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Wireless Motion Sensors for Spatiotemporal Gait Analysis Using Fitknees: A Validity and Test-Retest Reliability Study

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ABSTRACT

Background: Gait analysis is essential for diagnosing movement abnormalities, assessing therapy effectiveness, and optimizing athletic performance. Conventional gait laboratories using force platforms and multi-camera systems are expensive and require controlled laboratory environments. Inertial Measurement Unit (IMU) technologies such as Fitknees®, a wireless motion-sensing system, provide a portable and affordable alternative for real-time gait analysis. The primary objective was to evaluate the validity of Fitknees and its test-retest reliability against the video-based motion analysis system Kinovea.

Methods: A cross-sectional comparison study was conducted in healthy adults. Validity analysis was performed on 12 participants (5 females, 7 males; aged 20–35 years), while 24 participants (10 females, 14 males; aged 23-51years) were included in the reliability analysis. Four Fitknees® sensors were positioned above and below both knees to capture lower-limb motion. Sensor data were transmitted wirelessly to a mobile application via Bluetooth while participants completed a 6-meter walking test at a self-selected speed. Temporal gait parameters, including stride time, stance time, and swing time, were recorded. These measurements were compared with corresponding values obtained from frame-by-frame analysis in Kinovea. For reliability assessment, participants completed four repeated gait trials, and measurement consistency was evaluated using Pearson correlation coefficients.

Results: Fitknees® demonstrated excellent validity for left stride time compared with Kinovea ($r = 0.937$, $p < 0.001$). Moderate positive correlations were observed for stance time on both limbs ($r = 0.641–0.627$, $p < 0.05$). Although correlations for swing time were lower, the system showed moderate to high test–retest reliability across temporal parameters, as measured by The Pearson correlation, coeffecient ranging from 0.54 to 0.79. These findings indicate that Fitknees® can reliably capture key temporal characteristics of gait.

Conclusion: Fitknees® demonstrated strong validity for stride time and moderate validity for stance time, with consistent reliability across repeated gait trials. The results support the potential of wearable IMU-based systems for objective gait assessment, offering a portable alternative to traditional motion analysis approaches. Further refinement of sensor placement and signal processing algorithms may improve the detection of dynamic gait phases such as swing time.

Keywords: Wearable sensors, gait analysis, inertial measurement unit (IMU), spatiotemporal gait parameters, validity and reliability, motion analysis, Fitknees®.

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INTRODUCTION

Human locomotion is characterized by the ability to maintain balance while alternating support between the lower limbs during walking. This dynamic single-limb support is a fundamental feature of bipedal gait and plays a crucial role in maintaining stability and forward progression during locomotion. As highlighted by Kobsar et al. (2020) [1], an accurate evaluation of gait is essential for understanding normal and pathological movement patterns. Consequently, gait analysis has become a critical tool in clinical biomechanics for evaluating musculoskeletal function, identifying movement abnormalities, monitoring rehabilitation progress, and optimizing athletic performance.

The gait cycle is traditionally divided into two major phases: the stance phase, during which the foot remains in contact with the ground, and the swing phase, when the limb advances in preparation for the next step. Each phase contains several sub-phases that collectively determine the efficiency and stability of walking. Parameters such as stride length, cadence, step length, and walking velocity are commonly used to characterize locomotor performance and balance during ambulation. According to Sutherland et al. (1997) [2], understanding these temporal and spatial parameters is fundamental for clinical gait assessment and for identifying deviations associated with musculoskeletal or neurological conditions.

In routine clinical practice, physiotherapists often rely on observational gait analysis (OGA) to assess walking patterns. OGA typically involves visual observation or analysis of video recordings during functional tasks. As discussed by Toro et al. (2003) [3], this approach remains widely used due to its practicality, low cost, and ease of implementation in everyday clinical settings. However, observational methods are inherently subjective and can be influenced by clinician experience, observational bias, and limited temporal resolution. These limitations may affect the validity, reliability, and sensitivity of clinical gait assessments.

To overcome these limitations, more sophisticated instrumented gait analysis systems have been developed. Multi-camera motion capture systems combined with force platforms allow detailed quantification of kinematic and kinetic parameters during walking. However, such laboratory-based systems require specialized infrastructure, expensive equipment, and complex data processing, limiting their accessibility in routine clinical settings. Early research demonstrated the effectiveness of these technologies but also highlighted the logistical challenges associated with their widespread clinical adoption [2].

As a more accessible alternative, video-based motion analysis software has gained popularity in both research and clinical practice. One such tool is Kinovea, an open-source software platform that enables frame-by-frame analysis of movement captured through standard video recordings. Research conducted by Fernández-González et al. (2020) and Guzmán-Valdivia et al. (2013) [4,5] demonstrated that Kinovea provides acceptable agreement with three-dimensional motion capture systems for several basic kinematic parameters, including joint angles, stride characteristics, and step timing. Because of its accessibility and low cost, Kinovea has become a commonly used tool for clinical movement analysis. Furthermore, recent work by Mohamed et al. (2024) [6] has shown that the software also demonstrates good reliability in measuring joint range of motion in clinical settings.

In parallel with advancements in video analysis, wearable inertial measurement unit (IMU) technologies have emerged as promising tools for real-time gait assessment outside laboratory environments. IMU sensors combine accelerometers, gyroscopes, and magnetometers to capture motion data during functional activities. A systematic review [1] reported that wearable inertial sensors demonstrate excellent validity and reliability for measuring temporal gait parameters such as step and stride times. Similarly, Prasanth et al. (2021) [7] highlighted the growing role of wearable technologies in enabling continuous and real-world gait monitoring.

Recent research has also explored hybrid approaches combining wearable sensors with vision-based systems to enhance measurement accuracy. For instance, Bijalwan et al. (2021) [8] proposed multi-sensor fusion frameworks integrating wearable sensors with camera-based motion capture to improve biomechanical gait analysis. Additionally, Chen et al. (2016) [9] strongly advocated integrating wearable sensor systems into rehabilitation monitoring, emphasizing their potential to enable pervasive mobility assessment in clinical practice.

Despite these technological advancements, a fundamental understanding of gait parameters and their biomechanical implications remains essential for interpreting locomotor patterns and identifying abnormalities. Reviews such as the work by Kharb et al. (2011) [10] emphasize that accurate measurement of temporal gait parameters is critical for evaluating walking efficiency, balance, and rehabilitation outcomes.

Given the growing interest in wearable gait-monitoring systems, there is a need to evaluate their measurement accuracy and reliability relative to established analysis methods. Therefore, the primary aim of the present study was to assess the validity and test-retest reliability of the Fitknees® IMU-based sensor system for measuring spatiotemporal gait parameters. Specifically, the study compares gait measurements obtained from Fitknees with those derived from Kinovea ®, a widely used video-based motion analysis software.

METHODOLOGY

Study Design:

This study was conducted as a cross-sectional comparison study to evaluate the validity and test–retest reliability of the Fitknees® wearable sensor system for measuring spatiotemporal gait parameters.

Two separate cohorts of healthy participants were recruited:

one for the validity analysis and another for the test–retest reliability analysis.

Participants:

A total of 36 healthy volunteers participated in the study.

For the validity analysis, 12 participants (5 females, 7 males) aged 20–35 years were recruited.

For the test–retest reliability analysis, 24 participants (10 females, 14 males) aged 23-51years were included.

Participants were recruited through voluntary participation from the local community.

The sample size was determined based on previous wearable sensor validation studies investigating gait parameters in healthy adults, which typically involve small cohorts with repeated walking trials to evaluate measurement validity and reliability [1, 11].

Inclusion Criteria:

Participants were eligible for inclusion if they:

- were between 20 and 51 years of age
- were able to walk independently without assistance
- reported no history of lower limb injury within the past 6 months
- had no current pain or discomfort affecting gait

Exclusion Criteria:

Participants were excluded if they reported:

- knee pain or lower limb pain during walking
- any musculoskeletal disorder affecting gait
- any neurological condition influencing motor control
- systemic conditions affecting balance or mobility
- use of orthoses, braces, or gait-assistive devices

Instrumentation

Fitknees®:

Fitknees® (Ashva Wearable Technologies Pvt. Ltd., Bangalore, India) is a wearable inertial measurement unit (IMU)-based motion-sensing system designed to capture lower-limb motion during walking.

The system consists of four wireless sensors incorporating accelerometers and gyroscopes. These sensors were positioned approximately 10–15 cm above and below both knees to capture thigh and shank movement during gait (Image 1).

Image 1: Sensor placement

Image 2: Waist belt along with gait app

Sensor data were transmitted wirelessly via Bluetooth to a dedicated mobile application, which processed the signals to derive spatiotemporal gait parameters, including:

- stride time
- stance time
- swing time

To maintain consistent signal transmission and minimize Bluetooth data loss, the mobile device running the application was placed in a waist-belt pouch near the sensors (Image 2).

Kinovea®:

Kinovea® is a free two-dimensional motion analysis software widely used for movement analysis in sports and rehabilitation.

For this study, gait recordings were captured with a high-resolution smartphone camera positioned perpendicular to the walking path, enabling accurate frame-by-frame analysis of temporal gait events (Image 3).

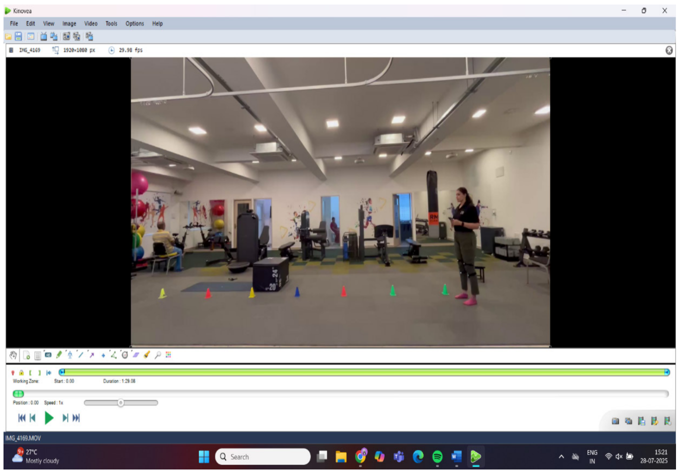

Image 3: Video analysis through Kinovea

Kinovea allows identification of gait phases through manual video annotation and frame analysis, enabling measurement of temporal parameters such as stride time, stance time, and swing time.

Video recordings were repeated for each participant to ensure consistent capture of gait cycles for analysis.

Experimental Procedure:

Participants were instructed to walk along a 6-meter walkway at their self-selected comfortable walking speed.

Before testing, Fitknees® sensors were securely attached to the participants› lower limbs according to the standardized placement protocol.

Each participant completed two walking trials for the validity analysis, while both sensor data and video recordings were collected simultaneously.

The middle steps of each trial were used for analysis to avoid acceleration and deceleration effects at the beginning and end of the walking path.

For the test–retest reliability analysis, participants completed four repeated walking trials under identical conditions.

Outcome Measures:

The primary gait parameters analyzed in this study were:

- Stride time – duration between consecutive heel strikes of the same foot
- Stance time – duration during which the foot remains in contact with the ground
- Swing time – duration between toe-off and the next heel strike of the same foot

Measurements obtained from the Fitknees® system were compared with those derived from Kinovea frame-by-frame video analysis.

Statistical Analysis:

The validity of Fitknees® measurements was assessed using Pearson correlation coefficients between temporal gait parameters measured by Fitknees® and those measured in Kinovea.

Test–retest reliability of the Fitknees® system was evaluated using Pearson coefficient correlations across repeated gait trials.

Statistical significance was set at $p < 0.05$.

Ethical Considerations:

All participants voluntarily participated in the study and provided informed consent before data collection. The study involved non-invasive motion assessment during normal walking and did not involve any medical intervention or clinical treatment. Participants were free to withdraw from the study at any time.

As this study involved minimal-risk biomechanical assessment in healthy volunteers without clinical intervention, formal institutional ethical approval was not required according to local guidelines. The procedures followed in this study adhered to general ethical principles for human research involving minimal risk activities.

Experimental Approach and Materials

Validity:

For the validity analysis, 12 healthy participants performed gait trials while wearing the Fitknees® sensor system. Temporal gait parameters, including stride time, stance time, and swing time, were measured simultaneously using both Fitknees® and Kinovea®.

Each participant completed five consecutive walking trials along a 6-meter walkway at a self-selected comfortable speed. The walking path was marked with cones placed at 1-meter intervals to assist with consistent walking distance and facilitate video analysis.

During each trial, participants walked in a straight line while wearing the Fitknees® sensors positioned above and below both knees according to the standardized placement protocol described earlier. Gait motion was recorded with a smartphone camera positioned perpendicular to the walking path, enabling clear visualization of the lower limbs.

Video recordings were captured using high-speed recording settings to improve frame-by-frame identification of gait events. The recorded videos were subsequently analyzed using Kinovea software, which enabled frame-by-frame analysis to determine temporal gait parameters.

To minimize the influence of gait acceleration and deceleration, middle steps within each walking trial were selected for analysis. Temporal parameters measured with the Fitknees® system were then compared with those obtained in Kinovea to assess the validity of the wearable sensor measurements.

Reliability:

Test–retest reliability of the Fitknees® system was evaluated using 24 healthy participants under identical experimental conditions.

Participants performed walking trials along the same 6-meter walkway while wearing the Fitknees® sensors. Each participant completed four consecutive walking rounds, each consisting of two back-and-forth paths along the marked walkway.

Before initiating the walking trials, participants were instructed to start the gait recording through the Fitknees® mobile application. The smartphone used for data acquisition was then securely placed in a waist-belt pouch positioned on the abdomen to maintain stable Bluetooth connectivity between the sensors and the mobile device (Image 4A).

Participants were instructed to walk at their natural, comfortable speed during all trials. At the end of each walking round, participants stopped in a neutral standing position facing the same direction to ensure consistency in data recording.

Following completion of the walking trials, the mobile device was handed to the examiner, who entered the participant's height and foot size into the application to allow accurate processing of the recorded gait data (Image 4B).

The following spatiotemporal parameters were extracted from the Fitknees® system for reliability analysis:

- stride time
- stance time
- swing time
- stance phase
- swing phase

Reliability was assessed by comparing measurements obtained across the repeated walking trials for each participant.

Across all trials, multiple gait cycles were recorded for each participant, resulting in a large dataset of temporal gait measurements for statistical analysis.

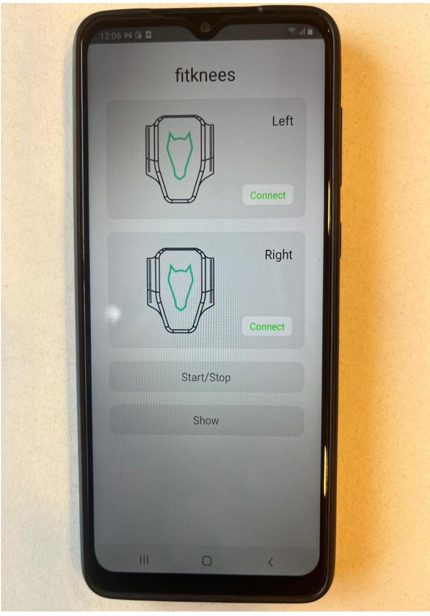

Image 4A: Gait mobile app main screen

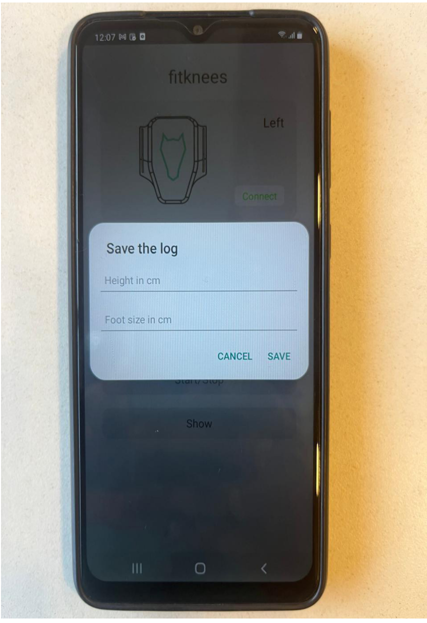

Image 4B: Gait mobile application "Save this log" screen

Outcome Measures:

For the kinematic analysis, participant anthropometric data, including height and foot size, were recorded, as these parameters were required for gait analysis processing.

Temporal gait parameters were obtained using Kinovea software through frame-by-frame video analysis. Key gait events, including initial contact (heel strike) and toe-off, were identified to determine the duration of the gait cycle's phases.

To ensure that the analysis represented the participant's natural walking pattern, only the middle steps of each walking trial were selected for analysis, thereby minimizing the influence of gait acceleration at the start and deceleration at the end of the walkway.

The following temporal gait parameters were analyzed:

Stride Time - The duration between two consecutive heel strikes of the same foot.

Stance Time - The duration from heel strike to toe-off of the same foot, representing the period during which the foot remains in contact with the ground.

Swing Time - The duration between toe-off and the subsequent heel strike of the same foot, representing the non-weight-bearing phase of the gait cycle.

RESULTS

Participant Characteristics:

The demographic characteristics of the participants included in the reliability analysis are presented in Table 1. A total of 24 healthy individuals participated in the study, with a mean age of 27.83 ± 5.63 years (range, 23 to 51 years). The average height of the participants was 163.00 ± 7.91 cm, with values ranging from 149 cm to 175 cm.

The sample consisted of 14 males (58.3%) and 10 females (41.7%), representing a balanced distribution of healthy adults suitable for assessing spatiotemporal gait parameters. No missing demographic data were recorded.

Table 1: Demographic characteristics of participants (n = 24)

Variable	Category	n (%)	Mean ± SD	Minimum	Maximum
Age (years)	—	—	27.83 ± 5.63	23	51
Height (cm)	—	—	163.00 ± 7.91	149	175
Gender	Male	14 (58.3%)	—	—	—
	Female	10 (41.7%)	—	—	—

Validity Analysis

The validity of the Fitknees® system was evaluated by comparing temporal gait parameters measured using Fitknees® with those obtained through Kinovea video analysis. The Pearson correlation results are presented in Table 2.

A strong positive correlation was observed between Fitknees® and Kinovea measurements for left stride time ($r = 0.937$, $p < 0.001$), indicating excellent agreement between the wearable sensor system and the video-based motion analysis method.

For stance time, moderate but statistically significant correlations were observed for both the left ($r = 0.641$, $p = 0.025$) and right limbs ($r = 0.627$, $p = 0.029$). Similarly, right stride time demonstrated a moderate positive correlation ($r = 0.616$, $p = 0.033$), further supporting the validity of Fitknees® for measuring temporal gait parameters.

In contrast, correlations for swing time were negligible for both the left ($r = -0.060$, $p = 0.853$) and right limbs ($r = 0.036$, $p = 0.911$), indicating limited agreement between the two measurement systems for this parameter.

Overall, the results demonstrate that Fitknees® provides highly accurate measurements of stride time and consistently detects stance time, highlighting its ability to capture key temporal characteristics of the gait cycle.

Table 2: Pearson correlation coefficients comparing temporal gait parameters measured using Fitknees® sensors and Kinovea® video analysis in the validity cohort (n = 12).

Correlations between Fitknees ® and KINOVEA							
Correlations							
		Fitknees ® Stride time Left	**Fitknees ® Stance time Left**	**Fitknees ® Swing time Left**	**Fitknees ® Stride time Right**	**Fitknees ® Stance timeR**	**Fitknees ® Swing timeR**
KINOVEA 1Stride timeL	Pearson Correlation	.937**	Strong correlation between left stide time				
	Sig. (2-tailed)	0.000					
	N	12					
KINOVEA 1Stance timeL	Pearson Correlation		.641*	Moderate cor-relation between left stance time			
	Sig. (2-tailed)		0.025				
	N		12				
KINOVEA 1Swing timeL	Pearson Correlation			-0.060	negative but negligible correlation between left swing time		
	Sig. (2-tailed)			0.853			
	N			12			
KINOVEA 1Stride timeR	Pearson Correlation				.616*	Moderate correlation between right stride time	
	Sig. (2-tailed)				0.033		
	N				12		
KINOVEA 1Stance timeR	Pearson Correlation					.627*	Moderate correlation between right stance time
	Sig. (2-tailed)					0.029	
	N					12	
KINOVEA 1Swing timeR	Pearson Correlation						0.036
	Sig. (2-tailed)						0.911
	N						12
**. Correlation is significant at the p < 0.01 level (2-tailed).							
*. Correlation is significant at the p < 0.05 level (2-tailed).							

Result For Test-Retest Reliability

The test–retest reliability of the Fitknees® system was evaluated using repeated walking trials across 24 participants. The reliability results are summarized in Tables 3-7.

Moderate positive correlations were observed for stride time measurements, with r = 0.639 (p = 0.007) for the right limb and r = 0.632 (p = 0.007) for the left limb, indicating consistent measurement performance across repeated trials.

Similarly, stance time demonstrated moderate reliability on both sides, with correlation coefficients of r = 0.646 (p = 0.009) for the right limb and r = 0.643 (p = 0.007) for the left limb.

For swing time, reliability differed between limbs. The right limb showed a low correlation (r = 0.157, p = 0.338), whereas the left limb demonstrated a strong correlation (r = 0.718, p = 0.001).

Analysis of stance phase measurements revealed moderate reliability for the right limb (r = 0.567, p = 0.025) and high reliability for the left limb (r = 0.788, p < 0.001). Similarly, swing phase measurements showed moderate reliability on the right (r = 0.554, p = 0.029) and strong reliability on the left (r = 0.798, p < 0.001).

Overall, the results indicate that the Fitknees® system demonstrates moderate-to-high reliability for most temporal gait parameters, particularly for stride time, stance time, and gait phase measurements.

Table 3: Pearson Correlation shows that there is a moderate reliability between the stride time

STRIDE TIME		
	RIGHT	LEFT
	Fitknees®	
Pearson Correlation	.639c	.632c
Sig.	0.007	0.007
N	24	24

Table 4: Pearson Correlation shows that there is a moderate reliability between the stance time

STANCE TIME		
	RIGHT	LEFT
	Fitknees®	
Pearson Correlation	.646c	.643c
Sig.	0.009	0.007
N	24	24

Table 5: Pearson Correlation shows there is poor reliability on the right but high reliability on the left side for swing time

SWING TIME		
	RIGHT	LEFT
	Fitknees®	
Pearson Correlation	.157c	.718c
Sig.	0.338	0.001
N	24	24

Table 6: Pearson Correlation shows moderate reliability on the right side and high reliability on the left side

STANCE PHASE		
	RIGHT	LEFT
	Fitknees®	
Pearson Correlation	.567c	.788c
Sig.	0.025	0.000
N	24	24

Table 7: Pearson Correlation shows moderate reliability on the right side and high reliability on the left side

SWING PHASE		
	RIGHT	LEFT
	Fitknees®	
Pearson Correlation	.554c	.798c
Sig.	0.029	0.000
N	24	24

DISCUSSION

The present study evaluated the validity and test–retest reliability of the Fitknees® wearable sensor system for measuring temporal gait parameters in healthy individuals. The results demonstrated strong validity for stride time and moderate validity for stance time when compared with Kinovea video-based motion analysis. Additionally, the reliability analysis indicated moderate-to-high consistency across repeated trials for most parameters, suggesting that the Fitknees® system can reliably capture key temporal characteristics of the gait cycle.

The strong correlation observed for stride time (r = 0.937) indicates excellent agreement between the wearable sensor measurements and the video-based reference method. Stride time is one of the most fundamental temporal parameters in gait analysis, as it reflects the overall rhythm and stability of walking. The high level of agreement observed in this study is consistent with findings [1], which demonstrated that inertial measurement unit (IMU) systems can accurately detect step and stride timing during walking in healthy adults.

Moderate correlations observed for stance time further support the capability of wearable sensor systems to detect key gait events during the weight-bearing phase. Accurate identification of stance time is particularly relevant in clinical populations, as abnormalities in stance duration are often associated with musculoskeletal injuries and neurological impairments.

In contrast, lower agreement was observed for swing time, particularly on the right limb. The swing phase is a shorter, more dynamic portion of the gait cycle, which may increase sensitivity to minor variations in sensor placement or signal processing. Similar challenges in detecting rapid gait events have been reported in previous wearable sensor studies. Tao et al. (2012) [12] highlighted that differences between sensor-based systems and video-based analysis methods may stem from variations in signal processing techniques and event detection algorithms.

Another factor that may influence agreement between the two measurement systems is the difference in data acquisition methodologies. While Fitknees® captures motion data in real time using inertial sensors, Kinovea relies on frame-by-frame video analysis and manual annotation. As noted, video-based systems such as Kinovea can demonstrate good agreement with motion capture systems for basic kinematic parameters [4]. Still, their accuracy may be influenced by frame rate, camera positioning, and observer-dependent analysis procedures.

The reliability results of the present study further support the measurement consistency of the Fitknees® system. Moderate to high correlations across repeated trials indicate that the system can provide stable measurements for most temporal gait parameters. Higher reliability observed in several parameters on the left side may reflect natural asymmetries in gait patterns or variations in sensor positioning during repeated trials.

From a broader perspective, the findings of this study support the growing role of wearable sensor technologies in clinical movement analysis. Wearable IMU systems offer several advantages over traditional laboratory-based gait analysis systems, including portability, lower cost, and the ability to capture movement in real-world environments.

Wearable sensing technologies have the potential to expand access to objective mobility assessment beyond specialized gait laboratories [9].

Furthermore, the ability to capture gait parameters using wearable sensors may facilitate more frequent monitoring of patient mobility during rehabilitation and sports performance evaluation. By enabling objective measurement of temporal gait parameters in routine clinical settings, wearable systems such as Fitknees® may help clinicians track recovery progression and identify movement abnormalities more efficiently.

STUDY LIMITATIONS

Several limitations should be considered when interpreting the findings of this study. First, the validity analysis was conducted on a relatively small sample of healthy individuals, which may limit the generalizability of the results. Future studies should include larger sample sizes and diverse populations, including individuals with musculoskeletal or neurological gait impairments.

Second, gait measurements were compared with Kinovea video analysis rather than a three-dimensional motion capture system, which is typically considered the gold standard for gait analysis. Although Kinovea has demonstrated acceptable reliability for movement analysis in previous studies, comparisons with laboratory-based motion capture systems may provide additional insights into the accuracy of wearable sensor measurements.

Third, only a single examiner performed the video analysis, which may introduce potential observer-related variability. Future studies should consider evaluating inter-rater reliability to further validate the robustness of the measurement procedures.

Future research should also explore improvements in sensor placement protocols, signal processing algorithms, and synchronization between wearable sensors and video systems. Advances in filtering techniques, machine-learning-based gait-event detection, and improved wireless communication may further enhance the accuracy and reliability of wearable gait analysis systems.

CONCLUSION

Wearable sensing technologies are increasingly transforming the field of movement analysis by enabling objective and accessible assessment of human locomotion. The findings of this study demonstrate that the Fitknees® wearable sensor system provides valid and reliable measurements for key temporal gait parameters, particularly stride time and stance time.

The strong correlation observed for stride time, compared with the Kinovea analysis, underscores the system's ability to detect critical gait events accurately. In addition, moderate to high reliability across repeated trials suggests that Fitknees® can provide consistent measurements during repeated gait assessments.

These results support the potential of wearable IMU-based systems as practical tools for spatiotemporal gait assessment in clinical and research settings. By offering a portable and cost-effective alternative to traditional gait analysis laboratories, wearable systems such as Fitknees® may contribute to broader adoption of objective gait measurement in rehabilitation, sports science, and mobility monitoring.

Further studies involving larger populations and comparisons with laboratory-based motion capture systems will help establish the full clinical utility of wearable gait analysis technologies.

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