

## Sarcopenia and Dynamic Balance in Older Adults: A Cross-Sectional Study at Kedungwuni II

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### Abstract

**Background:** Sarcopenia is characterized by progressive loss of muscle mass and muscle function and may coexist with impaired mobility and balance in older adults. However, the relationship between operationally identified sarcopenia and dynamic balance may vary according to population characteristics and measurement methods.

**Objective:** This study examined the association between operational sarcopenia classification and dynamic balance among older adults attending Kedungwuni II Primary Health Center, Pekalongan Regency.

**Methods:** This analytical cross-sectional study included 32 adults aged  $\geq 60$  years recruited by total sampling in February 2026. Sarcopenia was classified operationally using Manual Muscle Testing (MMT) and lower-limb anthropometric measurements because DXA and BIA were unavailable. Dynamic balance was assessed using the Timed Up and Go Test (TUGT). Data were summarized descriptively and analyzed using Spearman rank correlation at  $\alpha=0.05$ .

**Results:** Thirty participants (93.8%) were classified as sarcopenic and 2 (6.3%) as non-sarcopenic. Seventeen participants (53.1%) had high fall risk and 15 (46.9%) had moderate fall risk according to the study's TUGT categorization. Mean TUGT was  $30.38 \pm 5.14$  seconds (range, 22 to 39 seconds). Spearman correlation showed a weak positive association ( $r=0.275$ ,  $p=0.128$ ; 95% CI,  $-0.08$  to  $0.57$ ). Exploratory simple linear regression yielded a 95% CI of  $-4.079$  to  $11.279$  for the sarcopenia coefficient and  $R^2=0.030$ .

**Conclusion:** No statistically significant association between the operational sarcopenia classification and dynamic balance was observed. The findings should be interpreted cautiously because of the small and highly unbalanced groups and the nonstandard sarcopenia classification.

### Keywords

Sarcopenia; Postural Balance; Aged; Accidental Falls; Timed Up and Go Test

### Introduction

Sarcopenia is an age-related condition involving clinically important changes in skeletal muscle quantity and function.<sup>1</sup> The Asian Working Group for Sarcopenia (AWGS) 2019 recommends an algorithm that considers muscle strength, muscle quantity, and physical performance and provides population-specific criteria for Asian older adults.<sup>2</sup> More recent global consensus work also recognizes muscle mass and muscle strength as core components of the conceptual definition of sarcopenia.<sup>1</sup> The condition is clinically important because its prevalence and consequences vary across populations, while physical inactivity, malnutrition, and chronic disease may contribute to its development.<sup>3</sup>

Dynamic balance is particularly relevant in older adults because safe mobility requires the integration of muscular, sensory, vestibular, proprioceptive, and cognitive systems.<sup>4</sup> The Timed Up and Go Test (TUGT) is a practical measure of functional mobility that requires an individual to rise from a chair, walk 3 m, turn, return, and sit. The original validation study demonstrated that the timed task is reliable and related to functional mobility measures.<sup>5</sup> TUGT has subsequently become one of the most frequently used measures in studies of postural control among older adults.<sup>6</sup>

Evidence suggests that muscle-related factors are relevant to balance, but the relationship is not necessarily explained by a single sarcopenia construct.<sup>7</sup> A large 2025 study of older adults found that dynamic balance was jointly influenced by gait speed, muscle strength, and age rather than by one muscle-related parameter alone.<sup>7</sup> Similarly, a cross-sectional study of community-dwelling older adults reported that some hip muscle strength measures were associated with dynamic balance while another strength measure was not, illustrating that associations may differ according to muscle group and balance task.<sup>8</sup> These findings are important when interpreting a study that uses a broad operational classification of sarcopenia and a single functional mobility test.

The present study was conducted in a primary care setting where DXA and BIA were not available. Consequently, the investigators used MMT and lower-limb anthropometric measurements as an operational screening classification rather than a definitive diagnosis according to AWGS 2019 or EWGSOP2. This distinction is important because AWGS 2019 defines definitive sarcopenia using standardized measures of muscle strength and muscle mass, while also allowing the concept of possible sarcopenia for primary care settings.<sup>2</sup> The use of a nonstandard operational classification may produce a substantially different prevalence from studies using consensus diagnostic criteria.<sup>3</sup>

Previous studies have reported associations between sarcopenia-related characteristics and postural balance, yet the magnitude and consistency of these relationships may vary with the assessment method and population.<sup>6,7,9</sup> Evidence from studies of postural control also indicates that balance is multidimensional and should not be attributed to muscle status alone.<sup>6,9</sup> The specific evidence base for older adults assessed in Indonesian primary care using TUGT alongside a locally defined operational sarcopenia classification remains limited. Therefore, the present study aimed to examine the association between operational sarcopenia

classification and dynamic balance among older adults in the Kedungwuni II Primary Health Center area, Pekalongan Regency. The hypothesis was that sarcopenia would be associated with poorer dynamic balance.

## Methods

This analytical cross-sectional study was conducted in the working area of Kedungwuni II Primary Health Center, Pekalongan Regency, Indonesia, in February 2026. The study examined the association between an operational classification of sarcopenia and dynamic balance. Both variables were assessed during the same study period. The target population comprised older adults aged  $\geq 60$  years who met the prespecified eligibility criteria. Because the eligible population available to the investigators consisted of 32 participants, all eligible individuals were included using total sampling.

Inclusion criteria were age  $\geq 60$  years, ability to perform activities independently, ability to communicate adequately, and ability to understand and follow the examination instructions. Exclusion criteria were diagnosed organ failure, arthritis, or fracture that could affect functional ability or balance. The recruitment flow documented in the study showed 32 eligible participants, all of whom agreed to participate and provided informed consent. No participant withdrawal or missing assessment was reported. The supplied study materials did not document the number of potentially eligible individuals who declined participation before inclusion; therefore, a formal participation rate could not be calculated.

No a priori sample size calculation or power analysis was performed because the investigators intended to include the entire available eligible population. A post hoc sensitivity estimate reported in the source manuscript indicated approximately 33% statistical power to detect a correlation of  $r=0.275$  at  $\alpha=0.05$  with  $n=32$ . The source manuscript estimated that approximately 101 participants would be required to achieve 80% power for the same assumed correlation. This calculation is presented only to describe the limitations of the available sample and was not used to alter the study data.

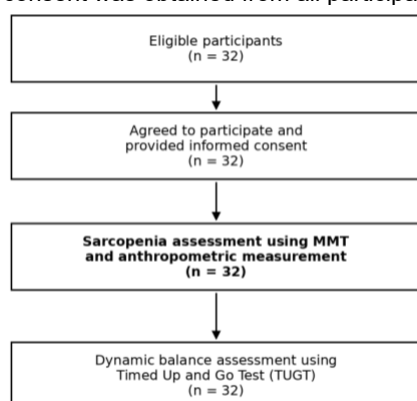
The study used an operational sarcopenia classification. The theoretical framework was based on AWGS 2019, but the investigators did not have access to dual-energy X-ray absorptiometry (DXA) or bioelectrical impedance analysis (BIA). Therefore, the classification should not be interpreted as a definitive AWGS 2019 or EWGSOP2 diagnosis. Muscle strength was assessed using Manual Muscle Testing (MMT) with the Oxford 0 to 5 scale. A score  $\leq 3$  was classified as reduced muscle strength for the purpose of this study. Lower-limb anthropometry was measured with a tape at five anatomical locations: the patella level, 5 cm above the patella, 10 cm above the patella, 5 cm below the patella, and 10 cm below the patella. The circumference of the right and left lower limbs was compared at each location. A side-to-side difference  $\geq 1.5$  cm at one or more measurement points was used as the operational criterion for reduced muscle mass. Participants meeting both the operational reduced-strength and reduced-mass criteria were classified as sarcopenic.

The operational anthropometric threshold and MMT rule were study-specific and were not validated against DXA or BIA in this sample. The assessment was performed by a single examiner using the same procedure for all participants, which supported procedural consistency. Inter-rater reliability and criterion validity against a reference method were not assessed. Previous work has reported high inter-rater reliability for MMT in selected clinical populations, but such findings cannot be assumed to apply directly to community-dwelling older adults.<sup>10</sup> This limitation was therefore retained as an important source of measurement uncertainty.

Dynamic balance was assessed with the Timed Up and Go Test (TUGT). Participants rose from a chair, walked 3 m, turned, walked back, and returned to a seated position while the elapsed time was recorded.<sup>5</sup> The study materials classified participants into normal mobility, low fall risk, moderate fall risk, and high fall risk. The final source manuscript, however, did not retain the numerical thresholds used to assign these four categories. To avoid reconstructing or inventing thresholds, this final manuscript reports the observed category frequencies and the continuous TUGT values but does not state unverified category cut-offs.

Before data collection, the investigators explained the study objectives, benefits, procedures, and participation requirements. Written informed consent was obtained from all participants. Demographic and clinical characteristics were recorded, followed by MMT, anthropometric assessment, and TUGT. The same examiner and standardized sequence were used for the examinations. Variables that may influence balance, including physical activity, body mass index, nutritional status, comorbidities, medication use, and sensory function, were not collected as analytical covariates. Consequently, the association reported in this study is an unadjusted association and may be affected by residual confounding.

Descriptive analysis was used to summarize participant characteristics, the operational sarcopenia classification, and TUGT results. Normality was assessed only for the continuous TUGT outcome using the Shapiro Wilk test. TUGT had a Shapiro Wilk statistic of 0.942 with  $p=0.085$ . The binary sarcopenia variable was not subjected to normality interpretation. The primary association analysis used Spearman rank correlation because the sarcopenia variable was binary and the groups were highly unbalanced. Statistical significance was set at  $\alpha=0.05$ . The source manuscript reports analysis using IBM Statistical Package for the Social Sciences (SPSS), version 20. An exploratory simple linear regression was also reported to provide an additional estimate of the association between sarcopenia classification and continuous TUGT. No multivariable adjustment was performed because the relevant covariates were not collected. The study received ethical approval from the Research and Community Service Institute of Universitas Muhammadiyah Pekajangan Pekalongan under ethical clearance No.078/KEP-UMPP/II/2026, and written informed consent was obtained from all participants.



**Figure 1.** Participant recruitment flow. All 32 eligible participants consented and completed the sarcopenia and TUGT assessments.

## Results

A total of 32 older adults met the eligibility criteria and were included in the analysis. All 32 participants provided informed consent and completed the study assessments. Participant characteristics are summarized in Table 1.

**Table 1.** Characteristics of the study participants

| Characteristic | Category     | n  | %     |
|----------------|--------------|----|-------|
| Sex            | Male         | 8  | 25.0  |
|                | Female       | 24 | 75.0  |
|                | Total        | 32 | 100.0 |
| Age, years     | 60–64        | 15 | 46.9  |
|                | 65–69        | 9  | 28.1  |
|                | 70–74        | 6  | 18.8  |
|                | ≥75          | 2  | 6.3   |
|                | Total        | 32 | 100.0 |
| Employment     | Working      | 4  | 12.5  |
|                | Not working  | 28 | 87.5  |
|                | Total        | 32 | 100.0 |
| BMI category   | Underweight  | 3  | 9.4   |
|                | Normal/ideal | 18 | 56.2  |
|                | Overweight   | 5  | 15.6  |
|                | Obesity      | 6  | 18.8  |
|                | Total        | 32 | 100.0 |

Women accounted for 24 participants (75.0%), while 8 (25.0%) were men. The largest age group was 60 to 64 years (46.9%). Most participants were not working (87.5%). Eighteen participants (56.2%) were classified as having normal or ideal BMI, while 18.7% were obese and 15.6% were overweight. The underweight category represented 9.4% of the sample. The operational sarcopenia classification is presented in Table 2. Thirty participants (93.8%) met the study-specific operational criteria, whereas 2 participants (6.3%) did not.

**Table 2.** Operational sarcopenia classification

| Operational classification | n  | %     |
|----------------------------|----|-------|
| Sarcopenia positive        | 30 | 93.8  |
| Sarcopenia negative        | 2  | 6.3   |
| Total                      | 32 | 100.0 |

The very high proportion classified as sarcopenic produced a markedly unbalanced comparison between the two groups. This distribution is important when interpreting the correlation analysis because only two participants were classified as non-sarcopenic. TUGT findings are summarized in Table 3. Seventeen participants (53.1%) were classified as having high fall risk and 15 (46.9%) as having moderate fall risk. No participant was classified as having low fall risk or normal mobility.

**Table 3.** TUGT category distribution

| TUGT category      | n  | %     |
|--------------------|----|-------|
| Normal mobility    | 0  | 0.0   |
| Low fall risk      | 0  | 0.0   |
| Moderate fall risk | 15 | 46.9  |
| High fall risk     | 17 | 53.1  |
| Total              | 32 | 100.0 |

The continuous TUGT result showed a mean of  $30.38 \pm 5.14$  seconds, with a range of 22 to 39 seconds. The operational sarcopenia variable had a mean coded value of  $0.94 \pm 0.24$  with a range of 0 to 1. These values are presented in Table 4.

**Table 4.** Descriptive statistics for TUGT and operational sarcopenia

| Variable                          | Mean±SD          | Range |
|-----------------------------------|------------------|-------|
| TUGT, seconds                     | $30.38 \pm 5.14$ | 22–39 |
| Operational sarcopenia, coded 0/1 | $0.94 \pm 0.24$  | 0–1   |

The Shapiro Wilk test for TUGT produced a statistic of 0.942 with  $p=0.085$ , indicating no evidence of departure from normality at the 0.05 threshold. The binary sarcopenia variable was not interpreted using a normality test.

**Table 5.** Shapiro Wilk test for TUGT

| Variable | W     | n  | p     |
|----------|-------|----|-------|
| TUGT     | 0.942 | 32 | 0.085 |

The primary association analysis is shown in Table 6. Spearman rank correlation indicated a weak positive association between the operational sarcopenia classification and TUGT ( $r=0.275$ ), but the association was not statistically significant ( $p=0.128$ ). The Fisher z based 95% confidence interval for the correlation was  $-0.08$  to  $0.57$ . An exploratory simple linear regression yielded a 95% confidence interval of  $-4.079$  to  $11.279$  for the sarcopenia coefficient and  $R^2=0.030$ , indicating that the operational sarcopenia classification accounted for approximately 3% of the observed variation in TUGT in this sample.

**Table 6.** Association between operational sarcopenia classification and TUGT

| Analysis                  | Estimate                                                  | p value      |
|---------------------------|-----------------------------------------------------------|--------------|
| Spearman rank correlation | $r=0.275$ ; 95% CI $-0.08$ to $0.57$                      | 0.128        |
| Simple linear regression  | 95% CI for coefficient $-4.079$ to $11.279$ ; $R^2=0.030$ | Not reported |

## Discussion

The main finding of this study was that the operational sarcopenia classification was not significantly associated with dynamic balance as measured by TUGT. The observed correlation was positive but weak ( $r=0.275$ ), and the 95% confidence interval crossed zero. At the same time, the study population had a very high proportion of participants classified as sarcopenic and substantial TUGT impairment, with all participants categorized as having moderate or high fall risk. These findings indicate that poor functional mobility was common in this sample, but the available data did not demonstrate a statistically significant relationship between the study-specific sarcopenia classification and TUGT.

The 93.8% operational prevalence of sarcopenia requires particular caution. Contemporary epidemiological evidence suggests that sarcopenia prevalence varies substantially according to population, diagnostic criteria, and measurement methods, with a global estimate of approximately 10% to 16% among older adults in one systematic review of meta-analyses.<sup>3</sup> The prevalence observed here is therefore considerably higher than broad community estimates. The most plausible methodological explanation is the use of a nonstandard classification based on MMT and side-to-side lower-limb circumference differences rather than standardized muscle mass assessment with DXA or BIA.<sup>2</sup> AWGS 2019 recognizes possible sarcopenia pathways for primary care, but definitive classification still relies on standardized assessment of muscle strength and muscle quantity.<sup>2</sup> Accordingly, the 93.8% figure should be interpreted as the prevalence of the operational classification used in this study, not as a population estimate of clinically confirmed sarcopenia.

The imbalance between the operational sarcopenia groups is another important explanation for the nonsignificant result. Only two participants were classified as non-sarcopenic. The post hoc estimate reported in the source study indicates low statistical power for detecting a correlation of the observed magnitude. A small comparison group can produce unstable estimates and makes it difficult to distinguish a truly absent association from an association that the study was not adequately powered to detect. The confidence interval of the Spearman correlation, which extended from  $-0.08$  to  $0.57$ , is consistent with substantial uncertainty around the observed estimate.

The present result should also be considered within the broader evidence on the relationship between muscle status and balance. Wang et al. reported that dynamic balance among older adults was jointly influenced by gait speed, muscle strength, and age, rather than by a single muscle characteristic.<sup>7</sup> A separate cross-sectional study found that several hip strength measures were related to dynamic balance in some age groups, while another hip muscle strength measure was not significantly related to tandem gait.<sup>8</sup> These findings support the interpretation that dynamic balance is influenced by multiple interacting domains.<sup>6</sup> A recent scoping review likewise showed that postural control research in older adults uses a wide range of measures and that TUGT is common, reinforcing that balance is not a single physiological construct.<sup>6</sup>

The current findings are therefore not sufficient to conclude that sarcopenia has no relevance to balance. Rather, they indicate that this particular operational classification did not show a statistically significant association with TUGT in a small primary care sample. The distinction is important because the measurement approach may have introduced classification error. MMT is a clinical strength assessment, but it is not a substitute for standardized muscle mass measurement.<sup>2</sup> The source study did not establish criterion validity against DXA or BIA, and the anthropometric threshold was developed for the study rather than derived from an internationally validated diagnostic algorithm. Measurement error could have affected both the unusually high prevalence and the strength of the observed association.

The absence of adjustment for confounding also limits interpretation. The study did not collect physical activity, nutritional status, comorbidities, medication exposure, or sensory function as covariates. These factors can influence both muscle health and balance.<sup>3,9</sup> Evidence from studies of postural control indicates that proprioception, joint mobility, pain, muscle strength, and plantar sensory information may contribute to balance performance.<sup>9</sup> Consequently, an unadjusted association between a broad sarcopenia classification and TUGT cannot isolate the independent contribution of sarcopenia. This limitation is particularly relevant in a primary care population in which multimorbidity and functional heterogeneity are expected.

From a clinical perspective, the finding that all participants had moderate or high TUGT risk categories remains relevant even though the primary association was nonsignificant. TUGT is a practical functional mobility test and can be incorporated into routine geriatric assessment.<sup>5</sup> The present findings support continued attention to mobility and fall risk screening rather than using sarcopenia status alone as a proxy for dynamic balance. In primary care and physiotherapy practice, assessment should therefore consider muscle strength, mobility, sensory function, physical activity, nutritional status, and other clinically relevant factors.<sup>2</sup> This multidomain approach is more consistent with the multifactorial nature of postural control.<sup>4,6</sup>

The study has several strengths. It was conducted in a real primary care setting, included the entire available eligible population, documented the recruitment process, and reported both categorical and continuous TUGT outcomes. The investigators also explicitly acknowledged that the MMT and anthropometric approach was operational rather than a definitive consensus diagnosis. These points improve transparency compared with the original version. Nevertheless, the study remains limited by its small sample, highly unbalanced exposure groups, lack of standardized sarcopenia diagnosis, absence of criterion validation, single-examiner assessment without formal inter-rater testing, and absence of confounder adjustment. These limitations substantially restrict external validity and causal interpretation.

Future studies should recruit larger and more representative primary care samples and use standardized AWGS 2019 or other current consensus methods for sarcopenia assessment. Where resources are limited, primary care algorithms for possible sarcopenia should be used transparently rather than relabeling a local screening classification as definitive sarcopenia.<sup>2</sup> Studies should also collect physical activity, nutritional status, BMI, comorbidities, medication exposure, and sensory function so that adjusted analyses can be performed. Longitudinal research would be particularly valuable for determining whether changes in standardized sarcopenia measures predict subsequent changes in dynamic balance and fall risk.

## Conclusion

In this sample of 32 older adults attending Kedungwuni II Primary Health Center, the study-specific operational classification of sarcopenia was not significantly associated with dynamic balance measured by TUGT. The observed association was weak and positive ( $r=0.275$ ;  $p=0.128$ ; 95% CI  $-0.08$  to  $0.57$ ), while the exploratory regression analysis produced a small  $R^2$  of  $0.030$ . Most participants were classified as sarcopenic (93.8%), and all participants were classified as having moderate or high TUGT risk according to the study categorization. These findings should not be interpreted as evidence that clinically confirmed sarcopenia is unrelated to balance. The small sample, the very small non-sarcopenic comparison group, the lack of standardized muscle mass measurement, and unmeasured confounding substantially limit inference. Future research should use standardized sarcopenia criteria, larger samples, and multidomain assessment of factors affecting balance.

### Author Contribution

Tri Asih Widiastuti: Conceptualization; Data curation; Writing, original draft; Writing, review and editing.  
Dzikra Nurseptiani: Conceptualization; Writing, review and editing.

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### Conflict of Interest Statement

The authors declare no conflict of interest.

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This study received no external funding.

### Ethics Statement

This study was approved by the Research and Community Service Institute of Universitas Muhammadiyah Pekajangan Pekalongan under Ethical Clearance No.078/KEP-UMPP/II/2026. Written informed consent was obtained from all participants before data collection.

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