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Comparative Analysis of Postural Sway in Normal and Intellectually Disabled subjects

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ABSTRACT

This study compares the patterns of postural swaying that are observed in individuals with intellectual impairments to those that are observed in those who do not have intellectual disabilities. Both the anteroposterior (AP) and mediolateral (ML) directions were utilized in order to investigate the phenomenon of postural sway, which is a fundamental component of human balance regulation. Individuals with intellectual disabilities had much larger postural sway in both the AP and ML directions, according to the findings, which show a considerable disparity between the two groups. Because of this, it appears that maintaining equilibrium among populations with intellectual disabilities is a particularly difficult task. It is essential to have a thorough understanding of these differences in order to develop individualized therapies that are aimed at enhancing postural stability and lowering the risk of falls among individuals belonging to this group.

Keywords: Balance, Postural sway, intellectually disabled

1. INTRODUCTION

When evaluating an individual's capacity to maintain equilibrium and manage their body's position in space, balance evaluation makes use of a variety of clinical procedures. One of these methods is postural sway, which refers to the natural oscillation of the body while standing. The Berg Balance Scale [1] is a tool that is frequently used for this purpose. It is a tool that analyzes sitting, standing, and transferring duties, and it provides insights into balance, particularly postural sway. It is also possible to measure mobility with the Timed Up and Go test [2], which involves timing tasks such as standing up from a chair, walking, turning, and sitting back down. This test is used to evaluate postural stability. Both the Functional Reach Test and the Romberg Test [3] contribute to the evaluation of balance by assessing the danger of falling and the degree to which the individual sways posturally.

The ability to maintain balance and postural sway is an important skill to have in everyday activities, sports, and mobility. They have a significant role in lowering the risk of injuries, particularly among elderly people who are more likely to sustain injuries as a result of falling. It is possible for individuals to improve their self-confidence, independence, and capacity to navigate their surroundings in a secure manner by improving their balance. Exercises and training programs that focus on balance are beneficial in lowering the risk of falling and improving postural sway and stability, which eventually leads to an improvement in general well-being and quality of life [4].

It is absolutely necessary to place a high priority on balancing assessment while taking into consideration people who have mental impairments and those who have typical development. Despite the fact that this group may experience a variety of effects on components of balance, such as postural sway, as a result of difficulties with coordination or sensory processing, proprioception, which refers to the body's knowledge of its position in space, also plays an important role. In spite of these obstacles, maintaining balance is still extremely important for their overall health because it encourages independence, participation in activities, and a reduction in the likelihood of injuries. It is vital for this population to undergo individualized assessment and interventions that address proprioceptive impairments and balance difficulties, including postural sway, in order to guarantee safe and efficient navigation.

2. RELATED WORK

Balance and fall risk assessment have been widely studied in many groups to understand fall causes and develop effective interventions. Maki et al. (1994) [5] stressed the relevance of lateral stability in lowering fall risk in ambulatory and independent older people. This study stressed the need of lateral balance to prevent falls in this demographic.

Swanenburg et al. (2009) [6] found that many fallers have smaller stance widths than non-fallers in a prospective research on falls prediction in older adults. This suggests that stance width may predict fall risk in older adults.

Gill et al. (2001) [7] examined trunk sway measurements of postural stability in clinical balance tests across age groups. Their results showed that older participants had more postural sway during stance and associated activities than younger and middle-aged participants. This suggests that older persons need specialized balance interventions due to age-related postural stability changes.

Barshan and Yüksek (2013) [8] compared body-worn sensor units for daily and sports activity recognition. The magnetometer had the greatest classification rates across sensing modalities, while the Gaussian Mixture Model (GMM) algorithm was best for activity recognition. This technology helps track balance-related behaviors in real life.

Scheffer et al. (2007) [9] examined risk factors, prevalence, assessment, and effects of older adults' fear of falling. A previous fall was the sole modifiable risk factor for fear of falling, underscoring the relevance of fall prevention methods to reduce fear and improve quality of life in older adults.

Finally, Era and Heikkinen (1985) [10] examined standing postural sway and unanticipated balance disturbance across age groups. Visual feedback affected postural control, as postural sway was considerably higher when participants closed their eyes than when they were awake. Sensory input is crucial to balance, especially in unexpected situations.

These studies improve our understanding of balance assessment, fall prediction, and intervention options across distinct groups, establishing the framework for future research to improve balance outcomes and reduce fall risk in various situations.

3. METHODOLOGY

Data was collected for a comparative study on postural sway between 20 normal subjects aged 18–24 and 20 intellectually disabled (ID) persons aged 16–32, inclusive. Weight and sex were not addressed in this research, allowing a concentrated examination of postural sway across intellectual level groups.

In this study, we utilized an inertial motion sensor (G Walk, BTS Engineering) equipped with a tri-axial accelerometer, tri-axial gyroscope, and tri-axial magnetometer to obtain quantitative movement data of the human body. The sensor was securely affixed to the sacrum (S2) of each subject's back, Fig 1. Data acquisition was conducted at a sampling frequency of 100Hz. During each postural state assessment, data were recorded for varying durations: Eyes Open condition lasted 2-2.5 minutes, Eyes Closed condition for 30-45 seconds, Feet Together condition for 60-75 seconds, and Tandem condition for 60-75 seconds.

All data were collected in real-time and automatically saved in text format for subsequent processing and analysis.

Fig 1: Placement of G-walk sensor

Only the angular displacement and angular velocity data related to the roll for the anteroposterior displacement and pitch planes for the mediolateral displacement of the center of gravity were considered essential because the balancing assessment was conducted in static mode. All other data being irrelevant for the study were discarded. Subsequently, a matrix was constructed comprising four columns representing angular displacement in the roll (ADr) and pitch (ADp) planes, as well as angular velocity in the roll (AVr) and pitch (AVp) planes.

The raw text data obtained from the sensor underwent conversion into Excel files. Following this, the offset of displacement data was removed from each file. Python, a versatile programming language, was employed to index the data according to the specific requirements for different postural states

Following the generation of simulation results using Python, various graphs were plotted to compare the postural states of both normal individuals and those with Intellectual Disability (ID) across different planes for both displacement and velocity parameters. Graphs representing normal individuals were depicted in red, while those for MR patients were shown in blue.

Subsequently, each individual Excel file underwent normalization to ensure uniformity within a range of 0 to 1. Following normalization, all participant files for each test were amalgamated into a single Excel file.

Utilizing the R programming language, a Gaussian Mixture Model was applied to the combined Excel file to obtain clustered data. Each row in the dataset was assigned a cluster number ranging from 1 to 8.

The maximum number of clusters covered by a subject reflects the path length, representing the overall distance traveled by the subject. Similarly, the maximum number of oscillations between clusters signifies the sway velocity, representing the average horizontal area covered by the movement of the center of force per second.

4. SIMULATION RESULTS

For both types of subjects, graphs were generated to compare the mediolateral displacement to the anteroposterior displacement, as well as the mediolateral velocity to the anteroposterior velocity. In this case, the normal subject was represented by the color red, whereas the ID subject was represented by the color blue. These graphs were acquired for a variety of leg positions, including feet apart with eyes open, feet apart with eyes closed, feet together with eyes open, and finally, with both feet together and eyes open. Graphs that are combined for one subject are displayed in figures 2(a) through 2(h), respectively..

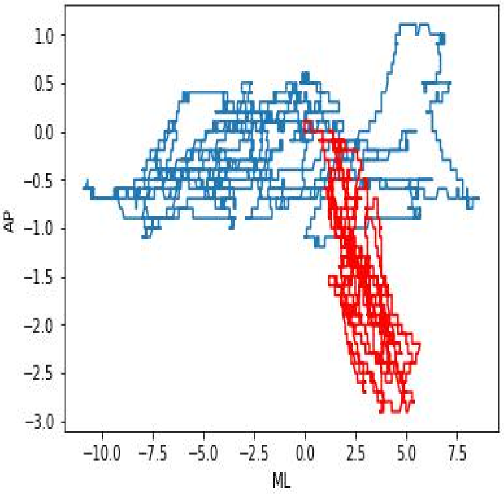

Fig 2 (a): Eyes open displacement

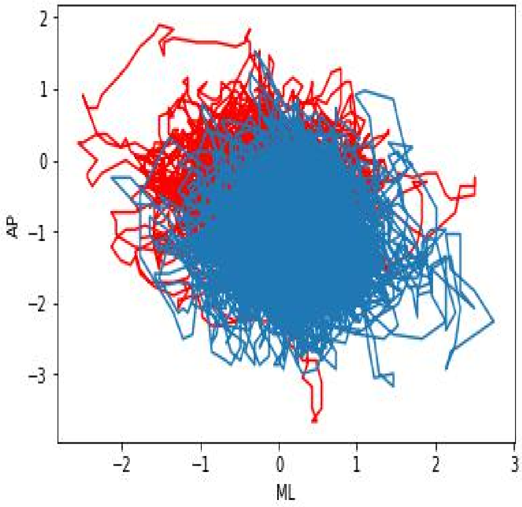

Fig 2 (b): Eyes open velocity

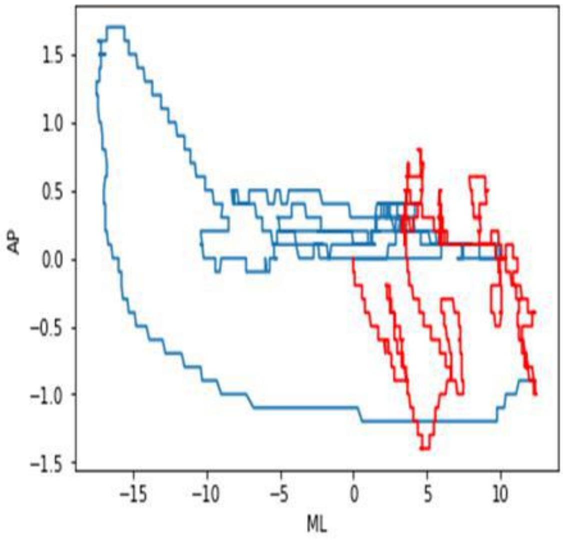

Fig 2 (c): Eyes close displacement

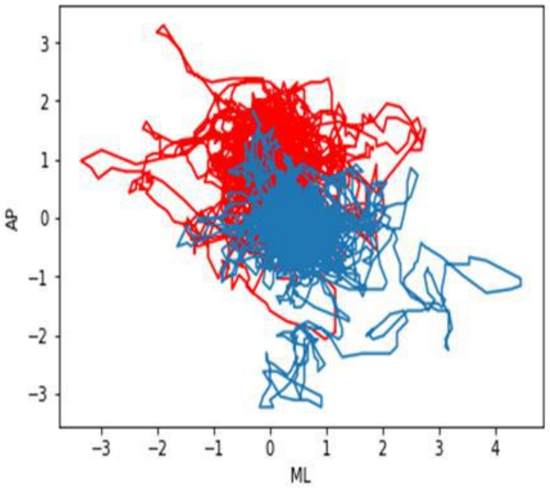

Fig 2 (d): Eyes close velocity

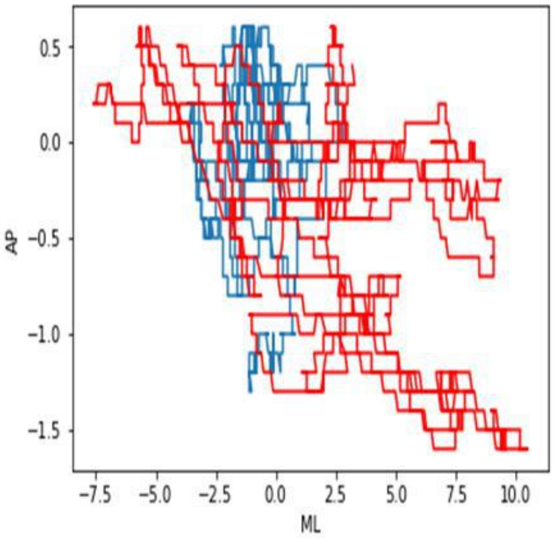

Fig 2 (e): Feet together displacement

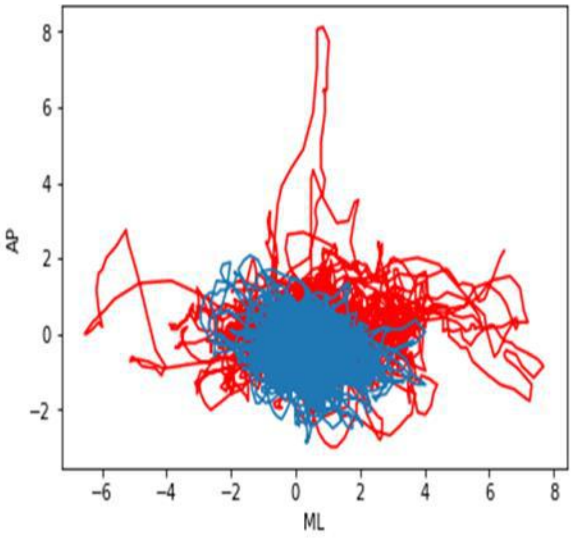

Fig 2 (f): Feet together velocity

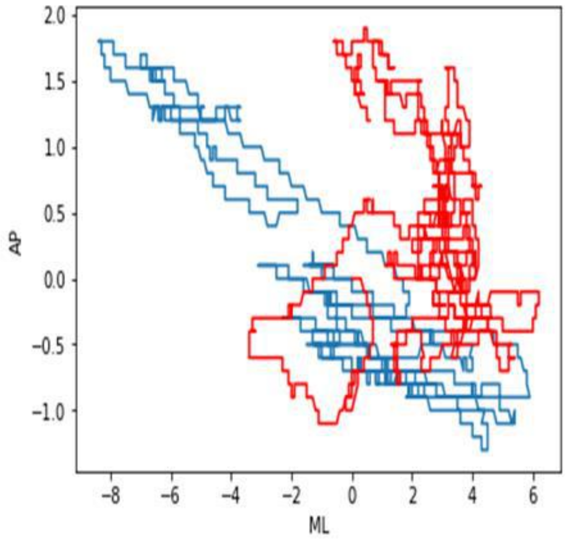

Fig 2 (g): Tandem displacement

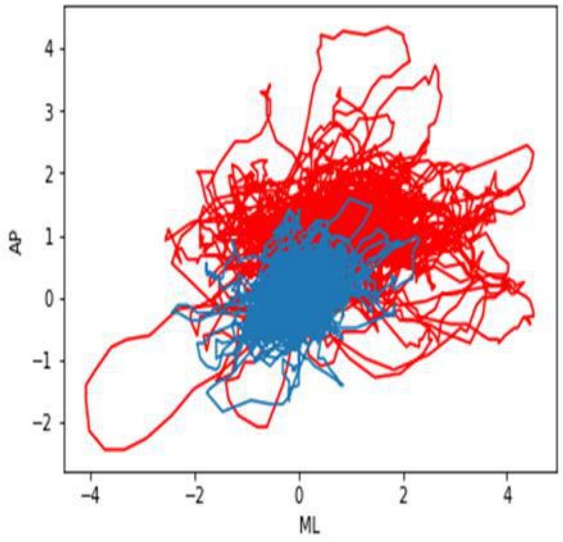

Fig 2 (h): Tandem velocity

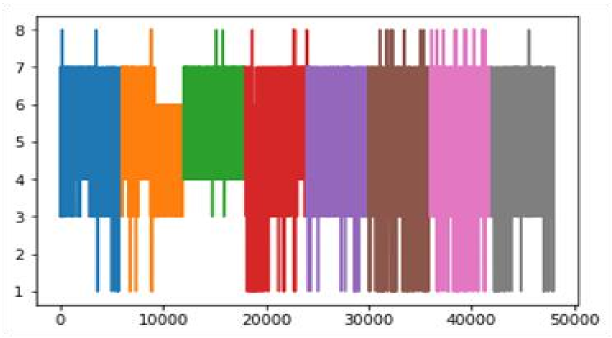

Fig 3: Clustered samples of normal and ID individuals. Horizontal axis represents samples and vertical axis represents cluster

5. CONCLUSION

In our study, we observed distinct patterns of postural sway among intellectually disabled (ID) subjects compared to typically developing individuals. Firstly, during both eyes open and eyes closed states, ID subjects exhibited a higher sway length in the mediolateral (ML) direction compared to the anteroposterior (AP) direction. Secondly, in the eyes closed state specifically, ID subjects demonstrated elevated sway velocity and greater sway length in both AP and ML directions. Thirdly, during the tandem state, ID subjects displayed increased ML sway length accompanied by reduced sway velocity. Furthermore, our findings indicate that during the eyes open state, both sway length and sway velocity were higher in ID subjects compared to typically developing individuals. Similarly, during the eyes closed state, sway length was notably elevated among ID subjects. Additionally, during the feet together state, both sway length and sway velocity were observed to be higher in ID subjects compared to their typically developing counterparts. These observations underscore the distinct postural sway characteristics present in ID subjects and emphasize the importance of tailored interventions to address their balance challenges.

From the clustered data obtained from Gaussian mixture model, eight clusters were obtained. Horizontal axis represents the number of samples of a normal subject up to 25000 samples and an ID subject from 25000 onwards in eyes closed state, it is observed that the cluster 5 contributes to the mean position of the pelvic region concluding to be a stable state whereas cluster 1 and 2 are samples with high anteroposterior sway which is dominant in ID subjects. All this being said, it can be concluded that ID subjects possess less balance compared to normal subjects and are at a higher risk of fall.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1]. Berg K, Wood-Dauphinee S, Williams JI, Gayton D. Measuring balance in the elderly: validation of an instrument. Can J Public Health. 1992;83 Suppl 2:S7-11.

[2]. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-148.

[3]. Du ncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol. 1990;45(6):M192-M197.

[4]. Cohen HS, Mulavara AP, Peters BT, Sangi-Haghpeykar H, Bloomberg JJ. Standing balance tests for screening people with vestibular impairments. Laryngoscope. 2014;124(2):545-550.

[5]. Ma ki B, Holliday P, Topper AK. Postural Balance & risk of falling in an ambulatory & independent Elderly Population. 1994.

[6].Sw anenburg J, de Bruin ED, Uebelhart D, Mulder T. Falls prediction in older people: a 1-year prospective study. Gait & Posture. 2009.

[7]. Gill J, Allum JH, Carpenter MG, Held-Ziolkowska M, Adkin AL, Honegger F, Pierchala K. Trunk sway measures of postural stability during clinical balance tests: effects of age. 2001.

[8]. Barshan B, Yüksek MC. Recognizing Daily and Sports Activities in Two Open Source Machine Learning Environments Using Body-Worn Sensor Units. 2013.

[9]. Scheffer AC, Schuurmans MJ, Van Dijk N, Van Der Hooft T, De Rooij SE. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. Age and Aging. 2007.

[10]. Era P, Heikkinen E. Postural sway during standing and unexpected disturbance of balance in random samples of men of different ages. 1985.