistically significant differences between the three age groups of elderly women in the investigated sample in terms of heel strike. The working hypothesis H₄ was accepted, confirming that there are statistically significant differences between the three age groups of elderly women in the investigated sample in terms of the toe-off phase. Hypothesis H₅ was also 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 proved to be an important causal factor that influences important biomechanical parameters such as the travel speed, toe off phase and support phase in the case of elderly women. Given the large enough size of the sample investigated, the generalization of the research results is supported with an acceptable margin of error for the elderly women in Romania.

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