Wearable Sensors for Turning Assessment to Discriminate Frailty Syndrome Among Community-Dwelling Older Adults

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Abstract

**Background:** Mobile health technologies such as wearable inertial sensors are emerging as complementary clinical assessments and potential to evaluate and analyze postural stability, mobility and gait. Turning is a challenging task and is reported to be one of the daily activities that leads to falling in older populations. We investigated differences in 180° walking turns and 360° turning on the spot among frail, pre-frail, and non-frail older adults utilizing wearable sensors, and determined cutoff points of the turning measures that best discriminated older adults with frailty from those without.

**Methods:** A cross-sectional study was conducted with community-dwelling older adults aged over 65 years. Frailty was assessed using Fried's phenotype method, and turning tasks were measured by wearable sensors. The turn duration (s) and angular velocity (°/s) in 180° and 360° turns were recorded for analysis.

**Results:** In total, 109 participants were enrolled including 50 pre-frail and 12 frail individuals. Frail older adults took significantly longer and had slower angular velocities to complete the 180° and 360° turning than either pre-frail (p=0.002 and p<0.001, respectively) or non-frail (p=0.03 and p<0.001, respectively) older adults after adjustments for gait speed. Cutoff times of 2.45 and 3.46 s were found to best discriminate frail people from those without frailty in both 180° (sensitivity 83.3%, specificity 71.1%, AUC 0.796) and 360° (sensitivity 91.7%, specificity 74.2%, AUC 0.857) turn tasks.

**Conclusions:** Older individuals with frailty syndrome had difficulty turning as evidenced by a longer turning duration and a slower angular velocity. The turn duration could be a potential biomarker of frailty in older populations. This simple and portable wearable technique could improve early detection of the onset of frailty, allowing the clinician to prescribe prevention and rehabilitation interventions for reversing their physical decline.

Introduction

Frailty is a common geriatric syndrome and is characterized by decreased physiological reserve and increased vulnerability towards adverse health outcomes, including falls, hospitalization, institutionalization, and death (1). The incidence rate of falls among frail older people in residential care settings was twice the rates in old people's homes and senior citizens' apartments (2). Frail older adults are 1.16-1 to 3.6 times (3) more likely to fall than those who are not frail. More than half of community-dwelling frail older adults had experienced a fall in the past year, and 6% of them had serious fall-related injuries (2). The consequences of falling, such as fractures and fear of falling (FoF), reduce an individual's level of activity, leading to further physical deconditioning and loss of independence (4).

The most common activities at the time of falling among frail ambulatory elderly are walking and postural change (5) and, in fact, approximately 35–40% of all steps taken in everyday walking are turns (6). Turning is a fundamental component of mobility in daily life but a challenging task that requires deceleration of locomotion, controlling medial-lateral balance, and rotation of the body towards the new direction while maintaining dynamic stability (7, 8). Impaired turning in older adults increases the risk of falling, and falls
during turning are particularly dangerous, because they usually result in contact of the femur with the ground leading to 8-fold more hip fractures than falls during straight-ahead walking (9).

Research related to turning has been widely conducted in older populations (10–13), and in patients with neurological disorders such as stroke (14) and Parkinson's disease (PD) (15). Previous studies showed that older people who fell often spent more time, took a greater number of steps, and displayed rigid inter-segmental movements with instability when completing a turn (12, 13). They also exhibited different kinematic and electromyographic characteristics in the lower limbs during turning compared to younger adults (11). However, research based on turning in frailty syndrome is limited. Galan-Mercant and Cuesta-Vargas found significant differences in 180° turning while walking between frail elderly and healthy controls using an inertial sensor with accelerometers and gyroscopes during the Timed Up and Go (TUG) test (16). Ansai and colleagues adopted the same test and further found that the turn duration and velocity can discriminate frail from pre-frail older adults when performing a 180° turn subtask using a motion analysis (17).

Despite interesting findings, frail older people presented significantly slower straight walking speeds than non-frail people in both studies, which could have influenced the results. Recent evidence showed that a reduced gait speed resulted in a lower turning velocity accompanied by shorter step lengths and longer step times (18), indicating that the turning performance was affected by the walking speed. Furthermore, walking turns that involve a transition between walking and turning may have different motor programming from turning in place (19) such as a 360° on-the-spot turn. It is one of the 14 items in the Berg Balance Scale and an important task to assess balance and fall risks (20), but has not previously been examined in frail people.

Mobile health technologies such as wearable, body-fixed sensors that quantify mobility are emerging as complementary clinical assessments. Recently, wearable sensors have been used for the evaluation of postural stability, gait and fall risk (21–23). A systematic review suggests that artificial intelligence (AI) algorithms seem to be able to support gait analysis in clinical evaluation based on inertial sensor data (22). The majority of turning studies have relied on three-dimensional motion capture system to assess turning performance. Although laboratory-based measures are quantitative and objective, they depend on expensive laboratory-grade equipment and strict testing protocols within a controlled environment. In contrast, wearable sensors can be easily applied at the point-of-care and can facilitate quantitative assessments in the clinical settings or home environments. Therefore, the aims of the study were to utilize wearable sensors identifying differences in 180° and 360° turning performances among frail, pre-frail, and non-frail older adults and determining cutoff points of turning measures that best discriminated frail from non-frail older adults.

**Methods**

**Design and participants**
This cross-sectional study was conducted among community-dwelling older adults aged over 65 years from community care centers in northern Taiwan. The inclusion criteria were (1) being aged over 65 years and (2) having no physical disability. The exclusion criteria were (1) severe neuromuscular diseases or musculoskeletal disorders, such as knee joint and lower back pain, that would affect assessments of physical performance, (2) Alzheimer’s disease diagnosed by a physician or meeting the diagnostic criteria for dementia, (3) severe mental illness or behavior problems that resulted in an inability to comprehend commands and follow instructions, and (4) visual impairments or severe cardiovascular diseases resulting in an inability to walk independently.

**Data collection procedures**

Data collection for the present study occurred from June to October 2019. In order to contact potential participants, a door-to-door approach and poster advertisements were used based on contact information provided by community care centers. Potential participants were informed of the study objectives and procedures by the research team. Those interested in participating gave informed consent, and the study protocol was approved by the Institutional Review Board of Taipei Medical University (JIRB: N201809043). Data collection consisted of a battery of frailty criteria, physical performance tests including walking and turning tasks, and individual-based interview questionnaires about sociodemographic data, FoF, and general cognitive function.

**Measurements**

**Fried frailty criteria**

The frailty status of participants was evaluated according to the five-item version of the Fried criteria (1, 24). The summed score of these five criteria, including weight loss, exhaustion, low physical activity, slowness, and weakness, classifies people into one of three frailty status: non-frail (score 0), pre-frail (score 1 or 2) and frail (score 3–5).

**Weight loss**

Weight loss was evaluated using the question: “In the last year, have you lost more than 4.5 kg (10 lbs) or 5% of your weight unintentionally (not due to dieting or exercise)?” An answer of “yes” scored 1 point.

**Exhaustion**

Exhaustion was measured using two questions from the Center for Epidemiologic Studies Depression (CES-D) scale (25): “How often do you feel that everything you do is an effort?” and “How often do you feel that you cannot get going?” An answer of “occasionally/a moderate amount of the time (3–4 days a week)” or “most/all of the time (5–7 days a week)” scored 1 point.

**Low physical activity**

Physical activity was assessed according to the International Physical Activity Questionnaire (IPAQ)-Taiwan edition (26). It was stratified by sex. Males with < 383 kcal of physical activity per week or females with <
270 kcal per week were considered to have low physical activity and scored 1 point.

**Slowness**

Slowness was determined by the duration in seconds to complete a 4.57-m (15-ft) walk test. The cutoff points were adjusted by sex and height. A duration of ≥ 7 s for males of ≤ 173 cm or females of ≤ 159 cm scored 1 point. A duration of ≥ 6 s for males taller than 173 cm or females taller than 159 cm scored 1 point. Additionally, those who were unable to perform the test due to physical limitations were also considered to be slow and scored 1 point.

**Weakness**

Weakness was identified by handgrip strength (in kg). Participants pulled the handle of a dynamometer with the greatest grip force and held it for 6 s. The mean of three trials was obtained from the dominant hand. The cutoff points were adjusted by sex and body-mass index (BMI). Handgrip strength in the lowest 20% quintile scored 1 point.

**Turning performance**

The 180° and 360° turning performances were respectively measured using the “Walk Test” and “360° Turn Test” developed by APDM Opal wireless sensors and Mobility Lab software (OPAL system, APDM, Portland, OR, USA) (27). An Opal is a lightweight (22-g) wearable inertial sensor, with a battery life of 16 h, and includes 8 gigabytes of storage. Three Opal inertial sensors were firmly attached to a participant by means of elastic Velcro bands: one on the middle part of the lower back (5th lumbar vertebra process) and two on shoes (on the top of each foot) (Fig. 1). Data were recorded at 128 Hz, stored in the internal memory of the Opal monitors, and later uploaded to a laptop computer for data analysis.

Participants were instructed to walk back and forth over a walking distance of 7 m at a convenient gait pace for 2 min with 180° turns at both ends. They were then asked to turn on the spot for 360° towards their preferred side. The duration and velocity of both the 180° and 360° turns were recorded for analysis. We used the horizontal rotational rate of the lumbar sensor to detect turning events. Only turns with a duration of 0.5–10 s, and turn angles of > 45° were considered. The turn duration (s) represents the time taken to complete a turn, while the turn velocity (°/s) represents the mean angular velocity of the trunk in the rotation axis during turning.

**Sociodemographic variables**

Sociodemographic data were collected by individual interviews and consisted of age, sex, educational level, number of chronic diseases, and history of falls in the past year. FoF was assessed by the Falls Efficacy Scale International (FES-I) (25, 28), which assesses subjects’ concerns about falling. It consists of 16 questions related to everyday activities and subjects are asked to rate whether they were “not at all”, “somewhat”, “fairly” or “very” concerned about falling when doing that particular activity. The summed score ranges 16–64, with a higher score indicating a greater FoF. An FES-I score of > 28 is interpreted as a high level of concern. General cognitive function was evaluated by the Mini-Mental State Examination (MMSE) (29), which assesses orientation to time and place, word registration, attention, calculation, recent
word recall, language, and visual construction. Cognitive impairment is defined as an MMSE score of $\leq 24$ points.

**Statistical Analysis**

Statistical analyses were performed using the Statistical Package for Social Sciences software (SPSS, Chicago, IL, USA) vers. 19.0. The statistical significance level was set to $p < 0.05$. We used an analysis of variance (ANOVA) with the Bonferroni post-hoc test for continuous variables and Chi-squared tests for categorical variables to compare differences among frail, pre-frail, and non-frail older adults. If variances among the groups were not equal according to Levene's test of homogeneity of variances, the Brown-Forsythe test with Dunnett's T3 post-hoc test was applied instead. For both turning tasks, a one-way analysis of covariance (ANCOVA), controlling for walking speed, was used to compare $180^\circ$ and $360^\circ$ turning durations and velocities among groups. A post hoc power analysis was conducted if significant differences exist. Receiver operating characteristic (ROC) curves were generated, and by using Youden's index, the $180^\circ$ and $360^\circ$ turning task cutoff durations were obtained. Cutoff durations in both turn tasks were used to discriminate frail from non-frail older adults.

**Results**

In total, 109 community-dwelling older adults (with a mean age of $72.14 \pm 5.89$ years, 78% females) were enrolled in the study (Table 1). Eleven percent of participants were identified as frail, and 45.8% had a pre-frail status. Significant differences between groups were found in terms of sex ($X^2 = 8.40, p = 0.015$), educational level ($X^2 = 29.14, p = 0.001$), number of chronic diseases ($F = 5.34, p = 0.009$), walking speed ($F = 13.51, p < 0.001$), and MMSE scores ($F = 4.50, p = 0.022$).
Table 1
Demographic characteristics among frail, pre-frail, and non-frail older adults

|                          | All participants (N= 109) | Frail (n = 12) | Pre-frail (n = 50) | Non-frail (n = 47) | p value |
|--------------------------|---------------------------|----------------|--------------------|--------------------|----------|
| Age, mean ± SD (years)   | 72.14 ± 5.89              | 73.78 ± 6.51   | 72.53 ± 6.12       | 71.30 ± 5.46       | 0.352    |
| Sex, n (%)               |                           |                |                    |                    | 0.015*   |
| Male                     | 24 (22.0)                 | 0 (0)          | 8 (16.0)           | 16 (34.0)          |          |
| Female                   | 85 (78.0)                 | 12 (100)       | 42 (84.0)          | 31 (66.0)          |          |
| Educational level, n (%) |                           |                |                    |                    | 0.001*   |
| Elementary school and below | 49 (45.0)                | 11 (92.0)      | 23 (46.0)          | 15 (30.0)          |          |
| Junior high school       | 13 (11.9)                 | 0 (0)          | 6 (12.0)           | 7 (14.0)           |          |
| Senior high school       | 27 (24.8)                 | 1 (8.0)        | 14 (28.0)          | 12 (25.0)          |          |
| College and above        | 20 (18.3)                 | 0 (0)          | 7 (14.0)           | 13 (27.0)          |          |
| Chronic disease, mean ± SD (no.) | 1.68 ± 1.59 | 2.08 ± 1.73   | 2.12 ± 1.80       | 1.10 ± 1.07       | 0.009*   |
| History of falls, n (%)  | 35 (32.1)                 | 5 (41.7)       | 17 (34.0)          | 13 (27.7)          | 0.603    |
| Walking speed, mean ± SD (m/s) | 0.93 ± 0.21 | 0.73 ± 0.22   | 0.89 ± 0.22       | 1.03 ± 0.11       | <0.001* |
| FES-I, mean ± SD (score/64) | 26.99 ± 10.60 | 30.58 ± 15.13 | 29.06 ± 11.15    | 23.87 ± 7.67      | 0.087    |
| MMSE, mean ± SD (score/30) | 26.97 ± 2.58 | 25 ± 3.62    | 26.72 ± 2.73      | 27.74 ± 1.69      | 0.022*   |

*Statistical significance: *p* < 0.05. FES-I, Falls Efficacy Scale-International; MMSE, Mini-Mental Examination State.

For the 180° degree turns, the duration (F = 6.436, *p* = 0.002) and velocity (F = 6.536, *p* = 0.001) significantly differed among the non-frail, pre-frail, and frail groups after adjustment for walking speed with high statistical power of 0.896 and 0.901. Post-hoc tests showed that the turning duration in frail older adults was longer than those of non-frail (*p* = 0.026) and pre-frail (*p* = 0.002) older adults, and similarly the turning velocity in frail older adults was slower compared to those with a non-frail (*p* = 0.004) and pre-frail (*p* = 0.002) status. With regard to 360° degree turns, there were significantly different durations (F = 9.869, *p* = 0.001) and velocities (F = 10.605, *p* < 0.001) among groups with high statistical power of 0.999 and 0.988. Post-hoc tests indicated that the turning duration was relatively longer and the velocity was slower in frail older adults compared to non-frail and pre-frail older adults (all *p* values < 0.001) (Table 2).
Table 2
The 180° and 360° turning performances among frail, pre-frail, and non-frail older adults

| Variable | Frail (n = 12) | Pre-frail (n = 50) | Non-frail (n = 47) | p for difference between non-frail and frail | p for difference between pre-frail and frail | Power |
|----------|----------------|-------------------|-------------------|---------------------------------------------|---------------------------------------------|-------|
|          | Mean    | SD    | Mean    | SD    | Mean    | SD    |                  |                  |                  |                  |
| 180° turn|         |       |         |       |         |       |                  |                  |                  |                  |
| Duration (s) | 2.93   | 0.69  | 2.34   | 0.36  | 2.23   | 0.32  | 0.026*            | 0.002*            | 0.896            |
| Velocity (°/s) | 119.41 | 30.54 | 175.11 | 42.55 | 194.04 | 32.11 | 0.004*            | 0.002*            | 0.901            |
| 360° turn|         |       |         |       |         |       |                  |                  |                  |                  |
| Duration (s) | 4.67   | 1.45  | 3.19   | 0.77  | 3.16   | 0.62  | <0.001*           | <0.001*           | 0.999            |
| Velocity (°/s) | 151.50 | 39.88 | 207.64 | 47.99 | 222.26 | 48.64 | <0.001*           | <0.001*           | 0.988            |

* Statistically significant: *p* < 0.05.

The ROC analysis showed that a cutoff time of 2.45 s best discriminated frail from non-frail older adults in terms of 180° turning measure (with an area under the ROC curve (AUC) of 0.796 (95% confidence level 0.654–0.939), sensitivity of 83.3%, and specificity of 71.1%). With regard to the 360° turning measure, a cutoff time of 3.46 s best discriminated frail from non-frail older adults (with an AUC of 0.857 (95% confidence level 0.750–0.965), sensitivity of 91.7%, and specificity of 74.2%) (Fig. 2).

**Discussion**

The present study utilized wearable sensors to investigate differences in turning performances among frail, pre-frail, and non-frail older adults when performing 180° walking turns and 360° turning on the spot, and also determined cutoff points of turning measures for discriminating frailty syndrome. The main finding was that frail older people had difficulty turning as evidenced by a longer duration and slower angular velocity in both turn tasks than either pre-frail or non-frail older people although turning performances were similar between pre-frail and non-frail older adults. Cutoff times of 2.45 and 3.46 s were found to best discriminate frail people from those without frailty for the 180° and 360° turns, respectively. Our study revealed wearable sensors for turning measurement are promising to identify frailty syndrome among older population living in the community.

Elderly with frailty syndrome were previously reported to have poor balance ability and muscle strength in their lower limbs (30–33), and both were significantly correlated with the turning ability. This may explain the consistent findings in the present and previous studies (16, 17), which showed the worst turning
performance with a longer duration and slower angular velocity in frail older adults. Such findings could particularly be confirmed in the current study since the walking speed was included as a covariate for analysis and the possible influence of walking speed on either turn duration and angular velocity was excluded.

Our study additionally found that cutoff times of 2.45 and 3.46 s for the 180° and 360° turns, respectively, best discriminated frail people from those without frailty. The AUCs for these two turning measures were 0.80 and 0.86, indicating that these turning assessments were highly accurate in discriminating between older people with and those without frailty syndrome. Previous studies showed that turning activity was able to differentiate older people with from those without frailty when analyzing all TUG subtasks (34). Turning features can also distinguish between people in the early stage of PD and healthy controls, even though their gait velocity is normal (35). These findings demonstrate that turning could be more sensitive than clinical measures of mobility for detecting declines in motor activity, and more vulnerable to impairment and deterioration than gait-related neuromotor systems (36). The turning duration could therefore be developed as a potential biomarker of frailty in older adults.

Using a slower angular velocity and additional time to accomplish a turn in the frail elderly, on the other hand, could be a compensatory or adaptive strategy in order to safely and successfully complete a turn. Enlarging the base of support along the medial-lateral axis is a postural adaptation to guarantee appropriate postural reactions for greater safety in curved walking (37, 38). Slowing down during a turn may contribute to accomplishing medial-lateral expansion of the base of support, thereby increasing the margin of stability. In fact, these features are observed when people walk. A systematic review of gait analysis in those with frailty showed distinct spatiotemporal gait characteristics, including a reduced cadence, shorter step length, and increased double-limb support time (39). They exhibited a cautious gait, which is an attempt to minimize postural instability and reduce balance-control challenges during walking.

Turning difficulty in the frail elderly could be related to poorer cognitive function. Older adults with mild cognitive impairment were found to have a longer duration and lower angular velocity during the turning subtask of the TUG (36). Turning involves a series of complex motor skills and some level of planning, organization, and orientation in space (40), which require relatively higher cognitive demands. Recent evidence showed that turns are associated with executive function (31), which is higher-order cognitive control of gait and posture (35, 36). Turns are additionally related to visuospatial and memory functions, since turning requires greater involvement of visuospatial processing to correctly enable directional movement (41). Although our participants did not present dementia, older adults with frailty were reported to have a greater likelihood of concomitant cognitive impairment than pre-frail and robust older adults (42), which mainly affected visuospatial ability, memory, processing speed, and general cognitive function (42). Therefore, the turning problem in frailty syndrome seems to be related to cognitive decline, and our frail older people did have a relatively lower cognitive function assessed by the MMSE than did non-frail older adults. Relationships between turning ability and cognition in this group would be of high interest to investigate in future studies.
Fear of falling (FoF) can also affect turning performance. FoF is a lack of self-confidence that usual activities can be performed without falling and is potentially a serious problem over and above falling per se (43). A previous study found that a higher level of FoF was associated with a longer turning duration and a greater number of steps during 360° turns, regardless of prior fall experience (44) in patients with PD. In a separate study, a higher level of FoF was also reported to correspond to a slower 180° walking-turn velocity in community-living older people with dementia. In fact, our participants with frailty had a relatively higher level of FoF than those without frailty, although this did not reach statistical significance. Mean scores of the FES-I in both frail and pre-frail groups were greater than the cutoff point of 28 points, indicating greater concern and greater FoF existed. It is commonly accepted that FoF seems to be linked to impaired functional capacity (45), and thus the higher level of FoF in our older people with frailty could affect their balance confidence and ultimately physical performance such as turning.

It is also worth mentioning that our results suggest that turn characteristics were unable to differentiate pre-frail and robust older people, indicating that the turning difficulty did not develop until the frail stage. This could be because turning-related functions in the pre-frail stage, which represents the group with greatest potential for transition and reversal frailty, have not significantly declined (31, 32). However, turning strategies, and the quality or even kinematic analysis of turning beyond the duration and velocity, which were previously explored in earlier studies (10–13), could be possible parameters for discriminating frailty, but were not investigated in the current study.

According to our data, the mean turn durations in 180° and 360° turns among frail older people were 2.93 and 4.67 s, respectively, which were quicker than those of Galan-Mercant and Cuesta-Vargas’s study (16). Their frail participants spent 5.327 s completing a 180° walking turn, and this might be because their subjects were 10 years older (mean ages of 83.71 vs. 73.78 years). Age was reported to have an influence on turning activity, which could explain the difference. Furthermore, Thigpen and colleagues previously suggested that taking longer than 3 s to navigate a 180° walking turn is indicative of turning difficulty (10). Slowness of turning of more than 4 s to complete a 360° turn based on the Berg Balance Scale was linked to a higher risks of falls (20). Therefore, frail older participants in the current study presented difficulty with turning and had higher risks of a fall. In fact, a higher proportion of fallers in our frail group was noted but was not statistically significant.

There are a couple of limitations to this study while generating research questions for follow-up studies. The sample size of the frail group was limited (12 frail older adults), which may not be fully representative of this population. However, the statistical tests presented high power values (more than 0.80), which ensure efficiency of the tests to compare the groups. A larger study in the future is still needed. Our study only assessed the turning duration and velocity without assessing strategies or the quality of movement. Additional work is required to explore more variables related to turning and other measurements of the level of impairment, such as muscle strength in the lower limbs, trunk control, or the static and dynamic balance capacity. These were reported in other populations to be associated with turning and could be contributing factors to turning dysfunction. This will help better understand the performance of turning and underlying mechanisms of turning difficulties among the frail elderly.
Conclusions

Our study conclude that wearable sensors for assessment of duration and angular velocity in the $180^\circ$ and $360^\circ$ turning tasks are promising to identify frail older people from pre-frail and non-frail older people living in the community. Cutoff times of 2.45 and 3.46 s for the $180^\circ$ and $360^\circ$ turns respectively were the best values in discriminating people with frailty from those without, suggesting that the turn duration could be a potential biomarker of frailty in older populations. This simple and portable wearable technique could improve early detection of the onset of frailty, allowing the clinician to prescribe prevention and rehabilitation interventions for reversing their physical decline.

Abbreviations

ANCOVA
Analysis of Covariance
ANOVA
Analysis of Variance
AUC
Area Under the ROC Curve
BMI
Body Mass Index
CES-D
Center for Epidemiologic Studies Depression scale
FES-I
Falls Efficacy Scale International
FoF
Fear of falling
IPAQ
International Physical Activity Questionnaire
MMSE
Mini-Mental State Examination
PD
Parkinson's disease
ROC
Receiver operating characteristic
SPSS
Statistical Package for Social Sciences software
TUG
Timed Up and Go test

Declarations
Ethics approval and consent to participate: The study was approved by the Institutional Review Board of Taipei Medical University (JIRB: N201809043).

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: HLC was a major contributor in study design, YLL and CWK have done the data collection, CYT analyzed and interpreted data, HLC and SCL have done the manuscript writing. All authors read and approved the final manuscript

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Figures

Figure 1

Equipment and positioning.
Figure 2

Receiver operating characteristic (ROC) curves of 180° (with a sensitivity of 83.3%, specificity of 71.1%, and area under the ROC curve (AUC) of 0.796) and 360° (with a sensitivity of 91.7%, specificity of 74.2%, and AUC of 0.857) turning durations among older adults with and those without frailty.