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RESEARCH ARTICLE

Use of stabilometry and functional indicators to assess the risk of falls in elderly people in long stay institutions

Ana Carolina Vieira Schlickmann, Kelser de Souza Kock

Medicine course of the University of Southern Santa Catarina; Tubarão (SC), Brazil

Abstract

Introduction: The World Health Organization defines a fall as moving the body to a lower floor without sufficient time to correct this event. It involves the patient's risk factors and interrelated environmental factors. Stabilometry is a means of quantifying postural balance through electromagnetic sensors and specific modes. **Objectives**: To evaluate the risk of falling through stabilometry in institutionalized older adults. **Methods**: A cross-sectional study was carried out. The sample was made up of older adults living in a Long-Term Institution. Participants were evaluated using stabilometry with a Nintendo Wii Balance Board, mobility and functional balance Time Up and Go (TUG), and handgrip testing using a dynamometer. **Results**: The sample consisted of 35 participants with a median age of 74.0. The main comorbidities were hypertension and heart disease. The drugs used were diverse and were concentrated in a few groups. Twenty-eight participants were able to maintain themselves and perform all functional tests. Handgrip strength averaged 9kgf for women and 23kgf for men. The sample's average TUG time was 19.9 seconds. Functionality data was not associated with falls. Posturographic stabilometer data obtained a median of 101.9 cm for distance, 3.15 cm/s for speed, and 6.8 cm 2 for area. Advanced age and stabilometry speed were associated with falls were observed. **Conclusion**: Stabilometry data were good indicators for evaluating postural oscillations that may preexist a fall.

Keywords: Stabilometry; falls; elderly; Long-term care; accidents; postural balance; hand strength; walking test.

BACKGROUND

The modernization of medicine contributed to the control of diseases in the geriatric population, causing the life expectancy of this population to increase significantly. However, aging-related events have remained non-modifiable risk factors for some problems. Among them, increasing age intrinsically impairs the ability to process visual, vestibular, and proprioceptive stimuli, all related to maintaining balance, often leading to falls[1,2]. The World Health Organization defines a fall as moving the body to a lower floor without sufficient time to correct this event. It involves the patient's risk factors as well as interrelated environmental factors[3]. With this increase in the elderly population, long-term care institutions are required more frequently to ensure older people's quality of life[4].

According to the National Health Surveillance Agency, Long-Term care Institutions (LTCI) are residential institutions, governmental or not, that house elderly people aged 60 or over in a collective home, guaranteeing this population conditions of freedom, citizenship, and dignity, whose operations standards are established in regulation[4].

Corresponding author: Kelser de Souza Kock
E-mail: kelserkock@yahoo.com.br

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In this way, changing the environment and not adapting to these institutions add an environmental risk factor to the risk of falling since changing the family environment to an LTCI leads to cognitive and functional psychological impacts. Furthermore, older adults who work have a 30% lower risk of falling than those who are retired(2), thus maintaining a relationship with the statement that functional impacts such as work restrictions contribute to this risk(2).

Falls in older people contribute to high rates of functional disability and mortality. The occurrence of chronic musculoskeletal diseases, low back pain, and osteoarthritis can aggravate neuromuscular conditions that are already weakened by aging(6). Studies show that these events are more associated with females, with the amount of medication ingested and with the presence of two or more morbidities(7). Furthermore, older adults who fall for the first time are susceptible to a second fall(8). Each year, it is estimated that 684,000 fatal falls occur in the world, the vast majority of which occur among adults over 60 years of age. Each year, the world estimates that 684,000 fatal falls occur, with the vast majority happening among adults over 60 years of age(8).

The process by which the central nervous system generates activity patterns to maintain the relationship between the center of mass and the base of support is called postural balance. It is precisely this imbalance that contributes to the conditions that cause falls(9). With each new posture adopted by humans, new responses are required to maintain balance(10). Posture can be understood as a set of angles that express the relative arrangement between the segments of a body and can be measured through posturography. The center of pressure (COP) is the average position of vertical forces on the feet and their point of application. The characteristics presented by the center of pressure have been used to verify the posture control mechanisms(11). Currently, there are several ways to quantify postural balance through force platforms, electromagnetic sensors, and specific questionnaires. Stabilometry is an objective method of studying body oscillation while standing on a force platform without any involuntary movements or external disturbances through the change of the center of pressure(12).

The Timed Up and Go (TUG) test is another example of a well-established test that, when associated with other methods, demonstrates positive results in assessing balance and risk of falling(13). However, despite being consolidated in the scientific world, these analysis techniques COP vary and there is no consensus on which resource should be used in the diagnosis(14), the correlation between functional tests seems to demonstrate more satisfactory results than when used in isolation(15). Another functional indicator widely used in the elderly is handgrip strength, which estimates sarcopenia and risk of frailty in the elderly(16).

For research purposes, the recreational platform Nintendo Wii Balance Board (NWBB) has been used to measure postural control through one-dimensional measurement(17). This device consists of a platform containing four force sensors capable of measuring only forces verticals that record balance changes, making this platform increasingly viable for clinical practice and preventing falls through early detection of these oscillations(18).

Given all the above, this work aimed to evaluate the risk of falling through stabilometry and functional indicators in older adults institutionalized in an LTCI in the city of Tubarão, Santa Catarina state, Brazil.

METHODS

A cross-sectional observational study was conducted. The study was composed of older adults residing in an LTCI in the city of Tubarão, Santa Catarina (Brazil). The LTCI has a total number of 53 older adults, and 32 employees make up the health team. All residents over 60 who agreed to participate in the study and signed the informed consent form were included in the present study. Residents whose medical records were incomplete or who were unable to remain in an upright position were excluded from the study. After approval by the research ethics committee, the sample was subjected to an interview formulated by the researcher, and data from the “residents' medical records” were consulted.

In this interview, the patient's sex cited, with the female and male being accepted as answers and the patient's age. The medical records were checked for the presence of comorbidities, continuous use of medications, movement limitations, previous episodes of falls, and injuries related to falls. After the interview, the sample underwent an evaluation with different testing instruments: stabilometry with the Nintendo Wii Balance Board platform, mobility and functional balance assessment TUG test, and handgrip test using a dynamometer. The TUG is a test that assesses mobility and functional balance. The patient is asked to sit with their back against the chair, and then we instruct them to stand and walk as quickly as possible, safely, for 3 meters in a straight line on the floor, return to the chair, and stay in the starting position of the test[19]. This test is measured using a stopwatch after the "go" command is performed in just one repetition. Time greater than 20 seconds indicates a risk of falling.

The handgrip strength test (HGS) with the dynamometer has the power to indicate the general state of strength and functional performance as a whole. The measurement is obtained with the JAMAR® (Jamar TMHidraulic Hand Dynamometer, Preston, Jackson, Missouri, USA) manual hydraulic dynamometer, with the patient sitting in a chair, shoulders in a neutral position and one of the hands on the thigh while the elbow of the limb to be measured was kept flexed at 90 degrees, with the forearm in neutral rotation. For all subjects, the grip of the dynamometer was adjusted individually, according to the size of the hands so that the rod closest to the body of the dynamometer was positioned over the second phalanges of the fingers: index, middle and ring fingers[20].

Stabilometry is the study of body sway while standing on a force platform without any involuntary movements or external disturbances by changing the center of pressure[14]. Some studies have demonstrated the accuracy and reproducibility of stabilometry performed by the Nintendo Wii Balance Board device[12,19]. The test was carried out in two moments. Initially, the patient was in an orthostatic position on the NWBB, with both feet supported on the platform and the arms extending the body, remaining like this for 30 seconds and with the eyes open. The Brain Blox software provided by the University of Colorado was used to obtain data on the COP[21].

From the COP raw data, the variables were obtained: 1) Total oscillation displacement or distance, which indicates the length of the COP trajectory over the support base; 2) Average speed (VM), which is the determination of how fast the COP movements were; 3) Area that is based on the calculation of an ellipse that encompasses 95% of the COP data, with the two axes of the ellipse being calculated based on the dispersion measurements of the COP signals. These variables were calculated according to the study by Duarte[10] and obtained using the Matlab R 2016a software (Mathworks Corporation, Natick, MA, USA). Figure 1 graphically presents the total displacement, velocity vectors, and area of the COP ellipse.

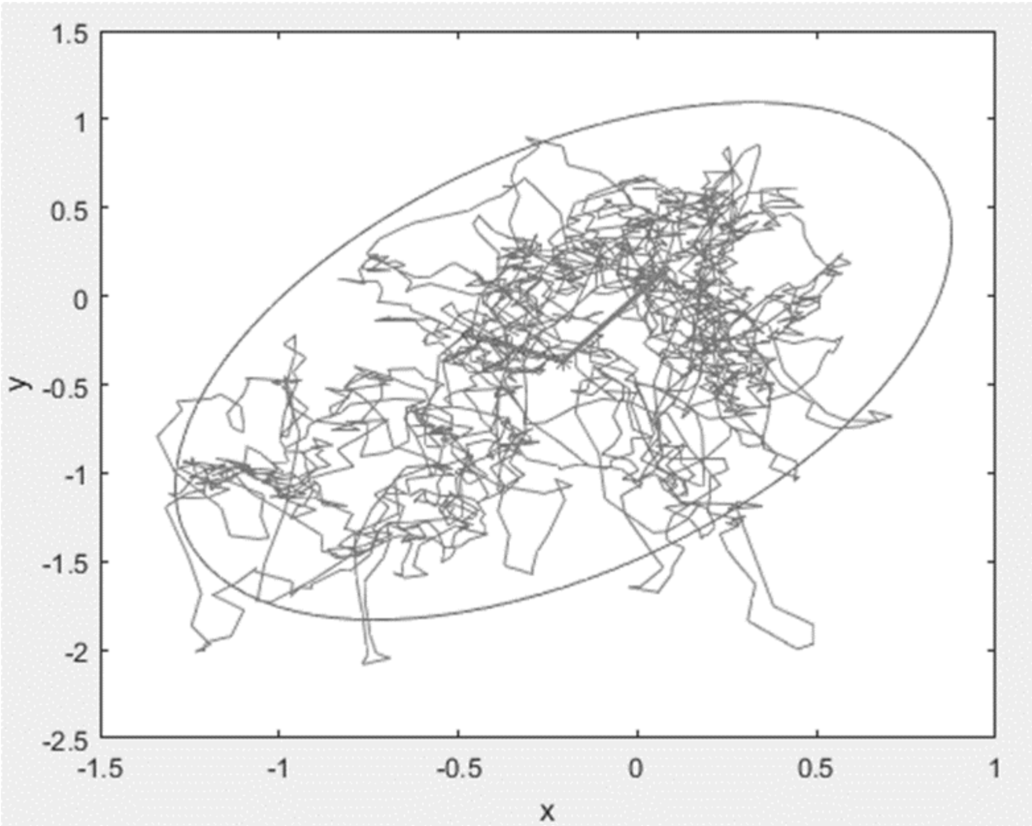

Figure 1. Demonstration of the total displacement, velocity vectors and area of the CoP ellipse

The Research Ethics Committee approved the study on 08/17/2022, opinion number 5.587.933, respecting the precepts of resolution 466/2012 of the National Health Council. The data were organized using Microsoft Excel and analyzed using SPSS 20.0 software. Quantitative variables were described using measures of central tendency and data dispersion. Qualitative variables were described using absolute and percentage frequencies. The Chi-square test was used to test differences in proportions. Numerical variables were tested using the Mann-Whitney test. The level of statistical significance adopted was 5% (p-value <0.05).

RESULTS

Fifty-three patients were selected. Of these, 18 were excluded for not signing the TCLE. The sample consisted of 35 participants with a median (p25-p75) age of 74.0 (62.0 - 79.5) years, 20 (57.1%) of whom were women. The main comorbidities involved cardiovascular system, such as hypertension and heart disease. In second place were psychiatric illnesses (Figure 2).

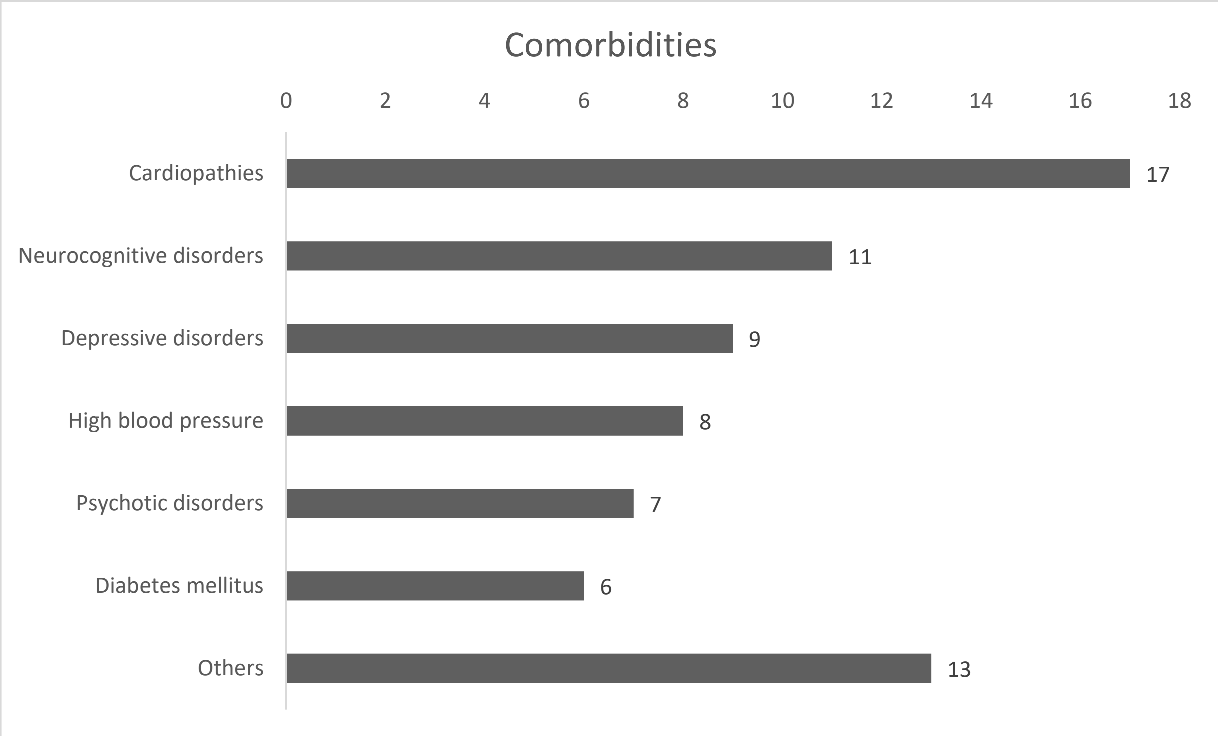

Figure 2. Comorbidities presented among patients participating in the research

Thirdly, neurocognitive disorders. Neurocognitive: Parkinson's, Alzheimer's, or other dementias; psychotic disorders and schizophrenia; others: epilepsy (1), human immunodeficiency virus (HIV) (2), hypothyroidism (1), hepatitis (1), COPD (1), pre-diabetes (1), previous stroke (2), alcoholism (1), anemia (1), osteoarthritis (1). Most of the sample had more than one disease synchronously. The medications used were diverse and concentrated in a few main groups. 65.7% of residents use antihypertensive medication; 45.7% of patients use some antipsychotic; 40% of patients use benzodiazepines; 34.2% of residents use antiplatelet drugs; 22.8% of residents use statins, and 14.2% of residents use antiparkinson drugs. Other medications such as antiretrovirals, antidiabetics, fibrates, proton pump inhibitors, antiepileptic, and Alzheimer's medications were found to have a lower frequency of use within the sample. Of the 35 participants in the sample, 28 could remain upright, walk, and perform all functional tests. In this way, only seven older adults carried out the HGS assessment. Functionality data are described in Table 1.

Table 1 – Handgrip strength, Timed Up and Go test and stabilometry data of the participants

	Median (p25 – p75)
Hand grip strength (kgf) – Women	9,0 (6,0 - 12,5)
Hand grip strength (kgf) – Men	23 (19,2 – 25,7)
Time Up and Go test time (s)	19,9 (14,1 – 30,4)
Stabilometry: Distance (cm)	101,9 (85,5 – 139,0)
Stabilometry: average speed (cm/s)	3,15 (2,6 – 4,3)
Stabilometry: area (cm2)	6,8 (3,1 – 11,9)

The occurrence of previous episodes of falls was identified in 5 (14.2%) patients. Table 2 shows the comparison of groups with and without previous episodes of falls. It can be observed that only advanced age and stabilometry speed were associated with falls. And a trend in the association of oscillation of the center of gravity distance assessed by stabilometry.

Table 2 – Comparison of handgrip strength, Timed Up and Go test and stabilometry data in LTCI participants in the groups with and without falls

	Group with Fall median (p25-p75)	Group without falling median (p25-p75)	p
Sex – n(%)			
Female	2 (10%)	18 (90%)	0,403
Male	3 (20%)	12 (80%)	
Age (years)	82,0 (77,5 - 84,0)	72,0 (60,0 - 76,0)	0,019
Hand grip strength (kgf) – Women	6,5 (5 – 12,5)	10 (6 – 13)	0,235
Hand grip strength (kgf) – Men	21,5 (21 – 26,5)	23,5 (17,7 – 27,2)	0,549
Time Up and Go test time (s)	24,3 (20,3 – 45,6)	16,6 (13,5 – 30,4)	0,262
Stabilometry: Distance (cm)	162,2 (105,8 – 200)	98,1 (84,7 – 122,8)	0,061
Stabilometry: average speed (cm/s)	5,2 (3,3 – 6,4)	3,0 (2,6 – 3,7)	0,039
Stabilometry: area (cm^2)	6,9 (3,2 – 35,4)	6,7 (2,4 – 11,4)	0,447

DISCUSSION

Falls have a significant negative impact on the lives of older adults as they can directly interfere with mobility, cause fractures, and consequently increase the risk of death in this population[6]. The main findings of this study demonstrated that, among the functional indicators evaluated, only stabilometry parameters were associated with episodes of previous falls. Advanced age was also a factor related to this outcome. Regarding the sample profile of the present study, the average age and the prevalence of females were similar to that of another study with institutionalized older adults[22]. This finding is because women have a longer life expectancy than men[23].

About the comorbidities variable, all older adults had two or more diseases; this is because it is an age group more prone to the incidence of morbidities and disabilities[4], the main ones being diseases of the cardiovascular system and neurological diseases, finding This was also found in the study by Seeger et al., conducted in an LTCI in the interior of the state of Rio Grande do Sul (Brazil)[22]. In the medications used by LTCI residents, there was a prevalence of antihypertensive and antipsychotic medications, which is in accordance with the higher prevalence of the diseases found. The majority of the sample used 5 or more medications, a finding found in other studies with the same population[23]. HGS is an indicator of sarcopenia and is lower in the female population than in the male population. Women have a smaller lean mass and consequently, less strength to perform this test[18].

The normative values according to the "European Working Group on Sarcopenia in Older People" to establish one for non-institutionalized elderly people: 30 kg for men and 20 kg for women, below this point, indicate sarcopenia(24). In this present study, the average HGS in women with falls was 6.5 kg, while that of the group without falls was 10.5. In men, the median strength in the group without a fall was 23.5, and in the group with a fall, 21.5. Therefore, regardless of whether or not they suffered a fall, the women in this study already show a positive correlation between this functional indicator and sarcopenia. In men, the values found are within the expected age range. Despite being a known indicator of sarcopenia(17,18), this finding did not demonstrate statistical significance when comparing HGS between groups with and without falls.

In the TUG test, a median of 16.6 seconds was obtained to perform this test in the group of older adults without falls, while the group with falls had a time of 24.3 seconds. This test also did not present statistical significance for falls in this study, although when isolated, a result of more than 20 seconds indicates a greater risk of this event(20). A survey conducted in 2020 with institutionalized older adults from Juiz de Fora, (MG), Brazil, classified a test execution time greater than 20 seconds as a high risk of falling and a time between 11 and 19 seconds as a moderate risk of falling(25). In this sense, even if they have not suffered the event, institutionalized older adults who have not fallen still need special attention and prevention of this occurrence since the accommodation environment in an LTCI, polypharmacy, and multiple comorbidities already predispose to an increase in the prospects for an event of this type(4-6). Despite these findings, the present study did not demonstrate statistical significance to precede falls.

In the stabilometric findings, the first indications were observed that stabilometry could be an isolated predictor for risk of falling, since regarding the methods analyzed in this present study, there is a recommendation that they always be used together for better data analysis(16). The average distance in millimeters from the extremes of oscillation of the center of body pressure in this test was 101.9 mm for older people. Those who suffered falls had a 62% increase in the test result, while the group without falls had only 98.1 mm of oscillation. Therefore, those who fell had a more significant imbalance, quantified by the 65.3% greater amplitude of the oscillation of the individual's postural center than the group without a fall. The reference values for the total distance of the COP present significant variability in the literature, depending on the calculation methodology and stabilometry time(27). A study carried out by Scoppa et al. suggests that the execution of this test will be easily affected by the individual's current fatigue or lack of attention when performing the test, which is why performances can never be considered stable or absolute(26). Changes and large areas of displacement are interpreted as phases of instability in which ankle torque quickly changes from one stable state to another, similar to a micro-fall(27).

As the speed variable is measured in mm/s, a median of 3.15 cm/s was found during sample analysis. This variable measures the speeds reached in the oscillation between the points of force exerted by the center of pressure (28). The average COP speed is the variable considered most reliable in the analysis of stabilometry data. This variable is influenced by age-related postural changes and neuromuscular phenomena found in this population(29).

The speed found in the group without a fall was 3.0 cm/s, while that of the group with a fall was 5.2 cm/s. The reference data suggested by the literature is broad, ranging from 1.97cm/s ± 1.6cm/s[29]. The p-value in the analysis of this data was 0.039, highlighting the greater statistical significance of this study. In other words, older adults who, if their center of pressure oscillates with more incredible speed on the force platform, have a greater risk of falling or even a greater risk of falling again. A study conducted by Maria Carolina S. Fornari in Porto, Portugal, compared the posturographic parameters of 76 older adults living in the community with an average of 71 years of age with data from young adults[30]. This study demonstrated an average speed of COP oscillation in the elderly age group of 1.16 ± 0.53 cm/s, within the reference values for the age, but below the findings found in this present study. As the survey analyzed older adults living in the community and not living in LTCI. This finding corroborates the hypothesis that older adults living in community homes have a higher rate of neurosensory changes resulting from changes in the environment, work restrictions as well as changes in routine, such as already mentioned previously in this study[2].

The area of oscillation analyzed in stabilometry did not demonstrate statistical significance in this present study. This area corresponds to the measurement of oscillation of the COP[27]. The median area of this test was 6.8cm2/s; in the group without falls, this number rose to 6.7cm2/s, while in the group with falls, it was 6.9cm2/s. A systematic review suggested several 4.8 cm2/s as the ideal oscillation area per second[29]. Both groups of older adults analyzed showed an increase in the oscillation area and presented a higher index of imbalance compared to the study by Maria Carolina Fornari, in which the older adults analyzed had a COP oscillation area of 2.19 ± 2.32[30].

The hypothesis that older adults in this study presented a greater area of oscillation compared to the survey in the City of Porto is due to the same assumptions in the previous paragraph. A study by the American Academy of Rehabilitation estimated that it would be necessary to apply the same test 4 times for a considerable reliability index to assess postural stability[11].

This present study has limitations, given the availability of length of stay at the LTCI and the participants' refusal to participate more than once. For this reason, the test was conducted only once. The small sample size was also a limitation of this study, as it may have interfered with the statistical power of the comparisons. It is also necessary to highlight the lack of studies that apply stabilometry as a method of evaluating balance in an initial analysis of the patient, as this method is the most used way to assess the effectiveness of intervention methods for postural improvement in the elderly. This method has been advantageous as it becomes a more tangible way to determine the improvement of a health condition and adherence to treatment[11]. The variables that evaluate postural control have been used as an outcome to assess the effectiveness of interventions to improve the state of balance[11] and make adherence to treatment, as well as the improvement of the postural state of the elderly, more quantifiable and objective. As a strength of this study, we can highlight that the clinical profile of the sample was similar to that of other studies that presented significant results involving the same population.

CONCLUSION

For the sample analyzed, the HGS tests and TUG Test were not effective in predicting falls. There was no correlation between sex and previous falls. Quantitative stabilometry data are good indicators of postural oscillation and can be used alone or in conjunction with other tests and functional indicators to evaluate postural oscillations that may pre-exist the fall.

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