

Technical white paper

Ambient Gait Measurement with Teton

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1. Overview

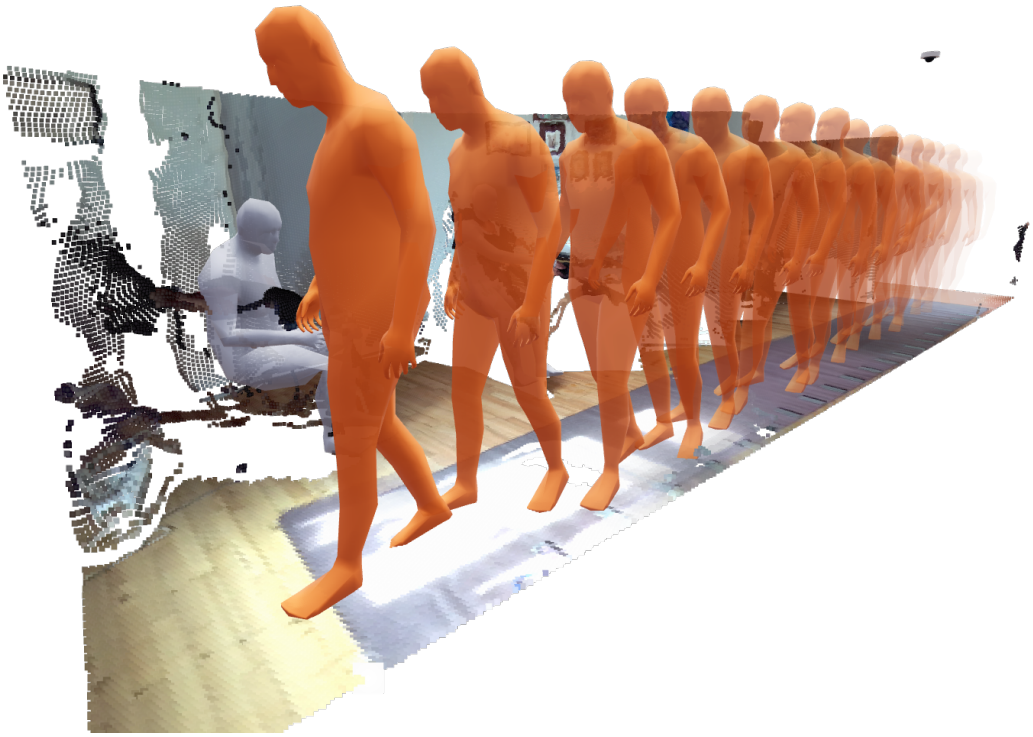


Figure 1: Field validation setup reconstructed in 3D. The scene shows the instrumented walkway with successive body-pose estimates illustrating a participant's path through the room.

Teton uses an in-room sensor to turn everyday walking into measurements of mobility. Three-dimensional body pose provides estimates of walking speed, step and stride length, and the timing of the gait cycle, without requiring a wearable sensor.

This paper presents a field validation study comprising 315 camera recordings paired with concurrent GAITRite reference data, collected from 15 participants performing 98 walks in a care-home room. Camera-derived gait metrics are compared with measurements from a GAITRite Platinum instrumented pressure walkway, providing an initial assessment of agreement in a care setting.

2. Introduction

Walking is a familiar activity with a complex underlying structure. How quickly a person moves, how far each step carries them, and how they divide time between the two legs describe different aspects of mobility. Walking speed has been associated with survival in older adults [1]. Beyond average values, stride-to-stride variability provides complementary information about locomotor control and changes associated with aging and disease [2].

A clinical assessment captures walking under defined conditions at a particular time. Walking in a resident's room offers another perspective: short journeys, pauses, changes of direction, and assistance form part of the person's usual routine. Repeated observations can describe this everyday pattern alongside periodic assessments. Prior work on passive in-home sensing has examined the relationship between such measurements and clinical function [3].

Teton's approach builds on its existing person tracking, pose estimation, and action recognition. Gait analysis uses the movement already observed in the room to resolve individual steps and cycles. The resident does not need to initiate a measurement, carry a device, or follow a marked course.

This field validation assesses agreement between Teton's gait measurements and an instrumented pressure-walkway reference under the conditions studied.

3. Measurement approach

3.1. From movement to gait cycles

The system detects and tracks people, estimates their three-dimensional body pose, and identifies walking activity. Changes in foot and leg motion are used to estimate initial contact and toe-off for each side. Initial contact marks the beginning of stance; toe-off marks the beginning of swing.

A complete cycle contains the bilateral contact and toe-off events followed by a recurrence of its opening event. A cycle may begin at either initial contact or toe-off; its duration is the elapsed time between successive occurrences of that event on the same foot.

Spatial measurements use estimated heel positions. The displacement between the opening and closing heel positions defines the cycle's direction of travel and stride length. Walking speed is calculated as stride length divided by stride time. Each metric is defined in its results section.

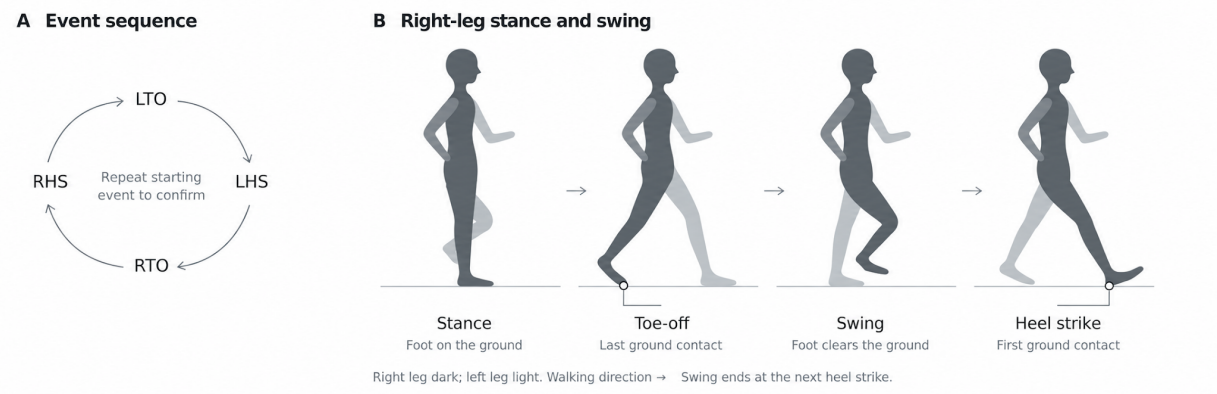


Figure 2: Gait events and phases. A: the detector accepts any rotation of the event ring and confirms a cycle when its starting event repeats (R/L: right/left; HS: heel strike; TO: toe-off). B: heel strike marks first ground contact and the start of stance; toe-off marks the end of ground contact and the start of swing. Swing ends at the next heel strike. Right-leg phases are shown; left-side events are equivalent.

3.2. From cycles to walk-level measurements

Each completed cycle contributes to running summaries of the available metrics. The mean describes the typical measured value, while the standard deviation describes variation among the contributing observations. Separate left and right summaries retain differences between sides.

For the comparison, cycle-derived measurements are summarized over each recorded walk and compared with the corresponding GAITRite summary.

4. Field validation in a care-home room

4.1. Study design

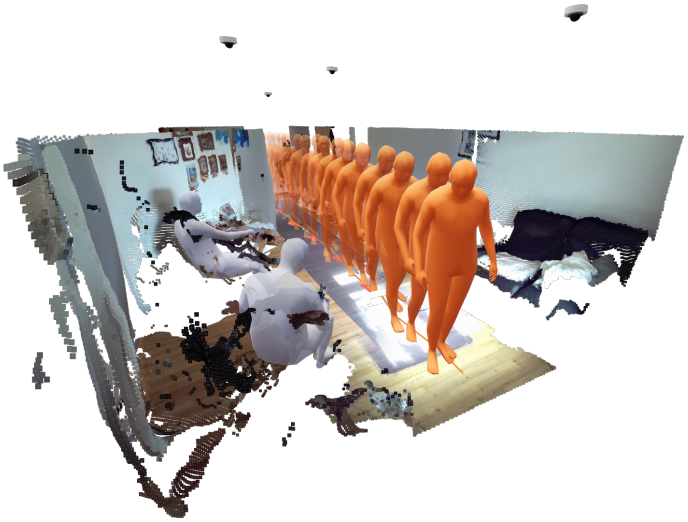


Figure 3: Field validation setup reconstructed in 3D. The scene shows the instrumented walkway and four camera locations, with successive body-pose estimates illustrating a participant's path through the room.

Walking was recorded concurrently from four camera views and a GAITRite Platinum instrumented pressure walkway in a care-home room (Figure 4). Camera and walkway coordinates were aligned using spatial calibration.

The field study included 15 participants and 98 recorded walks, yielding 315 camera recordings. All participants provided informed consent.

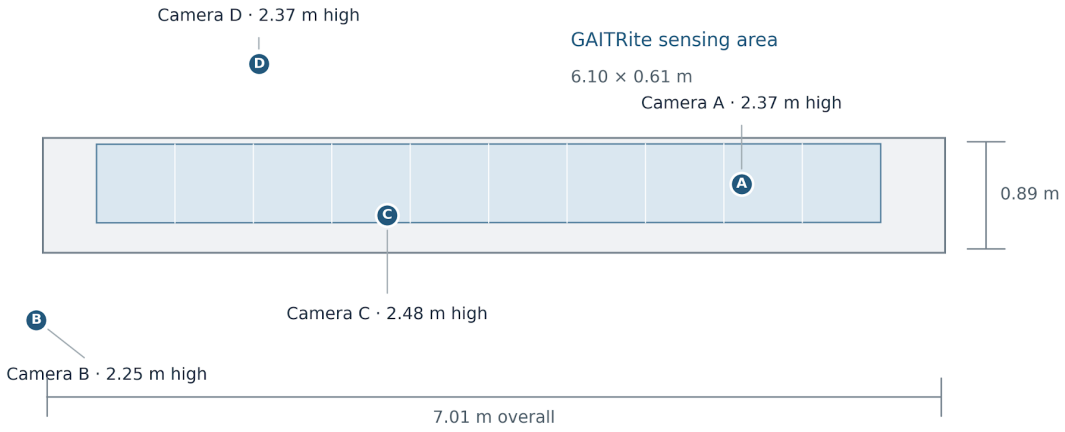


Figure 4: Camera and walkway layout, viewed from above. Camera markers show floor-projected positions from the shared calibration; labels give height above the floor. The blue region is the active sensing area. Horizontal distances are drawn to scale; camera symbols are schematic.

4.2. Reference comparison

In this study, concurrent GAITRite measurements provided an independent reference for evaluating Teton's camera-derived gait metrics. GAITRite is an instrumented pressure walkway that records the location and timing of foot contacts to derive spatial and temporal gait measurements. It is used in clinical assessment and research; the manufacturer reports that it has been cited in over 5,000 research publications since 2005 [4]. Instrumented pressure walkways are an established reference method for validating gait estimates from other devices and modalities: Apple's iPhone validation and Google's smartwatch study both used a Zeno pressure walkway [5, 6].

Each camera-derived walk summary was compared with its corresponding GAITRite whole-walk export. Camera-derived metrics used complete cycles within the active walkway region during the interval from the first to the last reference contact.

4.3. Statistical analysis

Agreement is calculated from paired camera-derived and reference whole-walk values pooled across all recorded camera views. The primary descriptions are mean and standard deviation (SD) of absolute error, signed mean bias, and descriptive limits of agreement (LoA). Absolute-agreement intraclass correlation, ICC(A,1), measures how closely the two methods agree on individual walk-level values, relative to the variation across the observed walks. Values closer to 1 indicate stronger agreement; both systematic bias and random differences reduce agreement. Because ICC also depends on the range of values measured, it is interpreted alongside absolute error and bias.

Each paired camera-walk observation has equal weight in the pooled point estimates. Repeated walks and multiple camera views from the same participant are correlated observations; they do not increase the number of independent participants.

5. Measurement results

The following results evaluate our latest model as of 2 November 2026 across seven gait metrics.

Results use combined-side whole-walk values. Absolute error is reported as mean and standard deviation (SD); signed error is Teton minus GAITRite. LoA denotes descriptive limits of agreement. Appendix B defines these statistics and their interpretation.

Pooling reflects the intended use in a resident's room, where people walk freely and change direction, so a fixed camera observes their gait from different angles throughout the day. Each camera observation retains its own reference comparison; views are not averaged before error is calculated. All finite paired values are included.

5.1. Walking speed

Walking speed describes how quickly a person moves along their walking path. It is calculated for each gait cycle as stride length divided by stride time.

Mean (SD) absolute walking-speed error was 0.057 (0.067) m/s, with ICC(A,1) of 0.98. Reference stride-speed values ranged from 0.329 to 2.015 m/s.

Table 1: Walking speed: agreement with GAITRite.

Absolute error (m/s) Mean (SD)	**Mean bias (m/s)**	**95% LoA (m/s)**	**ICC(A,1)**
0.057 (0.067)	0.025	-0.141 to 0.190	0.98

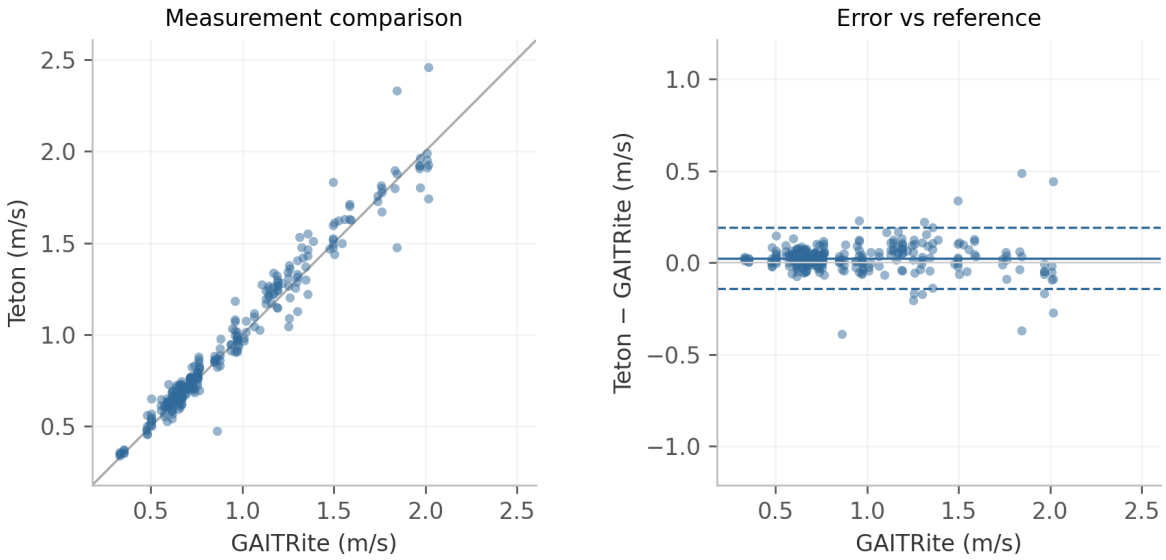


Figure 5: Walking speed pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

5.2. Stride time

Stride time is the duration of one complete gait cycle. It is measured between successive occurrences of the same event on the same foot, either initial contact to initial contact or toe-off to toe-off.

Mean (SD) absolute stride-time error was 49.5 (49.5) ms, with ICC(A,1) of 0.95. Mean bias was −22.9 ms, indicating shorter estimated cycles than the reference on average.

Table 2: Stride time: agreement with GAITRite.

Absolute error (ms) Mean (SD)	**Mean bias (ms)**	**95% LoA (ms)**	**ICC(A,1)**
49.5 (49.5)	-22.9	-152.7 to 107.0	0.95

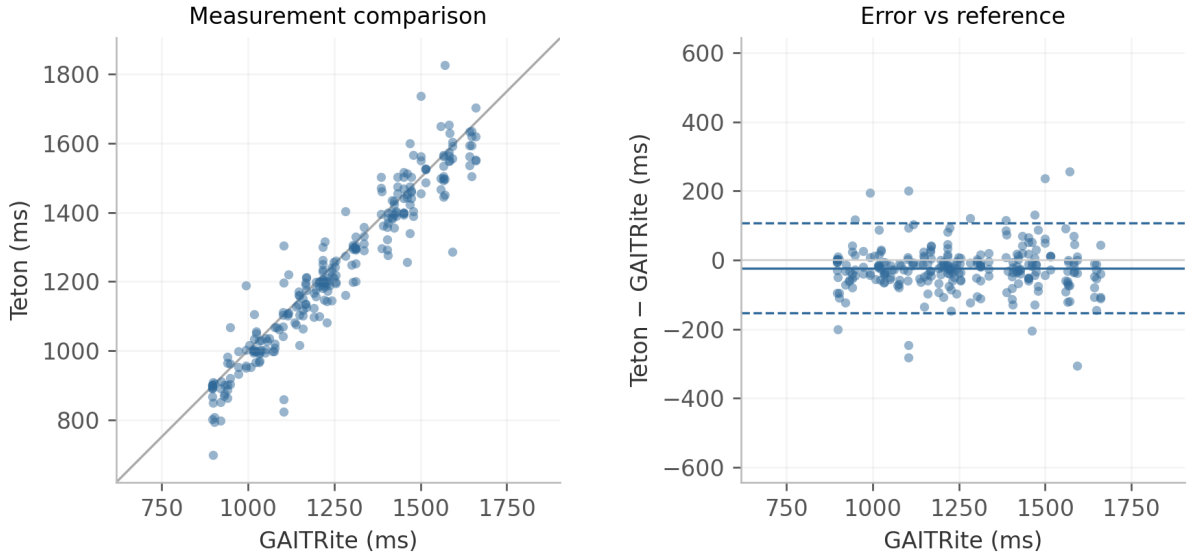


Figure 6: Stride time pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

5.3. Stride length

Stride length is the distance covered over one complete gait cycle. It is calculated as the straight-line displacement of the same heel between the cycle's opening and closing events.

Mean (SD) absolute stride-length error was 0.069 (0.074) m, with ICC(A,1) of 0.95. Mean bias was +0.006 m; descriptive limits of agreement were −0.191 to +0.204 m.

Table 3: Stride length: agreement with GAITRite.

Absolute error (m) Mean (SD)	**Mean bias (m)**	**95% LoA (m)**	**ICC(A,1)**
0.069 (0.074)	0.006	-0.191 to 0.204	0.95

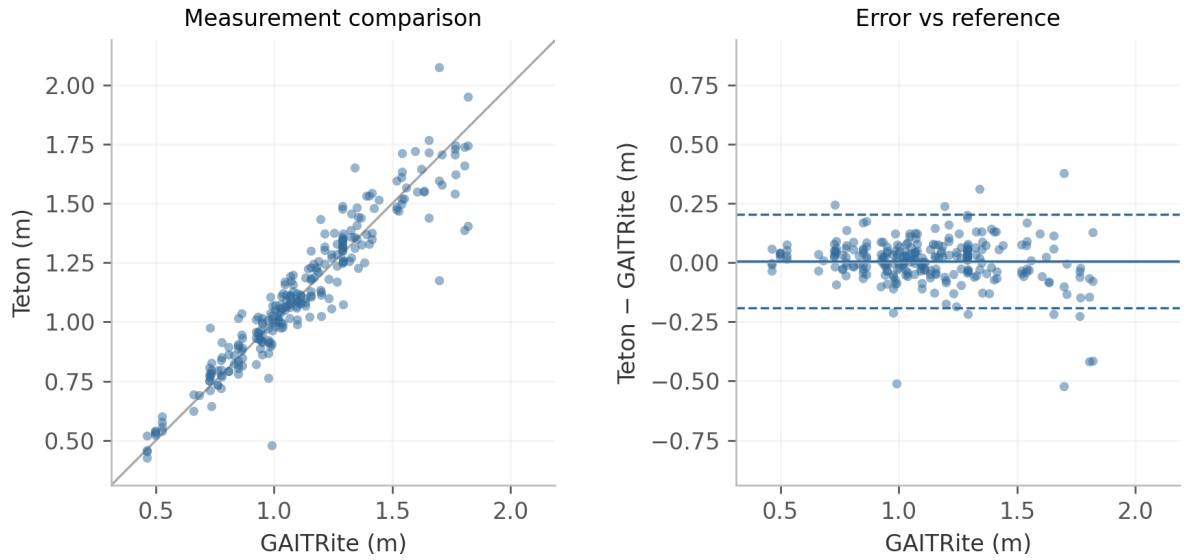


Figure 7: Stride length pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

5.4. Step time

Step time is the elapsed time between initial contact of one foot and the next initial contact of the opposite foot.

Mean (SD) absolute step-time error was 28.6 (29.9) ms, with ICC(A,1) of 0.93. Mean bias was −10.3 ms.

Table 4: Step time: agreement with GAITRite.

Absolute error (ms) Mean (SD)	**Mean bias (ms)**	**95% LoA (ms)**	**ICC(A,1)**
28.6 (29.9)	-10.3	-88.9 to 68.3	0.93

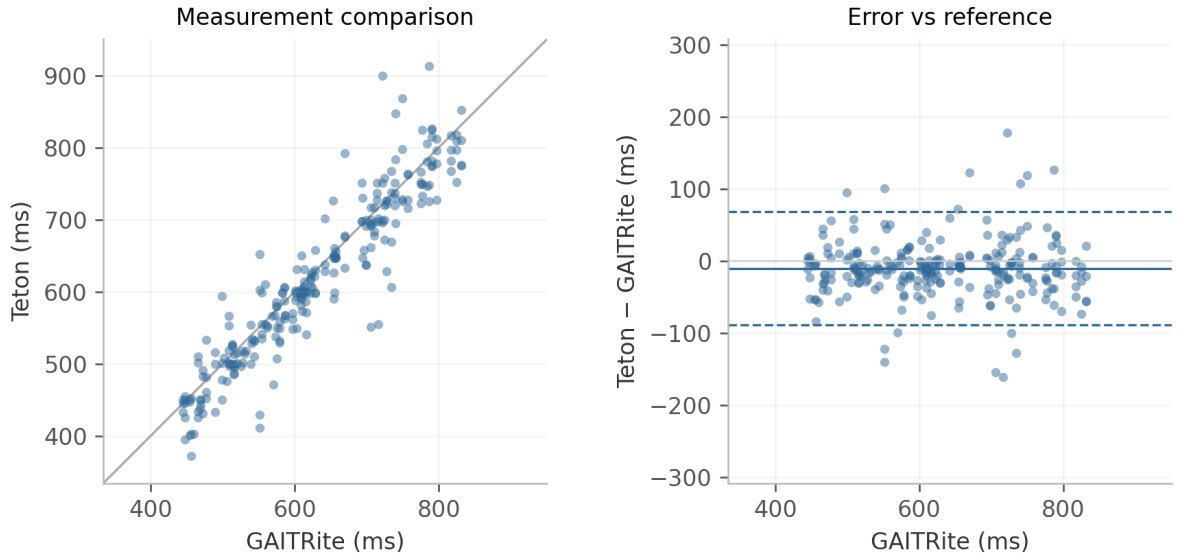


Figure 8: Step time pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

5.5. Step length

Step length is the forward distance between successive initial contacts of opposite feet. It is measured along the cycle's direction of travel.

Mean (SD) absolute step-length error was 0.040 (0.041) m, with ICC(A,1) of 0.93. Mean bias was +0.003 m.

Table 5: Step length: agreement with GAITRite.

Absolute error (m) Mean (SD)	**Mean bias (m)**	**95% LoA (m)**	**ICC(A,1)**
0.040 (0.041)	0.003	-0.109 to 0.116	0.93

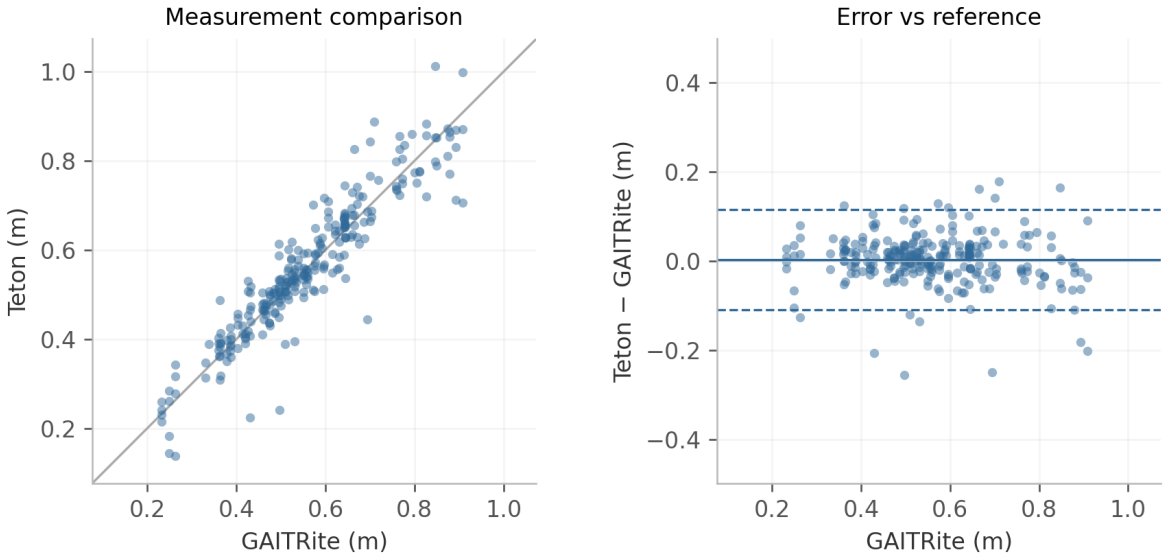


Figure 9: Step length pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

5.6. Step width

Step width is the side-to-side separation between successive heel positions at initial contact. It is measured perpendicular to the direction of travel and reported as a positive distance.

Mean (SD) absolute step-width error was 0.032 (0.028) m, with ICC(A,1) of 0.83. Mean bias was −0.006 m, while descriptive limits of agreement were −0.088 to +0.075 m. A small mean bias therefore coexisted with appreciable observation-level error.

Table 6: Step width: agreement with GAITRite.

Absolute error (m) Mean (SD)	**Mean bias (m)**	**95% LoA (m)**	**ICC(A,1)**
0.032 (0.028)	-0.006	-0.088 to 0.075	0.83

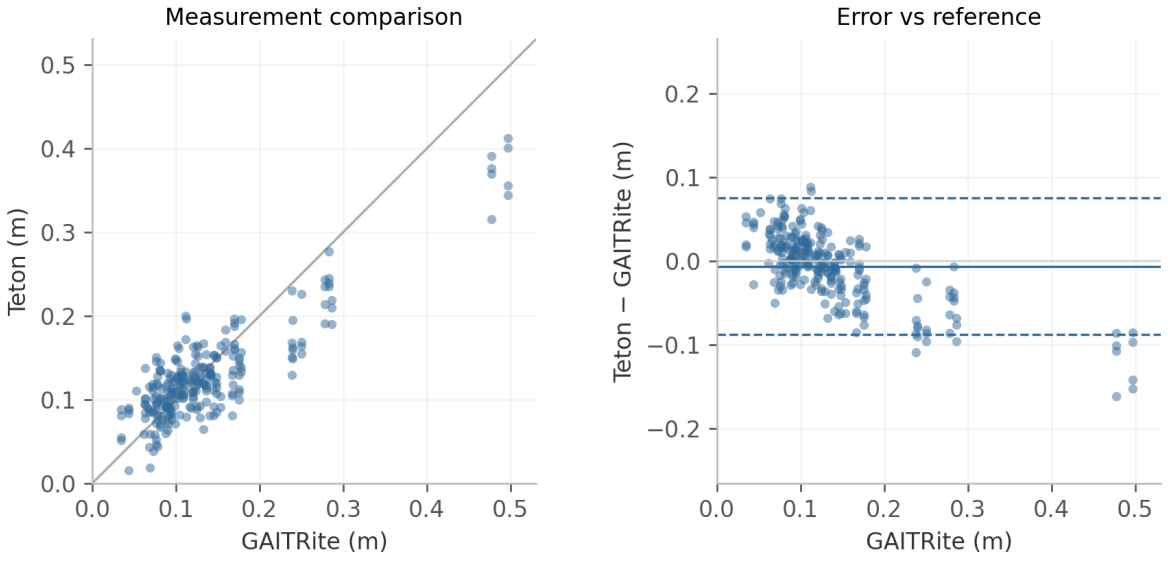


Figure 10: Step width pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

5.7. Double support time

Double support time is the percentage of a gait cycle during which both feet are in contact with the ground. It combines the two periods of overlapping foot contact within the cycle.

Mean (SD) absolute double-support-time error was 5.98 (5.02) percentage points, with ICC(A,1) of 0.35. These results identify support-phase estimation as a priority for refinement before interpreting the measurements interchangeably with the walkway reference.

Table 7: Double support time: agreement with GAITRite.

Absolute error (pp) Mean (SD)	**Mean bias (pp)**	**95% LoA (pp)**	**ICC(A,1)**
5.98 (5.02)	0.29	-15.03 to 15.60	0.35

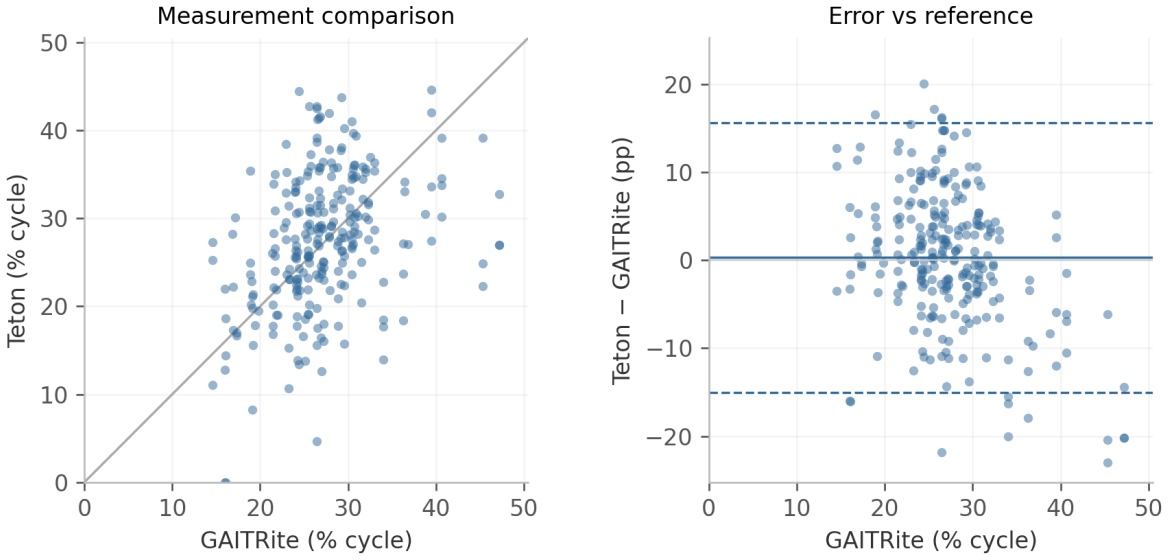


Figure 11: Double support time pooled across recorded views. Each point is one paired camera-walk observation. Left: measurement comparison with identity line. Right: error versus reference, with mean bias (solid) and descriptive 95% limits of agreement (dashed). Reference and error axes use equal numerical spans.

6. Discussion

This field validation demonstrates that Teton's ambient camera-based gait measurements can achieve strong agreement with an instrumented pressure walkway for several core spatiotemporal gait metrics in a care-home environment. Agreement was strongest for walking speed, step and stride timing, followed by step and stride length. These findings support the feasibility of obtaining quantitative gait measurements from an in-room camera system during ordinary walking, without dedicated gait measurement equipment.

The results are also encouraging when compared with published validation studies of other accessible gait measurement technologies. Across selected metrics, Teton's results were numerically comparable to or more favourable than those reported for Apple's iPhone, Google's Pixel Watch, and OneStep (Table 8). For example, Teton achieved a walking-speed ICC of 0.98, compared with 0.92 for Apple and 0.88 for Google, and a walking-speed Pearson correlation of 0.980, compared with 0.88 for Google and 0.97 for OneStep. These comparisons provide useful context, although differences in sensing modalities, reference systems, populations, and evaluation protocols prevent conclusions of overall superiority or equivalence.

Table 8: Selected published statistics for walking speed, step length and stride length.

Metric / statistic	**Teton**	**Apple iPhone [5]**	**Google Pixel Watch [6]**	**OneStep smartphone app [9]**
Walking speed SD of absolute error (m/s) ↓	**0.067**	0.150	—	—
Stride length Absolute mean bias (m) ↓	**0.006**	—	—	0.091
Walking speed Absolute mean bias (m/s) ↓	**0.025**	—	—	0.095
Walking speed Pearson r ↑	**0.980**	—	0.88	0.97
Walking speed ICC ↑	**0.98**	0.92	0.88	0.96
Step length ICC ↑	**0.93**	0.84	0.83	0.90
Step length SD of absolute error (m) ↓	**0.041**	0.050	—	—
Step length Absolute mean bias (m) ↓	**0.003**	—	—	0.032
Stride length ICC ↑	**0.95**	—	—	0.93
Step length Pearson r ↑	**0.932**	—	0.80 / 0.81 (L/R)	0.91

Lower SD of absolute error and absolute mean bias, and higher ICC and Pearson r, are favourable. Pearson r describes association rather than absolute agreement. Bold: Teton; green: favourable (or tied) to all exact comparator values shown in that row. Apple: validation set, 179 participants [5]. Google: Pixel Watch, 246 participants, segment-level ICC; step-length ICC was 0.83 for each side [6]. OneStep: pooled conditions, 20 healthy adults, thigh-mounted iPhones versus Vicon [9]. Teton and Apple use ICC(A,1); Google does not specify the ICC form, and OneStep reports inter-system ICC. Populations, protocols, aggregation and reference systems differ. These selected statistics do not establish overall superiority.

An important distinction is how these measurements are obtained. Camera-based gait and biomechanical analysis is well established in specialist systems such as Vicon, which provide optical and markerless motion capture within dedicated hardware and software packages [8]. Teton brings selected spatiotemporal gait measurements into a lightweight system using an in-room camera and compute unit. Gait measurement extends the functionality of Teton devices already deployed in care homes for fall monitoring and other activity-related functions, with no additional gait-specific equipment required in the resident's room. Unlike approaches requiring wearable devices, attached markers, or dedicated walking assessments, this setup offers the possibility of collecting gait information where a resident already lives without any additional burden.

Metric-specific performance and areas for improvement. While agreement was strong for several core gait metrics, performance varied across measurements. The shared-walk comparison in Appendix A provides supporting evidence of consistent walking-speed agreement across the four camera views. Step width and double support time showed weaker agreement, indicating opportunities for further refinement. Double support time is particularly sensitive to errors in foot-contact timing, as the interval spans the initial contact of one foot and the toe-off of the opposite foot. Small timing errors can therefore represent a substantial fraction of this brief period. Lower agreement for double support than for several other gait metrics has also been reported in smartphone and smartwatch validation studies, including Apple's iPhone and Google's smartwatch evaluations [5, 6].

Study limitations and generalizability. The cohort size and single-room setting limit claims of generalization. Participants and walks with more paired recordings contribute more to the pooled estimates. Although the recordings span a broad range of reference walking speeds, from 0.329 to 2.015 m/s, the recording mix has not been established as representative of daily walking in care homes. Broader validation should include additional participants, rooms, facilities, camera configurations, and walking conditions. Development comparisons on a repeatedly inspected benchmark provide evidence for algorithm selection, while independent evaluation is needed to characterize performance beyond that benchmark.

Opportunities for longitudinal mobility monitoring. The potential value of ambient gait capture extends beyond individual walking assessments. For residents living in care homes, repeated measurements could establish a longitudinal record of their usual walking patterns and how these vary over days and weeks. Research in independently living older adults has demonstrated the feasibility of repeated unobtrusive gait measurement and examined its relationship with clinical function [3, 7]. Teton's existing in-room infrastructure provides an opportunity to extend this approach into care-home environments.

For care staff, opportunities to observe a resident's walking are intermittent and shaped by the care routine, from brief encounters in a hallway to assistance with transfers or scheduled assessments. Ambient gait monitoring could provide additional context between these encounters, potentially helping staff recognize gradual mobility changes and prompting closer assessment. For physiotherapists, longitudinal gait summaries could support evaluation of rehabilitation progress and help establish whether improvements observed during supervised sessions carry over into daily activity.

These applications remain prospective. Measurement agreement alone does not establish diagnostic thresholds, fall-risk prediction, sensitivity to clinical change, or improved care outcomes. Demonstrating clinical value will require studies examining reliable within-person

trends, the recognition of meaningful mobility changes, and how care teams use this information in practice.

Together, these findings establish a promising foundation for bringing quantitative gait measurement into everyday care-home environments. The combination of strong agreement for several core gait metrics and integration into existing ambient monitoring infrastructure creates an opportunity to move from occasional gait assessments toward repeated, unobtrusive measurement of mobility in daily life.

7. Conclusion

This field study evaluated Teton's ambient gait measurements against GAITRite in a care-home room. Across 15 participants and multiple camera viewpoints, the results demonstrated strong agreement on common gait metrics such as walking speed and step and stride timing and length.

These findings support the use of Teton's existing in-room devices to automatically capture key measures of everyday walking, without wearables, visual markers, or additional gait-specific equipment. By extending mobility observation beyond staff encounters and scheduled assessments, adding gait measurements offers care teams a fuller picture of residents' walking patterns over time, adding objective context to their day-to-day observations.

Acknowledgements

We thank Solvejg Henneberg Pedersen, lead physician in geriatric and stroke medicine at the Holbæk Hospital, for providing the GAITRite Platinum system on loan for this study.

Appendix A: Walking-speed agreement across views

This supporting comparison uses the same 31 walks from 7 participants across all four camera views (124 recordings). Walking-speed estimates showed strong agreement with GAITRite in each view, with ICC(A,1) values of 0.96–0.99 and mean absolute errors of 0.031–0.058 m/s. These results provide example evidence of consistent agreement across camera views under the conditions studied. Camera labels correspond to Figure 4. The subset is exploratory and unevenly distributed: one participant contributed 15 walks.

Table A1: Walking-speed agreement across camera views on shared walks.

Camera	Participants	Recordings	Absolute error Mean (SD), m/s	Mean bias m/s	95% LoA m/s	ICC(A,1)
A	7	31	0.049 (0.045)	+0.021	−0.104 to +0.146	0.96
B	7	31	0.058 (0.044)	+0.031	−0.099 to +0.162	0.96
C	7	31	0.031 (0.028)	+0.021	−0.051 to +0.092	0.99
D	7	31	0.034 (0.026)	+0.023	−0.050 to +0.095	0.99

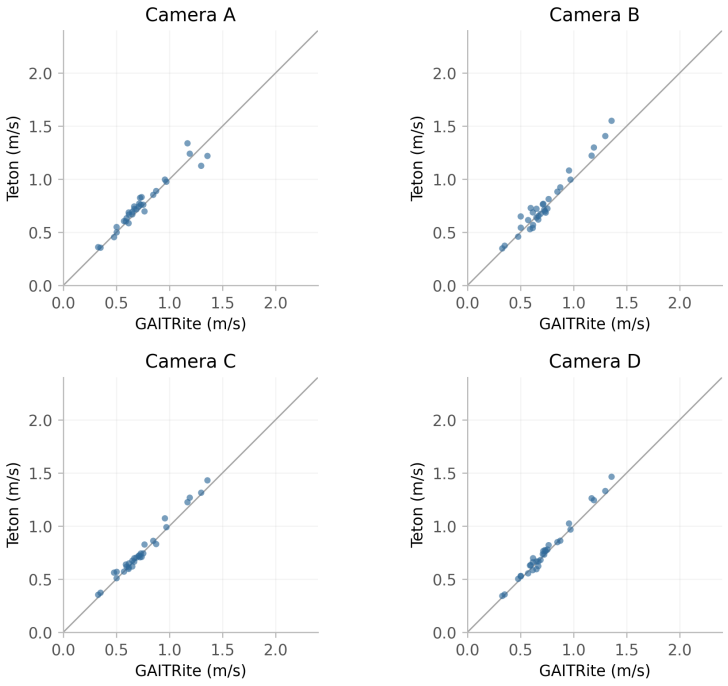


Figure A1: Walking-speed agreement across four camera views on the same 31 walks. Each point pairs a camera measurement with its GAITRite walk summary; the line indicates equality. All panels use identical axes.

Appendix B: Interpreting the agreement statistics

All comparisons use paired walk-level measurements. Signed error is Teton minus GAITRite: positive bias indicates overestimation and negative bias indicates underestimation. Mean absolute error describes the average size of the differences, irrespective of direction. The SD reported alongside it describes variation in absolute errors.

Following Bland and Altman [10], descriptive 95% limits of agreement are calculated as mean signed error $\pm$ 1.96 $\times$ the SD of signed errors. They describe the spread of differences between the two methods and are distinct from confidence intervals for an estimated statistic.

ICC(A,1) is the single-measure, absolute-agreement intraclass correlation coefficient described by McGraw and Wong [11]. It should be interpreted alongside absolute error and bias, because its value also depends on the variation between measurements. Repeated observations from the same participant are correlated; the study does not establish test-retest repeatability or a minimal detectable change.

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