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RELATIONSHIP BETWEEN CONVENTIONAL SINGLE LEG STANCE BALANCE ASSESSMENT AND SENSOR-BASED TEST USING ELECTRONIC WOBBLE BOARD

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Graphical abstract

Abstract

Assessing balance is essential for determining the likelihood of falling, particularly in older populations and rehabilitative situations. Traditional methods of assessing balance, such as the Single Leg Stance (SLS), have been shown to be beneficial. However, these methods do not give the same level of information as more modern instruments. This study examines the accuracy and reliability of a sensor-based balance evaluation tool known as the Fitness Balance Board (FIBOD). FIBOD is a unique instrument that is used for both balance training and correct assessment, besides existing balance evaluation methods. While conducting the study, individuals with good health were recruited and a series of trials were conducted under different 'test and trial' settings to assess the efficacy of SLS in comparison to FIBOD. The Overall Stability Index (OSI) of FIBOD has a mean value of 3.66±2.54, which suggests that it is highly sensitivity. The Medio-Lateral Stability Index (MLSI) and Anterior-Posterior Stability Index (APSI) had average values of 2.71±2.32 and 2.21±1.53, respectively. In addition, the angular velocity of the sway was measured at 3.60±2.89 degrees per second. The Pearson correlation coefficient of -0.814 between OSI and SLS in closed-eye situation indicates a significant and substantial negative association. The confidence interval ranging from -0.922 to -0.589 demonstrated a strong connection.

Keywords: FIBOD, Balance Assessment, Single Leg Stance, Sensor-based, Stability Indices

Abstrak

Penilaian keseimbangan adalah penting untuk menilai risiko jatuh, terutamanya dalam kalangan populasi yang menua dan dalam skenario pemulihan. Ujian Single Leg Stance (SLS) yang tradisional, walaupun berguna, tidak menyediakan butiran seperti yang dibekalkan oleh alat yang lebih canggih. Kajian ini meneroka penggunaan Papan Keseimbangan Kecergasan berbasis sensor (FIBOD), sebuah alat inovatif yang direka untuk latihan keseimbangan dan penilaian yang tepat, untuk melengkapi penilaian keseimbangan tradisional. Kami melibatkan subjek yang sihat untuk membandingkan keberkesanan SLS berbanding dengan FIBOD di bawah pelbagai keadaan ujian. Secara khusus, adalah penting untuk diperhatikan bahawa Indeks Kestabilan Keseluruhan (OSI) FIBOD mencatatkan nilai purata 3.66±2.54, yang menunjukkan sensitivitinya. Ini diikuti oleh Indeks Kestabilan Medio-Lateral (MLSI) dan Indeks Kestabilan Anterior-Posterior (APSI), yang masing-masing mencatat nilai purata 2.71±2.32 dan 2.21±1.53. Tambahan pula, kelajuan ayunan direkodkan pada 3.60±2.89 darjah per saat. Hubungan terbalik yang signifikan ditunjukkan oleh nilai korelasi Pearson sebanyak -0.814 antara OSI dalam keadaan mata tertutup dan SLS dengan mata tertutup. Julat selang keyakinan untuk korelasi ini adalah dari -0.922 hingga -0.589, menunjukkan bahawa hubungan tersebut kuat. Data yang disajikan di sini menerangi kemampuan halus FIBOD dalam menilai keseimbangan, menunjukkan potensinya untuk diintegrasikan dengan realiti maya untuk meningkatkan lagi keberkesanan latihan dan keupayaannya untuk memotivasi individu. Penemuan ini menekankan kehalusan yang lebih baik dari FIBOD dalam penilaian keseimbangan, yang berpotensi untuk merevolusikan pendekatan yang telah ditubuhkan dengan menyampaikan penilaian risiko jatuh yang lebih tepat berkat keupayaannya untuk menyediakan lebih banyak maklumat.

Kata kunci: FIBOD, Penilaian Imbangan, Pendirian Kaki Tunggal, Berasaskan Penderia, Indeks Kestabilan

1.0 INTRODUCTION

Recently, falls, especially among the elderly, have become a major public health issue [1]. Each year, 37.3 million people have serious falls, which can cause hip fractures, fear, activity limits, social isolation, and depression [2, 3]. Such poor results reduce an individual's quality of life, especially since the elderly often struggle to recover physically and mentally [4]. By 2050, the global old population (those over 60) is expected to reach over two billion, making it crucial to recognize the issue and implement effective fall-related injury and complications prevention strategies [5]. Gait and balance problems have long predicted falls [6]. These shortcomings highlight the importance of clinical evaluation instruments being accurate and objective [7].

Research has shown a clear link between balance impairments and fall risk, although objective testing techniques are scarce [7]. The high cost of specialized equipment and the lack of skills are major hurdles [8, 9]. Traditional tests like the Berg Balance Scale (BBS) and Romberg test have had mixed results, but their subjectivity and probable contradictions demand an alternative [7].

Recent research indicates that sensor-based balance boards have the capacity to provide a more specific and measurable assessment of stability and balancing the field of balance evaluation. The research outcome emphasized that more straightforward and reliable tools in both clinical and home environments is needed. This was done by comparing several sensor-based platforms those are based on traditional assessment methods [10, 11]. The effectiveness of such devices in rehabilitation procedure has been a topic of greater study. The primary emphasis is given on their contribution to enhancing postural control and mitigating the risk of falls of the older people [12].

Questionnaires or evaluations of functional posture and gait are typically the basis of conventional clinical balance examinations. However, these types of evaluations are essentially subjective and qualitative by character [13]. Recent progress has been made by utilizing whole-body motion analysis [14], ground reaction forces [15], and muscle activations [16] to create more precise and quantifiable methods for evaluating the chance of falling. However, these procedures are not economically feasible for widespread implementation. These require significant setup time; hence restrict their application for regular clinical utilization.

On the other hand, wearable mobile sensors, such as inertial measurement units (IMU), provide a more feasible alternative. Due to their portability, these sensors are appropriate for inconspicuous data gathering in non-laboratory environments [17, 18]. These sensors can readily capture both the frequency and intensity of human movements. The IMUs are capable of measuring both accelerations caused by gravity and body motion. This allows recording of real-life actions and offers more precise depiction of an individual's regular movement patterns and susceptibility to falling down.

The FIBOD is a cutting-edge electronic wobbling balance board that utilizes the IMU technology. This assessment investigates and improves balance using important indicators including the overall stability index (OSI), medio lateral index (MLSI), and anteroposterior stability index (APSI) [19, 20]. Recent research has shown its potential to significantly improve balance training and assessment. A recent study found that this technology might enhance balance training and assessment. In a prior exploratory study, FIBOD, which contains interactive instructional modules and visual feedback systems, improved elder participants' balancing abilities. This reduced their risk of falling and increased their training participation. Over four weeks, 24 FIBOD training sessions were given to 21 research participants. The exercise improved balance and reduced fall injuries. This suggests that FIBOD might be used for home balance training [19].

In a second investigation of seventeen individuals in good health, standing on both legs vs one leg significantly altered OSI and MLSI. FIBOD found these discrepancies. These data indicate that FIBOD sensors may detect variations in balance abilities [18]. The electronic wobble board is a viable clinical and home balance test option, as shown by additional investigations [19, 20]. Another research also compared FIBOD balance scores to Romberg test results from physiotherapists. This study found a high correlation between balance metrics. This indicates that sensor-based balance scores of FIBOD balance evaluations might replace expert assessments [21].

This study indicates that FIBOD not only matches the reliability of traditional evaluations but also provides a higher sensitivity in distinguishing between different levels of balance capabilities.

These results are crucial given the portability and usability of the gadget. Portable and sensor-based technologies provide comprehensive balance analysis outside of clinical settings. These gadgets overcome drawbacks of the typical balancing measurement methods. Also, sensor-based evaluation platforms reduce the need for expertise.

This study compares objective measurements of FIBOD to those from traditional techniques to determine its suitability as a scale assessment tool. A total of 21 subjects were recruited to do balance tests using the Single Leg Stance (SLS) examination and the electronic wobble board FIBOD. This investigation examines the relationship between OSI, MLSI, APSI and sway velocity scores of FIBOD against the traditional scores of SLS, as well as identifying the benefits of employing them. Previously, the sensor-based test on FIBOD has not been systematically compared with SLS conventional balance assessment.

2.0 METHODOLOGY

Figure 1 depicts the sequence of steps followed in this investigation. Volunteers underwent a rigorous screening process to determine their appropriateness based on specific criteria for inclusion and exclusion. Subsequently, they participated in many trials during which their data were gathered and subsequently analyzed. The study has received ethical approval from the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia (MOH), with the identification number NMRR-ID-23-01539-UOJ. This research was carried out in compliance with the rules and regulations in the Declaration of Helsinki and in accordance with legal regulations of the nation. Each and every participant has provided consent and explicit agreement to take part in the experiments that have been conducted.

2.1 Subjects

Inclusion Criteria: Participants in this study must fulfill certain criteria. Individuals must have the capacity to stand and walk independently, without depending on any external aid or displaying any indications of limping [22]. Individuals must also comprehend and adhere to directions. Furthermore, it is imperative that they have not experienced any injuries or discomfort during the last six months. Participants are required to be free of contractures, scoliosis, or kyphosis in the spine, upper limbs, or both [23]. Prior to the commencement of the experiment, all participants were required to provide written informed consent. A total of 21 participants aged between 18 and 30, encompassing both male and female individuals, were selected to partake in this study.

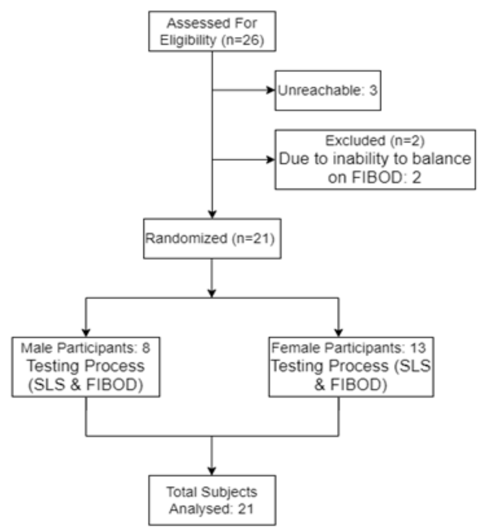

Figure 1 Flow Diagram of Progress through the Phases of Screening, Enrolment and Analysis

Exclusion criteria: Participants with neurological or orthopedic diseases, including knee or ankle injuries, musculoskeletal problems, or other disorders affecting the lower limbs, were excluded from this study. The exclusion criteria encompass those with cognitive impairments, unstable angina, pregnancy, and uncontrolled diabetes mellitus, visual or hearing impairments. Individuals with specified medical disorders, such as cerebellar dysfunction or vestibulocochlear dysfunction, which might possibly affect stability and balance, were also not eligible. Additional grounds for exclusion were refusing to sign the informed consent form, having conditions that result in a balance deficit, or taking any prescribed medication within the last three months [16, 22].

2.2 Experimental Set Up

SLS: The single leg stance test was employed to assess balance, with participants instructed to stand on their dominant leg [13]. A stopwatch was the primary equipment used for the duration measurement. The experiment was carried out in a spacious, enclosed room within an office space. In preparation for the test, the area was thoroughly checked to ensure it was free from obstructions [14]. Additionally, measures were put in place, such as a soft-landing area, to prevent falls should a participant lose their balance. Figure 2 shows the methodology of the single leg test.

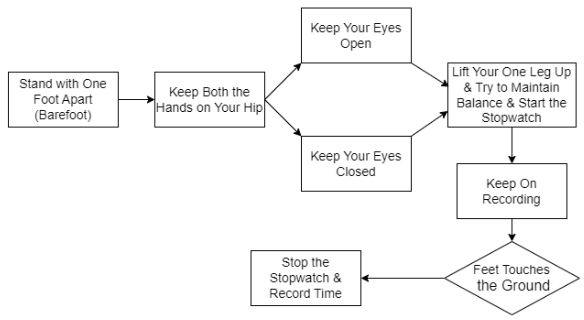

Figure 2 Single leg stance trial process

Participants were at first briefed on the actual test procedure which would require them to stand on their dominant leg, starting with their eyes open and subsequently with their eyes closed [15]. It was emphasized that their hands should be kept on their hips throughout the test's duration. For the eyes-open phase, participants stood with both feet flat on the ground, placing their hands on their hips. After participants confirmed their comfort with hands on hips, they were required to lift one foot off the ground, all the while keeping their eyes open [14]. Participants were required to maintain their balance for 45 seconds with any disruptions noted accordingly. The stopwatch began as the foot was raised and was stopped either when the participant lost balance or if there was a notable shift in the standing foot's weight. Following a short rest interval, the eyes-closed segment of the test was initiated, as shown in Figure 3. Participants repeated the previous steps but with their eyes closed for this phase. The stopwatch's functionality remained the same, marking the duration of maintained balance [16]. The recorded time began when opposite foot left the ground and stopped immediately when opposite foot touched the ground and/or when hands left the hips.

Prior to the main test, participants underwent a pretest to familiarize themselves with the requirements and nuances of the procedure. This familiarization allowed participants to practice the stance, ensuring that they were comfortable and understood the expectations clearly [17].

The adopted scoring mechanism was simple. The duration (in seconds) for which participants managed to maintain their balance during each segment was recorded. If the balance was maintained for the whole duration of 45 seconds, it was shown as ">45". Achieving a score of ">45" is regarded a performance standard, indicating that those who reach this score have a minimal probability of experiencing balance-related problems [13]. If the balance was kept for a length less than this specified timeframe, the precise time was recorded, and shorter durations may suggest higher levels of risk. The performance indicators for this evaluation encompassed not only the time of sustained balance, but also the examination of body sway and any occurrences of foot displacement from its initial position [15]. This comprehensive evaluation provided a complete comprehension of the participants' capacity to sustain equilibrium.

The Single Leg Stance test was chosen for this study based on its proven effectiveness in evaluating static balance, its adaptability in different environments due to its low equipment needs, and its capacity to deliver immediate and unbiased information regarding an individual's balance performance. The ease and safety of its administration, together with its ability to directly evaluate balance in difficult settings (with eyes open and closed), highlight its importance in assessing balance. Furthermore, the validity of the SLS test is supported by several studies that have confirmed its dependability in assessing balance and forecasting the likelihood of falling, especially among older individuals. However, this comprehensive examination gave a deep understanding of people's balance abilities, making it suitable for comparison in this study.

Figure 3 Single leg stance (SLS)

FIBOD Specifications

The research used the FIBOD, an electronic wobbling balance board (Figure 4). This innovation advances technology that combines training and evaluation. It can conduct therapy in clinics, balancing training at home, and increasing health and well-being. It was designed to be versatile and user-friendly. The gadget is distinguished by its light weight of about 1.3 kilograms and compact dimensions, measuring 15.5 inches in diameter. This feature enables simple and adaptable usage in any place. The gadget possesses the capacity to incline up to 20° in either direction, enabling a variety of equilibrium challenges that replicate real-world situations [11, 18].

Figure 4 The Visual Feedback to Give to the User While Using the FIBOD with the Software Module

FIBOD's platform uses a variety of sensors which includes gyroscopes, accelerometers, and inertial measurement units. The sensors can capture exact movement data with ±0.04% accuracy and ±0.06 degrees repeatability [11, 18]. The high precision of balance evaluations allows real-time feedback during balance workouts, which is vital for effective training [18].

The unique software of FIBOD uses attractive visual and animations to guide users through different exercises and movements. This feature is helpful to ensure the users to execute their workouts accurately and maintain motivation. After each session, users receive prompt feedback on their balancing score and bio-feedback data, which enable them to track improvement over time and maintain their motivation to continue practicing [19].

FIBOD supports Bluetooth connectivity and works with Android devices at a data sampling rate of 20Hz [18]. This feature allows users to receive enhanced visual cues on their smartphones or TVs, making the training experience more organized.

Experiment Protocol with FIBOD: Participants were introduced to the FIBOD sensor-based balance tool, which was positioned on a soft round sponge for stabilization. A table with a display tablet was positioned at a comfortable viewing height, providing visual prompts for the subjects. An auxiliary supportive stand was available for participants to achieve an initial balance if needed. Figure 5 shows the process for the FIBOD trials.

To commence, participants were instructed to step onto the FIBOD, colloquially referred to as the wobble board. With feet strategically positioned shoulder-width apart and hands resting naturally alongside their body, they were guided to fixate on a specific point presented on the tablet screen.

Participants had 120 seconds to familiarize themselves with the FIBOD's physical features and intricacies before the examination. They became comfortable with the gear via this preparation. After this session, a 30-45-second pause was given before the official evaluation.

For the primary assessment, participants underwent six trials, each lasting 10 seconds. These studies were done with eyes open and closed, giving each condition equal space. Each trial required participants to use real-time visual input on the monitor to maintain balance and keep the FIBOD horizontal. A fifteen-second rest break between trials was necessary to prevent fatigue and ensure consistency. This approach was scientifically used to analyze balance in both visual conditions using the FIBOD system.

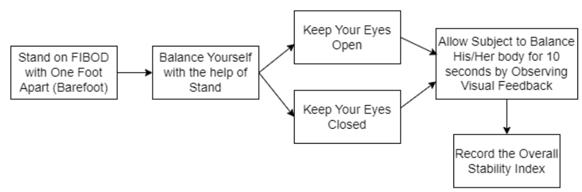

Figure 5 FIBOD trial process

2.3 Performance Metrics

There are multiple aspects included in performance matrices of FIBOD. In the course of the specified 10-second time, one of the major metrics that is analyzed is the degree or severity of departure from the horizontal position. Metrics used to quantify this variation includes the Overall Stability Index (OSI), the Medio-Lateral Stability Index (MLSI), and the Anterior-Posterior Stability Index (APSI) [18]. These indices are mainly standard deviations used to assess the fluctuations around the zero point instead of group mean. APSI measures standard deviations along the anterior-posterior axis, while MLSI measures them along the medial-lateral axis. The OSI represents a combination of both the MLSI and APSI indices. All collected data is documented and included in a report, allowing users to track their performance improvements over time [11]. When the values of OSI, MLSI, and APSI are higher, it indicates that the individual's balance is weaker, which means that they deviated from the horizontal posture more frequently or with more severity [18]. For this reason, a higher OSI, for example, would suggest that the participant had a greater likelihood of experiencing difficulties in keeping their equilibrium throughout the trial.

One of the performance metrics that was recorded for the SLS test was the amount of time it took for the individuals to keep their balance. During the 10-second trial, the individual's involuntary steps and compensatory movements are painstakingly logged. This includes every action that the person does. These unexpected movements serve as unambiguous markers of balance disturbances, and a larger frequency of such events suggests that there may be difficulties in maintaining equilibrium.

Comparing the results obtained under both the eyes-open and eyes-closed condition is an additional essential component of the metrics. Using this contrast, extent to which a person relies on visual input in order to maintain their equilibrium can be detected. If a subject displays a greater number of disturbances or deviations while performing with their eyes closed, this may suggest that they have a significant need on visual feedback in order to maintain balance. When considered as a whole, these metrics provide a comprehensive knowledge of the capabilities of an individual with regard to balance when interacting with the FIBOD.

3.0 RESULTS AND DISCUSSION

Correlation analyses were performed to examine the relationship between the outcomes of the FIBOD test and the SLS test using Pearson correlation. The FIBOD test yielded measurements for the Overall Stability Index (OSI), Medio-Lateral Stability Index (MLSI), Anterior-Posterior Stability Index (APSI), and Sway Velocity (SV). Each of these values was recorded, and subsequent correlation graphs were generated for each of them.

For the SLS test with open eyes, values for all subjects exceeded 45 seconds, and showed no correlation with FIBOD scores. In contrast, for the closed eyes SLS, the mean duration was 28.36±13.31 seconds. As expected, subjects could maintain their balance for a shorter period during eyes closed condition compared to eyes open. Therefore, the results presented in this paper focused on closed-eye conditions only.

The matrix plot illustrating the correlation between the OSI under closed-eye conditions and the SLS with closed eyes is shown in Figure 6. A Pearson correlation coefficient of r=-0.814 was established, with a 95% confidence interval (CI) spanning from -0.922 to -0.589.

For the FIBOD test under closed-eye conditions, the recorded values were as follows: OSI had a mean value of 3.66 ± 2.54, MLSI had a mean value of 2.71 ± 2.32, APSI had a mean value of 2.21 ± 1.53, and sway velocity had a mean value of 3.60 ± 2.89 degree per second. In the equation above the graph, the intercept 43.99 suggests the SLS duration when OSI is zero, and the slope -4.266 indicates that SLS duration decreases by about 4.266 seconds for each one-degree per second increase in OSI, showing an inverse relationship between these variables.

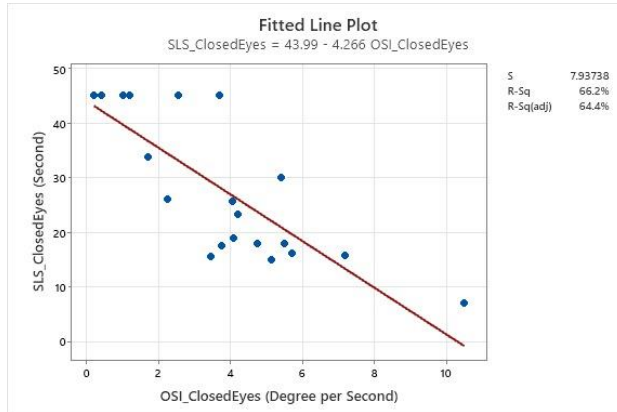

Figure 6 Correlation between Overall Stability Index (OSI) with Closed Eyes and Single Leg Stance (SLS) with Closed Eyes.

Following this, the matrix plot highlighting the relationship between the Medio-Lateral Stability Index (MLSI) with closed eyes and the SLS with closed eyes is presented in Figure 7. This analysis rendered a Pearson correlation coefficient of r=-0.785, with its 95% CI ranging between -0.909 and -0.535. In the equation above the graph, the intercept 40.58 indicates the SLS duration when MLSI is zero, and the slope of -4.508 shows that SLS duration decreases by about 4.508 seconds for each one-degree per second increase in MLSI, demonstrating an inverse relationship between these variables.

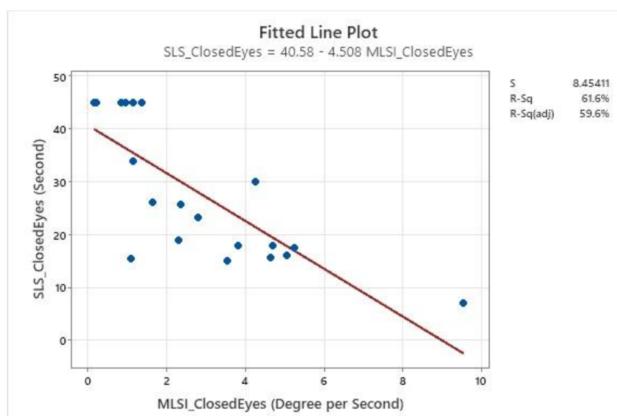

Figure 7 Correlation between Medio-Lateral Stability Index (MLSI) with Closed Eyes and Single Leg Stance (SLS) with Closed Eyes

Additionally, the correlation between the Anterior-Posterior Stability Index (APSI) under closed-eye conditions and the SLS under similar conditions is shown in Figure 8. The Pearson correlation coefficient for this comparison was r=-0.693, with a 95% CI of -0.866 to -0.373. In the equation above the graph, the intercept 41.71 indicates the SLS duration when APSI is zero, and the slope of -6.034 shows that SLS duration decreases by about 6.034 seconds for each one-degree per second increase in APSI, demonstrating an inverse relationship between these variables.

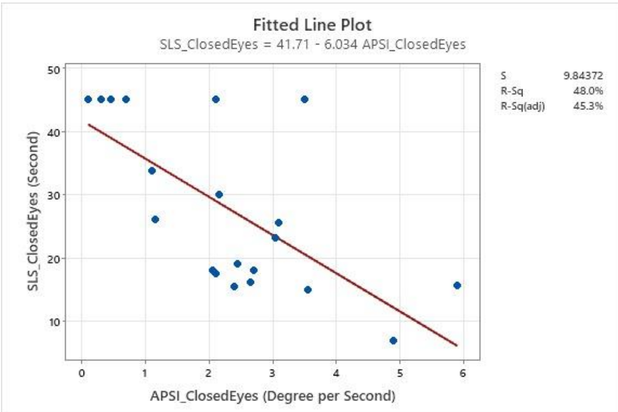

Figure 8 Correlation between Anterior-Posterior Stability Index (APSI) with Closed Eyes and Single Leg Stance (SLS) with Closed Eyes

Lastly, the correlation between Sway Velocity (SV) from the FIBOD test under closed eyes condition and the SLS is visualized in the matrix plot of Figure 9. This pairing yielded a Pearson correlation value of r=-0.610, with 95% CI of -0.825 to -0.243. In the equation above the graph, the intercept 38.47 indicates the SLS duration when SV (Sagittal Velocity) is zero, and the slope of -2.807 shows that SLS duration decreases by about 2.807 seconds for each one-degree per second increase in SV, demonstrating an inverse relationship between these variables.

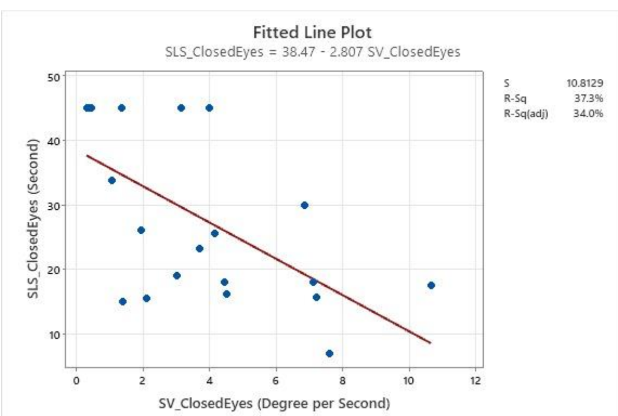

Figure 9 Correlation between Sway Velocity (SV) from Fitness Balance Board (FIBOD) with Closed Eyes and Single Leg Stance (SLS)

Analyses involving the FIBOD with open eyes versus the SLS with open eyes were deemed inappropriate for the scope of this study, as all SLS values under open-eye conditions exceeded 45 seconds. Supplementary analyses contrasting the FIBOD with open eyes and the SLS with closed eyes were also performed, but these did not show a strong correlation, and thus were not considered significant for the objectives of this study.

A key observation is the inverse relationship between OSI (Overall Stability Index) values and SLS duration. An increase in OSI values, which indicates greater instability, corresponds with a decrease in SLS duration, suggesting poorer balance. This finding aligns with the OSI's intended purpose to objectively quantify stability, where higher values represent greater instability. The strong negative correlation coefficient of r=-0.814 between the Overall Stability Index (OSI) under closed-eye conditions and the SLS under the same visual conditions is indicative of the feasibility of using FIBOD as a balance assessment tool. A standout observation from the Single Leg Stance (SLS) test was the general ability of participants to maintain balance for a full 45 seconds with open eyes The fact that this may imply that a balancing time of forty-five seconds might be deemed conventional for healthy adults when visual signals are present highlights the intricacy of the situation. It is also important to note that the mean time of the SLS test with closed eyelids was 28.3576 seconds, which is a substantial decrease from the open-eye condition.

However, the analysis becomes more complex when the FIBOD outcomes were examined. Unlike the SLS test's consistent results, the FIBOD test's advanced measurements show a more complex equilibrium picture. For example, the correlation coefficients for the Medio-Lateral Stability Index (MLSI) and the Anterior-Posterior Stability Index (APSI) with the SLS test under closed-eye settings were r=-0.785 and r=-0.693, respectively. These results were obtained from the studies that were conducted. The existence of both of these values sheds information on the capability of the FIBOD to catch balance deviations that may not be noticeable in the typical SLS test.

As a result of the absence of visual signals, the SLS and FIBOD tests presented a significantly more difficult task while the eyes were closed. Although several people exhibited longer balance durations in the SLS test, their FIBOD outcomes were poorer. This corroborates the idea that time does not necessarily serve as an indicator of the quality of balance. Several factors affect the assessment of true balance proficiency. These include bodily instability, weight changes, and muscular tension changes. The FIBOD is particularly engineered to better gather these attributes.

This study illuminates the constraints of the standard Single Leg Stance (SLS) test when compared to the FIBOD's more sophisticated data. Other studies have praised the effectiveness of FIBOD in terms of both assessing and teaching balance, particularly when it is combined with interactive virtual reality training programs [18, 19, 21].

Furthermore, difficulties such as the ceiling effect that is associated with traditional balance scales such as the Berg Balance Scale (BBS) highlight the advantage of FIBOD in terms of capturing the intricacies of balance, particularly among individuals who have higher levels of performance. With FIBOD and other sensor-based gadgets, healthy people may better understand their balance. Traditional balance tests like the SLS provide fundamental information, but new tools deepen balance comprehension. One of the many aspects of this complex talent is long-term balance. Traditional balance tests like the SLS provide fundamental information, but new tools deepen balance comprehension. One of the many aspects of this complex talent is long-term balance. True balance requires stability, muscular control, and proprioception. Modern methods like the FIBOD capture these features more comprehensively. FIBOD's potential may be studied further, especially for a wide range of people.

4.0 CONCLUSION

This study provides a comprehensive analysis between the Fitness Balance Board (FIBOD) and the conventional Single Leg Stance (SLS) test, by giving emphasis to the enhanced capabilities of the FIBOD device in evaluating balance of the healthy population. This research shows that the FIBOD is not only an effective tool for sensor-based balance assessments but also highlights the disadvantages of traditional methods like the SLS. Stability and balance are better assessed using FIBOD performance metrics including OSI, MLSI, APSI, and sway velocity. These data show that FIBOD can reduce fall risk, improve balance, and aid clinicians in interpreting stability data. Furthermore, the reliable and feasible nature of FIBOD as an alternative tool to conventional balance assessment methods is emphasized by the consistent results obtained, corroborate previous research. The FIBOD is a highly reliable and intelligent device for training in and assessing balance. It is expected to play a crucial role in future research on balance and stability.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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