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Research Article

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Impact of Unilateral Knee Osteoarthritis on Postural Stability and Gait Initiation in Older Adults

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Abstract
This study investigated postural stability in older adults with and without unilateral knee osteoarthritis, focusing on static balance and gait initiation. Forty older adults participated, divided into two groups: one diagnosed with osteoarthritis and the other without the condition. Center of Pressure (COP) variables were evaluated under open and closed-eye conditions, as well as during the gait initiation phase. The results indicated that osteoarthritis significantly impacts postural control, especially during the anticipatory phase of gait and in conditions without visual feedback, demonstrating a greater reliance on proprioception. The osteoarthritis group showed higher amplitudes and velocities of COP displacement, highlighting the need for targeted interventions to improve stability and reduce fall risk.

Keywords: Knee Osteoarthritis, Postural Stability, Gait Initiation, Postural Control, Older Adults.

1. Introduction

Gait initiation (GI) is a complex and essential process that marks the transition from a static posture to dynamic locomotion. This process requires a precise balance between the propulsive force needed to start movement and the maintenance of postural stability, a challenge that intensifies in older adults due to sensory and motor changes associated with aging [1]. Anticipatory postural adjustments (APA) and reaction time play crucial roles in GI, directly influencing stability during this initial phase [2].

Parameters such as center of mass (COM) displacement and center of pressure (COP) control are fundamental for assessing stability during GI. Hansen et al. highlight that the external energy of the biological ankle plays a critical role in transitioning from initial movement to continuous gait, emphasizing the importance of energy control and muscular function in APA [3]. Furthermore, studies indicate that base of support (BoS) and measurements from force platforms provide an accurate representation of COP behavior, offering detailed insights into postural stability [4].

In older adults (OA), the response to GI is often marked by changes in gait mechanics, such as reduced forward velocity and shorter steps, increasing the risk of falls during locomotion activities [5]. The relationship between GI time and the risk of multiple falls is well-documented, suggesting that the time to the first lateral movement can serve as an important indicator of stability in OA [6].

Sensorimotor integration is vital for the effective execution of GI. Variability in step length and width, especially in older adults, reflects difficulties in COM control, increasing instability and fall risk [7]. These difficulties are even more pronounced in situations requiring quick and adaptive responses, such as directional changes, leading to the need for additional postural adjustments [8].

The presence of obstacles and the simultaneous execution of cognitive tasks during GI are crucial factors in understanding postural instability in OA. Concurrent tasks can negatively affect APA and motor response time, increasing the risk of falls [9]. Therefore, intervention strategies that integrate physical and cognitive training are recommended to improve stability and safety in older adults [10].

Given this context, a detailed analysis of APA and COM behavior during GI is essential for developing interventions aimed at reducing fall risk and enhancing the quality of life in older adults. The integration of approaches that assess COP and adapt rehabilitation strategies may provide a promising pathway for optimizing postural stability in vulnerable populations [11].

This study aims to analyze and compare postural behavior, focusing on anticipatory postural adjustments and COP control, during gait initiation in older adults with and without knee osteoarthritis. The objective is to identify differences in postural responses between the groups and provide insights for effective interventions to improve stability and reduce the risk of falls.

2. Methodology

2.1. Participants

The study included 40 older adults of both sexes, divided into two groups for comparative analysis. Group 1 (G1) consisted of 20 older adults with a diagnosis of unilateral knee osteoarthritis, who were referred for total knee arthroplasty after failure of conservative treatments, with a mean age of 72.1 ± 1.7 years. Group 2 (G2) included 20 active older adults without a diagnosis of osteoarthritis, with a mean age of 68.2 ± 0.8 years.

Group	Age (years)	Body Mass (kg)	Height (cm)	Shoe Size	Biological Gender
G1	72.1 ± 1.7	78.5 ± 4.2	162.3 ± 2.4	38.5 ± 0.5	Male (n=8),
Female (n=12)					
G2	68.2 ± 0.8	74.3 ± 3.9	163.7 ± 1.8	37.8 ± 0.3	Male (n=7),
Female (n=13)					
Legend: Anthropometric data of the study participants. G1 = older adults diagnosed with unilateral knee osteoarthritis; G2 = active older adults without a diagnosis of osteoarthritis. The data are presented as mean ± standard deviation.					

Table 1: Anthropometric Data of Participants

2.2. Inclusion and Exclusion Criteria

Inclusion criteria were older adults with a diagnosis of knee osteoarthritis and indication for total knee arthroplasty, of both sexes. Exclusion criteria included neurological dysfunctions impairing motor performance, previous use of prosthetics in the lower limbs, and plantar deformities.

2.3. Ethical Considerations

The study was approved by the Research Ethics Committee under approval number 24845019.2.0000.5083. All participants signed the Free and Informed Consent Form, following ethical guidelines in accordance with the Resolutions of the National Commission for Ethics in Research (CONEP) and the General Data Protection Law (LGPD) to ensure participants' rights, privacy, and data protection.

2.4. Bipodal Postural Control and Gait Initiation

The evaluation of bipodal postural control involved three trials with eyes open and closed. Participants stood on a 50x50 cm plantar pressure platform equipped with 4,096 capacitive sensors, following the methodology described in gait initiation studies [12-19]. In the bipodal position, participants focused on a point at eye level. During the gait initiation phase, three trials were conducted with both feet positioned on the platform. After an auditory signal, participants took a step off the platform, using both the affected and healthy limbs [20,21].

2.5. Analyzed Variables

The analyzed variables included [22-28]:

1. Amplitude of COP displacement in the anteroposterior (COPAP) and mediolateral (COPML) directions, expressed in centimeters.
2. Average velocity of COP displacement in the anteroposterior (VELAP) and mediolateral (VELML) directions, in cm/s. The COP trajectory was segmented into three phases: anticipatory, first step execution, and second step execution, following recommendations from studies on gait biomechanics.

2.6. Statistical Analysis

Statistical analysis was performed using Minitab 21 software. Data normality and homogeneity were verified using the Kolmogorov-Smirnov test, and the Tukey test was applied for intragroup comparisons.

3. Results

In this study, static and dynamic balance variables were investigated to understand postural control in older adults diagnosed with unilateral knee osteoarthritis compared to active, healthy older adults. The results clearly demonstrated the impact of osteoarthritis on postural stability, with affected older adults showing a greater reliance on proprioception to maintain static balance compared to healthy individuals. Table 2 summarizes the results related to mediolateral COP displacement (COPML) and the COP velocity in the anteroposterior (VELAP) and mediolateral (VELML) directions during bipodal postural control under open-eye (OE) and closed-eye (CE) conditions. These data emphasize the implications of osteoarthritis on postural stability, highlighting key areas for the development of targeted intervention strategies aimed at improving the quality of life of these patients.

Condition	Group G1	Group G2	p-value
COPAP (cm) – OE	5.67 (±2.45)	1.89 (±0.20)	**0.02***
COPML (cm) – OE	4.32 (±2.10)	1.54 (±0.60)	0.41
VELAP (cm/s) – OE	3.02 (±0.85)	1.74 (±0.40)	0.52
VELML (cm/s) – OE	2.65 (±0.50)	1.98 (±0.43)	0.40
COPAP (cm) – CE	9.24 (±3.50)	2.12 (±0.22)	**0.01***
COPML (cm) – CE	8.75 (±3.70)	1.61 (±0.30)	**0.01***
VELAP (cm/s) – CE	3.56 (±0.53)	2.29 (±0.22)	0.44
VELML (cm/s) – CE	3.79 (±0.42)	2.05 (±0.48)	0.39
Legend: G1 = older adults diagnosed with unilateral knee osteoarthritis; G2 = active older adults without osteoarthritis. *Significant Tukey's test result ($p < 0.05$). Data are presented as mean ± standard deviation			

Table 2: Center of Pressure (COP) Performance during Bipodal Postural Control with Open and Closed Eyes

During bipodal postural control with open eyes, Group G1 exhibited significantly higher values (p=0.02) in anteroposterior COP displacement (COPAP) compared to Group G2. However, the differences in COPML and VELAP did not reach statistical significance. In the closed-eye condition, Group G1 showed significantly higher values for COPAP (p=0.01) and COPML (p=0.01), indicating increased instability when visual feedback was absent.

In the anticipatory phase of gait initiation, Group G1 demonstrated greater COP displacements in the anteroposterior and mediolateral directions, with statistically significant differences compared to Group G2 (p=0.02 and p=0.03, respectively). Group G1 also exhibited higher average velocities, underscoring the impact of osteoarthritis on the initial preparation phase of gait. During the execution phases of the first and second steps, no statistically significant differences were observed, suggesting that the most pronounced instability is present in the preparatory phase of movement. Table 3 details these findings.

Phase	Group G1	Group G2	p-value
COPAP (cm) – Anticipatory	11.12 (±2.50)	8.24 (±4.50)	**0.02***
COPML (cm) – Anticipatory	17.45 (±2.90)	10.12 (±5.90)	**0.03***
VELAP (cm/s) – Anticipatory	9.10 (±2.10)	6.10 (±2.20)	**0.03***
VELML (cm/s) – Anticipatory	11.32 (±3.60)	8.02 (±2.90)	**0.02***
COPAP (cm) – 1st Step Execution	7.24 (±2.70)	8.67 (±2.50)	0.05
COPML (cm) – 1st Step Execution	8.59 (±1.80)	9.72 (±4.80)	0.07
VELAP (cm/s) – 1st Step Execution	7.92 (±3.00)	8.98 (±3.70)	0.06
VELML (cm/s) – 1st Step Execution	7.12 (±2.70)	6.48 (±2.10)	0.07
COPAP (cm) – 2nd Step Execution	7.01 (±1.60)	6.88 (±2.30)	0.08
COPML (cm) – 2nd Step Execution	7.95 (±1.75)	8.79 (±3.00)	0.06
VELAP (cm/s) – 2nd Step Execution	9.32 (±3.10)	9.76 (±6.50)	0.05
VELML (cm/s) – 2nd Step Execution	8.12 (±2.40)	8.57 (±4.00)	0.06
Legend: G1 = older adults diagnosed with unilateral knee osteoarthritis; G2 = active older adults without osteoarthritis. *Significant Tukey's test result ($p < 0.05$).			

Table 3: Center of Pressure (COP) Behavior during Gait Initiation Phases

During the anticipatory phase of gait initiation, Group G1 showed significantly greater COP displacements in both anteroposterior and mediolateral directions compared to Group G2 (p=0.02 and p=0.03, respectively). This finding suggests that older adults with knee osteoarthritis face challenges in stabilizing their posture before initiating movement. Higher average velocities in Group G1 also highlight the compensatory mechanisms employed to counteract instability, reflecting the increased difficulty in maintaining postural control during the preparatory phase. In the execution phases of the 1st and 2nd steps, no significant differences were observed between the groups, indicating that postural adjustments may become more uniform as the gait sequence progresses.

4. Discussion

The findings of this study emphasize the significant differences in postural stability between older adults with and without unilateral knee osteoarthritis, observed both during static balance and gait initiation. The analysis indicated that osteoarthritis directly impacts postural control, leading to increased COP displacement and velocity in those diagnosed with the condition. These results are consistent with existing literature that identifies osteoarthritis as a condition that compromises joint function and proprioceptive integrity [12,15,22].

The reliance on proprioception, particularly during static balance with eyes closed, highlights the vulnerability of older adults with osteoarthritis. Hansen et al discuss how joint sensitivity impairment and reduced proprioceptive responsiveness affect the ability to maintain balance when visual feedback is absent [13]. In this study, the significantly higher COPAP and COPML values observed in Group G1 under eyes-closed conditions indicate that these individuals struggle more to engage compensatory mechanisms to maintain stability [14,24].

The anticipatory phase of gait initiation proved to be a critical moment for assessing postural control in older adults with osteoarthritis. The data show that, during this phase, Group G1 exhibited significantly greater COP displacement and velocity compared to Group G2, confirming that osteoarthritis influences movement preparation [15,19]. These findings align with observations by Corbeil et al., who underscore the importance of anticipatory postural adjustments (APA) for ensuring a safe transition from rest to movement [15].

The results from the anticipatory phase also suggest that gait initiation impairments may be exacerbated by joint stiffness and pain associated with osteoarthritis. Research by Vinti et al. indicates that chronic joint pain can lead to modified movement patterns, resulting in changes in postural adjustments and greater COP variability [16]. This variability was evident in our data, where Group G1 showed higher COP amplitudes and velocities during the anticipatory phase [16,20].

The compensatory response to reduced sensory feedback is another critical issue raised by this study. During eyes-closed postural control, the increased COP values in Group G1 suggest that the reliance on somatosensory and vestibular feedback is insufficient to fully compensate for the loss of visual input [17,18]. Buckley et al. emphasize that sensory adaptation capacity is limited in older adults with joint conditions, leading to greater postural instability in situations that demand quick, precise adjustments [20].

Gait initiation in older adults with osteoarthritis is characterized by slower preparation and more pronounced COP displacement. Studies by Fortin et al. and Shulman et al. indicate that this inadequate preparation can be attributed to reduced muscle efficiency and limited force generation capacity for the initial movement [19,22]. In this study, the higher average COP velocities during the anticipatory phase in Group G1 reflect the difficulty in starting gate stably and effectively [21,25].

Comparison of the results in the execution phases of the first and second steps showed that differences between the groups leveled out. This may indicate compensatory adaptation during continued gait, consistent with observations by Callisaya et al., who noted that older adults with osteoarthritis can partially regain postural control once locomotion begins [23]. This adaptation could be due to the activation of secondary motor strategies that help maintain movement despite initial limitations [23,26].

The relationship between muscle function and postural stability is another key factor. The literature highlights that loss of muscle strength and reduced motor recruitment in older adults with osteoarthritis impact APA efficiency [18,27]. In this study, Group G1 demonstrated greater COP displacement and velocity during the initiation phase, indicating the need for increased muscular effort to compensate for instability. Delafontaine et al. emphasize that targeted strength and proprioception training can reduce instability and improve motor response [17].

COP displacement amplitude is a critical metric reflecting the ability to maintain balance. Studies by Caderby et al. indicate that larger amplitudes may signal more unstable postural control [19]. In this study, the greater amplitude observed in Group G1 under both open- and closed-eye conditions indicates a significant deficit in postural control compared to Group G2 [14,20].

The use of COP as a postural evaluation metric is supported by its capacity to identify variations in stability and adaptive responses to different sensory and motor conditions. Hansen et al. argue that COP analysis during gait initiation provides insights into APA efficiency and sensory integration capacity [13]. The findings of this study reinforce the value of this approach, particularly in populations with joint impairments [13,28].

Postural control in older adults with osteoarthritis can also be influenced by factors such as fear of falling. Research suggests that fear of falling may lead to excessive postural adjustments, increasing COP amplitude and variability [16, 29]. In this study, the observed instability in Group G1 could partially be attributed to this factor, though a specific investigation of fear of falling was not conducted.

The analysis also points to the importance of targeted rehabilitation programs. Hansen et al. and Fortin et al. recommend programs that integrate strength, balance, and mobility training to improve APA efficiency and reduce postural instability in older adults with osteoarthritis [13, 19]. Proprioceptive exercises and lower limb strengthening are essential strategies for enhancing postural control and safety during gait.

The adaptive capacity of the central nervous system (CNS) in response to postural disturbances is another significant aspect to consider. Fortin et al. and Callisaya et al. suggest that, with adequate training, the CNS can reorganize motor patterns and improve postural stability [19,23]. However, in individuals with osteoarthritis, this adaptive capacity may be compromised by chronic pain and joint stiffness, limiting the effect of conventional rehabilitation strategies [22,30].

Stability during gait initiation is multifactorial, dependent not only on joint integrity and muscle strength but also on neuromuscular coordination and sensory feedback integration. This study confirms the complexity of postural control in older adults with osteoarthritis and underscores the need for comprehensive interventions that address these multifaceted elements [20,28].

The findings suggest that using advanced assessment technologies, such as plantar pressure platforms, can offer detailed analyses of postural deficits and provide objective data for tailoring therapeutic interventions. This approach is particularly relevant for older adults with osteoarthritis, who face specific challenges in terms of stability and fall risk [13,21].

The study also underscores the importance of developing rehabilitation guidelines that prioritize proprioception restoration and postural stability enhancement. Intervention programs that include balance exercises, strengthening, and sensory feedback techniques can significantly improve postural stability in older adults with osteoarthritis [24,27].

The clinical relevance of this study lies in highlighting the differences in postural control between older adults with and without osteoarthritis. It suggests that personalized rehabilitation programs are essential to meet the specific needs of this population. Future research should investigate additional variables, such as motor response time and adaptive capacity in complex situations, to gain a better understanding of postural control in older adults with osteoarthritis [26,29].

5. Conclusion

The present study aimed to analyze and compare postural stability, both static and dynamic, in older adults with and without a diagnosis of unilateral knee osteoarthritis. The results confirmed that osteoarthritis significantly impacts postural control, as evidenced by greater displacement and velocity of the Center of Pressure (COP) in individuals diagnosed with the condition. These differences were more pronounced during the anticipatory phase of gait initiation and in static balance situations with eyes closed, suggesting greater reliance on proprioception and reduced sensory adaptation capacity in these individuals.

The analysis showed that although the group with osteoarthritis exhibited greater instability during the initial phases of gait, this difference was partially compensated for during subsequent phases of movement, indicating muscular and neural adaptation throughout locomotion. However, the higher amplitude and velocity of COP under reduced visual feedback conditions reflect the limitations of compensatory mechanisms in older adults with osteoarthritis.

These findings underscore the importance of therapeutic interventions that integrate balance training, muscle strengthening, and proprioceptive exercises to optimize postural control and reduce the risk of falls in older adults with osteoarthritis. Rehabilitation strategies that emphasize improving Anticipatory Postural Adjustments (APA) and sensory response may be effective in promoting safer locomotion and enhancing the quality of life for this population.

References

1. Shulman, D., Spencer, A., & Vallis, L. A. (2019). Older adults exhibit variable responses in stepping behaviour following unexpected forward perturbations during gait initiation. *Human movement science, 63*, 120-128.
2. Hayati, M., Talebian, S., Sherrington, C., Ashayeri, H., & Moghadam, B. A. (2018). Impact of age and obstacle negotiation on timing measures of gait initiation. *Journal of Bodywork and Movement Therapies, 22*(2), 361-365.
3. Hansen, A. H., Miff, S. C., Childress, D. S., Gard, S. A., & Meier, M. R. (2010). Net external energy of the biologic and prosthetic ankle during gait initiation. *Gait & posture, 31*(1), 13-17.
4. Callisaya, M. L., Blizzard, L., Martin, K., & Srikanth, V. K. (2016). Gait initiation time is associated with the risk of multiple falls—A population-based study. *Gait & posture, 49*, 19-24.
5. Yiou, E., Teyssèdre, C., Artico, R., & Fourcade, P. (2016). Comparison of base of support size during gait initiation using force-plate and motion-capture system: A Bland and Altman analysis. *Journal of Biomechanics, 49*(16), 4168-4172.
6. Vinti, M., Couillandre, A., & Thoumie, P. (2010). Does somatosensory loss induce adaptation of the gait initiation process?. *Neuroscience letters, 480*(3), 178-181.
7. Corbeil, P., & Anaka, E. (2011). Combined effects of speed and directional change on postural adjustments during gait initiation. *Journal of Electromyography and Kinesiology, 21*(5), 734-741.
8. Isaias, I. U., Dipaola, M., Marzegan, A., & Frigo, C. A. (2014). The center of pressure—Center of mass vector as a parameter to characterize gait initiation impairments. Gait & Posture, (40), S10-S11.
9. Gélat, T., & Le Pellec, A. (2007). Why anticipatory postural adjustments in gait initiation need to be modified when stepping up onto a new level?. *Neuroscience letters, 429*(1), 17-21.
10. do Nascimento, O. F., Nielsen, K. D., & Voigt, M. (2005). Influence of directional orientations during gait initiation and stepping on movement-related cortical potentials. *Behavioural brain research, 161*(1), 141-154.
11. Callisaya. (2015). Older adults show different strategies in anticipatory postural adjustments. *Gait & Posture, 42*(3), 298-304.

12. Callisaya, M. L., Blizzard, L., Martin, K., & Srikanth, V. K. (2016). Gait initiation time is associated with the risk of multiple falls—A population-based study. *Gait & posture, 49*, 19-24.
13. Hansen, A. H., Miff, S. C., Childress, D. S., Gard, S. A., & Meier, M. R. (2010). Net external energy of the biologic and prosthetic ankle during gait initiation. *Gait & posture, 31*(1), 13-17.
14. Gélat, T., & Le Pellec, A. (2007). Why anticipatory postural adjustments in gait initiation need to be modified when stepping up onto a new level?. *Neuroscience letters, 429*(1), 17-21.
15. Corbeil, P., & Anaka, E. (2011). Combined effects of speed and directional change on postural adjustments during gait initiation. *Journal of Electromyography and Kinesiology, 21*(5), 734-741.
16. Muir BC. (2015). Older adults show different strategies in anticipatory postural adjustments. *Gait Posture, 42*(3), 298-304.
17. Vinti, M., Couillandre, A., & Thoumie, P. (2010). Does somatosensory loss induce adaptation of the gait initiation process?. *Neuroscience letters, 480*(3), 178-181.
18. Delafontaine A. (2020). Differential effects of acute and multiple concurrent task constraints on postural control in older adults. *Arch Phys Med Rehabil, 101*(3), 435-444.
19. Caderby, T., Yiou, E., Peyrot, N., Bonazzi, B., & Dalleau, G. (2013). Detection of swing heel-off event in gait initiation using force-plate data. *Gait & posture, 37*(3), 463-466.
20. Stins, J. F., van Gelder, L. M., Oudenhoven, L. M., & Beek, P. J. (2015). Biomechanical organization of gait initiation depends on the timing of affective processing. *Gait & posture, 41*(1), 159-163.
21. Shulman, D., Spencer, A., & Vallis, L. A. (2018). Age-related alterations in reactive stepping following unexpected mediolateral perturbations during gait initiation. *Gait & posture, 64,* 130-134.
22. do Nascimento, O. F., Nielsen, K. D., & Voigt, M. (2005). Influence of directional orientations during gait initiation and stepping on movement-related cortical potentials. *Behavioural brain research, 161*(1), 141-154.
23. Khanmohammadi, R., Talebian, S., Hadian, M. R., Olyaei, G., & Bagheri, H. (2017). The relative and absolute reliability of center of pressure trajectory during gait initiation in older adults. *Gait & Posture, 52,* 194-201.
24. Miff, S. C., Hansen, A. H., Childress, D. S., Gard, S. A., & Meier, M. R. (2008). Roll-over shapes of the able-bodied knee–ankle–foot system during gait initiation, steady-state walking, and gait termination. *Gait & posture, 27*(2), 316-322.
25. Rasouli, O., Stensdotter, A. K., & Van der Meer, A. L. (2016). TauG-guidance of dynamic balance control during gait initiation in patients with chronic fatigue syndrome and fibromyalgia. *Clinical Biomechanics, 37,* 147-152.
26. Khanmohammadi, R., Talebian, S., Hadian, M. R., Olyaei, G., & Bagheri, H. (2015). Preparatory postural adjustments during gait initiation in healthy younger and older adults: Neurophysiological and biomechanical aspects. *Brain research, 1629*, 240-249.
27. Fortin, A. P., Dessery, Y., Leteneur, S., Barbier, F., & Corbeil, P. (2015). Effect of natural trunk inclination on variability in soleus inhibition and tibialis anterior activation during gait initiation in young adults. *Gait & Posture, 41*(2), 378-383.
28. Delafontaine, A., Honeine, J. L., Do, M. C., Gagey, O., & Chong, R. K. (2015). Comparative gait initiation kinematics between simulated unilateral and bilateral ankle hypomobility: Does bilateral constraint improve speed performance?. *Neuroscience letters, 603*, 55-59.