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RESEARCH

Development of a Low-Cost Technology for the Assessment of Human Gait and Clinical Movement in Elderly Populations in Remote Areas

Desarrollo de una tecnología de bajo costo para la evaluación de la marcha humana y el movimiento clínico en poblaciones de edad avanzada en áreas remotas

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Abstract

This study presents a technological advancement and a methodological approach to adopt portable technology in the field of human function and disability assessment, specifically in the analysis of human gait. The research was designed as a project aimed at establishing an accessible and user-friendly ambulatory gait evaluation service. The system records spatiotemporal variables of lower-limb movement and the associated forward displacement of the body. The implementation of this infrastructure has demonstrated its ability to reduce access barriers for elderly individuals, a population that naturally experiences age-related motor changes and often faces challenges in accessing specialized gait analysis services due to geographic and socioeconomic constraints. These services are typically concentrated in urban centers, particularly in emerging economies, limiting their availability to vulnerable populations. The findings highlight the potential of this low-cost solution to enhance mobility assessment and facilitate early detection of gait impairments in underserved communities.

Keywords: gait analysis, portable technology, human movement assessment, elderly population, spatiotemporal parameters, low-cost solution, accessibility in healthcare, remote health monitoring, biomechanics, emerging economies.

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Resumen

Este estudio presenta un avance tecnológico y un enfoque metodológico para adoptar tecnología portátil en el campo de la evaluación de la función humana y la discapacidad, específicamente en el análisis de la marcha humana. La investigación fue diseñada como un proyecto destinado a establecer un servicio de evaluación ambulatoria de la marcha accesible y fácil de usar. El sistema registra variables espaciotemporales del movimiento de las extremidades inferiores y el desplazamiento hacia adelante asociado del cuerpo. La implementación de esta infraestructura ha demostrado su capacidad para reducir las barreras de acceso para las personas mayores, una población que experimenta naturalmente cambios motores relacionados con la edad y que a menudo enfrenta desafíos para acceder a servicios especializados de análisis de la marcha debido a limitaciones geográficas y socioeconómicas. Estos servicios suelen concentrarse en centros urbanos, particularmente en economías emergentes, lo que limita su disponibilidad para poblaciones vulnerables. Los hallazgos resaltan el potencial de esta solución de bajo costo para mejorar la evaluación de la movilidad y facilitar la detección temprana de alteraciones de la marcha en comunidades desatendidas.

Palabras clave: Análisis de la marcha, tecnología portátil, evaluación del movimiento humano, población adulta mayor, parámetros espaciotemporales, solución de bajo costo, accesibilidad en atención sanitaria, monitoreo remoto de salud, biomecánica, economías emergentes

Introduction

According to Gonzales (1) and Feldson (2), the recognition of health vulnerability in individuals has often been considered a secondary issue compared to geographic and economic factors. This has driven significant interest in studies focusing on the biomechanical analysis of functional movement patterns, particularly gait. Various studies have explored physical variations among participants beyond diagnosis-related criteria, examining the progression of movement alterations through a combination of surrogate variables and indicators (3, 4). However, these functional analyses are typically conducted in controlled environments, where standardized healthcare protocols fail to account for the influence of real-world conditions on participants' movement behavior. Additionally, the infrastructure required for gait assessment often necessitates patient travel to specialized centers, limiting accessibility—especially in countries with emerging economies where such services are concentrated in urban areas. This issue is particularly critical in cities like Cali, Colombia, where the elderly population continues to grow.

Similar challenges have been reported in recent Colombian studies, which highlight the need for technological innovations that adapt gait evaluation to the constraints of vulnerable populations and urban peripheries (5).

To address these challenges, there is a pressing need for a portable gait assessment system that prioritizes usability and interoperability with both users and existing technology. Such a system would be particularly beneficial for elderly individuals, as it would allow gait evaluation to take place in their daily environments, minimizing external disturbances and physiological constraints that could affect assessment outcomes.

Recent research highlights the importance of expanding gait assessment beyond controlled clinical settings, emphasizing the need for portable and user-friendly systems capable of capturing data in natural environments. For example, modern wearable inertial sensors combined with machine learning models have demonstrated high accuracy in detecting mobility impairments in elderly populations (6). Similarly, advancements in real-time gait monitoring with lightweight devices have been shown to improve early detection of frailty and fall risk, thereby supporting preventive interventions (7).The integration of mobile health platforms with sensor-based gait analysis has also been recognized as a promising strategy to enhance accessibility in low-resource settings, reducing the gap between laboratory-based evaluations and daily-life monitoring (8).

Technological developments in gait assessment, however, have traditionally focused on executing protocols in controlled environments. In Colombia, the National University has developed a clinical gait laboratory capable of capturing and synchronizing dynamic and kinematic data. While this modular system integrates various movement parameters, its design remains unsuitable for daily-life environments (9). Other advancements, such as e-textiles and wireless sensor networks, have supported the development of non-invasive and mobile computational services. However, most of these proposals emphasize future healthcare environments instead of being designed for real-world gait assessment.

Inertial measurement unit (IMU)-based motion analysis remains an emerging research area. The APDM system (10) employs angular velocity signals from the leg to measure four temporal gait parameters: stance time, swing time, step time, and cadence. The Tech MCS Studio system from Technaid (11) assesses frequency, stance time, and roll, while the Shimmer system (12) quantifies spatial gait parameters with high accuracy in step length measurement, as validated by Zhuang *et al.* (13). Additionally, Patterson *et al.* (14) investigated optimal sensor placement to enhance measurement precision.

Compared with existing systems, the proposed design not only visualizes movement kinematics but also captures spatiotemporal parameters and anthropometric records, including hip circumference, thigh length, leg length, and foot length. These measurements contribute to a kinematic model of gait that optimizes the alignment of measurement unit axes. This study thereby provides biomechanical insights into gait assessment while focusing on elderly populations and structural determinants that contribute to functional limitations. Additionally, it promotes early intervention strategies to mitigate mobility deterioration and offers tools for comprehensive management of movement restrictions influenced by environmental factors.

The remainder of this paper is structured as follows: the *Methodology* section describes the instruments and procedures used for participant selection, the application of the developed technology, and the variables considered in gait assessment. The *Results* section presents the study population and gait analysis outcomes. Finally, the *Discussion* and *Conclusions* section highlights the key findings and their broader implications.

Materials and Methods

To validate this study, a dedicated technological infrastructure was developed, as illustrated in Figure **1**. The system captures the movement data of the lower limbs of an individual equipped with the data acquisition system, positioned at Geographical Point 1, which can be either fixed or mobile. The sensors used for data collection form a wireless Body Area Network (BAN), which transmits information to a concentrator. The data then pass through a Gateway, establishing a Personal Area Network (PAN).

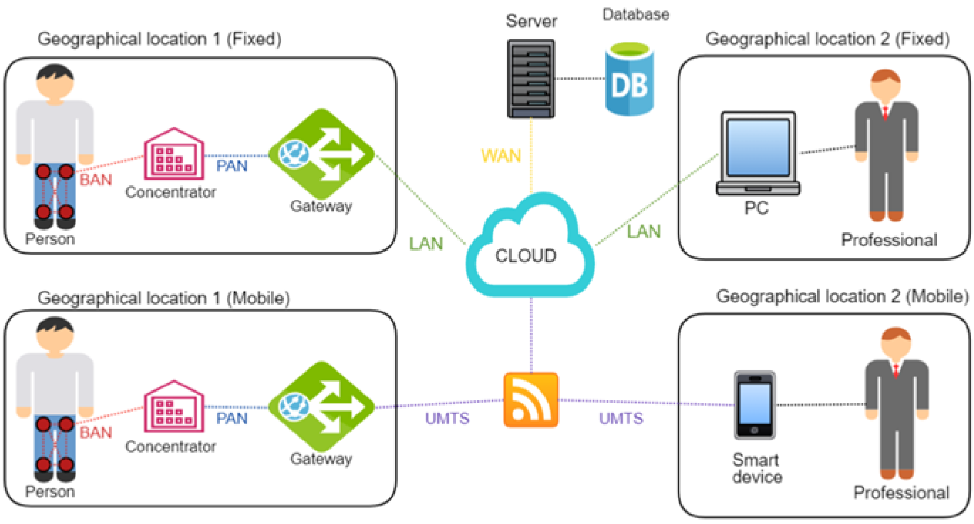

Figure 1. General architecture of the system

To enable cloud-based processing, the collected data are transmitted via a Local Area Network (LAN) to a virtualized server environment, where they are stored and processed. Once uploaded to the cloud, the data can be accessed remotely from any location (Geographical Point 2), whether fixed or mobile. Healthcare professionals can retrieve and analyze the information through a user interface, accessible via a computer or smart device, ensuring real-time and remote gait assessment capabilities.

Measurement System and Wearable Technology

Figure **2** presents a detailed overview of the measurement system and the corporal technology (C), which consists of multiple motion capture sensors—specifically inertial measurement units (IMUs). These wearable data acquisition devices (WDs) transmit movement data via radiofrequency to the concentrator (CT), which encapsulates and forwards the information to the Gateway (GW). Both the wearable devices and the concentrator are integrated into an Instrumented Suit (IS), designed for individuals undergoing gait pattern assessment.

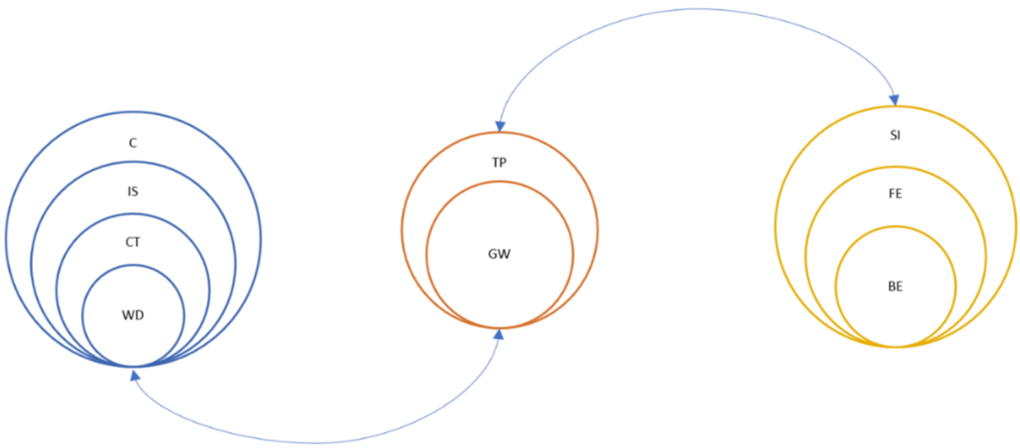

Figure 2. Detailed architecture of the system

A bidirectional communication system connects the corporal technology (C) with the system interface (SI), incorporating a data transmission and processing subsystem (TP). The SI is a cloud-based computing platform for managing, analyzing, and visualizing individual movement data. This interface is structured into two main components:

- Back-end (BE) servers, which handle data processing and storage.
- Front-end (FE) servers, which provide a user interface (UI) that allows healthcare professionals to visualize, manage, and control remote gait monitoring.

Furthermore, this subsystem can seamlessly interact with existing healthcare management platforms through telehealth standards, utilizing an application programming interface (API) for interoperability.

Components of the Body Measurement and Technology Subsystem

The elements comprising the measuring and corporal technology subsystem (SC) are illustrated in Figure **3**.

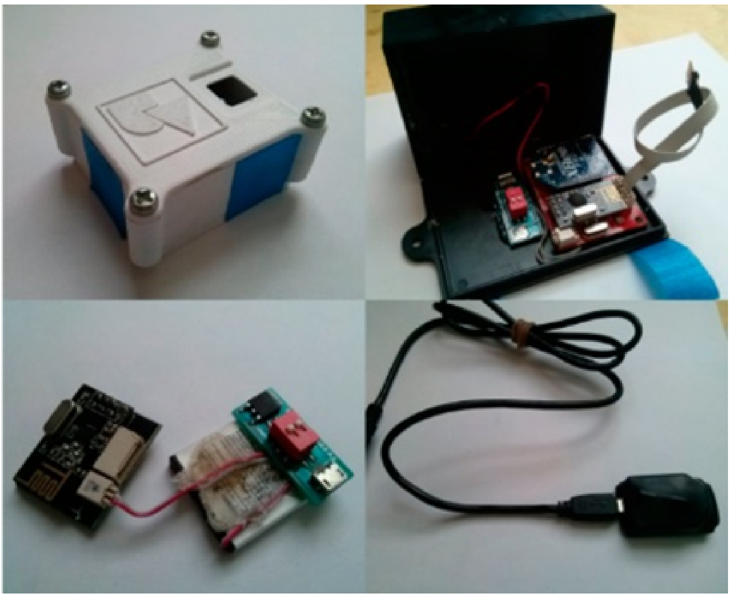

Figure 3. Components of the body measurement and technology subsystem

Before conducting gait assessments, each measurement unit within the SC subsystem must undergo a calibration process. This procedure begins by activating the measuring unit and maintaining it in a horizontal position. An oscillatory movement is then performed until a 45° angle is reached. Once the sensor readings stabilize, three sequential movements are carried out, following a smooth continuous motion in the frontal plane, forming a trajectory similar to an infinity symbol (∞).

Since the gait model is structured as a skeletal system composed of rigid, non-deformable linear segments, the placement of the measuring units on the lower limbs is determined by identifying regions with minimal muscular mobility during the gait cycle. To ensure accurate sensor positioning, participants are advised to wear form-fitting garments. Additionally, an elastic support system with Velcro straps was designed to securely attach the seven integrated measurement units, as illustrated in Figure **4**.

To develop the user interface (UI), two applications were designed to enhance both data capture (Figure **4**) and information visualization (Figure **5**). These applications incorporate features that facilitate interaction, such as:

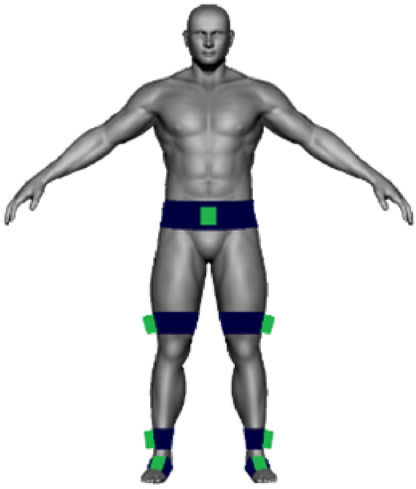

Figure 4. Localization of corporal technology

- **Color coding** for easy identification of each sensing unit's placement.
- **Function-based** grouping commands to streamline data management.
- **Customizable initial settings** tailored for physiotherapists to optimize the assessment process.

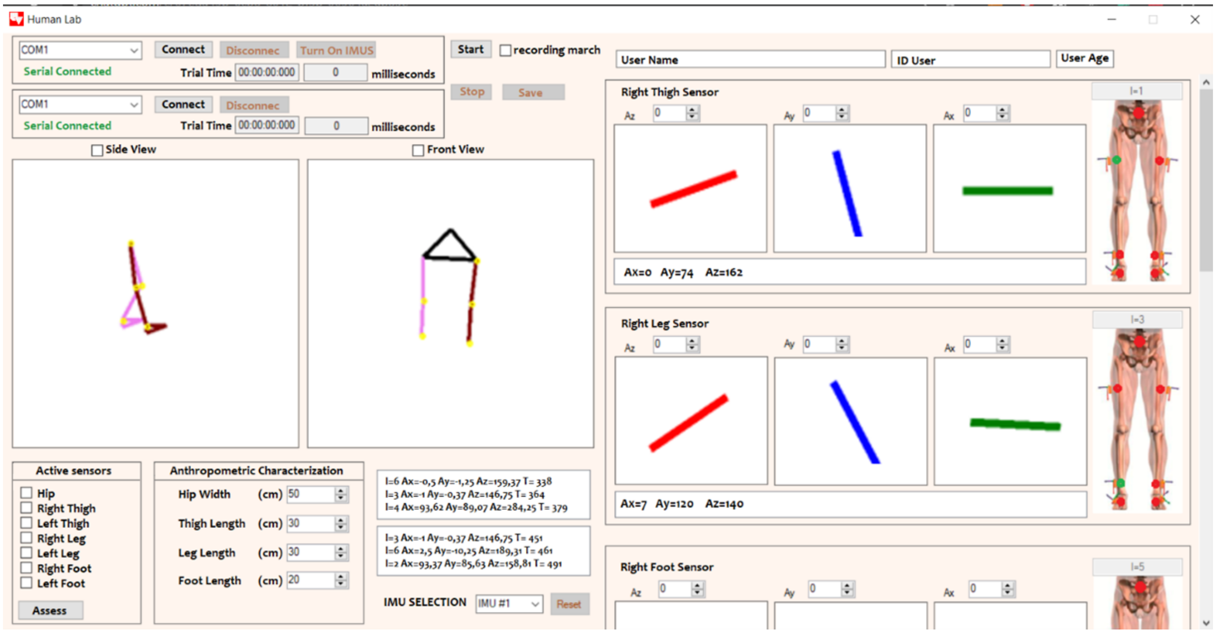

Figure 5. Motion capture user interface

Gait Data Acquisition and Display Interface

To acquire gait data, the system first establishes communication with the SC subsystem within the communication zone. Once the connection is established, the anthropometric zone records key anthropometric parameters, including hip contour, thigh length, leg length, and foot length, ensuring an accurate characterization of the kinematic gait model. The orientation-setting zone is then used to align the measurement unit axes with each lower limb, optimizing data accuracy.

The application also includes a display zone, which allows physiotherapists to visualize the subject's gait pattern in real-time using sensor-derived data. The collected information can be stored via the <save>command within the communication zone, ensuring data preservation for subsequent analysis.

For efficient data interpretation, the display interface (Figure **6**) is organized into distinct functional zones, designed for intuitive data access:

- Anatomical Data Zone – Displays patient-specific anthropometric measurements.
- Graphic Animation Zone – Provides real-time gait visualization.
- Trend Curve Zone – Depicts temporal variations of key biomechanical parameters.
- Instant Value Zone – Displays real-time readings of critical gait variables.

This specialized interface serves as a comprehensive tool for physiotherapists, facilitating a detailed analysis of lower limb mobility, comparisons between left and right hemibodies, and calculations of stride length, time, and speed for each gait phase. Additionally, a kinegram is displayed from both the frontal and sagittal planes to enable vector position tracking across lower limb segments and foot positioning assessment in the transversal plane. The lower section of the interface presents joint angle data (hip, knee, and ankle), along with the temporal distribution of the gait cycle, providing a complete representation of the subject's walking dynamics.

Complementary Data Collection and Database Structure

To enrich the dataset and ensure a comprehensive gait analysis, three complementary instruments and a structured protocol were employed:

- Socio-demographic Survey – Collected demographic and contextual information, including age, gender, ethnic background, socioeconomic status, residential area, and architectural characteristics of the living environment, to characterize the study population.

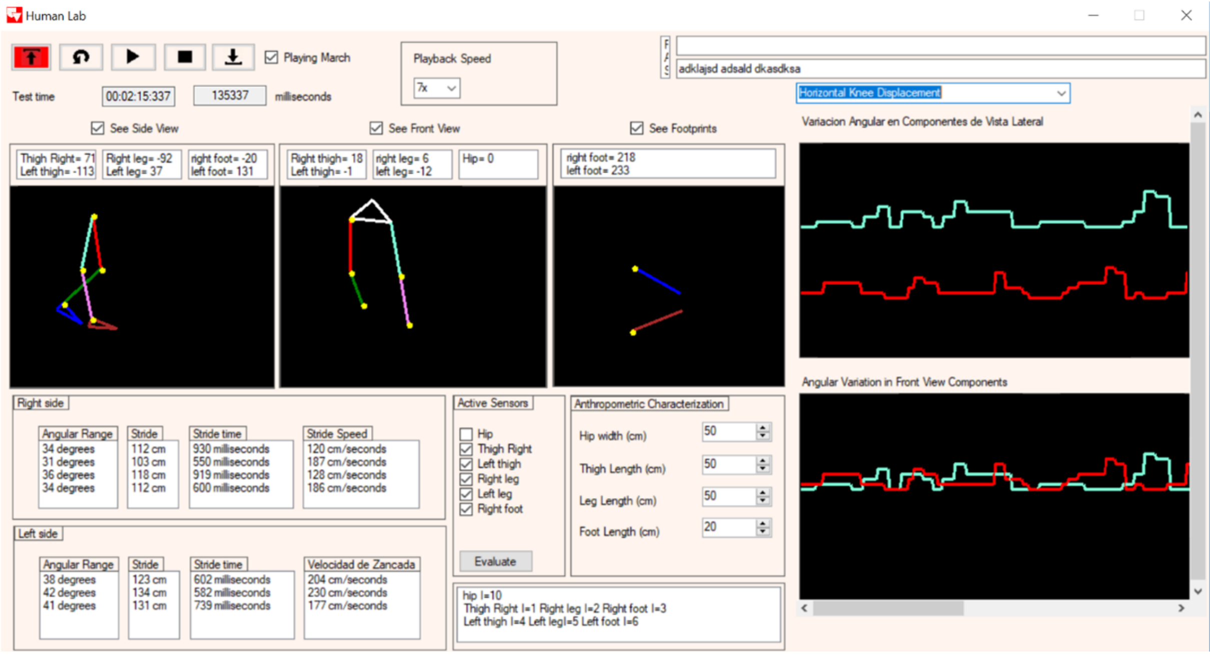

Figure 6. User interface visualization of the march

- Health Condition Assessment – Identified pathologies or conditions that could restrict movement or alter gait patterns, ensuring a nuanced interpretation of the collected data.
- Gait Analysis Protocol – Applied an observational method to systematically assess walking patterns under controlled and real-world conditions.

Database Architecture

To efficiently manage the collected data, a relational database was designed to store patient records, healthcare professional data, rehabilitation therapy details, and gait analysis results. The entity-relationship model, illustrated in Figure 7, is structured into four primary tables:

- fac_p_profesionales – Stores information about healthcare professionals (specialists and nurses).
- fac_m_tarjetero – Contains personal and demographic data of patients.
- fac_t_terapias – Records clinical rehabilitation therapy sessions.
- fac_y_marcha – Stores gait analysis data captured by the instrumented suit.

In addition, the database includes secondary tables for supplementary attributes, such as gender (fac_m_sexo), marital status (fac_m_civil), occupation (fac_m_ocupacion), therapy type (fac_t_tipo_terapia), injury classification (fac_o_lesion), affected side (fac_o_lado), specialty

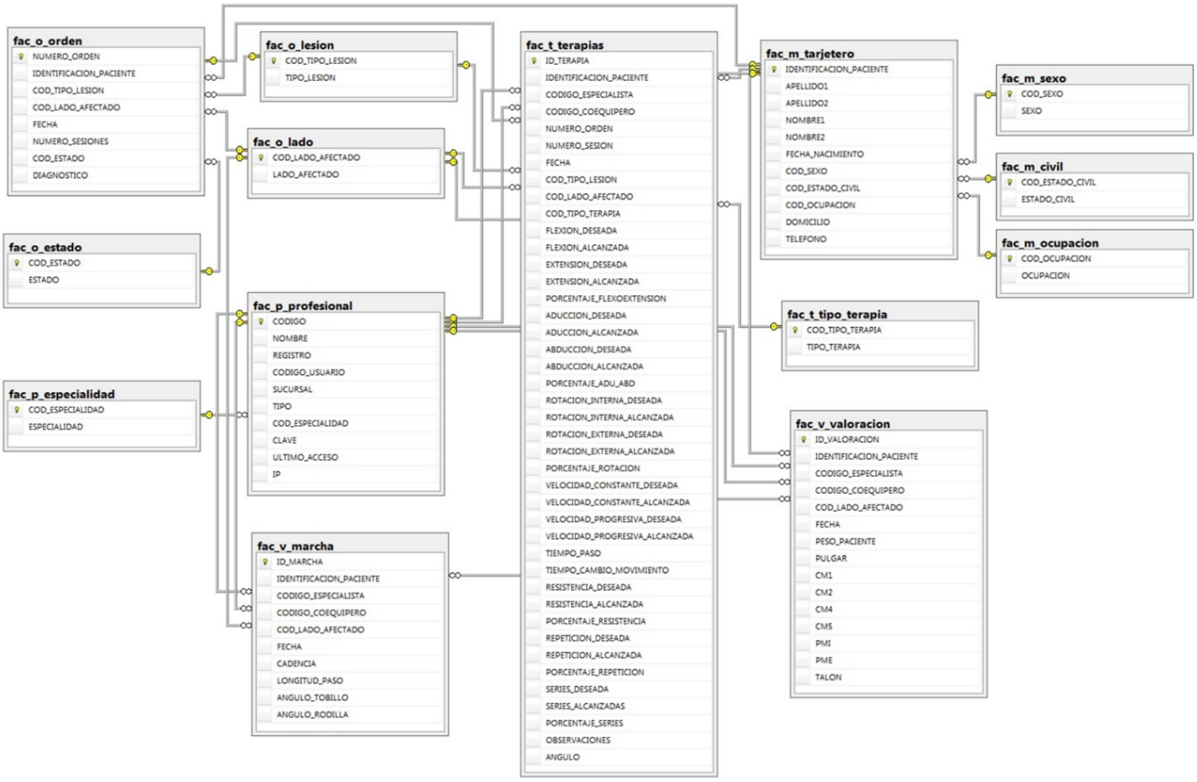

Figure 7. Entity-relationship model of the database

(fac_p_especialidad), patient status (fac_o_estado), and treatment order (fac_o_orden).

This scalable and modular database architecture allows seamless integration with future technological advancements and healthcare applications, ensuring adaptability and interoperability in clinical and research environments.

Participant Selection and Gait Assessment Protocol

The primary inclusion criterion for the gait assessment group was an age of 60 years or older, with no documented history of gait disorders associated with physical or psychological conditions. All participants underwent an eligibility interview conducted by a physiotherapist. A customized assessment tool was developed to systematically record personal data, clinical history, pathological and traumatic background, pharmacological and surgical history, mobility conditions, and the individual's subjective perception of their gait performance.

The selected participants underwent a structured gait assessment using the SC system, ensuring that the wearable components were placed without direct skin contact to prevent potential allergic reactions, pressure discomfort, or thermal sensitivity issues.

To enhance familiarity and confidence with the assessment process, a standardized gait evaluation protocol was implemented. This protocol included an initial demonstration of the assessment system by a trained research team member, which aimed to reduce anxiety among participants and minimize psychological influences that could affect gait performance (Figure **8**).

Figure 8. Adjusting sensors to the body of the participants

Gait Assessment Protocol

According to the assessment protocol, each participant—equipped with the SC system—was instructed to walk naturally over a stable, level surface along a straight five-meter trajectory. During this period, the SC system continuously transmitted real-time motion data related to the participant's lower-limb kinematics.

Assessment Variables

To define the gait assessment variables, the analysis was structured around eight gait phases, categorized based on stance and swing phases (Figure **9**). The stance phase, which constitutes approximately 60 % of the gait cycle, comprises the following five phases:

Initial contact (IC): The moment the heel first touches the ground.

Foot descent (FD): The phase where weight is transferred to the stance leg, marking the first double support period.

Midstance (MS): The body advances over the stable leg, while the contralateral limb begins its forward motion.

Terminal stance (TS): The entire body weight is supported by the stance limb, as the opposite limb moves forward.

Pre-swing (PS): The weight is partially shifted to the contralateral limb, marking the second double support period.

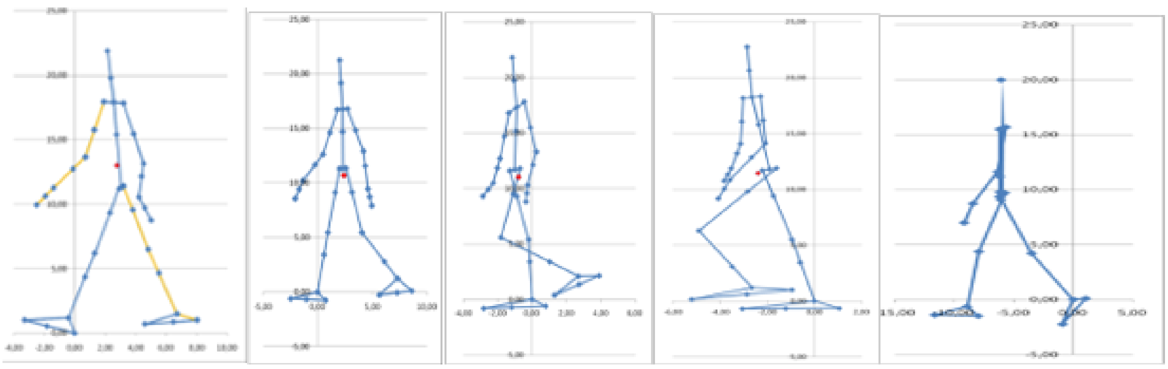

Figure 9. Stance phases: Initial contact, loading response, mid-stance, total stance and pre-swing

The swing phase accounts for approximately 40 % of the gait cycle and consists of three distinct phases, as illustrated in Figure **10**).

Initial swing (IS): The foot lifts off the ground, and the leg begins to advance forward.

Mid-swing (MS): The limb continues its forward motion, while the knee begins to extend in preparation for ground contact.

Terminal swing (TS): The knee reaches full extension, and the limb is positioned for initial contact, marking the transition into the stance phase.

Gait Analysis Variables

For gait analysis, the following variables were selected: walking speed, stride length for each limb, and joint angles of the hip, knee, and ankle across all gait phases, including initial

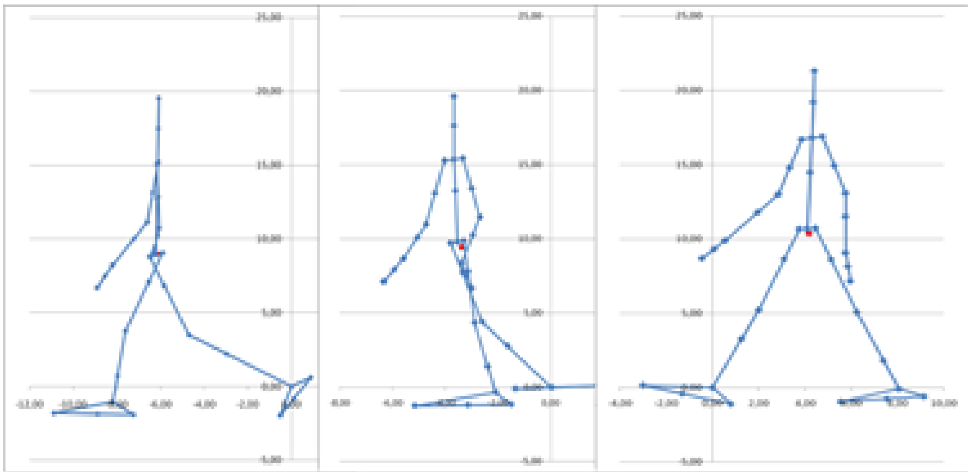

Figure 10. Swing phases: Initial swing, mid-swing and total swing

contact, foot descent, mid-stance, terminal stance, pre-swing, mid-swing, and terminal swing. In addition, socio-demographic variables were incorporated to contextualize the study population. These parameters were subsequently integrated into the technical specifications of the system and established as comparative criteria.

Furthermore, twenty nine motion indicators were estimated based on clinical-functional assessment criteria (see Table 1). To validate both the indicators and the technology, several testing protocols were established. These included defining multiple calibration tests for the motion capture system, leveraging results from preliminary objectives. The commercial gait analysis system installed at the Gait Laboratory of Universidad Autónoma de Occidente was used as a reference standard (see Figure **9**). The recorded test results demonstrated a 1 % accuracy in the measured variables, ensuring the system's reliability.

Although the proposed system demonstrated a 1 % accuracy compared with the commercial gait analysis laboratory, a more robust statistical validation process is still required. Future stages of this research should incorporate inter- and intra-subject reliability metrics (*e.g.*, intraclass correlation coefficients and Bland–Altman plots) to ensure reproducibility of the measurements. Similar methodological approaches have been highlighted in recent validation studies of wearable gait analysis systems in older adults (7,8).

Impact of Gait Characterization Variables

The research results considered the impact of assessing specific variables for gait characterization in each participant. These variables included:

Demographic factors: Gender, age, and disability status.

Table 1. Indicators used for the assessment

Indicators	Calculation formulas	Type of indicator	Source of information	Unit of measurement	Standard value
Gait Speed	total distance (cm/total time (s)	Quantitative	database generated by the software and organized by the physical therapist	Real number	91 cm/s
Stride Speed	total distance (cm)/total of steps	Quantitative	database generated by the software and organized by the physical therapist	Real number	139
Initial contact					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	154,3
Knee angle					160,8
Ankle angle					87,1
Loading response					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	167,5
Knee angle					161,8
Ankle angle					88
Mid-Stance					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	178
Knee angle					167,8
Ankle angle					86,5
Terminal Stance					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	193,8
Knee angle					173
Ankle angle					85,6
Pre-swing					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	183,7
Knee angle					160,4
Ankle angle					95,3
Initial Swing					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	179,3
Knee angle					133
Ankle angle					94,5
Mid-Swing					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	162,8
Knee angle					130,5
Ankle angle					90,4
Terminal Swing					
Hip angle	Real number	Result indicator	database generated by the software and organized by the physical therapist	Degrees (°)	154,7
Knee angle					160,3
Ankle angle					89,4

Living environment: Place of residence, type of terrain, number of floors in the household, and number of household members.

Reproductive history: Number of pregnancies.

Socioeconomic and mobility factors: Household head status, mobility restrictions, employment status.

Lifestyle and health habits: Physical activity level, smoking and alcohol consumption.

Health perception and medical history: Self-reported health status, history of pathologies, trauma, surgeries, medications, and vertigo.

Gait-related conditions: Use of assistive devices, presence of pain while walking, sensation of weakness or shortness of breath.

Functional mobility: Number of blocks the participant can walk, ability to walk at different speeds, difficulty moving on inclined surfaces.

Anthropometric measurements: Hip width and lower limb segment lengths (thigh, leg, and foot).

These variables were crucial in analyzing the participants' functional walking patterns and understanding how different biomechanical, environmental, and health factors influence gait performance.

Results

Description of the Studied Population

The study population belongs to Commune 20, located in the mountainside region of Cali, Colombia (Figure **11**). This commune encompasses eight neighborhoods and three urban developments, distributed along the sloped terrain (Development Plan 2008–2011 – Commune 20).

The area comprises 15,828 households, with 83.4 % classified in socioeconomic stratum 1, the lowest category on Colombia's six-tier scale (1–6). Additionally, some zones face infrastructure challenges, including poorly maintained inner roads and deteriorated signage and delineation, which may influence mobility and accessibility.

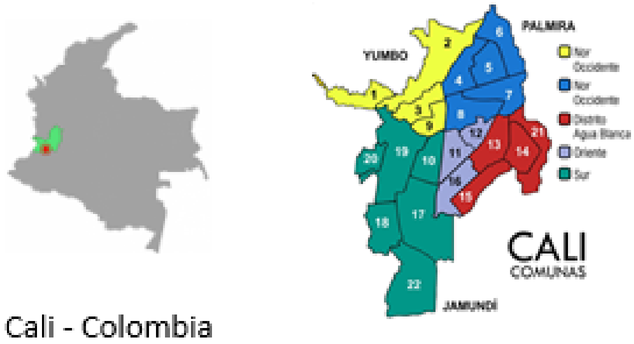

Figure 11. Distribution of communes in Cali

This section provides a concise analysis of the experimental results, their interpretation, and the conclusions drawn from the study.

The assessment system was applied to a total of 12 participants, consisting of 4 men and 8 women, aged between 62 and 92 years. The age distribution followed a normal pattern (p = 0.33), with an average age of 73 years.

Regarding residential terrain conditions, 50 % of the participants lived in flat areas, 33.33 % in moderately hilly terrain, and the remaining 16.67 % in steeply inclined areas.

Anthropometric measurements— including thigh, leg, and right foot length—were recorded to parameterize the gait model for each individual and determine the optimal placement of sensors. The recorded measurements were:

Thigh length: 40–55 cm, Leg length: 35–48 cm, Foot length: 20–30 cm, (Figure **12** presents a detailed visualization of these measurements).

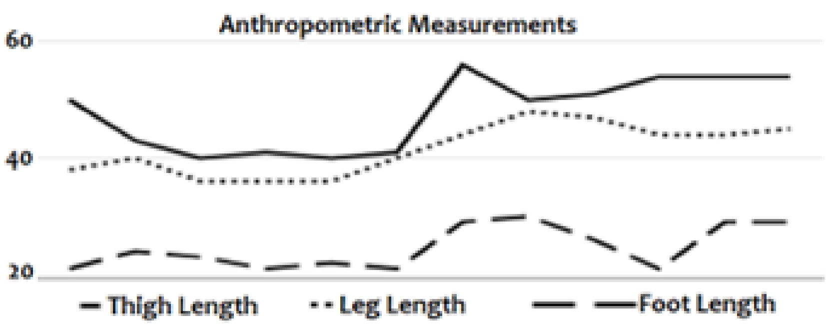

Figure 12. Anthropometric measurements of the lower limb segments

The collected data enabled a comparative analysis of the left and right lower limbs for each participant, assessing potential discrepancies in stride length between hemibodies. The results indicated that only three participants exhibited variations exceeding 10 cm in stride length, a difference that could be considered statistically significant (see Figure **13**).

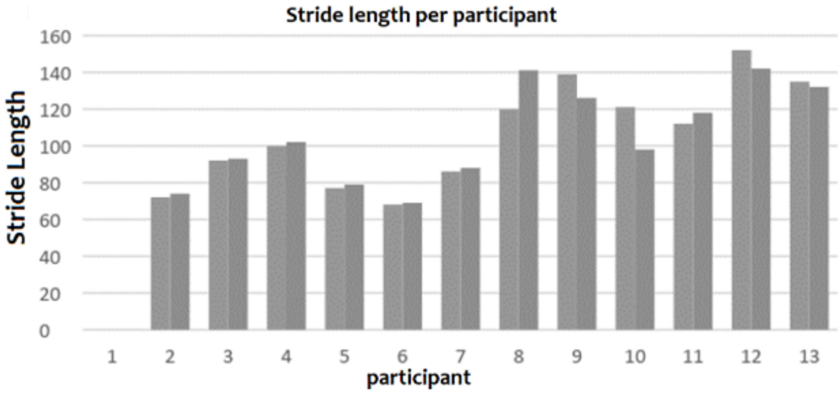

Figure 13. Comparison of the stride length of the lower limbs (right and left) for each participant

The application recorded and displayed the walking speed of each participant, revealing expected variations in stride velocity based on clinical and socio-demographic conditions. Despite these differences, the reported values remained within normal ranges for each individual (see Figure **14**).

The minimum recorded speed was 83 cm/s, while the maximum speed reached 330 cm/s. The median walking speed was 207 cm/s, with an interquartile range of 156.5 – 277 cm/s.

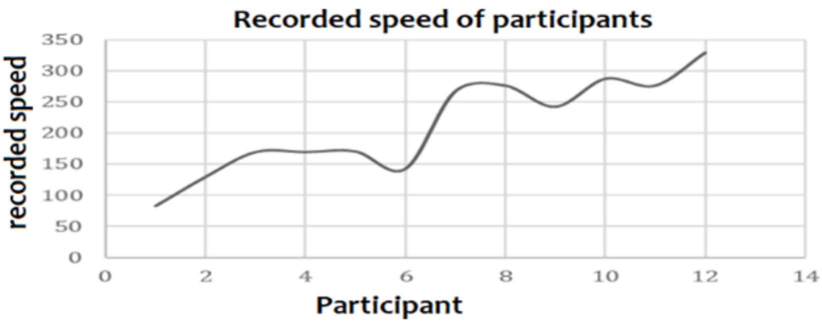

Figure 14. Speed analysis between participants

Analysis

The gait analysis was conducted from the initial contact phase to the final swing phase of the same lower limb. The system generated angular position reports for each joint, using the horizontal position (0°) as a reference.

During the support phase (initial contact, foot descent, medium support, and total support), the ankle exhibited the least mobility among the lower limb joints, showing more uniform and consistent motion patterns across all participants. In contrast, the knee demonstrated the greatest fluctuations in angular position, indicating it as the most mobile joint during these phases.

In the initial contact and medium support phases, the motion angles of the hip, knee, and ankle displayed a high degree of homogeneity among participants (see Figure **15**). However, in the foot descent phase, the data followed a non-normal distribution with variance differences likely attributed to variations in terrain conditions that directly affected foot contact with the ground.

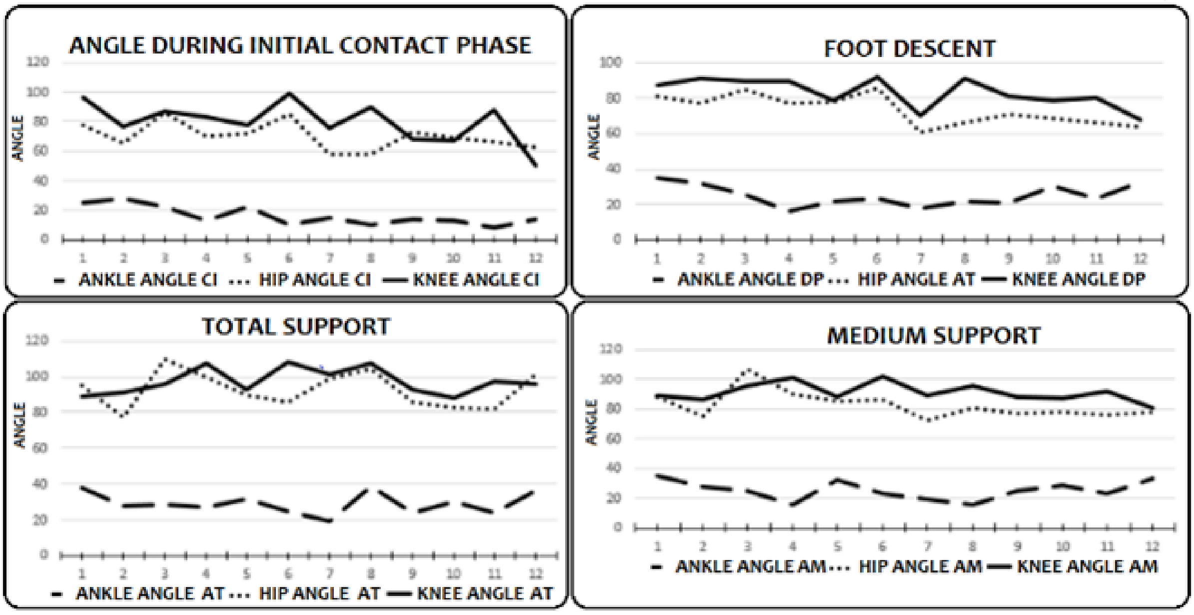

Figure 15. Articular mobility angles of the lower limb in the support phases

Final Support and Swing Phase Analysis

During the final support phase, the hip and knee joints exhibited mobility ranges exceeding 100° relative to the horizontal plane. Both articulations demonstrated similar motion patterns, whereas the ankle remained below 50°, showing a considerably lower range of movement.

For group-level analysis, the pre-swing and swing phases revealed variable mobility patterns across the full range of joint motion. These variations must be interpreted considering the individual conditions of each participant (see Figure **16**.)

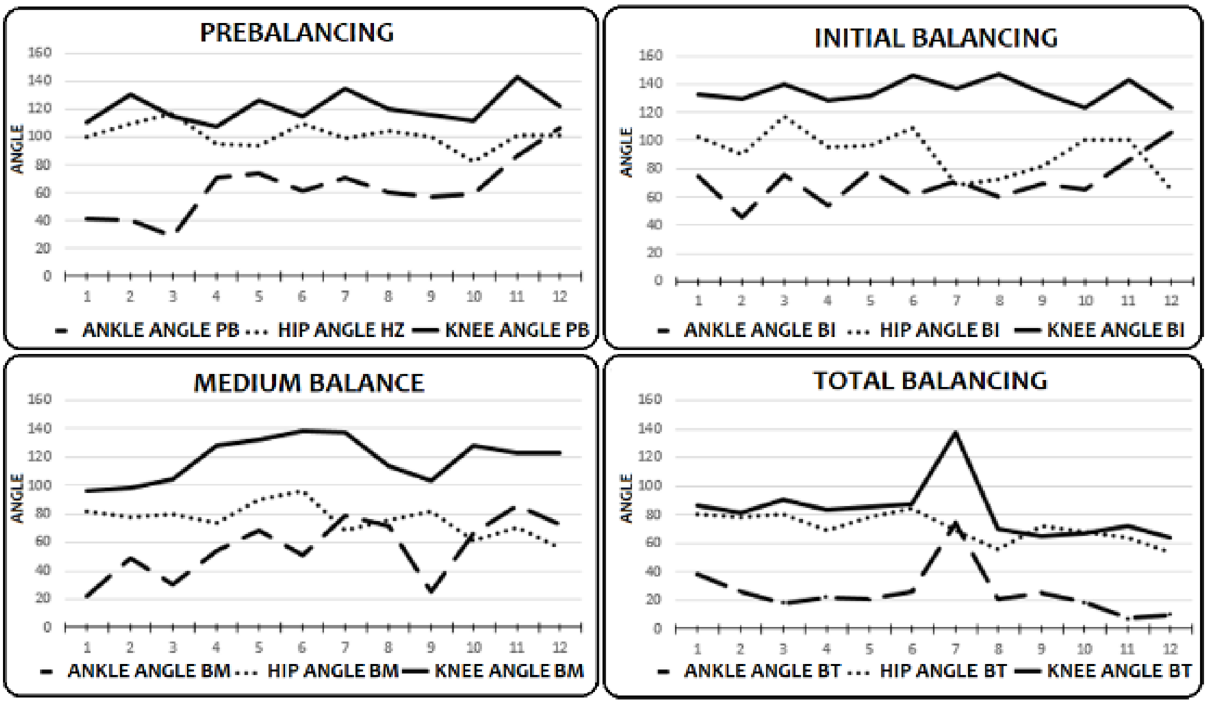

Figure 16. Articular mobility angles of the lower limb in pre-swing and swing phases

Additionally, a screening tool was implemented to identify extreme mobility points, which may indicate compensatory mechanisms due to musculoskeletal alterations. This tool helps detect mobility impairments in specific gait phases, serving as early warning signals for potential risk factors. Identifying these anomalies is particularly relevant for the elderly population, as altered gait mechanics may increase the risk of falls and related adverse events.

Individual Motion Pattern Assessment

The gait analysis was conducted individually to establish correlations between motion patterns, terrain conditions, and clinical/anthropometric factors. According to the kinematic parameters defined by Perry (1992), the joint mobility of the hip, knee, and ankle fluctuates throughout the gait cycle as follows:

- Ankle: Plantar flexion ranges from 7° to 20°, while dorsiflexion reaches 10°, returning to a neutral position.
- Knee: Performs a flexion from 18° to 65°, achieving full extension only during total support.
- Hip: Predominantly flexes up to 30°, with extension reaching 10°, occurring in 50

Comparison with Fieldwork Results

The experimental data obtained showed significantly higher angles than those reported in the literature, particularly for the hip and ankle joints. These statistically significant differences suggest that anthropometric measurements and age variations influence gait mechanics.

A clear correlation was identified between lower limb length and walking speed, aligning with expected biomechanical principles.

Postural Adjustments and Instability

The hip joint exhibited an increased range of motion, likely as a postural compensation mechanism to maintain balance. The ankle joint exhibited the greatest variations in motion angles, which may be associated with a perceived instability while walking.

Conclusions

This study builds on technological advancements in motion analysis using portable inertial sensors at an affordable cost. Its primary objective is to provide objective data for assessing essential human activities through a structural determinant approach, identifying factors that contribute to functional limitations.

Additionally, it promotes early prevention strategies to mitigate functional decline and offers comprehensive management tools that consider environmental influences on mobility restrictions.

The integration of body-adaptable sensors introduces a portable and ambulatory methodology for motion analysis, offering operational and configuration advantages over traditional gait analysis laboratories. Furthermore, this approach enhances the user's emotional comfort, allowing individuals to perform natural movement activities in familiar environments, avoiding the altered behavior that may arise from feeling observed in a clinical setting.

Clinical and Functional Applications

Beyond serving as a diagnostic tool, the developed software facilitates:

- Monitoring of musculoskeletal and neurological pathologies affecting mobility.
- Pre- and post-intervention assessments to evaluate treatment effectiveness.
- Motion analysis guidance for adapting orthoses and prostheses.

Study Context and Social Impact

The system was tested in a mountainside population exposed to sloped terrain and limited urban transportation access. The Siloé community was specifically chosen due to its high economic and geographic vulnerability, characterized by varying inclines and architectural barriers that increase joint stress during activities like climbing stairs and walking on steep surfaces.

The data collected provided insight into the locomotion characteristics of the local population, shaped by their environmental conditions. Given the importance of monitoring elderly individuals vulnerable to mobility impairments, these technologies emerge as valuable assessment tools in real-life conditions.

This project carries significant social impact, addressing both individual mobility challenges and broader environmental factors. Universidad del Valle has prioritized the open-access development of this technology, ensuring its widespread availability for community service, reinforcing its commitment to socially driven innovation.

Future research should validate this low-cost and portable gait assessment system with larger and more diverse populations, incorporating clinical cohorts with musculoskeletal and neurological conditions. Expanding the scope of evaluation beyond elderly individuals will allow a more comprehensive understanding of its applicability across different health contexts. Likewise, integrating machine learning models for the automated classification of gait patterns could strengthen the predictive capacity of the tool, supporting early diagnosis and personalized rehabilitation strategies. These steps would contribute to consolidating the system as a scalable solution for healthcare services in both urban and rural environments, ensuring its long-term sustainability and clinical relevance.

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