

Research Paper

Impact of Hallux Valgus on Dynamic Balance in Community-dwelling Older Adults

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ABSTRACT**Objectives:** We intend to examine the effects of hallux valgus (HV) on dynamic balance in community-dwelling older adults.**Methods:** This comparative study was conducted on 29 functionally independent older adults with HV. The subjects were divided into the mild HV severity group and the moderate/severe HV severity group, determined using the Manchester scale. The 4 square step test (FSST) and timed-up and go (TUG) test were used to measure their dynamic balance. The independent t-test was performed to compare the two groups' balance performance.**Results:** Significant differences were observed between the two groups. Participants with mild HV severity performed significantly better in the FSST ($P < 0.05$) and TUG test ($P < 0.05$) compared to those with moderate and severe HV severity. Regarding the normative cut-off value of FSST, all the participants were categorized as fallers.**Discussion:** HV negatively impacts the dynamic balance of community-dwelling older adults with moderate and severe severity grading. This finding suggests that adjusting treatment strategies may be required when managing falls and balance issues in older adults with HV deformities.**Keywords:**

Hallux valgus (HV), Balance, Older adult, Fall

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Highlights

- Hallux valgus (HV) affects the dynamic balance in community-dwelling older adults.
- Older adults with moderate and severe HV severity performed poorer in balance tests than those with mild severity.
- HV deformity places older adults at risk of falls.

Plain Language Summary

This study examined the dynamic balance of older people residing in the community concerning the severity of a foot condition known as hallux valgus. The older adults with HV who participated in the study were divided into two groups according to the severity of the deformity. Dynamic balance was assessed using two tests, and the findings for the two groups were compared. Based on the results, the older adults with moderate or severe HV had poorer dynamic balance than those with mild HV severity.

Introduction

Falls pose a significant concern for older adults globally, prompting extensive studies to prevent them by understanding associated risk factors [1]. Some studies have underscored hallux valgus (HV) as a potential risk factor for falls in older adults [2, 3]. This progressive foot condition develops over several years and is characterized by the abduction of the first toe and the medial displacement of the first metatarsal bone [4]. As HV is common among older adults, with prevalence rates as high as 35.7% [5], there is an increasing need to examine the subtle effects of HV severity on different aspects of functional performance in older adults.

Ensuring stability in older adults is crucial for fall prevention, with balance being a key component. To maintain stability during activities of daily living, balance will need to be maintained during walking, turning, getting up from a chair, stepping over objects, taking a step in any direction, and even coordinating various stepping movements to avoid objects [6, 7]. It is, therefore, imperative to assess whether potential risk factors for falls, such as HV, can affect these aspects and consequently influence the risk of falls.

The impact of HV severity on balance has been previously investigated, but the findings have shown inconsistency [8-12]. Menz and Lord were among the first investigators looking at the effects of HV on balance [8]. They investigated the impact of HV on gait and acceleration patterns of the head and pelvis. The results indicated significant moderate to severe HV effects on velocity and step length, while mild HV showed no significant

impact. Recently, Yoshida et al. observed a reduction in walking speed among the elderly group with HV compared to those without it [10]. It is worth noting that the sample size was relatively small, consisting of only 10 participants in each group.

Barbee et al., on the other hand, specifically compared older adults with and without HV, revealing no significant changes in walking speed or alterations in the center of mass between the two groups [9]. As seen, there seem to be conflicting results found with the speed of walking, and further studies are required to confirm these findings. While these three studies have used force plates to assess the center of mass, center of pressure, and other gait parameters during walking, the test only consists of walking in a straight line. Maintaining balance in the real world is more than walking in a straight line. The assessment of stability or balance is nuanced, as different tasks, such as turning or stepping over objects, may influence it differently [13, 14]. Thus, it would be interesting to see the effects of HV severity on other aspects of mobility, like turning and getting up from a chair.

There have been studies examining functional outcomes but with inconsistent findings. For example, Shima et al. found an impaired balance using the timed-up and go (TUG) test and Berg's balance test in the HV group [15]. On the contrary, Kavlak, in a study involving older men and utilizing a goniometer to assess HV, reported no discernible impact on the TUG, thus demonstrating further conflicting findings [12]. It is noteworthy, however, that the reliability of clinical goniometer measurements for HV has been scrutinized in previous research [16].

Concerning the assessment of HV severity, the evaluation methods also vary. These may include radiological evaluation [17], clinical goniometry [16], plantar pressure [16], and the Manchester scale [18]. Notably, the Manchester scale has been established as reliable and valid for assessing HV severity [18, 19]. Its efficiency, cost-effectiveness, and practicality in a busy clinical setting set it apart, making it quickly adopted by clinicians. In contrast to other studies that utilized equipment-intensive methods such as motion sensors [20], foot printers [10], radiological assessments [15], less reliable techniques like goniometry [3, 12] or non-standardized methods [11], in the current study, the authors have opted for a technique that seamlessly translates to real-world clinical practice. Thus, this study was carried out to compare the impact of different HV severity on dynamic balance in community-dwelling older adults utilizing clinically-based tools.

Given the conflicting findings, varied outcome measures, and diverse assessment techniques for measuring HV severity, it is imperative to delve deeper and confirm the effects of HV severity on balance in older adults. To enhance clinical and patient relevance, investigating the impact of HV during tasks such as turning, coordination, and stepping over an objects, activities prevalent in daily life and linked to an increased risk of falls would be beneficial [21]. This study thus aims to compare the effects of varied severity of HV on dynamic balance tests that are relevant to the patient. This study utilizes the TUG test and the 4 square step test (FSST), which examines various components of balance that have not been thoroughly investigated in previous HV trials. This study also uses the Manchester scale to assess the severity of HV. These methods are quick, reliable, and valid. The outcomes are correlated to the risk of falls, and, most importantly, they can be used in most clinical settings, giving the clinician a method to assess the severity of HV' effects.

There are various ways to use the findings of a study. Clinicians can compare their patient findings and add to the data pool. Methods such as these can lead to increased data that can be easily used to evaluate outcomes of treatment regimens and develop fall prevention programs. In addition, considering the distinctive foot morphology [22, 23] and cultural practices prevalent among older adults in Asian populations, it is crucial to add to the pool of data available. Currently, there is data from countries such as the USA [9], Europe [3], Japan [10], but a lack of data from areas such as Indonesia, Malaysia, and Thailand. It would be interesting to compare clinically significant findings across various morpholo-

gies as the world becomes more cosmopolitan. This study will enhance comprehension and provide practical findings for managing balance issues in older adults with HV across diverse ethnicities.

Materials and Methods

This study is a cross-sectional comparative study, examining mean differences between the groups with mild HV and moderate to severe HV. The sample size was determined through G*Power software version 3.1. Based on an alpha error probability of 0.05, a power of 80%, and an effect size of 0.96, drawn from the study by Ji et al. [24], the calculated sample size was set at 30. The participants were community-dwelling older adults above 60 with HV deformity on at least one foot. Recruitment was carried out through a convenience sampling method in Klang Valley, Malaysia, in 2020. The inclusion criteria included a score of 6 on the Katz index of independence in activities of daily living scale and the ability to walk unassisted. The exclusion criteria comprised cognitive, vision, or auditory impairments, prior foot surgeries, systemic diseases, diabetes, severe cardiovascular diseases, and neurological disorders. These criteria were based on those in a previous study [9].

The subject's HV severity was measured using the Manchester scale. The photographs from the scale were compared with the subjects' feet, and the HV severity was graded based on the closest resembling photo. Those subjects with mild HV deformity were put in one group, whereas those with moderate and severe HV deformity were put in another group for comparison. For those who presented with bilateral HV deformities with differing severities, the worst severity was considered for the grouping. The Manchester scale's validity and reliability has been established in previous studies [18, 19], justifying its application in this study.

The categorization of older adults into mild and moderate/severe HV groups aligns with established research methodologies. An initial study comparing a group with mild severity with a group with moderate to severe HV found no significant impact of mild HV on function [8]. Subsequently, recent investigations have predominantly focused on moderate to severe HV [9, 15, 24], comparing this group with participants with mild or no HV. Barbee et al. delved into the effects of moderate to severe HV on balance [9]. Park et al. examined gait patterns in moderate-severity HV [25], and Shima et al. explored postural stability in participants with moderate to severe HV [15].

This classification facilitates a comparative analysis of functional outcomes between the two groups, providing insights to guide decisions on diverse management strategies if necessary. This categorization also streamlines implementation in clinical settings, enabling effective assessment using the Manchester scale. Additionally, it facilitates direct comparisons with normative values for selected outcome measures, enhancing the study's clinical relevance.

In addition, there have been changes in gait patterns with the prevalence of HV [10, 26]. To measure the dynamic balance, the subjects underwent FSST followed by TUG with their usual footwear. FSST measures an individual's ability to take a step in different directions. Numerous studies have supported FSST psychometric properties [27-29]. TUG is a performance-based measure of dynamic balance and risk of falls in older adults. It is a highly reliable and valid test [30, 31]. The independent t-test was used to compare the dynamic balance between the two groups. The data were analyzed using SPSS software, version 27, at a significant level of $P < 0.05$.

Data and statistical analyses

Data were analyzed using SPSS software, version 23 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were performed on demographic data, including age (Mean±SD) and gender (frequency). All variables were tested for normality of distribution. The Mean±SD of the

mean times for each group for the TUG test and FSST were also calculated. The independent sample t-test was used to determine significant differences between the mild HV group and the moderate to severity HV group when performing the TUG and the FSST. The level of significant differences was set at $P < 0.05$.

Results

A total of 29 subjects were recruited with a mean age of 71.69 ± 7.26 years. The subjects' characteristics are provided in Table 1.

Of all subjects, 52% presented with mild HV and 48% with moderate and severe HV. The functional performances of the two groups were assessed using the FSST and the TUG test.

For the mild HV group, the mean scores for FSST and TUG test were 11.96 ± 2.52 and 8.78 ± 1.90 seconds, respectively. Whereas for moderate and severe HV group, the mean scores for FSST and TUG test were 14.46 ± 3.15 and 10.71 ± 1.87 seconds, respectively (Table 2). Figures 1 and 2 illustrate the FSST and TUG test results of the mild HV and moderate/severe HV groups.

The mild HV group demonstrated significantly less time in completing the FSST ($t = -2.37$, $P = 0.025$) and TUG ($t = -2.75$, $P = 0.011$) test compared to the moderate and severe HV group (Table 3).

Table 1. Subjects' characteristics (n=29)

Variables	Mean±SD/No. (%)	
	Mild HV Group (n=15)	Moderate/Severe HV Group (n=14)
Age (y)	70±6.58	73.50±7.74
Gender	Male	6(40)
	Female	9(60)

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Table 2. FSST and TUG test

Outcome Measure	Mean±SD	
	Mild HV Group (n=15)	Moderate/Severe HV Group (n=14)
FSST (s)	11.96±2.52	14.46±3.15
TUG test (s)	8.78±1.90	10.71±1.87

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Table 3. The independent t-test results

Outcome Measure	t	P
FSST (s)	-2.37	0.03*
TUG test (s)	-2.75	0.01*

*Significant at $P < 0.05$.

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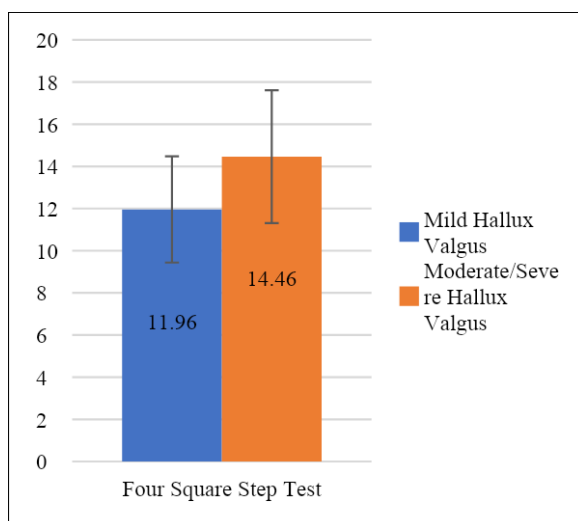
Discussion

This study examined the effect of HV severity on dynamic balance in community-dwelling older adults. The study comprised 29 participants, with 15 individuals in the mild HV group (52%) and 14 in the moderate to severe HV group (48%). Both groups exhibited comparable mean ages, with an equivalent distribution of men and women in each group.

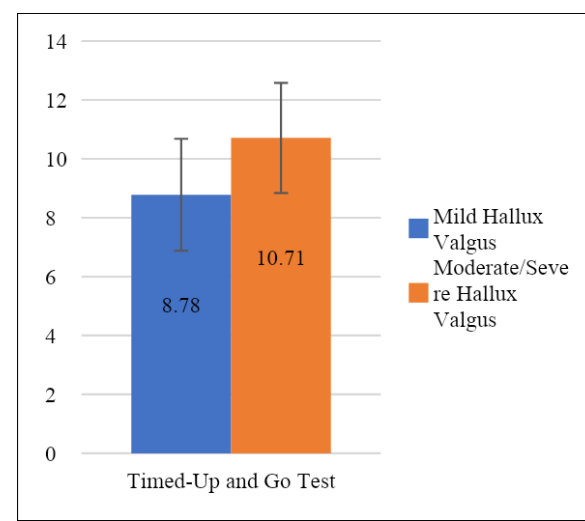
In addition, this study aimed to determine the effects of severity of HV, verified by a clinically relevant, valid, and reliable tool, on outcomes that are relevant to patients. The current pressure on the need for evidence-based practice has resulted in bumper crops of trials utilizing technologically advanced and equipment-heavy instruments to assess outcomes [32]. Does this make the gap between the researcher and the clinician even wider? Coster has emphasized that when choosing an outcome measure or a measurement tool, aspects such as relevance to the patient and clinician should be considered [32]. This issue includes evaluating whether the outcome measure can capture change and, if performance-based, determining its suitability for the patient population to perform.

HV has undergone a fair amount of investigation, as evidenced by numerous studies [2, 3, 8, 9, 10, 15, 20]. Despite this, the practical applicability of certain outcomes in a clinical setting has been limited. Specifically, measures such as force platform assessments [9, 20] have been confined to laboratory environments, lacking direct relevance to a patient's daily functional performance. In this study, we opted for the Manchester scale, a tool acknowledged for validity and reliability. Utilizing the scale's requirement for capturing foot images is both straightforward and accurate, particularly with the ubiquity of smartphones equipped with capable cameras in most clinical settings. This approach ensures easily comprehensible outcomes for patients, potentially holding greater relevance than more intricate radiological measurements.

In this study, we categorized the patients into mild HV severity and moderate to severe HV severity. People with mild severity seemed to have relatively normal postural sway [33], and those with moderate to severe HV had significantly decreased step length and velocity compared to the no or mild HV group [8]. Subsequently, we found that investigators had omitted the mild severity group from their studies [9, 15]. In this study, we wanted to compare any differences between the two groups, as

**Figure 1.** FSST result

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**Figure 2.** TUG test result

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this may determine any modifications to physiotherapy and other management. In this study, the mild HV group demonstrated a significantly shorter time in completing the FSST and TUG test than the moderate and severe HV group. Shima et al. found similar results, where TUG, falls efficacy scale, Berg's balance test, and velocity were significantly lower in the HV group (moderate to severe) as compared to the control group with no HV [15]. These researchers, however, had included participants with bilateral HV. The current study's findings are complementary to those of Shima et al. as it looks at HV found in one foot [15]. This is also important as the prevalence of unilateral HV is at 29.8% of the study population [34].

Biomechanically, the hallux and the first metatarsophalangeal joint play a vital role in gait and stability. The hallux impacts the propulsive phase in walking. Behaving as a pivot, the first metatarsophalangeal joint facilitates the forward transference of the body [2, 35]. There is also reduced capacity to generate force by the great toe, which may decrease peak swing speed in older adults with HV [2, 10, 36]. Moreover, it has been suggested that efficient toe-off is affected by the continued subluxation of the first metatarsophalangeal joint in HV [10]. This condition leads to decreased cadence and speed of walking [10, 36], which may lead to an increased risk of falls [37].

In addition, factors that contributed to decreased walking speed, long foot-flat, and short push-off duration [36] may also alter propulsion during the terminal stance and early swing phase. The longer contact duration at the hind foot may also explain the compensation due to the weak propulsion during weight transfer. Several studies have reported that HV could modify the loading patterns of the foot [36, 38, 39], which may have a detrimental influence on the stability and function of the foot. It has also been reported that older adults with moderate to severe HV also had greater peak pressures and increased pressure-time integral [39]. Previous studies have reported that with HV, there is an increased pressure at the first and second metatarsal heads [38] and at the third to fifth toes [36]. These increased pressures can lead to longer total duration at the hindfoot, decreased metatarsophalangeal motion at the terminal stance, reduced toe-off pitch angle, reduced peak vertical force, and slow peak swing speed, leading to decreased walking speed [36]. The effects will lead to some of the changes found in our study and that of Shima et al. [15].

Barbee et al. found no significant differences in the center of mass-center of pressure inclination angles between

people with moderate to severe HV and people without hallux valgus [9]. There could be several reasons for these differing results. The absence of these effects in the study conducted by Barbee et al. might be attributed to the nature of the presented task [9]. It is conceivable that the task was of short duration, conducted in a straight line, and potentially prone to greater practice effects than a task such as the TUG, which inherently involves completing the task as quickly as possible.

The TUG test is one of the assessments used to identify increased fall risk in older adults [1]. Based on a recent study that investigated 169 older adults, it was found that the TUG test time of more than 10.2 s discriminates between the subjects with high and low fall risk [40]. In the present study, the mild hallux valgus group exhibited a TUG test time of 8.78 s, while the moderate/severe HV group recorded a TUG time of 10.71 s. Notably, the latter places the moderate/severe group in a category associated with a high risk of falls, as indicated by Choo et al.'s study in 2021 [40]. This finding holds practical significance for clinicians, considering the widespread use of the TUG test in managing older adults. The inclusion of an assessment for the severity of HV may now be deemed essential, potentially necessitating specific management interventions.

The FSST is a valuable tool for assessing dynamic balance related to stepping tasks in various directions, including forward, backward, and side movements. In a near-fall circumstance, it is essential to be proficient in protective stepping in varied directions. It has been found that when people fall, almost equal numbers of people fall in the forward, backward, and lateral directions [41]. Therefore, the FSST may also be a relevant and necessary measure when assessing the risk of falls in older adults. This study found that the mild HV group demonstrated significantly less time in completing the FSST tests than the moderate and severe HV group. Currently, there are no studies investigating the effects of HV severity on FSST. A previous study has reported that an FSST time of more than 10.14 s discriminates between fallers and non-fallers [42]. In the current study, the FSST time is 11.96 s in the mild HV group and 14.46 s in the moderate/severe HV group, categorizing both groups as fallers. For the FSST test, as it is performance-based and related to function, lower performance should alert the clinician to look at factors such as HV in patients and manage them accordingly.

The present study has successfully filled existing gaps and reinforced the evidence from previous research regarding the adverse impact of HV deformities on the

balance performance of older adults. These findings underscore the need for diverse treatment strategies in addressing falls and balance concerns among older adults with HV deformities. The study also emphasizes the potential translatability of methods and the results in the clinical setting.

Conclusion

The study's findings illuminate the significant impact of HV severity on dynamic balance in older adults. By employing the Manchester scale, a clinically relevant tool, the study unveils distinctions between mild and moderate/severe HV groups in functional tests, emphasizing the practical relevance of these outcomes. This research contributes to addressing gaps in existing literature, providing insights crucial for clinicians in managing older adults with HV. It underscores the potential applicability of its methods and findings in real-world clinical settings.

Study limitations and future recommendations

This study has limitations. The cross-sectional design restricts causal inference and observing changes over time. The sample size may impact generalizability, requiring consideration of larger cohorts. Demographic homogeneity and a specific geographic focus limit broader applicability. While chosen outcome measures are relevant, broader assessments could provide a more comprehensive understanding. The convenience sampling method introduces potential selection bias, affecting external validity. Future studies should address these limitations for a more robust understanding of HV and its impact on dynamic balance.

Future research should prioritize refining user-friendly clinical tools for assessing HV severity in diverse clinical settings. Longitudinal studies are warranted to investigate the progression of HV deformities and their evolving impact on dynamic balance in older adults. Intervention studies targeting this population can evaluate the effectiveness of various interventions in improving balance and reducing fall risk. Incorporating patient-centered outcomes is essential for understanding the holistic implications of HV on daily activities and quality of life. Comparative studies between different measurement tools should be conducted to guide clinicians in their selection. Additionally, initiatives to implement findings in routine clinical practice, educational programs for healthcare professionals and older adults, and collaborative efforts between researchers and clinicians can bridge the gap between research and practical applica-

tions. Developing cost-effective assessment tools accessible in various clinical settings will enhance widespread adoption and address the disparity between advanced research instruments and clinical needs.

Ethical Considerations

Compliance with ethical guidelines

The procedures used in this study adhere to the principles of the Declaration of Helsinki. All participants provided their informed consent, and the current study was approved by the Faculty of Health Sciences Research Review Committee of MAHSA University, Malaysia, (Code: FOHS/PT/20/UG76).

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Authors' contributions

Conceptualization and study design: Yee Lin Loo, and Mahadevi Barathi; Experiments: Loo Yee Lin; Data interpretation, analysis and writing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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