Data Article

Dataset for gait analysis and assessment of fall risk for older adults

Pablo E. Caicedo\textsuperscript{a,}\textsuperscript{*}, Carlos F. Rengifo\textsuperscript{b}, Luis E. Rodriguez\textsuperscript{c}, Wilson A. Sierra\textsuperscript{c}, Maria C. Gómez\textsuperscript{d}

\textsuperscript{a} Faculty of Engineering, Corporación Universitaria Autónoma del Cauca, Colombia
\textsuperscript{b} Department of Electronics, Instrumentation and Control, Universidad del Cauca, Colombia
\textsuperscript{c} Biomedical Engineering Program, Escuela Colombiana de Ingeniería Julio Garavito, Colombia
\textsuperscript{d} Clínica Universidad de La Sabana, Colombia

\textbf{A R T I C L E  I N F O}

\textbf{Article history:}
Received 11 October 2020
Accepted 13 November 2020
Available online 21 November 2020

\textbf{Keywords:}
Gait analysis
Fall risk assessment
Performance oriented mobility assessment
POMA
Short physical performance battery
SPPB
Gait parameters
Motor function test

\textbf{A B S T R A C T}

This article presents a five-part dataset for human gait analysis in a healthy older adult population (37 women and seven men; age $69.98 \pm 8.57$ years, body mass index $27.71 \pm 4.57$). Part 1 compromises demographic data for the 44 participants, along with the results of the Short Physical Performance Battery (SPPB) motor function test and the Mini-Mental State Examination (MMSE). We used the MMSE to ensure the participants could understand the experimental protocol instructions. Part 2 presents the anthropometric measurements of the participants. Part 3 shows the results for each item of the Gait component of the Performance Oriented Mobility Assessment (POMA-G). Part 4 contains five files per participant, storing motion-capture data for the lower limb in the Coordinate 3D (C3D) format. These files were generated using a Vicon motion analysis system, consisting of 24 reflective markers and seven cameras (Vantage V5) sampled at 100 Hz. Part 5 contains 26 gait parameters for each C3D file obtained using Nexus 2.9.3. The dataset is available in a Mendeley repository (Reserved DOI: 10.17632/xgw6bg3g8h.1).

\textsuperscript{*} Corresponding author.

\textbf{E-mail address:} pablo.caicedo.r@uniautonoma.edu.co (P.E. Caicedo).

\textbf{Social media:} \textsuperscript{\textbullet} (P.E. Caicedo), \textsuperscript{\textbullet} (C.F. Rengifo), \textsuperscript{\textbullet} (W.A. Sierra)

https://doi.org/10.1016/j.dib.2020.106550

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Specifications Table

| Subject | Biomechanics |
|---------|--------------|
| Specific subject area | Human gait analysis is the systematic study of how locomotion patterns vary between people according to specific characteristics such as age, anthropometry, pathologies, or walking conditions. |
| Type of data | Table |
| How data were acquired | Kinematic data were collected using a Vicon motion analysis system at 100 Hz. A physiotherapist administered SPPB [1], POMA-G [2], and MMSE [3] to 44 participants. The spatial and temporal gait parameters were calculated using the Nexus 2.9.3 software. |
| Data format | Raw and analyzed |
| Parameters for data collection | An engineer with six years of experience in gait analysis placed 24 markers on each participant according to Conventional Gait Model version 2.3 (CGM2.3) [4, 5]. The 24 markers comprised ten markers on each leg and four around the pelvis. |
| Description of data collection | The dataset contains demographic and anthropometric data, the global test scores for the SPPB and MMSE, the assessment of each item on the POMA-G when evaluated by two physiotherapists, five 3D files per participant, and 26 parameters for each participant on the C3D file. |
| Data source location | Escuela Colombiana de Ingeniería Julio Garavito, Bogotá D.C./Cundinamarca/Colombia 4.7827° N, 74.0426° W |
| Data accessibility | Reserved DOI: 10.17632/xgw6bg3g8h.1 |

Value of the Data

- The dataset is intended to train machine-learning models to predict analytical outcomes with the SPPB and POMA-G from the Cartesian position of the reflective markers. The data set can also be used to compare fall risk assessments based on the SPPB and POMA-G versus techniques such as Lyapunov exponents [6, 7] Floquet multipliers [8], and recurrence quantification analysis [9].
- Researchers and clinicians who use data-oriented algorithms to assess fall risk will benefit from this dataset because they can use the Cartesian position of the markers as inputs for their algorithms. Then, they can compare the resulting evaluation with screening tools accepted in their clinical environments.
- The dataset should serve as a basis to validate new fall risk assessment algorithms that complement motor function tests, such as SPPB and POMA. This use of the dataset as a complementary approach is effective because in these motor function tests, the resulting scores can be influenced by the test administrator’s experience and level of concentration.

1. Data Description

File 01_demography_sppb_mmse.xlsx contains each participant’s sex, age, mass, height, body mass index, number of self-reported falls in the last month, and the results of SPPB and MMSE.

File 02_anthropometry.xlsx contains the linear distance between right and left anterior superior iliac spine (L), distance between right anterior superior iliac spine and right medial malleolus (H1), distance between left anterior superior iliac spine and left medial malleolus (H1), left
knee width, right knee width, left ankle width, and right ankle width for each participant. Fig. 1 shows the first three distances.

File 03_poma_test.xlsx contains some participant’s results for the seven POMA-G test items. Each participant was filmed by three cameras while walking in a straight line through a room. Two physiotherapists independently evaluated the videos. One physiotherapist was an expert, who has administered the test daily for the past five years. The other physiotherapist was familiar with the test but has administered it once a year. Each physiotherapist-rater evaluated the videos twice with a difference of one week. These data are intended to calculate intra and interrater agreement. The missing results are due to unexpected failures in video cameras.

Folder 04_C3D_files contains five C3D files per each participant. Each participant walked five times using 24 reflective markers, ten at each leg and four around the hip (Fig. 2). The markers were located according to CGM2.3 [4, 5].

File 05_gait_parameters.xlsx contains 26 gait spatiotemporal gait parameters for each participant. Each parameter is described at this link. https://www.vicon.com/support/faqs/?q=how-does-nexus-plug-in-gait-and-polygon-calculate-gait-cycle-parameters-spatial-and-temporal.

2. Experimental Design, Materials and Methods

2.1. Materials

The optical motion capture system comprised seven cameras (Vantage V5) sampled at 100 Hz and distributed around a rectangular area 15 m long and 6 m wide. Each camera was mounted on a tripod 1.90 m above the floor. The gait parameters were calculated according to the CGM2.3 by Nexus movement analysis software, version 2.9.3. During system calibration, which was repeated every day during the ten days required to capture the data for the 44 participants, the Vicon software reported an accuracy better than 0.3 mm.

Also, three RGB cameras (Thieye T4, Thieye T5 y Thieye T5 edge) were distributed as indicated in Fig. 3 to film the participants while they were walking and wearing reflective markers. Thus, both the Vicon and the RGB cameras recorded the participant’s movement simultaneously.
2.2. Data collection protocol

This experimental protocol was used to obtain the dataset:

1. A physiotherapist asks the participant’s sex, age, and the number of self-reported falls over the last month, along with the participant's mass and height to calculate body mass index.
2. A physiotherapist administers the MMSE.
3. A physiotherapist administers the SPPB.
4. An engineer identifies bony landmarks and measures inter anterior-superior-iliac-spine distance, pelvic depth, clinical leg length, knee diameter, and ankle diameter. These measurements are required to calculate joint angles from the Cartesian positions of the markers.
5. The participant is asked to remain immobile to estimate the joint’s center of rotation using the CGM2.3 and the anthropometric parameters obtained from the previous step.
6. The participant is asked to walk ten times between two points at a distance of 12 m apart. For each gait, a C3D file and three videos are generated.
**Table 1**

Data processing for data collection protocol Steps 5 and 6.

| Data processing sequence                                                                 | Step of the data collection protocol |
|------------------------------------------------------------------------------------------|---------------------------------------|
| Assign labels to the markers according to CGM2.3 (Fig. 2).                              | Yes 6                                 |
| Eliminate false markers generated by unwanted reflections.                              | Yes 6                                 |
| Fill the gaps in the trajectories of the four markers of the pelvis using the Nexus Rigid Body Fill option, which is used only when the relative positions between the markers are constant. | Yes 6                                 |
| Apply the sequence of filling options: (i) Rigid Body Fill, (ii) Pattern Fill, and (iii) Spline Fill to the markers in thighs, shanks and feet. | Yes 6                                 |
| Fit CGM2.3 to each participant using the tools: (i) Scale Subject, (ii) Static Skeleton Calibration – Markers Only, and (iii) CGM2.3 – Calibration. | Yes 6 No                              |
| Filter the resulting trajectory using the pipeline Filter Trajectories – Woltring.        | No 6 Yes                              |
| Calculate the gait parameters using the pipeline Calculate Gait Cycle Parameters, which is a Vicon’s implementation of CGM2.3. | No 6 Yes                              |

2.3. **Data processing**

Table 1 presents the data-processing steps carried out using Nexus.

The best five trials of each participant were included in the dataset. These trials have 0 unused markers and 0 markers unlabeled.

2.4. **Fall risk assessment using POMA**

Two physiotherapist used POMA-G to assess participants by watching three videos of each participant (Fig. 3). These videos were looped for one minute, and then the raters had two
minutes to complete the seven POMA-G questions. This process was repeated for the videos of each participant. Then, one week later, the physiotherapist-raters used POMA-G again to assess the participants by watching the same videos; however, for this new rating session, the videos were presented in a different order than in the previous week.

Ethics Statement

The experiments described in this work have been carried out following the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Also, the participants gave their informed consent approved by the Ethics Committees of both, the Escuela Colombiana de Ingeniería and Clínica Universidad de la Sabana.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

Acknowledgments

The authors would like to recognize and express their sincere gratitude to Corporación Universitaria Autónoma del Cauca [ISNI: 0000 0004 0483 8740] (Colombia), Universidad del Cauca [ISNI: 0000 0001 2158 6862] (Colombia), Escuela Colombiana de Ingeniería [ISNI: 0000 0001 2323 9370] (Colombia), and to Clínica Universidad de La Sabana [ISNI: 0000 0001 2111 4451] (Colombia) for the financial support granted during this project. The authors also would like to thank Enago (www.enago.com) for the English language review.

References

[1] J.M. Guralnik, L. Ferrucci, E.M. Simonsick, M.E. Salive, R.B. Wallace, Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability, N. Engl. J. Med. (1995) https://doi.org/10.1056/NEJM199503230230902.
[2] M.E. Tinetti, Performance-oriented assessment of mobility problems in elderly patients, J. Am. Geriatr. Soc. 34 (1986) 119–126 https://doi.org/10.1111/j.1532-5415.1986.tb05480.x.
[3] M.F. Folstein, S.E. Folstein, P.R. McHugh, “Mini-mental state”, A practical method for grading the cognitive state of patients for the clinician, J. Psychiatr. Res. (1975) https://doi.org/10.1016/0022-3965(75)90026-6.
[4] F. Leboeuf, R. Baker, A. Barré, J. Reay, R. Jones, M. Sangeux, The conventional gait model, an open-source implementation that reproduces the past but prepares for the future, Gait Posture (2019) https://doi.org/10.1016/j.gaitpost.2019.04.015.
[5] J. Cockcroft, Q. Louw, R. Baker, Proximal placement of lateral thigh skin markers reduces soft tissue artefact during normal gait using the conventional Gait model, Comput. Methods Biomech. Biomed. Engin. (2016) https://doi.org/10.1080/10255842.2016.1157865.
[6] S. Meh dizadeh, A robust method to estimate the largest Lyapunov exponent of noisy signals: a revision to the Rosenstein’s algorithm, J. Biomech. 85 (2019) 84–91 https://doi.org/https://doi.org/10.1016/j.jbiomech.2019.01.013.
[7] K.S. van Schooten, S.M. Rispens, M. Pijnappels, A. Daffertshofer, J.H. van Dienen, Assessing gait stability: the influence of state space reconstruction on inter- and intra-day reliability of local dynamic stability during over-ground walking, J. Biomech. 46 (2013) 137–141 https://doi.org/https://doi.org/10.1016/j.jbiomech.2012.10.032.
[8] J.B. Dingwell, H.G. Kang, Differences between local and orbital dynamic stability during human walking, J. Biomech. Eng. 129 (2007) 586–593 https://doi.org/10.1115/1.2746383.
[9] M.A. Riley, R. Balasubramaniam, M.T. Turvey, Recurrence quantification analysis of postural fluctuations, Gait Posture 9 (1999) 65–78 https://doi.org/10.1016/S0966-6362(98)00044-7.