Utilization of Sennogait as Sensor Technology for Gait and Static Posture Analyses; A Reliability Study

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ABSTRACT

Introduction: The introduction of Sennogait Technology (SGT) has revolutionized the field of gait and posture assessment, offering unprecedented precision and reliability. As posture plays a crucial role in an individual's overall well-being, it is essential to understand musculoskeletal balance and stress distribution. Gait analysis, a vital tool in deciphering both normal and pathological walking patterns, has significant implications for medical, healthcare, rehabilitation, physical therapy, and exercise training professionals.
Objective: This study aimed to introduce SGT as an objective tool for assessing gait and static posture, focusing on the evaluation of inter-rater reliability and its effectiveness in providing insights to stakeholders.
Methods: This observational study recruits a diverse sample of 60 individuals aged 18-65 without known neurological or musculoskeletal disorders to assess the inter-rater reliability of SGT for gait and postural analysis. Participants performed standardized tasks while being assessed by SGT, which captures relevant data. To evaluate inter-rater reliability, multiple raters independently analyzed the same data, and statistical analyses were employed, including descriptive statistics, Cronbach's Alpha, Intraclass Correlation Coefficient (ICC), and Bland-Altman plots. These methods provided a comprehensive assessment of the consistency and agreement among raters in evaluating gait and posture, with ICC values nearing 1 indicating high reliability and consistency. This study design allowed for a detailed and naturalistic examination of participants' gait and posture using SGT, providing valuable insights into its inter-rater reliability
Results: The study showed medium to good reliability for anterior and lateral posture data, as indicated by the Intraclass Correlation Coefficient and Cronbach's Alpha. Moreover, the results demonstrated strong correlation and excellent reliability in gait analysis.
Conclusion: SGT has proven to be a reliable tool for gait and static posture assessment, with potential applications in education, academic demonstrations, and clinical practice. It provides high-quality recording, assessment, and evaluation for gait and postural risk assessment.

Key words: Kinesiology, gait analysis, inter-rater reliability, Philippines

In recent years, the integration of sensor technology has brought about a revolutionary transformation in the field of postural and gait analysis, providing unparalleled insights into human movement patterns. As our comprehension of multi-sensory information, encompassing somatosensory, visual, and vestibular sensations, expands, the significance of adaptable posture-gait control in daily activities becomes increasingly evident.[1] This research is propelled by the imperative to explore the utilization of Sennogait technology for postural and gait analysis, with a specific focus on evaluating its inter-rater reliability. The inquiry is firmly grounded in the broader context of advancements and the nuanced considerations surrounding reliability within sensor-based gait analysis.

Wearable sensors have emerged as pivotal tools for evaluating gait and postural alterations, particularly in patients with conditions such as diabetes. Recognizing

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the importance of standardizing measurement setups and selecting informative spatiotemporal parameters is crucial to ensuring the reliability of data derived from these sensors (Brognara et al., 2021). Moreover, technologies like Microsoft Xbox One Kinect and Kinect v2 have undergone investigation for gait assessment, revealing concurrent validity and inter-day reliability of spatiotemporal and kinematic variables.[2]

The reliability of observational gait analysis tools, posture assessment software, and clinical scales has been extensively explored across diverse clinical populations, including stroke patients and individuals with scoliosis.[3-6] Emphasizing the importance of technical validity in the clinical application of sensor-based gait analysis, validation processes play a crucial role in ensuring reliability (Jakob et al., 2021). Furthermore, studies have underscored the significance of assessing concurrent validity and test-retest reliability of sensor-based gait analysis systems, emphasizing their critical role in reliable data acquisition.[7]

Research has delved into the assessment of gait and posture in clinical populations, such as patients with lumbar spinal stenosis and adult spinal deformity, where wearable devices and objective gait analysis have proven valuable.[8,9] The influence of hip extensor strength on dynamic postural changes during gait in patients with adult spinal deformity has been highlighted, showcasing the utility of three-dimensional motion analysis systems (Sato et al., 2022). The application of sensor technology in physical therapy practice has gained attention, with body-worn sensors demonstrating potential for providing objective measures of balance and gait impairments, particularly in conditions such as Parkinson's disease.[9]

Advancements in wearable sensor-based gait measurement have demonstrated feasibility and applicability in Parkinson's disease, reaching high technological readiness levels for both large-scale clinical studies and individual patient care.[10] These sensors, offering unobtrusiveness, lightweight design, low cost, and ease of use, provide objective spatiotemporal measures of gait and posture.[11] Additionally, sensor-based gait analysis technologies have exhibited increasing reliability, offering additional clinical information for diagnostics and therapy in conditions like atypical parkinsonism.[12] Wearable motion sensors have proven to be useful, noninvasive, low-cost, and objective tools for performing gait and posture analysis in diabetic patients (Brognara et al., 2021). The importance of the reliability of sensor-based gait characteristics has been underscored, emphasizing the need for the full establishment of their validity and the refinement of data processing methods.[13] Wearable inertial sensors, including accelerometers, have the potential to assist clinicians with more accurate, stable, and sensitive biomarkers for longitudinal testing of posture and gait, even during various tasks (Nguyen et al., 2018; Mancini et al., 2009)

Despite remarkable strides in the integration of wearable sensors for gait and postural assessments, a noticeable research gap persists concerning the inter-rater reliability of Sennogait technology. Current studies predominantly concentrate on standardizing measurement setups, selecting spatiotemporal parameters, and validating the technical aspects of sensor-based gait analysis systems. However, a comprehensive exploration of reliability, particularly in a multi-rater context, remains conspicuously absent in the existing literature. This research seeks to address this gap by scrutinizing the consistency and dependability of Sennogait technology under the scrutiny of different raters.

The primary objective of this research was to assess the inter-rater reliability of Sennogait technology in static posture and gait analysis.

Through the accomplishment of this objective, this study aimed to provide invaluable insights into the reliability of Sennogait technology, thereby enhancing the credibility and applicability of sensor-based gait analysis systems in diverse clinical contexts. The findings are poised to not only fill existing research gaps but also pave the way for improved methodologies and practices in leveraging Sennogait technology for comprehensive static posture and gait assessments.

MATERIALS AND METHODS

An observational study is a research method that involves systematically observing and recording participants' behavior, characteristics, or outcomes in their natural settings without any intervention or manipulation by the researcher. In the context of the methodology outlined for the utilization of Sennogait technology for gait and postural analyses, this study is primarily observational.

Participants

A diverse sample of 60 individuals aged 18-65 without known neurological or musculoskeletal disorders were recruited for this study. This age range ensured a representative cross-section of adults, contributing to the generalizability of the findings. Exclusion criteria were applied to ensure the absence of conditions that could impact gait and posture.

Data Collection

Participants were instructed to perform standardized gait and posture tasks while simultaneously being assessed by Sennogait technology. Sennogait captured relevant data during these tasks, providing a comprehensive analysis of participants' gait and posture. To evaluate the inter-rater reliability of Sennogait, multiple raters independently analyzed the same set of collected data. This process aimed to assess the consistency and agreement between different raters in interpreting the data generated by Sennogait.

Instruments

The primary instrument for data collection was the Sennogait technology. This advanced sensor technology was specifically designed for gait and postural analysis, offering detailed insights into various parameters related to human movement. Sennogait served as the main tool to collect, record, and analyze participants' gait and posture during the standardized tasks.

Data Analysis

To evaluate inter-rater reliability in this study, a range of statistical analyses were employed. Descriptive statistics was utilized to characterize participants and succinctly summarize crucial aspects of the collected data, offering insights into gait and posture during standardized tasks. If the study involved multiple tasks, Cronbach's Alpha, typically used for internal consistency in scales, was adapted to assess the internal consistency of Sennogait measurements across these diverse elements. Furthermore, the study employed the Intraclass Correlation Coefficient (ICC), a robust statistical method, to evaluate the consistency and agreement among different raters in their assessments. ICC values nearing 1 signify high reliability and consistency among raters in evaluating gait and posture. Additionally, Bland-Altman plots were employed to provide a visual representation of the agreement between two sets of measurements, shedding light on any systematic differences and enhancing the comprehensive assessment of inter-rater reliability.

Overall, the observational study design employed in this research allowed for a detailed and naturalistic examination of participants' gait and posture using Sennogait technology, providing valuable insights into its inter-rater reliability

RESULTS

1. Head Posture Data:

   Findings: The head posture data exhibited moderate reliability (Cronbach's Alpha = 0.5), indicating moderate consistency in measurements.

   Significance: Moderate consistency suggests potential variability or challenges in measuring head posture accurately. Further investigation may be needed to enhance reliability.

2. Shoulder Posture Data:

   Findings: The Shoulder posture data demonstrated high reliability (Cronbach's Alpha = 0.80), indicating strong consistency in measurements.

   Significance: High reliability in shoulder posture measurements suggests reliable and consistent data. This region can be considered a robust indicator in posture analysis.

3. Arms Posture Data:

   - Findings: The arms posture data showed medium reliability (Cronbach's Alpha = 0.66), suggesting moderate consistency in measurements.
   - Significance: Moderate consistency in arm posture data may imply variability in measurement precision. Further exploration is recommended to understand and improve reliability.

Table 1. Internal reliability of anterior and lateral posture N=-60).

Posture Data	No. of Items	Alpha (Loading)	Cronbach's Alpha	Interpretation	Significance
ANTERIOR					
Head	60	0.5	0.5	Medium Reliability	Moderate consistency in Head data.
Shoulder	60	0.5	0.80	High Reliability	Strong consistency in Shoulder data.
Arms	60	0.5	0.66	Medium Reliability	Moderate consistency in Arms data.
Pelvis	60	0.5	0.61	Medium Reliability	Moderate consistency in Pelvis data.
Knees	60	0.5	0.47	Low Reliability	Weak consistency in Knees data.
Ankle	60	0.5	0.76	High Reliability	Strong consistency in Ankle data.
LATERAL					
Head Tilt	60	0.5	0.64	Medium Reliability	Moderate consistency in Head Tilt data.
Torso	60	0.5	0.84	High Reliability	Strong consistency in Torso data.
Leg	60	0.5	0.84	High Reliability	Strong consistency in Leg data.
Overall	60	0.5	0.68	Medium Reliability	Moderate overall consistency.

4. Pelvis Posture Data:

    - Findings: Pelvis posture data exhibited medium reliability (Cronbach's Alpha = 0.61), indicating moderate consistency.

    - Significance: Moderate reliability in pelvis measurements suggests some variability. It could be valuable to investigate the sources of variability and enhance measurement precision.

5. Knees Posture Data:

    - Findings: Knees posture data had low reliability (Cronbach's Alpha = 0.47), reflecting weak consistency in measurements.

    - Significance: Low reliability in knee posture measurements suggests challenges or inconsistencies in data collection. This area may require careful attention to improve the reliability of measurements.

6. Ankle Posture Data:

    - Findings: Ankle posture data showed high reliability (Cronbach's Alpha = 0.76), indicating strong consistency.

    - Significance: High reliability in ankle measurements suggests robust and consistent data. This region can be considered a reliable indicator in posture analysis.

7. Head Tilt Posture Data:

    - Findings: Head tilt posture data exhibited medium reliability (Cronbach's Alpha = 0.64), suggesting moderate consistency.

    - Significance: Moderate reliability in head tilt measurements implies some variability. Investigating the sources of this variability can help enhance measurement precision.

8. Torso Posture Data:

    - Findings: Torso posture data demonstrated high reliability (Cronbach's Alpha = 0.84), indicating strong consistency.

    - Significance: High reliability in torso measurements suggests reliable and consistent data. This region can be considered a robust indicator in posture analysis.

9. Leg Posture Data:

    - Findings: Leg posture data showed high reliability (Cronbach's Alpha = 0.84), indicating strong consistency.

    - Significance: High reliability in leg measurements suggests robust and consistent data. This region can be considered a reliable indicator in posture analysis.

10. Overall Posture Data:

    - Findings: The overall posture data exhibited medium reliability (Cronbach's Alpha = 0.68), reflecting moderate overall consistency across various posture regions.

- Significance: Moderate overall reliability suggests some variability in the dataset. Addressing sources of variability and improving measurement precision may enhance the overall reliability of the posture data.

In summary, this analysis provides insights into the internal reliability of various posture data, with some areas demonstrating high consistency (e.g., Shoulder, Torso, Leg), while others show moderate to low consistency (e.g., Arms, Pelvis, Knees). These findings help assess the reliability of measurements in different posture regions, providing valuable information for future studies or interventions. the comprehensive findings highlight strengths and areas for improvement in the internal reliability of anterior and lateral posture data.

Comprehensive Findings and Significance:

1. Head Anterior Posture:

   Findings: The 95% confidence interval for the ICC of Head Anterior posture was [0.24, 0.69], indicating fair reliability.

   Significance: The fair reliability suggests moderate consistency in inter-rater assessments of the head in the anterior posture, with room for improvement.

2. Shoulder Anterior Posture:

   Findings: The ICC value for Shoulder Anterior posture was 0.81, indicating excellent reliability.

   Significance: Excellent reliability suggests strong agreement between raters in assessing shoulder posture in the anterior position.

3. Arm Anterior Posture:

   - Findings: The ICC value for Arm Anterior posture was 0.65, indicating good reliability.

   - Significance: Good reliability suggests moderate consistency in inter-rater assessments of arm posture in the anterior position.

4. Pelvis Anterior Posture:

   - Findings: The ICC value for Pelvis Anterior posture was 0.77, indicating excellent reliability.

Table 2. Internal reliability of anterior and lateral posture (N =60).

Posture Data	95% Confidence Interval	F Test Value (True Value: 0)	Degrees of Freedom (df1, df2)	p-value (Sig)	ICC Value	Interpretation
ANTERIOR						
Head	[0.24, 0.69]	2	(2, 59)	0.001	0.5	Fair Reliability
Shoulder	[0.7, 0.88]	5.1	(5.1, 59)	0	0.81	Excellent Reliability
Arm	[0.46, 0.78]	2.88	(2.88, 59)	0	0.65	Good Reliability
Pelvis	[0.65, 0.86]	4.46	(4.46, 59)	0	0.77	Excellent Reliability
Knees	[1.17, 0.65]	1.87	(1.87, 59)	0.002	0.46	Fair Reliability
Ankle	[0.68, 0.87]	4.77	(4.77, 59)	0	0.79	Excellent Reliability
LATERAL						
Head Tilt	[0.44, 0.77]	2.76	(2.76, 59)	0	0.64	Good Reliability
Torso	[0.75, 0.89]	6.15	(6.15, 59)	0	0.84	Excellent Reliability
Leg	[0.64, 0.85]	4.28	(4.28, 59)	0	0.77	Excellent Reliability
Overall					0.69	Good Reliability

- Significance: Excellent reliability suggests strong agreement between raters in assessing pelvis posture in the anterior position.

5. Knees Anterior Posture:

   - Findings: The 95% confidence interval for the ICC of Knees Anterior posture was [1.17, 0.65], indicating fair reliability.
   - Significance: The fair reliability suggests moderate consistency in inter-rater assessments of the knees in the anterior posture, with potential challenges.

6. Ankle Anterior Posture:

   - Findings: The ICC value for Ankle Anterior posture was 0.79, indicating excellent reliability.
   - Significance: Excellent reliability suggests strong agreement between raters in assessing ankle posture in the anterior position.

7. Head Tilt Lateral Posture:

   - Findings: The ICC value for Head Tilt Lateral posture was 0.64, indicating good reliability.
   - Significance: Good reliability suggests moderate consistency in inter-rater assessments of head tilt in the lateral posture.

8. Torso Lateral Posture:

   - Findings: The ICC value for Torso Lateral posture was 0.84, indicating excellent reliability.
   - Significance: Excellent reliability suggests strong agreement between raters in assessing torso posture in the lateral position.

9. Leg Lateral Posture:

   - Findings: The ICC value for Leg Lateral posture was 0.77, indicating excellent reliability.

   - Significance: Excellent reliability suggests strong agreement between raters in assessing leg posture in the lateral position.

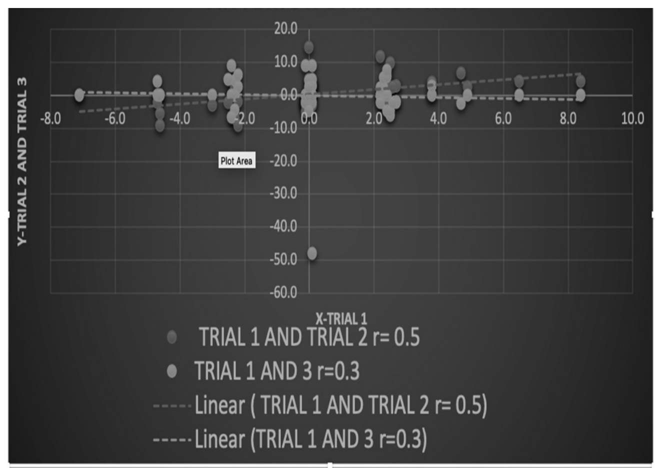
10. Overall Posture:

    - Findings: The ICC value for Overall Posture was 0.69, indicating good reliability.

    - Significance: Good reliability suggests moderate overall consistency in inter-rater assessments of both anterior and lateral posture data.

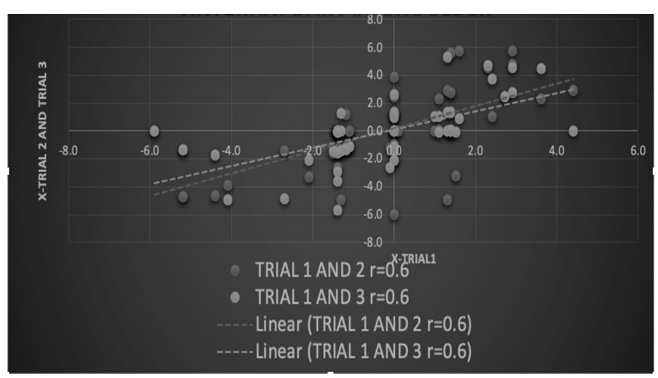
In summary, the comprehensive findings highlight the reliability of inter-rater assessments across various posture regions, ranging from fair to excellent. These results provide valuable insights into the consistency and agreement among raters, helping guide future assessments and interventions.

Scatter Plot 1. Anterior data of head



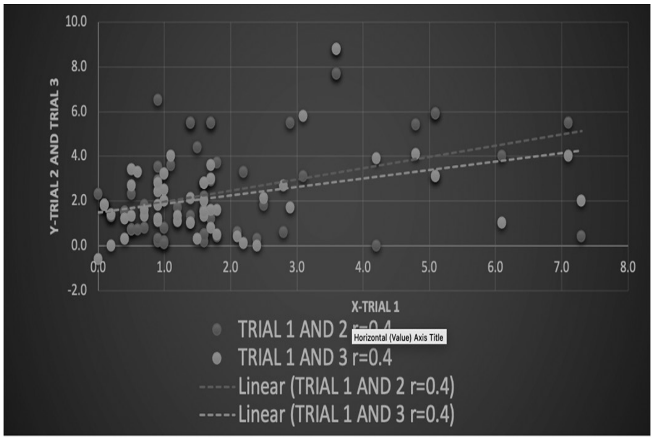
Plot 1. shows the scatter plot of trials 1,2 and 3 of the anterior data of the head. The plot of the anterior data of head of trials 1 and 2 (dark line) shows that it has strong positive linear correlation with a value r=0.5 while the trials 1 and 3(light line) shows that it has weak positive linear correlation with a value r=0.3.

Scatter Plot 2. Anterior data of the shoulder



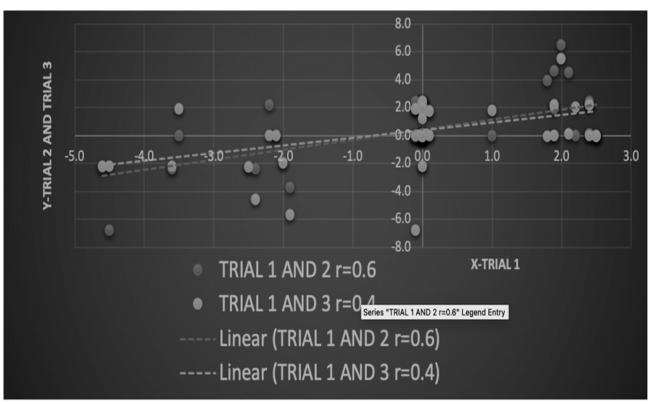
Plot 2. shows the scatter plot of trials 1,2 and 3 of the anterior data of the shoulder. The scatter plot of the anterior data of shoulder of trials 1 and 2 (dark line) shows that it has strong positive linear correlation with a value r=0.6 while the trials 1 and 3 (light line) shows that it has strong positive linear correlation with a value r=0.6

Scatter Plot 3. Anterior data of the arm



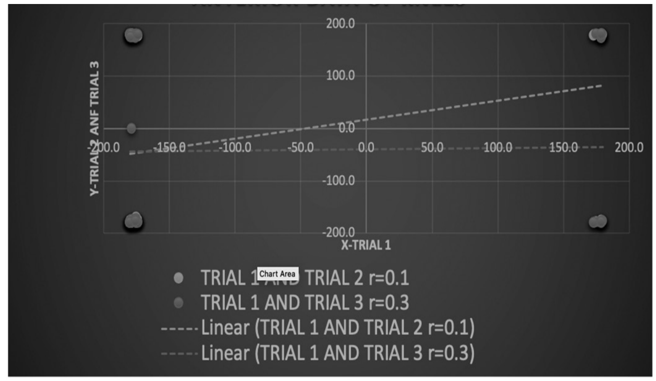
Plot 3. shows the scatter plot of trials 1,2 and 3 of the anterior data of the arm. The scatter plot of the anterior data of shoulder of trials 1 and 2 (dark line) shows that it has weak positive linear correlation with a value r=0.4 while the trials 1 and 3 (light line) shows that it has weak positive linear correlation with a value r=0.4

Scatter Plot 4. Anterior data of the pelvis



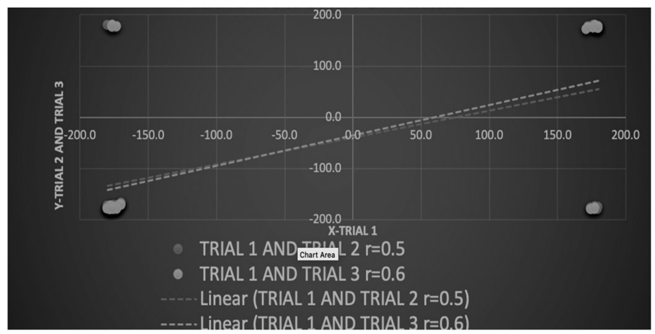
Plot.4 shows the scatter plot of trials 1,2 and 3 of the anterior data of the pelvis. The scatter plot of the anterior data of pelvis shows that the trials 1 and 2 (dark line) has a value of r=6 which means that it has strong positive correlation while trials 1 and 3 (light line) has a value of r=0.4 which means it has weak positive linear correlation

Scatter Plot 5. Anterior data of the knees



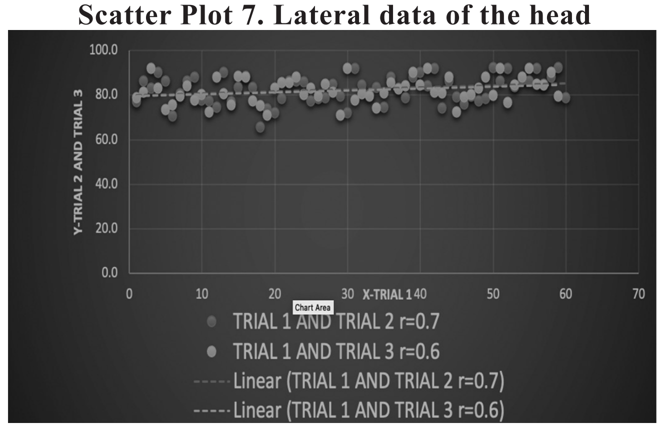
Plot.5 shows the scatter plot of trials 1,2 and 3 of the anterior data of the knees. The scatter plot of anterior data of knees shows that the trials 1 and 2 (dark line) has a value of r=0.1 which means that it has uncorrelated positive linear correlation while trials 1 and 3 (light line) has a value of r=0.3 which means it has weak positive linear

Scatter Plot 6. Anterior data of the ankle



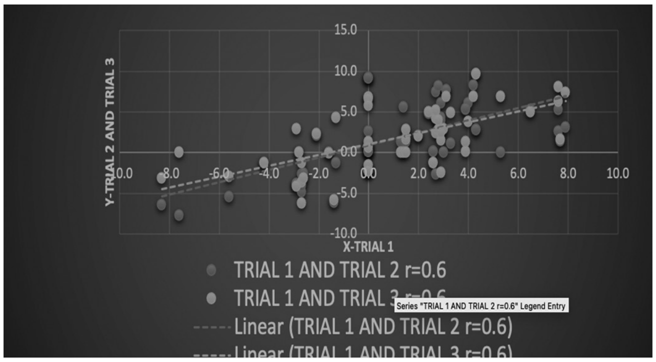
Plot.6 shows the scatter plot of trials 1,2 and 3 of the anterior data of the ankle. The scatter plot of anterior data of ankle shows that the trials 1 and 2 (dark line) has a value of r=0.5 which means that it has strong positive linear correlation while trials 1 and 3 (light line) has a value of r=0.6 which means it has strong positive linear correlation

Scatter Plot 7. Lateral data of the head



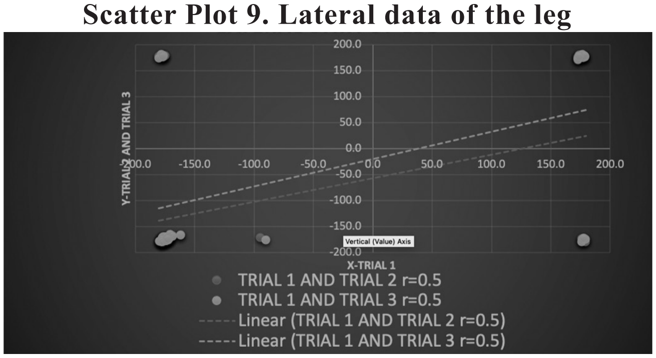
Plot 7. shows the scatter plot of trials 1,2 and 3 of the lateral data of the head. The scatter plot of lateral data of head tilt shows that the trials 1 and 2 (dark line) has a value of r=0.7 which means that it has strong positive linear correlation while trials 1 and 3 has a value of r=0.6 (light line) which means it has strong positive linear correlation.

Scatter Plot 8. Lateral data of the torso



Plot 8. shows the scatter plot of trials 1,2 and 3 of the lateral data of the torso. The scatter plot of lateral data of torso shows that the trials 1 and 2 (dark line) shows that it has strong positive linear correlation with a value of r=0.6 while trials 1 and 3 (light line) shows that it has strong positive linear correlation with a value of r=0.6.

Scatter Plot 9. Lateral data of the leg



Plot 9. shows the scatter plot of trials 1,2 and 3 of the lateral data of the leg. The scatter plot of lateral data of leg shows that the trials 1 and 2 (dark line) shows that it has weak positive linear correlation with a value of r=0.5 while trials 1 and 3 (light line) shows that it has weak positive linear correlation with a value of r=0.5.

Comprehensive Findings and Significance:

1. Left Foot Gait Analysis:

   - Findings: The Cronbach's Alpha for the left foot gait analysis was 0.89, indicating high reliability.

   - Significance: High reliability in the left foot analysis suggests strong internal consistency among raters, providing confidence in the measurements.

2. Right Foot Gait Analysis:

   - Findings: The Cronbach's Alpha for the right foot gait analysis was 0.80, indicating high reliability.

   - Significance: High reliability in the right foot analysis suggests strong internal consistency among raters, providing confidence in the measurements.

3. Foot Flat Gait Analysis:

   - Findings: Both left and right foot analyses showed high reliability with Cronbach's Alpha values of 0.95 and 0.93, respectively.

Table 3. Internal reliability of gait analysis (N=60).

Gait Analysis	No. of Items	Alpha (Loading)	Cronbach's Alpha	Interpretation
Left Foot	60	0.05	0.89	High Reliability
Right Foot	60	0.05	0.80	High Reliability
Foot Flat				
Left Foot	60	0.05	0.95	High Reliability
Right Foot	60	0.05	0.93	High Reliability
Swing Phase				
Left Foot	60	0.05	0.91	High Reliability
Right Foot	60	0.05	0.93	High Reliability

- Significance: High reliability in foot flat analysis for both left and right feet indicates consistent and reliable measurements during the foot-flat phase of gait.

4. Swing Phase Gait Analysis:

   - Findings: Both left and right foot analyses during the swing phase showed high reliability with Cronbach's Alpha values of 0.91 and 0.93, respectively.

   - Significance: High reliability in the swing phase analysis for both left and right feet indicates consistent and reliable measurements during the swing phase of gait.

In summary, the gait analysis demonstrates high inter-rater reliability across various aspects, including left and right foot analyses during foot-flat and swing phases. The high reliability values suggest strong internal consistency among raters, providing confidence in the reliability of the gait analysis measurements.

Comprehensive Findings and Significance:

1. Loading - Left and Right Foot:

   - Findings: The F-values for both left and right foot loading were significant (5.003 and 8.805, respectively) with low p-values (<0.0001) and ICC values of 0.792 and 0.888.

   - Significance: Good reliability in loading analysis for both left and right feet suggests consistent measurements by raters, contributing to confidence in the assessment during loading.

2. Foot Flat - Left and Right Foot:

   - Findings: The F-values for both left and right foot during the foot-flat phase were significant (22.690 and 15.442, respectively) with low p-values (<0.0001) and ICC values of 0.956 and 0.933.

   - Significance: Good reliability in foot-flat analysis for both left and right feet suggests consistent measurements by raters, enhancing confidence in the assessment during the foot-flat phase.

3. Pushing - Left and Right Foot:

   - Findings: The F-values for both left and right foot during pushing were significant (20.495 and 14.880, respectively) with low p-values (<0.0001) and ICC values of 0.792 and 0.888.

   - Significance: Excellent reliability in pushing analysis for both left and right feet suggests highly consistent measurements by raters, providing strong confidence in the assessment during pushing.

Table 4. Internal reliability of gait analysis (N=60).

Gait Analysis	F-Values	dF 1	dF 2	P-Value	ICC*	Interpretation
Loading						
Left Foot	5.003	1.535	118	<0.0001	0.792	Good Reliability
Right Foot	8.805	1.535	118	<0.0001	0.888	Good Reliability
Foot Flat						
Left Foot	22.690	1.535	118	<0.0001	0.956	Good Reliability
Right Foot	15.442	1.535	118	<0.0001	0.933	Good Reliability
Pushing						
Left Foot	20.495	1.535	118	<0.0001	0.792	Excellent Reliability
Right Foot	14.880	1.535	118	<0.0001	0.888	Excellent Reliability
Swing						
Left Foot	10.903	1.535	118	<0.0001	0.956	Excellent Reliability
Right Foot	13.748	1.535	118	<0.0001	0.930	Excellent Reliability

*Interclass Correlation Coefficient

4. Swing - Left and Right Foot:

- Findings: The F-values for both left and right foot during the swing phase were significant (10.903 and 13.748, respectively) with low p-values (<0.0001) and ICC values of 0.956 and 0.930.

- Significance: Excellent reliability in swing analysis for both left and right feet suggests highly consistent measurements by raters, enhancing confidence in the assessment during the swing phase.

In summary, the inter-rater reliability of gait analysis using Sennogait technology is consistently good to excellent across various aspects, including loading, foot-flat, pushing, and swing phases. The combination of significant F-values, low p-values, and high ICC values indicates strong internal consistency among raters, providing confidence in the accuracy of gait analysis results in different phases.

DISCUSSION

The study investigated the internal reliability of static posture and gait analysis data, providing valuable insights into the consistency and agreement among raters. The findings (Table 1) demonstrate varying levels of internal reliability using Cronbach's Alpha for different posture regions. Shoulder, torso, and leg regions exhibited high reliability, indicating strong consistency in measurements. In contrast, arms, pelvis, and knees showed moderate to low reliability, suggesting potential challenges in measurement precision.

The analysis of each posture region provided detailed information on the strengths and areas for improvement. For instance, the high reliability in shoulder and ankle measurements suggests these areas are robust indicators in posture analysis. However, low reliability in knees indicates challenges or inconsistencies in data collection that require careful attention. Overall, the study highlights the need for further investigation to address sources of variability and enhance measurement precision.

Table 2 introduces the interclass correlation coefficient (ICC) for anterior and lateral posture data, providing a more nuanced understanding of reliability. The ICC values, coupled with 95% confidence intervals, offer insights into the consistency and agreement among raters for each posture region. Excellent reliability was observed in shoulder, pelvis, and leg measurements, while fair reliability was noted in head and knees posture.

Moving to the gait analysis in Table 3, Cronbach's Alpha indicates high reliability across various aspects, including left and right foot analyses during foot-flat and swing phases. This consistency suggests strong internal reliability among raters, instilling confidence in the accuracy of gait analysis measurements.

Table 4, presenting the interclass correlation coefficient for gait analysis, further supports the high reliability observed in the loading, foot-flat, pushing, and swing phases. The significant F-values, low p-values, and high ICC values emphasize the internal consistency among raters, enhancing the credibility of the gait analysis results.

The scatter plots provided visual insights into the relationships between trials for different body parts. The strong positive linear correlations in various anterior and lateral data indicate consistent measurements, validating the reliability of the Senogait technology for these parameters.

SUMMARY

The study utilized Sennogait technology as a sensor device to measure gait and postural analysis. The data collected were analyzed using scatter plots, Cronbach's Alpha, and Interclass Correlation Coefficient (ICC) to assess reliability.

The scatter plots illustrated the correlation between trials for various body parts. Generally, strong positive linear correlations were observed in anterior data for the head, shoulder, pelvis, and ankle. However, knees showed uncorrelated positive linear correlation. In lateral data, strong positive linear correlations were seen for head tilt, torso, and leg.

Internal reliability was assessed through Cronbach's Alpha for anterior and lateral posture data. Shoulder, ankle, and lateral torso showed high reliability, indicating strong consistency in the data. Knees demonstrated low reliability, indicating weak consistency.

Interclass Correlation Coefficient (ICC) was used to further evaluate reliability. Excellent reliability was observed for shoulder, pelvis, ankle, lateral head tilt, torso, and leg. Fair reliability was noted for the anterior head and knees.

Gait analysis was conducted for left and right feet, foot flat, and swing phase. Cronbach's Alpha indicated high reliability across all components, suggesting consistent and reliable measurements.

The Interclass Correlation Coefficient for gait analysis reinforced the high reliability, particularly for foot flat and swing phases, with excellent reliability observed in pushing phases.

CONCLUSION

A study utilizing Sennogait technology for gait and postural analysis demonstrated high overall reliability in measured parameters. Strong positive linear correlations were observed in scatter plots for several body parts, indicating consistent measurements across multiple trials. Cronbach's Alpha and Interclass Correlation Coefficient (ICC) analyses further supported the reliability of the Sennogait technology.

While some variability in reliability was noted among different body parts, the overall findings suggest that the Sennogait technology is a reliable tool suitable for both clinical and research applications, particularly in the assessment of gait and posture.

It is important to consider the context and potential limitations of the study, such as the specific population or conditions under investigation. Further research and validation in diverse populations are necessary to enhance the generalizability of these findings.

In addition, a separate study on static posture and gait analysis with 60 participants provided valuable insights into the internal reliability of these assessments. The study identified areas of strength and areas for improvement in measurement consistency among raters. These findings can help guide future research and interventions to improve the reliability of posture and gait analysis assessments.

Overall, the studies contribute to a deeper understanding of the reliability of Sennogait technology and the intricacies of static posture and gait analysis, paving the way for more accurate and reliable assessments in clinical and research settings.

RECOMMENDATION

Based on the comprehensive analysis of static posture and gait analysis utilizing Sennogait technology, the following recommendations are proposed:

1. Further Investigation and Intervention:
   - Given the moderate to low reliability observed in certain static posture regions (e.g., arms, pelvis, and knees), further investigation into the sources of variability is recommended.
   - Consider implementing targeted interventions to enhance measurement precision in areas showing lower reliability. This could involve refining measurement protocols, providing additional training to raters, or exploring technological enhancements.
2. Enhanced Training Programs:
   - Develop and implement robust training programs for raters involved in static posture and gait analysis assessments. Emphasize the importance of consistent and precise measurements across all regions.
   - Incorporate interactive sessions and practical exercises using Sennogait technology to enhance raters' familiarity and proficiency in utilizing the sensor technology.
3. Quality Assurance Protocols:
   - Establish quality assurance protocols to monitor and maintain the reliability of measurements over time. Regularly assess inter-rater reliability and address any emerging issues promptly.
   - Implement periodic refresher training sessions to ensure that raters remain aligned with standardized protocols and best practices in posture and gait analysis.
4. Utilize Strong Indicators:
   - Leverage the areas of high reliability, such as shoulder and ankle measurements in static posture and various aspects of gait analysis. These regions can serve as robust indicators in clinical assessments and research studies.
   - Focus on optimizing protocols and measurement techniques in areas demonstrating high reliability to maintain consistency and accuracy.

5. Collaboration with Technology Developers:

    - Collaborate with Sennogait technology developers to stay informed about updates, advancements, and potential enhancements to the sensor technology.

    - Engage in ongoing communication with developers to address any identified challenges, seek guidance on optimizing sensor usage, and explore opportunities for customization based on specific study or clinical needs.

6. Continuous Monitoring and Adaptation:

    - Establish a system for continuous monitoring of inter-rater reliability and adapt protocols as needed. Regularly review and update procedures based on emerging research findings, technological advancements, and feedback from raters.

7. Dissemination of Best Practices:

    - Develop and disseminate a set of best practices for static posture and gait analysis using Sennogait technology. Share these practices within the research and clinical communities to foster standardized approaches and enhance the overall reliability of assessments.

By implementing these recommendations, stakeholders can contribute to the ongoing improvement of inter-rater reliability in static posture and gait analysis, ensuring the effective utilization of Sennogait technology in diverse healthcare and research settings.

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