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ORIGINAL RESEARCH

# Predictive factors for risk of falls and fear of falling in adult and older women with dizziness

*Fatores preditores para risco de quedas e preocupação em cair em mulheres adultas e idosas com tontura*

*Factores predictivos de riesgo de caídas y preocupación por caer en mujeres adultas y mayores con mareo*

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**ABSTRACT |** This study aimed to investigate the predictive factors for the risk of falls and fear of falling in adult and older women with dizziness by a cross-sectional design. Its sample included women aged at least 50 years who had complaints of recurrent dizziness in the previous three months. Their cognitive skills, fear of falling, dizziness level, quality of life, and plantar pressure were assessed. Descriptive and inferential analysis of the data were performed on SPSS®, version 23.0. Clinical test scores were subjected to the Kolmogorov-Smirnov test for normality and independently compared between sample subgroups. Linear regression was used to determine the association between the variables that showed correlations between each other. Of the 59 evaluated women, their mean age totaled 69.05 years. The tests indicated mild cognitive impairment (MMSE 24.12), moderate dizziness (VAS 5.05), and high fear of falling (FES-I 30.22). This study found significant correlations between higher plantar pressure and incidence of falls, and the influence of dizziness on quality of life predicted fear of falling in 43% of participants. This research observed greater fear of falling as its sample showed greater evidence of loss of cognitive skills and higher dizziness levels. Fear of falling was associated with the influence of dizziness on quality of life. Our findings suggest that the greater distribution of weight discharge in volunteers' left and right forefeet with their open eyes showed an association with higher rates of falls.

Keywords | Quality of Life; Labyrinth Diseases; Balance.

**RESUMO |** Este estudo teve como objetivo investigar os fatores preditores para o risco de quedas e preocupação em cair de mulheres adultas e idosas com tonturas. O delineamento do estudo foi do tipo transversal. A amostra foi composta por mulheres com idade mínima de 50 anos e com queixa de tontura recorrente nos últimos três meses. Foram submetidas à avaliação da capacidade cognitiva, preocupação em sofrer quedas, nível de tontura, qualidade de vida e análise das pressões plantares. A análise descritiva e inferencial dos dados foi realizada por meio do SPSS® versão 23.0. Os escores dos testes clínicos foram submetidos ao teste de Kolmogorov-Smirnov para normalidade e comparados de forma independente entre subgrupos amostrais. A regressão linear foi empregada para conferir associação entre as variáveis que obtiveram correlação. Das 59 mulheres avaliadas, a média de idade média foi de 69,05 anos.

This study belongs to a dissertation in Health Product-Applied Sciences at Universidade de Goiás (UEG), titled Multifactoriness of body balance in women with vestibular dysfunctions of peripheral origin, by Toledo RC, presented in 2020.

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Os testes indicaram leve perda cognitiva (MEEM 24,12), tontura moderada (EVA 5,05) e alta preocupação com quedas (FES-I 30,22). Houve correlações significativas entre maior pressão plantar e incidência de quedas, e a influência da tontura na qualidade de vida previu em 43% a preocupação em cair. Observou-se que a preocupação em cair foi maior à medida que a amostra apresentava maiores indícios de perda da capacidade cognitiva, maiores níveis de tontura. A preocupação em cair apresentou associação com a influência da tontura sobre a qualidade de vida. Além disso, nossos achados sugerem que a maior distribuição da descarga de peso na região do antepé, tanto esquerdo como direito com olhos abertos, apresentaram associação com maiores índices de quedas.

Descritores | Qualidade de vida; Doenças do Labirinto; Equilíbrio.

**RESUMEN |** Este estudio tuvo el objetivo de investigar los factores predictivos de riesgo de caídas y la preocupación por caer en mujeres adultas y mayores con mareos. El diseño del estudio fue del tipo transversal. La muestra estuvo compuesta por mujeres con edad mínima de 50 años y que se quejaban de mareo recurrente en los últimos tres meses. Se sometieron a una evaluación de capacidad cognitiva, preocupación por caer, nivel de mareo, calidad de vida y análisis de las presiones plantares. Se realizó el análisis descriptivo e inferencial de los datos a través del SPSS® versión 23.0. Las puntuaciones de las pruebas clínicas se sometieron a la prueba de Kolmogorov-Smirnov para normalidad y se compararon de forma independiente entre subgrupos muestrales. Se utilizó la regresión lineal para comprobar la asociación entre las variables que estaban correlacionadas. De las 59 mujeres evaluadas, la media de edad fue de 69,05 años. Las pruebas indicaron una pérdida cognitiva leve (MEEM 24,12), mareo moderado (EVA 5,05) y alta preocupación por caer (FES-I 30,22). Hubo correlaciones significativas entre mayor presión plantar e incidencia de caídas, y la influencia de los mareos en la calidad de vida predijo la preocupación por caer en un 43%. Se observó que la preocupación por caer era mayor a medida que la muestra presentaba mayores indicios de pérdida de capacidad cognitiva y mayores niveles de mareo. La preocupación por caer se asoció con la influencia de los mareos en la calidad de vida. Además, nuestros hallazgos sugieren que la mayor distribución de la descarga de peso en la región del antepié, tanto izquierdo como derecho con los ojos abiertos, se asociaron con índices de caídas más altos.

Palabras clave | Calidad de vida; Enfermedades del Laberinto; Equilibrio.

## INTRODUCTION

Dizziness affects from 5 to 10% of the global population, ranking as the seventh most common disease in women and the fourth in men. Its increasing prevalence in women may be related to their hormonal factors, migraines, and the increased demand for health care[1,2]. Dizziness significantly increases as people age, reaching its peak from ages 65-75 years, becoming the most common symptom in older adults after age 65 years. In particular, 45% of older adults reported dizziness, which often manifests itself as rotational dizziness. However, despite its high prevalence and impact, only 46% of people who experience dizziness seek medical care[3].

According to Herdman et al.[4], dizziness may constitute a trigger factor for falls and risk of subsequent falls, since vestibular dysfunctions limit the postural control of these individuals, increasing instability and body misalignment.

Falls can negatively impact the quality of life of older adults, affecting their memory, causing them physical and mental stress, triggering cognitive difficulties, and influencing emotional aspects, such as insecurity, anxiety, panic, and depression, thus damaging social relationships. As a consequence of falls, these individuals become susceptible to serious injuries or tend to limit their activities due to physical injuries or fear of falling. Such dread, combined with previous falls, makes older adults less confident, leaving them with less autonomy and afraid to carry out certain activities[5]. Falling can severally impair the quality of life of older individuals (alterations that can be mild, moderate, or severe), disrupt their balance, damage their memory, and create physical and mental stress and cognitive difficulties. Moreover, this set of changes can trigger insecurity, anxiety, panic, and depression, affecting the quality of their social relationships and quality of life[6].

The changes due to aging make older adults less sensitive to vibration, tactile pressure, pain, and skin temperature. Considering these factors, Mold et al.[7] and Speers et al.[8] state that the older population may show altered distribution of plantar pressure, which favors the emergence of calluses and painful areas, affects their postural control, and predisposes them to falls. Thus, the distribution of plantar pressure has been

studied to compare weight discharge in the orthostatic position and during gait. Electronic pressure pedometry offers a resource that can analyze plantar pressure, an objective and quantitative test of plantar pressure distribution on a platform the sensors of which can capture, compare, and measure pressure in several areas of the plantar surface, evincing the effectiveness of conservative or surgical interventions for conditions of the feet[9]. The way older adult distribute weight on their feet affects their ability to safely walk and move. Any change in plantar pressure distribution can lead to an abnormal gait, hindering locomotion and increasing the risk of falls. Irregular or unbalanced plantar pressures can be considered a risk factor for falls in older individuals. Thus, any change in the distribution of plantar pressure can impair the stability and balance of the body[7-9].

Understanding the factors related to falls has great relevance for clinical practice since fear of falling is associated with adverse health outcomes in the general population, especially in its older section. Mostly, falls cause injuries and/or fractures, which greatly impact the health and quality of life of this population. A cross-sectional study with the older adults (n=6,616) found a 27.6% prevalence of falls, 11% of which resulted in fractures. Among those who fell, 53.5% did so once; 21.2%, twice; 13.3%, thrice falls; and 12%, four or more times. Older adults who experience falls often restrict their daily and social activities to prevent subsequent ones. Thus, avoiding falls requires understanding risk factors and their consequences and actions toward prevention[10,11].

Healthcare providers must be aware of all signs patients show, such as a simple complaint of dizziness, which may help them observe, investigate, and analyze possible factors and clinical and social characteristics that directly or indirectly act on patients' overall quality of life[12]. The high incidence of dizziness in women and older adults is worrying because of its challenges. Dizziness commonly occurs in older adults, especially women, negatively affecting quality of life due to the risk of falls and injuries. Furthermore, dizziness substantially impact populations' quality of life since it is associated with falls that can result in injuries, mobility limitations, and increased fear of falling, which results in significant health costs. Thus, identifying risk factors for fear of falling is crucial to implement targeted preventive interventions and improve quality of life by reducing health costs.

Thus, this study aimed to investigate the predictive factors for risk of falls and fear of falling in adult and older women with dizziness.

## METHODOLOGY

### Study design

This cross-sectional study was conducted at the Musculoskeletal Research Laboratory at Universidade de Goiás (UEG). Non-probabilistic convenience sampling was used as the sample selection criterion so participants were selected according to their attendance and availability at the sample recruitment site and during data collection process. Inclusion criteria included women aged at least 50 years who complained of dizziness, could follow simple verbal commands, and answer the collection instruments. Participants with neurological diseases, lower limb dysfunction, walking aid devices, uncorrected visual dysfunction, and severe cognitive deficit according to the mini mental state examination (MMSE) were excluded.

The MMSE is composed of two parts: one that encompasses orientation, memory, and attention (with a maximum score of 21 points) and another that addresses specific skills such as naming and understanding (with a maximum score of nine points). This totals a maximum score of 30 points[13,14]. Regarding the impact of schooling, recent studies have shown that the standard cutoff score varies according to education level: below 13 points for illiterates; up to 18 points for individuals with one to 11 years of study, and up to 26 points for those with more than 11 years of education. Cognitive loss is considered mild for scores from 21 to 24 points; moderate, from 10 to 20; and severe, when equal to nine or below it[15].

Volunteers consented to participate in the study by signing an informed consent form.

Participants were recruited from six social care sites in the municipality of Goiânia (GO), namely: Associação de Moradores do Bairro Feliz, Centro de Excelência do Esporte, Associação de Idosos do Brasil, Obras Sociais do Centro Espírita Irmão Áureo, Comunidade Seio de Abraão, and Centro de Convivência da Igreja Santo Expedito e Sagrados Estigmas. The were applied in a single moment at the recruitment institutions in a room aimed at the assessment from March to August 2019. In total, 81 women were assessed.

### Assessment instruments

Additionally, participants' weight, height, and body mass index (BMI) were recorded. Because it is a broad concept, it was initially explained to participants that the term "dizziness" referred to the sensation of disturbed balance, instability, imbalance, or vertigo, often followed by a perception that the surrounding environment is in rotational motion. The clinical assessment protocol included four individually applied instruments. The assessment instruments were individually applied in a single session in a space set for it in the institutions from which the sample was recruited.

Baropodometry was used to analyze the distribution of plantar pressure points exerted by the body on a static force platform. For this, an AM3 strength platform was used, guided by the Footwork PRO software. The platform is sensitive to plantar pressure, including piezoelectric sensors and having a 490×490-mm active surface, 565×420×25-mm dimensions, and a 150-Hz frequency. The main variables used in the baropodometric assessment were the pressure distribution at different points in the plantar region, such as: peak plantar pressure (maximum pressure in specific plantar areas, that is, selected anatomical regions), mean plantar pressure (mean pressure value representing specific plantar areas, that is, selected anatomical regions), foot contact area, and plantar load. The sample was subjected to baropodometric analysis in bipodal posture for 30 seconds in two different conditions: eyes open and eyes closed. Overall, three attempts were performed for each test condition.

The dizziness level was measured by a visual analog scale (VAS) ranging from zero to 10 in which participants were instructed to assign a score to dizziness, in which zero would indicate the lowest dizziness level and 10, the highest, enabling patients to quantify the intensity and sensation of their symptoms manifested as dizziness and imbalance[16]. VAS has its proven usefulness to assess pain and has been used as a consistent resource to evaluate dizziness.

Fear of falling was measured using the falls efficacy scale international (FES-I). This scale was developed by members of the Prevention of Falls Network Europe[17], consisting of questions that address the fear of falling during daily tasks, such as cleaning the house, preparing food, picking up an object on the floor and above the head, going up and down stairs and/or ramps, among others. FES-I has questions about fear with the possibility of falling when performing 16 activities, with respective scores from one to four. The total score can range from 16 (absence of fear) to 64 (extreme fear) and the higher the score, the greater individuals' fear of falling[17].

The self-perception of the effects imposed by dizziness symptoms and the influence of these factors on the quality of life of individuals was assessed by the dizziness handicap inventory (DHI), composed of 37 items, of which 16 are related to emotional aspects; 10, to physical aspects; and 11, to dizziness and instability. Answers range from "yes," "sometimes," and "no," with respective scores of four, two, and no points[18,19]. The score ranges from zero to 100, and the higher the handicap, the greater the impairment due to dizziness to quality of life. Scores from zero to 25 are graded as absence of handicap; from 26 to 50, as mild handicap; from 51 to 75, as moderate handicap; and from 76 to 100, as severe handicap[19].

### Data analysis

The descriptive and inferential analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS®, version 23.0). Clinical test scores were subjected to the Kolmogorov-Smirnov test for normality. The data following a normal distribution were submitted to Pearson's correlation coefficient (r) to verify the relationship between the applied tests and mean plantar pressures. Positive values indicate directly proportional correlations, whereas negative values, inversely proportional ones. Those who followed an abnormal distribution were subjected to a logarithmic transformation before the regression test. Values from 0.10-0.29 indicate a weak correlation; from 0.30-0.49, a moderate correlation; and from 0.51-1, a strong correlation. Linear regression was used to determine the association between the variables that obtained correlations. For internal consistency analysis, Cronbach's alpha was used, which showed a high reliability (0.93). The significance level adopted for all tests was 5% ($p \leq 0.05$).

## RESULTS

Of the 81 assessed women, only 59 met the established criteria. Participants' mean age totaled 69.05 years (±13.77), of which 84.7% were older than 60 years.

Table 1 describes mean age, anthropometric characteristics, and test score values. Participants' mean BMI totaled 26.21 kg/m² (±4.19), indicating overweight in the studied sample. Of the applied tests, MMSE showed a mean score of 24.12 (±3.82), corresponding to a mild loss of cognitive skills. VAS had a 5.05 mean score (±2.75), indicating moderate dizziness. Regarding history of falls, 40.7% of the women had suffered at least one fall in the previous year. FES-I had a 30.22 mean score (±10.27), whereas DHI, a 33.46 one (±26.01).

Table 1. Description of anthropometric data and test scores – Goiânia (GO), 2023

| Characteristics | Mean (±SD) | Minimum | Maximum |
|---|---|---|---|
| Age (years) | 69.05 (±13.77) | 50 | 93 |
| Weight (kg) | 66.06 (±13.62) | 41.50 | 99 |
| Height (cm) | 1.59 (±0.81) | 1.45 | 1.77 |
| BMI (kg/m²) | 26.21 (±4.19) | 17 | 35.90 |
| MMSE | 24.12 (±3.82) | 11 | 30 |
| FES-I | 30.22 (±10.27) | 15 | 60 |
| DHI | 33.46 (±26.01) | 0 | 100 |
| VAS | 5.05 (±2.75) | 1 | 10 |

BMI: body mass index; MMSE: mini mental state examination; FES-I: falls efficacy scale international; DHI: dizziness handicap inventory; VAS: visual analog scale for dizziness; SD: standard deviation

Table 2 describes mean plantar pressures. Results significantly varied between open and closed eye conditions and between left and right feet. With eyes open, mean maximum pressure totaled 19.51 (±6.10) for left feet and 23.53 (±6.62) for right feet. Concerning mean pressure, this study found an average of 27.32 (±7.05) for left feet and 29.55 (±7.54) for right feet. With closed eyes, mean forefoot pressure totaled 19.86 (±5.69) for left feet and 24.86 (±6.98) for right feet, whereas mean rearfoot pressure totaled 25.67 (±6.48) for left feet and 29.20 (±8.10) for right feet.

Table 2. Description of mean plantar pressure under the two test conditions (eyes open and eyes closed) – Goiânia (GO), 2023

| Test condition | | Plantar pressures | Mean (SD) | Minimum | Maximum |
|---|---|---|---|---|---|
| Eyes open | Left foot | MFP | 19.51 (±6.10) | 1.00 | 33.79 |
| | | MRP | 27.32 (±7.05) | 13.52 | 40.50 |
| | Right foot | MFP | 23.53 (±6.62) | 12.71 | 45.56 |
| | | MRP | 29.55 (±7.54) | 3.42 | 45.86 |
| Eyes closed | Left foot | MFP | 19.86 (±5.69) | 5.73 | 34.24 |
| | | MRP | 25.67 (±6.48) | 12.01 | 43.79 |
| | Right foot | MFP | 24.86 (±6.98) | 12.32 | 47.48 |
| | | MRP | 29.20 (±8.10) | 3.99 | 47.36 |

MFP: mean forefoot pressure; MRP: mean rearfoot pressure; SD: standard deviation

According to the correlation test, the FES-I score was inversely proportional to the MMSE, VAS, and DHI scores, that is, individuals' fear of falling increased as participants showed greater evidence of cognitive skill loss ($p<0.01$), dizziness levels ($p<0.01$), and influence of dizziness on quality of life ($p<0.01$).

The correlation test showed a significant difference between the number of falls in the previous year and mean pressures. The number of falls was higher in individuals with higher mean pressure on their left and right forefeet with their eyes open ($p=0.03$; $p=0.02$), right rearfeet with their eyes open ($p=0.02$), and right forefeet with their eyes closed ($p=0.03$), indicating that those who showed greater distribution of plantar pressure in their forefeet with both their left and right with eyes open had higher rates of falls.

Simple linear regression showed that the influence of dizziness on quality of life could predict 43% of fear of falling [$F$ (44.725, $p<0.001$; $R^2=0.430$)]. On the other hand, the number of previous falls could predict an 11.8% increase in mean pressure of the left forefeet with open eyes [$F$ (7.606, $p<0.05$; $R^2=0.102$)] (Table 3).

Table 3. Regression models for prediction of cognitive skills, dizziness level, number of falls, fear of falling, quality of life, and plantar pressures – Goiânia (GO), 2023

| Predicted Variables | Predictor Variables | $R^2$ | SE | B | β | P |
|---|---|---|---|---|---|---|
| Cognitive skills (MMSE) | Fear of falling (FES-I) | 0.092 | 0.075 | 0.003 | 0.032 | 0.010* |
| Dizziness level (VAS) | | 0.194 | 2.475 | 1.352 | 0.456 | <0.001** |
| Number of falls | | 0.036 | 1.278 | 0.029 | 0.230 | 0.080 |
| Fear of falling (FES-I) | Quality of life (DHI) | 0.430 | 7.758 | 0.262 | 0.663 | <0.001** |
| Left MFP – eyes open | Number of falls | 0.102 | 0.110 | 0.031 | 0.343 | 0.008* |
| Left MRP – eyes open | | 0.053 | 7.971 | 1.655 | 0.263 | 0.044* |
| Right MFP – eyes closed | | 0.276 | 3.77 | 0.056 | 0.589 | 0.076 |
| Right MRP – eyes closed | | 0.436 | 3.42 | 0.768 | 0.432 | 0.086 |

MMSE: mini mental state examination; FES-I: falls efficiency scale international; DHI: dizziness handicap inventory; VAS: visual analog scale for dizziness; MFP: mean forefoot pressure; MRP: mean rearfoot pressure; CC: coefficient of correlation; $R^2$: multiple squared correlation coefficient, adjusted based on sample size; SE: standard error; B: non-standardized coefficient.

*$p<0.05$

**$p<0.001$

## DISCUSSION

The results in this study contributed to an understanding of the factors that influence the fear of falling in adult and older women. Several elements play a significant role in this context. First, cognitive function configured a determining factor, and the fear of falling was greater in individuals with greater evidence of loss of cognitive skills, which suggests that cognitive decline may affect the perception of the risk of falls and increase associated fears. The intensity of self-reported dizziness also plays a crucial role. Individuals who reported greater dizziness also had greater fear of falling, highlighting the direct influence of dizziness on the perception of balance and fear of falling.

Another relevant finding was the association between quality of life and fear of falling. Those who faced a greater influence of dizziness on their quality of life also showed greater fear of falling. This highlights the interconnection between general well-being and fear of falling, suggesting that quality of life may negatively suffer from this concern. In addition to these factors, this study also raised the possibility that differences in plantar pressure, especially in the forefeet, may be associated with a history of previous falls.

This study observed that dizziness levels were correlated with participants' fear of falling. In other words, women who reported greater fear of falling also tended to experience more intense dizziness. This observation suggests that dizziness plays an important role in fall risk perception. Experiences of dizziness can affect individuals' sense of balance and security walking or performing everyday activities. Thus, fear of falling may increase as episodes of dizziness become more frequent or intense. A possible explanation suggests that advancing age affect vestibular and proprioceptive skills and other balance-related sensory stimuli, thus limiting stability and body alignment and control in individuals suffering from vertigo[20]. Functional impairments in the aforementioned aspects impair balance and increase accident risk. Therefore, imbalance favors falls since the body is unable to resist the action of gravity and move in space. This correlation between dizziness and fear of falling is relevant as it emphasizes the importance of assessing and addressing dizziness as part of fall prevention strategies in adult and older women[21] and may indicate the need for interventions to reduce dizziness not only to improve quality of life, but also to reduce fear of falling and actual risks of falls.

Participants in this study who showed more significant evidence of cognitive skill loss were more likely to express fear of falling. This means that the deterioration of cognitive functions, such as memory, attention, and thinking ability, was associated with fear of falling. several factors can explain this association. First of all, the loss of cognitive skills can impair environment perception and risk assessment, making individuals less safe in their daily activities[22]. Individuals may have difficulty recognizing obstacles or situations that pose falling risks. Moreover, cognitive function plays a key role in motor coordination and the ability to react to imbalances.

According to Cruz et al.,[23] specific cognitive functions are responsible for execution, attention, and memory. The motor and sensory systems are interconnected by neurological processes that are essential for motor planning, attention in dual task execution, and responses to environmental circumstances. Under compromised cognitive functions, individuals may have a slower reaction time and be unable to perform compensatory movements to prevent falls. This contributes to their concern regarding imminent falls. Studies indicate that individuals with cognitive decline and those with dementia disorders are more likely to suffer falls[24,25], which justifies the further development of studies that explore this theme.

This study observed that the number of previous falls failed to effectively predict fear of falling in our sample, which contrasts with previous studies, which found a significant correlation between a history of falls and the probability of future falls in older women[25]. This divergence may be related to degenerative changes in the visual, vestibular, motor, and proprioceptive systems that occur with aging. Thus, individuals who have experienced falls may adopt an activity restriction approach, avoiding situations considered threatening. However, by avoiding such situations, they may limit the opportunity to develop balance and mobility skills, which, in turn, may contribute to worsening their fear of falling. This dynamic highlights the complexity of the relation between a history of falls, fear of falling, and prevention actions, highlighting the need for more comprehensive intervention strategies to address these issues in older adults[5,25].

Fear of falling could predict up to 43% of the variation in the quality of life of study participants. This suggests that fear of falling significantly impacts participants' overall well-being and functional ability. The worsening of quality of life is also associated with a decrease in autonomy and independence, that is, with a decrease in functional capacity. Some physical impairments

interfere with functionality, such as postural instability, cognitive impairment, immobility, and urinary and fecal incontinence[26]. These dysfunctions directly interfere with functional capacity since independent decision-making and movement constitute factors that improve older individuals' quality of life. Furthermore, postural impairment, whether the result of proprioceptive (perception of posture and body movement), vestibular (head position and movement), or visual (spatial relations) alterations can cause imbalances and directly interfere with quality of life. The ability to maintain balance and move safely is essential for independence and overall satisfaction in daily life[27,28].

The results of plantar pressures in adult and older women noticeably differed in weight distribution during tests with open and closed eyes. Open eyes evinced an asymmetry between the feet, with greater pressure on the right ones. The transition to closed eyes decreased overall pressure, indicating the crucial influence of vision on postural stability. Significant variations in individual values highlight the need for personalized approaches. These findings offer valuable insights for fall prevention strategies, emphasizing the importance of interventions that improve proprioception and balance, especially under visual deprivation. The findings of this study corroborate previous research, such as Machado et al.[29], who also observed changes in plantar pressure distribution in older adults, especially when compared to younger adults. In this specific study, the distribution of plantar pressure increased in the most distal zones from the medial zone to the forefoot in both open and closed eye conditions. These results suggest a significant change in the biomechanics of plantar pressure associated with aging.

In our sample, we observed that the mean forefoot pressure totaled 44.41%, whereas the mean rearfoot pressure, 55.59%. Although the mean plantar pressures in the two regions are close to the reference values, we noticed a trend of higher pressure in the forefoot region (greater than 40%) than in the rearfoot region. This prevalence of projection of the center of gravity to the forefoot region may be associated with an increase in postural instability, which justifies its correlation with the number of previous falls in women. Inadequate interaction of the systems responsible for body balance, such as the vestibular, visual, and proprioceptive systems, can limit the ability to perform compensatory movements to regain balance, making people more susceptible to falls[30]. The prevalence of plantar pressure in the left and right forefeet with eyes open was higher in those who had experienced more previous falls. The increase in the mean forefoot pressure suggests a shift from the center of body mass to the front of the body. Previous research, such as that by Menz and Lord[31], highlighted that changes in the feet are directly related to performance in tests of coordination, stability, and function. A wider displacement of the body interferes with greater ground work, which can result in inadequate stability responses, particularly in people with foot problems, leading to increased plantar pressure.

The increase and poor distribution of plantar pressure in older adults can be attributed to increased stiffness of the soft tissues of the feet, especially in the rearfoot[31]. Moreover, our results suggest that these changes may differ under visual restriction. Testing the sample with their eyes closed significantly increased the mean right forefoot pressure. Regression analysis indicated that the number of falls predicted an 11.8% increase in mean left forefoot pressure with the eyes open. These greater age-related changes in the left foot can raise discussions about the role of lateral preference since left legs usually support more body weight in most people[31]. Moreover, factors such as decreased tibiotarsal range of motion, increased lower limb joint stiffness, and reduced plantar fascia and soft tissue thickness contribute to changes in plantar pressures and gait biomechanics as people age, making them more susceptible to falls. These changes in the distribution of plantar pressures, along with deficits in balance, joint mobility, static posture, and gait, are considered risk factors for falls[29-31].

Thus, the development of analysis and study methods related to the causes and risk factors of falls in older adults is fundamental. The performance of healthcare providers is essential to prevent falls. Regarding educational measures, development of intervention programs emphasizing the improvement of motor and balance and/or guidance to older adults and their caregivers can eliminate or minimize factors related to falls and their possible consequences[32]. The results of this study may increase the understanding of factors related to the prevention of falls in older adults, which still occurs often in this population. Findings reinforce the importance of a multidisciplinary approach that considers physical and mental aspects, such as fear of falling, because this condition can cause older adults to limit their own necessary and expected activities in their daily lives.

Our findings enabled us to understand the factors that increase the fear of falling in adult and older women, including cognitive function, a history of falls, quality of life, and dizziness intensity. Moreover, we observed

a possible association between differences in plantar pressure and previous falls. Nevertheless, it is important to highlight some limitations of this study, such as its lack of an accurate clinical diagnosis to classify the type of dizziness reported by the participants. Dizziness is a subjective and nonspecific symptom, requiring clinical evaluation for accurate diagnosis. Therefore, it is essential to consider the subjectivity and temporality of the reported complaints. We recommend that studies further develop the understanding of these issues.

## CONCLUSION

This study found that several factors, including cognitive function, dizziness level, number of previous falls, and quality of life can predict fear of falling. This research showed that fear of falling occurred more often in women with greater dizziness and DHI scores, indicating the impact of dizziness on quality of life. Furthermore, cognitive decline was associated with a greater fear of falling due to its interference with the ability of individuals to react to imbalances. Fear of falling also configured a significant factor in quality of life, affecting the autonomy, independence, and functional capacity in the studied sample. This study also suggests that plantar pressure distribution, especially in the forefoot, plays an important role in postural stability and is associated with the risk of falls.

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## REFERENCES

1. Bittar RSM, Oiticica J, Bottino MA, Ganança FF, Dimitrov R. Population epidemiological study on the prevalence of dizziness in the city of São Paulo. Braz J Otorhinolaryngol. 2013;79(6):688-98. doi: 10.5935/1808-8694.20130127
2. Ishii C, Nishino LK, Campos CHC. Caracterização vestibular no ciclo menstrual. Braz J Otorhinolaryngol. 2009;75(3):375-80. doi: 10.1590/S1808-86942009000300012
3. Moraes AS, Soares WJS, Rodrigues RAS, Fett WCR, E Ferriolli, Perracini MR. Tontura em idosos da comunidade: estudo de base populacional. Braz J Otorhinolaryngol. 2011;77(6):691-9. doi: 10.1590/S1808-86942011000600003
4. Herdman SJ, Blatt P, Schubert MC, Tusa RJ. Falls in patients with vestibular deficits. Am J Otol. 2000;21(6):847-51.
5. Lopes KT, Costa DF, Santos LF, Castro DP, Bastone AC. Prevalência do medo de cair em uma população de idosos da comunidade e sua correlação com mobilidade, equilíbrio dinâmico, risco e histórico de quedas. Rev Bras Fisioter. 2009;13(3):223-9. doi: 10.1590/S1413-35552009005000026
6. Cogo LA, Fedosse E, Santos VAV. Qualidade de vida e aspectos auditivos de trabalhadores do transporte coletivo urbano. Rev CEFAC. 2016;18(1):40-6. doi: 10.1590/1982-0216201618112715
7. Mold JW, Vesely SK, Keyl BA, Schenk JB, Roberts, M. The prevalence, predictors, and consequences of peripheral sensory neuropathy in older adults. J Am Board Fam Pract. 2004;17:309-18. doi: 10.3122/jabfm.17.5.309
8. Speers RA, Kuo AD, Horak FB. Contribuitions of altered sensation and feedback responses to changes in coordination of postural control due to aging. Gait Posture. 2002;16:20-30. doi 10.1016/s0966-6362(02)00003-6
9. Mickle KJ, Munro BJ, Lord SR, Menz HB, Steele JR. Foot pain, plantar pressures, and falls in older people: a prospective study. J Am Geriatr Soc. 2010;58(10)1936-40. doi: 10.1111/j.1532-5415.2010.03061
10. Socher DD, Socher JA, Azzi VJB. Evaluation of quality of life pre- and post-vestibular rehabilitation in patients with benign paroxysmal positional vertigo associated with Meniere's disease. Int Arch Otorhinolaryngol. 2012;16(4):430-6. doi: 10.7162/S1809-97772012000400002
11. Macedo C, Gazzola JM, Ricci NA. Influence of sensory information on static balance in older patients with vestibular disorder. Braz J Otorhinolaryngol. 2015;81(1):50-7. doi: 10.1016/j.bjorl.2014.11.004
12. Magrini A, Momensohn-Santos T. A análise e a caracterização de uma população de idosos com perda auditiva e queixa de tontura. Rev Kairos. 2019;22(1):353-65. doi: 10.23925/2176-901X.2019v22i1p
13. Folstein MF, Folstein SE, McHugh PR. Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. J Psychiatric Res. 1975;12:189-98. doi: 10.1016/0022-3956(75)90026-6
14. Bertolucci PHF, Brucki SMD, Campacci SR, Juliano Y. O mini-exame do estado mental em uma população geral: impacto da escolaridade. Arq Neuropsiquiatr. 1994;52:1-7. doi: 10.1590/S0004-282X1994000100001
15. Brucki SMD, Nitrini R, Caramelli P, Bertolucci PHF, Okamoto IH. Sugestões para o uso do mini-exame do estado mental no Brasil. Arq Neuropsiquiatr. 2003;61(3-B):777-81. doi: 10.1590/S0004-282X2003000500014
16. Toupet M, Ferrary E, Grayeli AB. Visual analog scale to assess vertigo and dizziness after repositioning maneuvers for benign paroxysmal positional vertigo. J Vestib Res. 2011;21(4):235-41. Doi: 10.3233/VES-2011-0420.
17. Delbaere K, Close JCT, Mikolaizak AS, Sachdev PS, Brodaty H, Lord SR. The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study. Age and Ageing. 2010;39:210-16. doi: 10.1093/ageing/afp225
18. Jacobson GP, Newman CW. The development of the Dizziness Handicap Inventory. Arch Otolaryngol Head Neck Surg. 1990;116(4):424-7. doi: 10.1001/archotol.1990.01870040046011
19. Castro ASO, Gazzola JM, Natour J, Ganança FF.Versão brasileira do Dizziness Handicap Inventory. Pro Fono. 2007;(19)1:97-104. doi: 10.1590/S0104-56872007000100011

20. Ferreira LMBM, Ribeiro KMBF, Lima KC. Prevalência de vestibulopatia em idosos institucionalizados de Natal – RN – Brasil. Rev CEFAC. 2015;17(5):1563-72. doi: 10.1590/1982-021620151752815

21. Tuunainen E, Jäntti P, Poe D, Rasku J, Toppila E, Pyykkö I. Characterization of presbyequilibrium among institutionalized elderly persons. Auris Nasus Larynx. 2012;39(6):577-82. doi: 10.1016/j.anl.2011.12.004

22. Da Paz, EG; Mendes, DJS; Oliveira, TCL; Barbosa, WO. Alterações de equilíbrio e risco de quedas em idosos com vertigem posicional paroxística benigna: uma revisão integrativa. Rev Neurocienc. 2022;30:1-17. doi: 10.34024/rnc.2022.v30.12925.

23. da Cruz DT, da Cruz FM, Ribeiro AL, da Veiga CL, Leite ICG. Associação entre capacidade cognitiva e ocorrência de quedas em idosos. Cad Saude Colet. 2015;23(4):386-93. doi: 10.1590/1414-462X201500040139

24. Taylor ME, Ketels MM, Delbaere K, Lord SR, Mikolaizak AS, Close JCT. Gait impairment and falls in cognitively impaired older adults: an explanatory model of sensorimotor and neuropsychological mediators. Age Ageing. 2012;41(5):665-9. doi: 10.1093/ageing/afs057

25. Pedalini ME, Cruz OL, Bittar RS, Lorenzi MC, Grasel SS. Sensory organization test in elderly patients with and without vestibular dysfunction. Acta Otolaryngol. 2009;129(9):962-5. doi: 10.1080/00016480802468930

26. Maria A, Coimbra V. As quedas no cenário da velhice: conceitos básicos e atualidades da pesquisa em saúde. Rev Bras Geriatr Gerontol. 2014;17(1):201-209. doi: 10.1590/S1809-98232014000100019.

27. Lima TM, Meiners MM, Soler O. Treatment adherence profile of hypertension patients from the Municipal Health Unit of Fátima, City of Belém, Pará, Amazônia, Brazil. Rev Panamazonica Saude. 2010;1(2):113-20. doi: 10.5123/S2176-62232010000200014

28. Bankoff ADP, Ciol P, Zamai CA, Schmidt A, Barros DD. Estudo do equilíbrio postural através da baropodometria eletrônica. Conexoes. 2004;2(2):87-104. doi: 10.20396/conex.v2i2.8637918

29. Almeida ST, Soldera CL, Carli GA, Gomes I, Resende Tde L. Analysis of extrinsic and intrinsic factors that predispose elderly individuals to fall. Rev Assoc Med Bras (1992). 2012;58(4):427-33.

30. Menz HB, Lord SR. The contribution of foot problems to mobility impairment and falls in community-dwelling older people. J Am Geriatr Soc. 2001;49(12):1651-6.

31. Scott G, Menz HB, Newcombe L. Age-related differences in foot structure and function. Gait Posture. 2007;26(1):68-75. doi: 10.1016/j.gaitpost.2006.07.009

32. Teixeira CS, Schmidt FC, Muraro MFR, Meereis ECW, Gonçalves MP. Prevalência de risco de quedas em idosas de uma instituição de longa permanência de Santa Maria (RS). Rev Kairos. 2014;17(1):45-56. doi: 10.23925/2176-901X.2014v17i1p45-56