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Fall Risk Assessment in Geriatrics: An HEBED Data Analysis

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Abstract
This study investigates postural stability and fall risk assessment based on Human Balance Evaluation Database (HBEDB). Force, moment and center of pressure (CoP) signals were extracted, and sway features like sway path length, area and mean velocity were computed. Then statistical analyses is performed to find correlation coefficients between sway features and clinical scores such as Falls Efficacy Scale (FES), Trail Making Test (TMT), and Mini-BESTest. Finally, a decision tree classifier was implemented to predict fall risk category. The obtained results indicate significant surface condition effects on sway metrics and high classification accuracy in fall risk prediction.
Keywords: Postural Stability, Stabilography, Fall Risk, HBEDB, Centre of Pressure, Decision Tree, Clinical Scores

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I. Introduction

Falls represent a significant public health concern, particularly among geriatric populations, leading to substantial morbidity, mortality, and economic burden. The impact of falls extends beyond physical injuries, contributing to social isolation, reduced self-confidence, activity limitations, and functional decline, ultimately threatening the independence of older adults. With the global population aging, the incidence of falls and fall-related injuries is expected to rise, further straining healthcare systems and social services. Falls are a major contributor to injuries and healthcare costs in the elderly [1]. Every year, a significant percentage of adults over 60 experience a fall, with approximately one in five falls resulting in serious injuries like traumatic brain injuries or hip fractures, leading to high medical expenses, emotional distress, physical discomfort, and a considerable burden on individuals, families, and society [2]. In many instances, falls lead to moderate to severe injuries, necessitating emergency department visits and hospitalizations, with fall-related death rates showing a marked increase in recent years [3]. The economic consequences of falls are substantial, encompassing direct medical costs, rehabilitation expenses, and long-term care needs, as well as indirect costs such as lost productivity and caregiver burden. Falls are complex events influenced by a multitude of interacting risk factors, including age-related physiological changes, chronic medical conditions, cognitive impairment, medication use, environmental hazards, and behavioral factors. A fall is defined as an unexpected event in which an individual loses their balance and ends up on the ground or a lower level [4]. A comprehensive understanding of these risk factors is essential for developing effective prevention strategies. Identifying individuals at high risk for falls is crucial for implementing targeted interventions and preventing adverse outcomes [5]. Addressing this escalating problem requires a multi-faceted approach encompassing risk assessment, tailored interventions, and environmental modifications to mitigate fall risk and promote healthy aging.

Fall Prevalence and Consequences

The Centres for Disease Control and Prevention defines a fall as an unintentional event resulting in a person coming to rest on the ground or another lower level, not due to an overwhelming external force or a major medical event [6]. Falls are a common and serious problem among older adults. Falls can result in various adverse outcomes, including physical injuries, psychological distress, reduced quality of life, and increased healthcare costs [7]. It is imperative to implement timely fall detection to facilitate appropriate medical responses and minimize the significant physical, social, and financial repercussions [8]. Falls are notably frequent among older adults, with a substantial proportion experiencing falls annually, and this rate tends to escalate with increasing age, especially among individuals residing in institutional settings [9]. Many falls do not result in injury, but about 20%-30% of falls cause moderate to severe injuries such as lacerations, hip fractures, or head trauma [10]. These injuries can make it hard for the person to get around or live independently and increase the risk of early death, even if they were not seriously injured, people who fall may develop a fear of falling. This fear may cause a person to limit their activities, which can lead to loss of physical fitness and, in turn, increase their risk of falling. Falls are the primary cause of traumatic brain injuries and fractures in older adults. Furthermore, falls can lead to hospitalization, disability, reduced quality of life, and even death [11]. Many older adults do not discuss falls with their healthcare providers, either because they believe falls are a normal part of aging or because they are embarrassed or afraid of losing their independence [12]. Older adults are hospitalized for fall-related injuries five times more often than they are for injuries from all other causes.

Unintentional falls have been identified as a prominent cause of unintentional injury deaths among individuals aged 65 and over [13]. As the population ages, the number of falls and fall-related injuries is expected to increase, placing a greater burden on healthcare systems and society. The global incidence of falls results in a significant number of fatalities annually, highlighting the critical need for comprehensive fall prevention strategies [14]. In light of these statistics, it is crucial to prioritize fall prevention efforts and implement effective strategies to reduce the risk of falls and improve the health and well-being of older adults [12].

II. Literature Review

Current research shows that exercise programs can be effective in reducing falls in community-dwelling older people, particularly strength and balance exercises for more than 3 hours per week [15]. Exergaming, which combines exercise with interactive video games, is emerging as a promising approach to enhance physical performance, cognitive function, and dual-task walking ability in older adults [16]. Recent technological advancements have led to the introduction of new virtual reality-based exercise methods for performing diverse tasks [17]. Interventions should be tailored to individual needs and risk factors to maximize their effectiveness. Various exercise interventions have been shown to reduce falls and the risk of falling [18]. Perturbation-based balance training may offer promise for reducing falls, yet consistent and significant enhancements in fall incidence have not been observed in frail older individuals or patient cohorts at heightened fall risk [11]. Interventions that incorporate exercise with multiple components, such as balance, strength, and gait training, have demonstrated a notable decrease in both the rate and risk of falling [15]. Physical therapists commonly address balance and strength deficits, but standardized falls screening is not fully integrated into practice, and therapy prescriptions vary significantly in frequency, intensity, and duration to achieve optimal outcomes [19]. Numerous studies have investigated various interventions aimed at reducing fall risk, including exercise programs, medication management, environmental modifications, and assistive devices [20].

However, some studies suggest that certain interventions, such as exercise combined with environmental assessment and modification, may paradoxically increase the risk of injurious falls in individuals with a history of falls [7]. In addition to physiotherapy exercise for balance, mobility and stabilizing strength, the use of motor imagery practice, a form of mental representation, has gained interest in the clinical community [21]. When evaluating stress and exercise reactions, the wearable device has been shown to successfully collect physiological responses from users, with significant differences[22]. Additionally, comparisons of air and sponge conditions in PCA and clustering have shown how important pressure distribution and air sample comfort are, indicating that advanced analysis is helpful in posture and sleep research [23].

III. Methodology

The data taken form [24] were used for this study. The dataset comprises 1930 trials from 163 subjects performing stabilography tests under varying conditions: Eyes Open/Closed and Firm/Foam surfaces. The key stabilometric parameters like sway path length, mean velocity, and sway area, were extracted from the CoP data and mean velocity were computed. To find group-wise comparisons between eyes open vs closed, firm vs foam,T-test were performed andAnalysis of Variance(ANOVA) provides surface condition effect on mean velocity. Then statistical analyses are performed to find correlation coefficients between sway features and clinical scores such as Falls Efficacy Scale (FES), Trail Making Test (TMT), and Mini-BESTest. Finally, a decision tree classifier was implemented to predict fall risk category. The obtained results indicate significant surface condition effects on sway metrics and high classification accuracy in fall risk prediction.

IV. Results and Discussion

Figure 1 shows four scatter plots showing the relationships between postural stability parameters (like path length, mean velocity and sway area) and clinical assessment scores and show a non linear correlation with FEST. The correlation between postural sway parameters and clinical assessment scores revealed valuable insights into the complex interplay between balance control and fall risk. The absence of strong linear correlations suggests that the relationship between postural sway parameters and clinical assessment scores may be complex and nonlinear.

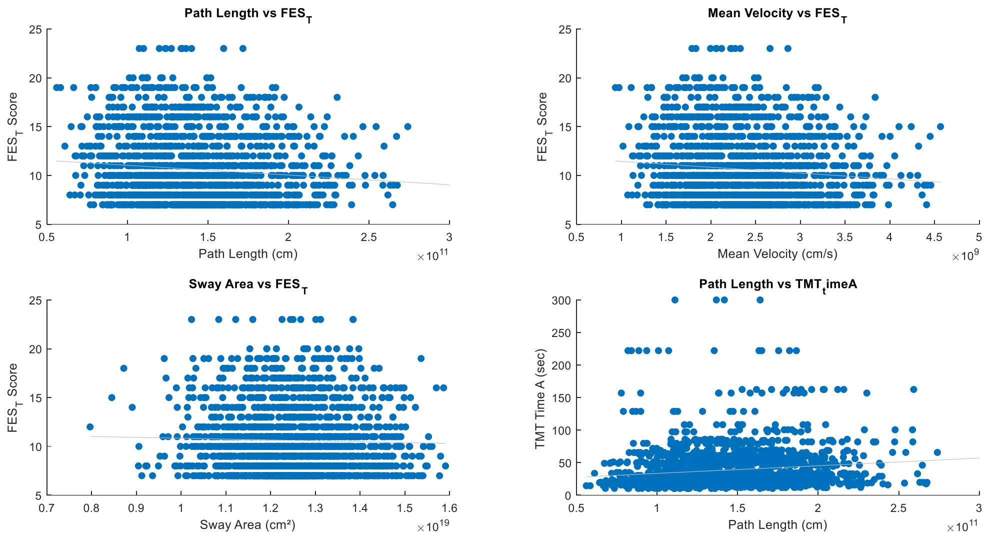
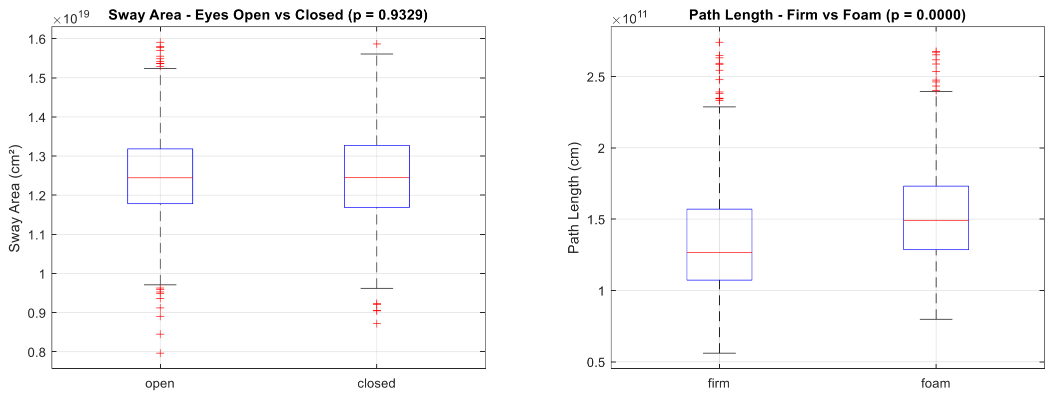


Figure 1 Scatter plots showing the relationships between postural stability parameters and clinical assessment scores

Figure 2 (a-c) shows the box plot of postural stability parameters under different sensory and surface conditions such as sway area, path length and mean velocity. These figures indicates that visual and surface conditions affect postural control. The results showed a substantial increase in all stabilometric parameters when the eyes were closed, as well as when standing on a foam surface when compared to a firm surface. Foam surfaces significantly affect path length and sway velocity, indicating their usefulness in balance assessment. These findings are consistent with established knowledge regarding the significance of visual input in preserving postural stability. Eyes closed condition shows a subtle increase in sway area variability, highlighting the role of vision in postural control. These patterns could be valuable in assessing fall risk or balance impairment in clinical populations.



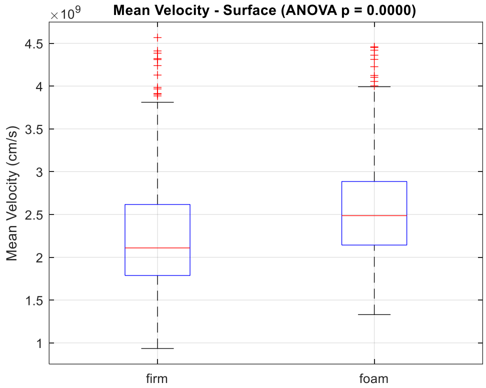


Figure 2 (a-c) Box plot of postural stability parameters under different sensory and surface conditions

V. Conclusion

This study underscores the importance of comprehensive fall risk assessment and the potential of quantitative measures of postural control, such as those derived from stabilometry, to improve the identification of individuals at high risk of falling. Ultimately, the integration of quantitative measures of postural control with clinical assessments and individual risk profiles holds promise for enhancing the accuracy and effectiveness of fall prevention strategies. The study's findings underscore the importance of addressing postural control deficits in fall prevention programs and considering the impact of both sensory and cognitive factors on balance performance.

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