Postural Sway as an Indicator of Balance: Establishing Normal Ranges and Risk Thresholds

Abstract

Postural sway refers to the natural movement of the body while maintaining an upright position. While it varies across individuals based on the strategies used to maintain balance, certain thresholds can indicate whether a person's sway is considered "normal" or at risk of balance impairments. This retrospective analysis examines postural sway measurements in healthy, community-dwelling adults and hospital inpatients with the goal of establishing normal sway levels and identifying thresholds that may indicate balance problems.

Introduction

Falls are a major public health concern, particularly among older adults. Postural sway is a key indicator of balance control with increased sway length associated with fall risk[1]. Understanding what constitutes "normal" sway in adults is essential for accurate assessment and effective intervention. This study defines "normal" postural sway and establishes thresholds to distinguish between low and high fall-risk groups by utilizing data collected from over 840 healthy, community-dwelling adults, and 300 hospital inpatients. Postural sway was measured using the Aspire sensor while participants stood for 30 seconds with their feet together.

Methodology

Postural sway measurements were collected from three distinct populations:

- Community-dwelling adults (healthy individuals)
- Convalescent ward inpatients (patients recovering from illness or surgery)
- Acute ward inpatients (patients with more serious health conditions)

Postural sway, an indicator of balance, was measured using the Aspire sensor, a 9-axis Inertial Measurement Unit (IMU) positioned near the L5 vertebra. Participants were instructed to stand with the insides of their feet touching and remain as still as possible for 30 seconds. Sway length was calculated, a parameter commonly used in clinical balance evaluations.

Community participants were healthy, independent, and fully mobile. Inpatient participants were categorized into low and high fall-risk groups based on clinical assessments: convalescent ward patients were evaluated using the Berg Balance Scale (BBS), while acute ward patients were assessed with the Elderly Mobility Scale (EMS). The risk threshold for the BBS was set at a score of < 45, and for the EMS, a score of < 14.

Results

The postural sway measurements of each group exhibited a skewed distribution as shown in Figure 1. The community-dwelling adults had the lowest mean sway at 19.5 cm, followed by the convalescent ward inpatients with a mean sway of 34.75 cm (78% greater than community group), and the acute ward inpatients with the highest mean sway at 62.51 cm (220% greater than community group).

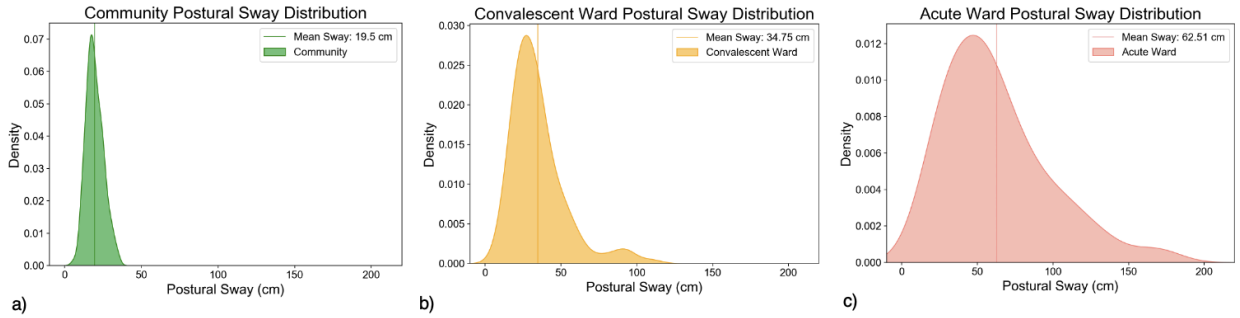

Figure 1. Normalized distributions of the 3 groups to the same scale: a) Community adults, b) Convalescent Ward inpatients, and c) Acute Ward.

Figure 2 superimposes the histograms of all three groups on a single plot, visually highlighting the distinct differences in sway. The vertical lines represent the mean sway for each group.

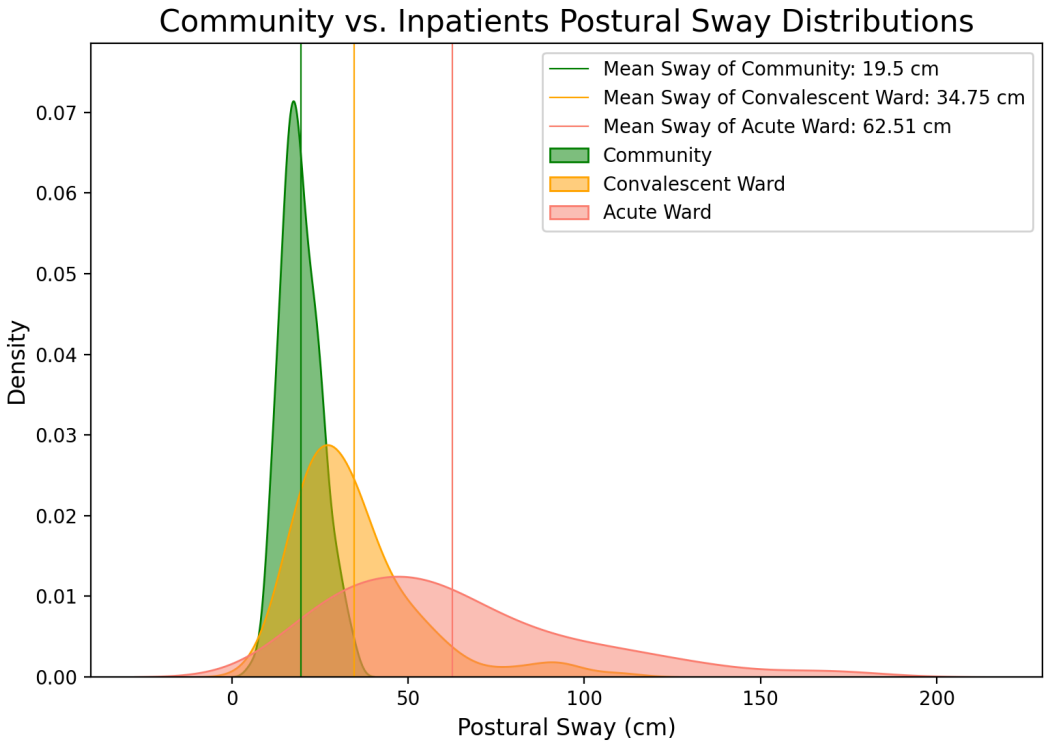

Figure 2. Distributions of the community adults, convalescent ward, and acute ward plotted together

Figure 3 compares the healthy community participants with the combined high-risk inpatients from the convalescent and acute wards. High-risk inpatients exhibited more than double the sway of the community group, with a mean sway of 53.17 cm. The mean sway of convalescent ward high-risk patients is 37.14 cm.

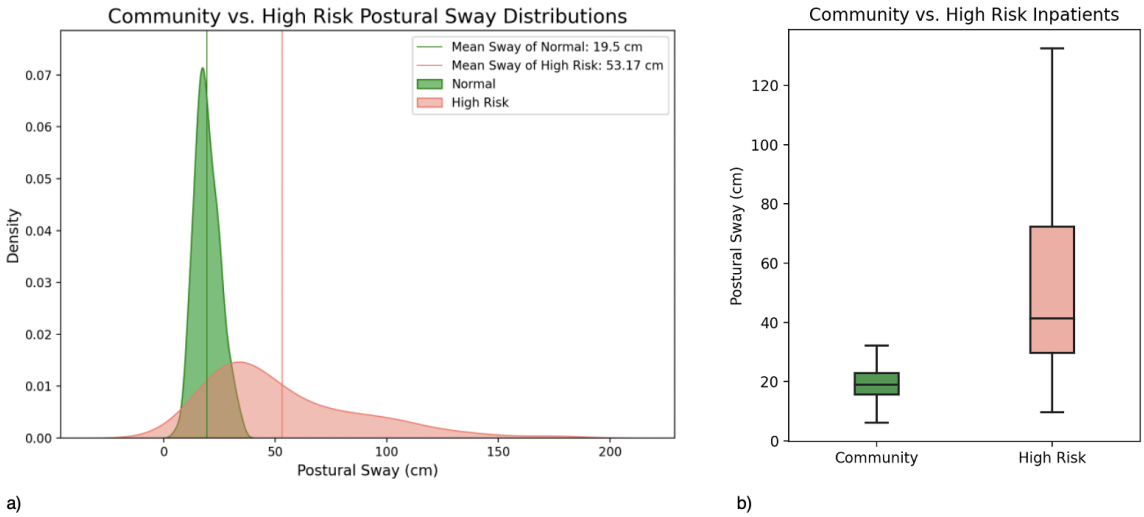

Figure 3. a) Distributions of the community group and high-risk inpatients from the convalescent and acute wards. b) Box plot showing the interquartile range of sway of the community and high-risk groups.

Postural sway was also analyzed across different age groups within the community-dwelling adults. The results are presented in Table 1. This breakdown provides insight into how sway varies with age and illustrates the relationship between aging and balance control.

Age Range	Mean Sway Length (cm)
20-34	18.07
35-49	18.54
50-64	21.78
65-74	24.88
75+	28.20

Table 1. Mean Sway of healthy, community adults by age group.

Discussion

The findings reveal significant differences in postural sway across the three populations, providing valuable insight into the relationship between postural sway and health status. Healthy,

community-dwelling adults demonstrate a much smaller range of sway compared to hospital inpatients, confirming that excessive sway is linked to increased health risks. Specifically, the community group's mean sway of 19.5 cm serves as a baseline for normal balance. In contrast, at-risk hospital inpatients, identified through BBS or EMS, had a mean sway of 53.17 cm, supporting the idea that greater sway is associated with fall risk.

The comparison between convalescent and acute ward inpatients highlights the impact of recovery status on balance. Convalescent patients had a mean sway of 34.75 cm, significantly higher than the community group but lower than the acute ward patients, who had the highest sway at 62.51 cm. This suggests that recovery from illness or surgery temporarily affects balance, with more severe health conditions leading to greater sway. When comparing only the high-risk inpatients of each ward, the convalescent ward's mean sway was 37.14 cm, while the acute ward had a much higher mean sway of 78.69 cm.

Figure 3 reinforces these findings by showing that high-risk inpatients have more than double the sway of the community group. These results underscore the potential of postural sway measurements to distinguish between normal and high-risk individuals. The mean sway of high-risk convalescent inpatients, 37.14 cm, could serve as a moderate risk threshold, while the combined mean sway of 52.17 cm of high-risk inpatients from both wards could define the high-risk threshold.

The breakdown of sway by age group, as shown in Table 1, provides further insight into how postural sway naturally increases with age. Understanding how sway changes across age groups can help refine risk thresholds and inform more targeted interventions for balance control as individuals age.

Conclusion

In summary, these findings help define "normal" postural sway at 19.5 cm and establish a threshold of 52.17 cm for identifying individuals with potential balance-related impairments putting them at risk of fall. This threshold provides a clear benchmark for distinguishing between healthy adults and those at higher risk. The results suggest that postural sway measurements could be valuable in screenings and clinical practice, aiding in the early identification of at-risk individuals and guiding interventions to prevent falls and improve mobility outcomes.

Future research should focus on refining these thresholds for at-risk populations and exploring how postural sway can be integrated into routine clinical assessments to further enhance patient care and outcomes.

References

Johansson, J., Nordström, A., Gustafson, Y., Westling, G., & Nordström, P. (2017). Increased postural sway during quiet stance as a risk factor for prospective falls in community-dwelling elderly individuals. Age and ageing, 46(6), 964-970.