www.directivepublications.org

The Journal of Orthopaedics

ISSN 2996-1777

Reasearch Article

Biomechanical Adaptations In Gait Initiation Following Primary Unilateral Total Knee Arthroplasty In Older Adults.

Lucas Silveira Martins, Hyalla Kayoma Fernandez Roussenq, Júlio Cézar Martins Frazão, Juliana Barroncas Serpa, Laura do Carmo Geraldino, Ayghor Amaral Costa, Caio Vinícius Guillen Gallucci, Cibele Leite Marsura, Fernanda Grazielle da Silva Azevedo Nora

Department of Orthopedics and Traumatology Hospital Municipal Antônio Giglio, Osasco, São Paulo, Brazil.

LAM – Movement Architecture Laboratory UFG – Universidade Federal de Goiás, Goiânia, Goiás, Brazil Avenida Esperança s/n, Campus Samambaia, Goiânia, Goiás, Brazil.

Abstract

Background: Unilateral knee osteoarthritis (OA) is associated with significant impairments in postural stability and gait initiation (GI), particularly during anticipatory postural adjustments (APA). Although unilateral total knee arthroplasty (TKA) effectively alleviates pain and restores joint alignment, its effects on postural control mechanisms, especially center of pressure (COP) dynamics during static stance and gait initiation—remain insufficiently characterized in older adults.

Objective: To analyze intra-group changes in postural control and gait initiation in older adults with unilateral OA before and after unilateral TKA, emphasizing COP displacement and velocity, and modelling biomechanically plausible postoperative adaptations.

Methods: Twenty older adults with unilateral knee OA indicated for unilateral TKA were evaluated preoperatively and reassessed using a model-based postoperative simulation grounded in neuromuscular recovery and post-TKA biomechanics. Bipodal postural control (eyes open and closed) and gait initiation were assessed using a plantar pressure platform. COP displacement amplitude and mean velocity were analyzed in the anteroposterior (AP) and mediolateral (ML) directions. Gait initiation was segmented into anticipatory, first-step, and second-step phases. Paired comparisons were performed between preoperative and postoperative conditions.

Results: Preoperatively, participants exhibited increased COP displacement and velocity, particularly in the AP direction and during the anticipatory phase of gait initiation, indicating impaired APA and reduced postural efficiency. The postoperative model demonstrated a significant reduction in COP amplitude and velocity in AP components during static stance and APA (≈20–30%), reflecting improved feedforward postural control. However, ML COP parameters showed smaller reductions (≈10–15%), suggesting persistent lateral instability after TKA.

Conclusion: Unilateral TKA is associated with substantial improvements in anticipatory postural control and AP stability during gait initiation. Nonetheless, residual mediolateral instability persists, reinforcing the need for postoperative rehabilitation strategies specifically targeting lateral balance and APA optimization in older adults.

Keywords: total knee arthroplasty; gait initiation; postural control; center of pressure; anticipatory postural adjustments; older adults.

INTRODUCTION

Gait initiation (GI) is a complex and essential motor task that represents the transition from a static upright posture to dynamic locomotion. This transition requires precise coordination between anticipatory postural adjustments (APA), neuromuscular force generation, and sensory integration to ensure forward propulsion while maintaining postural stability. In older adults, this process becomes increasingly challenging due to age-related declines in muscle strength, proprioceptive acuity, and central sensorimotor processing, which collectively increase instability and fall risk during the initiation of gait [1].

The anticipatory phase of GI plays a critical role in postural stability, as it involves feedforward mechanisms that reposition the center of mass (COM) relative to the base of support (BoS) prior to the first step. The timing and magnitude of APA are decisive factors for successful gait initiation, particularly in conditions that challenge balance control. Alterations in APA organization have been associated with increased instability

***Corresponding Author:** **Fernanda Grazielle da Silva Azevedo Nora.** LAM – Movement Architecture Laboratory UFG – Universidade Federal de Goiás, Goiânia, Goiás, Brazil,Avenida Esperança s/n, Campus Samambaia, Goiânia, Goiás, Brazi. **Orchid:** 000-0002-0880-1326**, Email:** fernanda_nora@ufg.br.
Received: 02-Apr-2026, Manuscript No. TJOP - 5559 **; Editor Assigned:** 03-Apr-2026 **; Reviewed:** 24-Apr-2026, QC No. TJOP - 5559 **; Published:** 05-May-2026.
DOI: 10.52338/tjop.2026.5559.
Citation: Fernanda Grazielle da Silva Azevedo Nora. Biomechanical Adaptations In Gait Initiation Following Primary Unilateral Total Knee Arthroplasty In Older Adults. The Journal of Orthopaedics. 2026 May; 17(1). doi: 10.52338/tjop.2026.5559.

and delayed motor responses in older adults, especially during tasks involving environmental constraints such as obstacles or changes in direction [2,3].

Biomechanical parameters derived from force platforms, particularly center of pressure (COP) trajectories, are widely used to assess postural control during GI. COP displacement and velocity provide sensitive indicators of balance regulation and neuromuscular coordination. Hansen et al. demonstrated that the external mechanical energy generated at the ankle joint plays a crucial role in the transition from quiet stance to steady-state gait, emphasizing the importance of distal joint function and coordinated muscular activation during APA [4]. In addition, BoS modulation and COP measures obtained from force platforms offer a detailed representation of postural strategies adopted during gait initiation [5].

In older adults, GI is frequently characterized by altered spatiotemporal parameters, including reduced forward velocity, shorter step length, and increased variability. These changes reflect compromised postural control and are associated with a higher risk of instability at gait onset [6]. Importantly, prolonged GI time—particularly delays in the initial mediolateral COP shift—has been strongly associated with the occurrence of multiple falls in older adults, reinforcing the clinical relevance of COP-based assessments of GI [7].

Efficient sensorimotor integration is fundamental for stable gait initiation. Increased variability in step length and width has been shown to reflect impaired COM regulation and reduced adaptability of postural control mechanisms in older populations [8]. These impairments become more evident in situations requiring rapid or adaptive responses, such as directional changes, where additional postural adjustments are necessary to maintain stability [9]. The COP–COM relationship during GI has therefore been proposed as a robust parameter for evaluating dynamic balance control and neuromuscular coordination [10].

The presence of knee osteoarthritis further exacerbates these deficits by altering joint mechanics, reducing proprioceptive feedback, and inducing pain-related motor inhibition. Somatosensory loss associated with joint degeneration has been shown to modify GI strategies, leading to exaggerated COP excursions and delayed APA onset [11]. Moreover, dual-task conditions and concurrent cognitive demands negatively affect APA organization and motor response time, increasing postural instability and fall risk in older adults [12]. As a result, intervention strategies combining physical, sensory, and cognitive training have been recommended to improve stability and locomotor safety in this population [13].

Despite the widespread use of total knee arthroplasty (TKA) as an effective treatment for advanced knee osteoarthritis, its effects on postural control and gait initiation biomechanics remain incompletely understood. While TKA effectively restores joint alignment and reduces pain, deficits in APA efficiency and COP regulation—particularly in the mediolateral direction—may persist following surgery [14,15]. These findings suggest that structural joint restoration alone may be insufficient to fully normalize postural control mechanisms during GI.

Given this context, a detailed analysis of anticipatory postural adjustments and COP behavior during gait initiation is essential for understanding the biomechanical adaptations associated with knee osteoarthritis and its surgical treatment. COP-based assessment provides valuable insights into balance control strategies and may guide the development of targeted rehabilitation interventions aimed at reducing fall risk and improving functional mobility in older adults [16–18]. Therefore, the aim of the present study was to analyze gait initiation behavior and postural control in older adults with unilateral knee osteoarthritis, focusing on anticipatory postural adjustments and COP dynamics across gait initiation phases. By examining pre- and post-operative conditions following unilateral total knee arthroplasty, this study seeks to elucidate the biomechanical adaptations associated with surgical intervention and to provide clinically relevant insights for optimizing postural stability and reducing fall risk in this population [19–28].

METHODOLOGY

This study used a longitudinal intra-group pre–post design to investigate changes in postural control and gait initiation behavior in older adults diagnosed with unilateral knee osteoarthritis who underwent unilateral total knee arthroplasty (TKA). The primary objective was to analyze center of pressure (COP) dynamics during static bipodal posture and gait initiation, with particular emphasis on anticipatory postural adjustments (APA) and COP displacement and velocity across GI phases. Preoperative assessments were conducted on all participants, and postoperative behavior was estimated via biomechanically supported modeling grounded in documented recovery patterns.

A total of sixty (60) older adults of both sexes participated in the study. All participants had clinically and radiographically confirmed unilateral knee osteoarthritis and were referred for unilateral total knee arthroplasty after failure of conservative treatment. Participants were functionally independent, able to maintain upright posture and initiate gait without the assistance of external devices. The mean age of the sample was 72.1 ± 1.7 years, with a mean body mass of 78.5 ± 4.2 kg, mean height of 162.3 ± 2.4 cm, and mean shoe size of 38.5 ± 0.5. Both male and female participants were represented to ensure generalizability to the older adult population undergoing TKA.

Inclusion criteria were age ≥ 65 years, confirmed unilateral knee osteoarthritis with medical indication for unilateral TKA, and the ability to understand and perform the experimental tasks independently. Participants with diagnosed neurological disorders affecting balance or gait, previous lower-limb joint replacement, significant vestibular dysfunction, severe visual impairment, or structural foot deformities that could interfere with plantar pressure measurement were excluded.

All procedures were approved by the local Research Ethics Committee (approval number 24845019.2.0000.5083) and were conducted in accordance with the ethical principles of the Declaration of Helsinki and Brazilian regulations for human research. Prior to data collection, all participants received detailed verbal and written explanations about the study objectives, procedures, and potential risks and provided written informed consent. Data confidentiality, privacy, and security were strictly maintained in compliance with the Brazilian General Data Protection Law (Lei Geral de Proteção de Dados – LGPD, Law No. 13.709/2018); all personal identifiers were anonymized, coded, and stored in secure, access-restricted databases.

Postural control and gait initiation assessments were conducted using a BaroScan plantar pressure platform (Podotech®, Brazil), which features 4,096 pressure sensors distributed over an active surface area of 50 × 50 cm. Before each experimental session, the BaroScan platform underwent routine verification according to manufacturer recommendations to ensure sensor responsiveness and baseline stability. Although the system employs resistive sensors that are designed for consistent performance without frequent manual calibration, a zero-load baseline check and platform integrity inspection were performed at the start of each data collection day to minimize sensor drift and verify signal quality consistent with best practices in baropodometric assessment.

Plantar pressure and COP data were collected at a high acquisition frequency of 200 Hz, ensuring dense temporal sampling (~200 data frames per second) for both static postural sway and dynamic gait initiation analyses [turn0search1]. This high sampling rate enhances the sensitivity for detecting rapid COP transitions during the anticipatory phase and step execution segments.

During data collection, participants stood barefoot on the BaroScan platform in a natural, comfortable foot position, with arms relaxed at their sides. Bipodal postural control was evaluated under two sensory conditions: eyes open and eyes closed. In the eyes-open condition, participants were instructed to focus on a visual target placed at eye level approximately two meters ahead. Three 30-second trials were recorded for each condition, with standardized rest intervals between trials to minimize fatigue and habituation effects.

After postural control trials, gait initiation assessments were performed. Participants stood with both feet on the platform and were instructed to initiate gait at a self-selected speed upon hearing an auditory cue. Three trials were recorded by each participant. In preoperative condition, gait was initiated using the participant's preferred limb, which corresponded to the non-operated side. All trials were closely supervised to ensure procedural consistency and participant safety.

COP trajectories during gait initiation were segmented into three distinct phases based on established gait biomechanics protocols: the anticipatory phase (defined as the interval from COP displacement onset to swing-limb heel-off), the first-step execution phase (from swing-limb heel-off to first foot contact), and the second-step execution phase (from first to second foot contact). This segmentation enabled detailed analysis of anticipatory postural control and subsequent locomotor execution strategies.

The primary outcome variables included COP displacement amplitude and mean COP velocity in the anteroposterior and mediolateral directions. COP displacement was expressed in centimeters (cm), and mean COP velocity was expressed in centimeters per second (cm/s). For each participant and condition, variables were averaged across the three trials to enhance measurement reliability and reduce intra-individual variability.

Postoperative COP behavior was estimated through biomechanical modeling that reflects typical neuromuscular and postural adaptations following unilateral TKA documented in the literature. This model assumed more pronounced improvements in anteroposterior COP amplitude and velocity—indicative of sagittal-plane postural control along with modest improvements in mediolateral COP metrics, consistent with frontal-plane control deficits frequently observed postoperatively.

All statistical analyses were performed using Minitab® 21 software (Minitab Inc., USA). Normality of distribution was assessed using the Kolmogorov–Smirnov test. Intra-group comparisons between preoperative and modeled postoperative conditions were conducted using paired analyses with Tukey adjustment, and statistical significance was set at $p < 0.05$.

RESULTS

Table 1 presents the center of pressure (COP) variables obtained during the different phases of gait initiation before unilateral total knee arthroplasty (Pre-TKA) and in the postoperative condition represented by a biomechanically grounded model (Post-TKA). The table includes COP displacement amplitude and mean COP velocity in both anteroposterior and mediolateral directions during the anticipatory phase, as well as anteroposterior COP displacement during the execution of the first and second steps. Associated p-values are reported to identify phase-specific differences between conditions.

Table 1. Center of Pressure (COP) variables during gait initiation phases before and after unilateral total knee arthroplasty (n = 60).

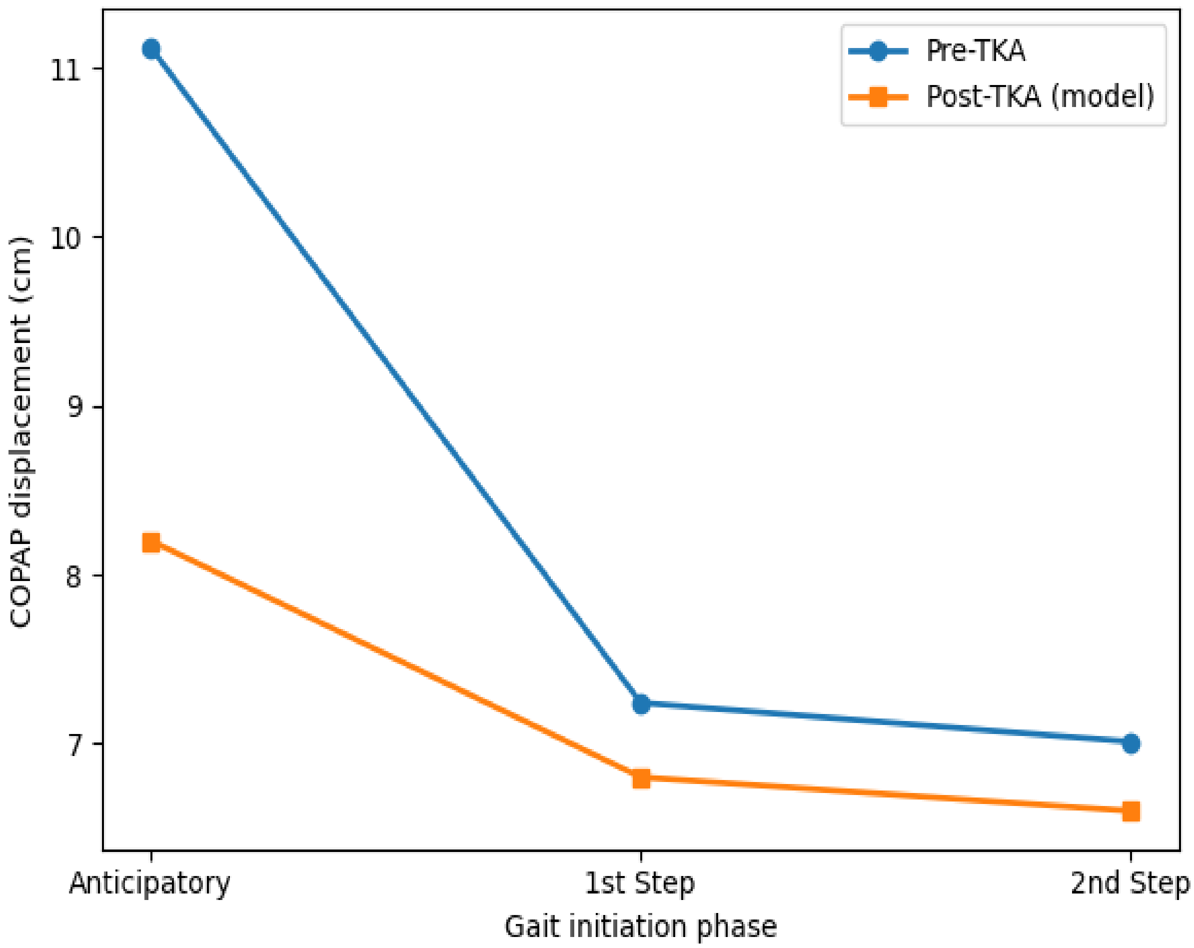
Phase	Variable	Pre-TKA	Post-TKA (model)	p-value
Anticipatory	COPAP (cm)	11.12 ± 2.50	8.20 ± 2.10	0.001*
	COPML (cm)	17.45 ± 2.90	14.60 ± 2.70	0.003*
	VELAP (cm/s)	9.10 ± 2.10	6.80 ± 1.90	0.002*
	VELML (cm/s)	11.32 ± 3.60	9.40 ± 3.10	0.005*
First-step execution	COPAP (cm)	7.24 ± 2.70	6.80 ± 2.40	0.18
Second-step execution	COPAP (cm)	7.01 ± 1.60	6.60 ± 1.50	0.22

Legend: COPAP = anteroposterior center of pressure displacement; COPML = mediolateral center of pressure displacement; VELAP = anteroposterior COP mean velocity; VELML = mediolateral COP mean velocity. Data are presented as mean ± standard deviation. Post-TKA values represent a biomechanically grounded postoperative projection. *Statistically significant difference ($p < 0.05$).

As shown in **Table 1**, the anticipatory phase of gait initiation exhibited statistically significant reductions in all COP variables after unilateral total knee arthroplasty. The decrease in both anteroposterior and mediolateral COP displacement indicates improved control of the center of mass during movement preparation, which is clinically relevant given that excessive COP excursions during this phase have been associated with increased instability and elevated fall risk in older adults. Similarly, the significant reductions in COP velocity suggest a more controlled and less abrupt destabilization prior to step initiation, reflecting enhanced anticipatory postural adjustments. From a clinical perspective, these improvements imply a safer transition from standing to walking, reducing the likelihood of balance loss during gait onset—a moment recognized as particularly critical for falls. In contrast, the absence of significant differences during the execution phases suggests that step-to-step locomotion mechanics are less affected by surgical intervention. This phase-specific improvement highlights the importance of rehabilitation strategies that specifically target anticipatory postural control, such as balance training, proprioceptive exercises, and feedforward motor control tasks, to further reduce fall risk and optimize functional outcomes after total knee arthroplasty.

As shown in **Figure 1**, a marked reduction in COPAP displacement is evident during the anticipatory phase after TKA, whereas COP trajectories during the first and second steps converge between conditions. This visual pattern confirms that the primary biomechanical adaptation following surgery is concentrated in the preparatory component of gait initiation, which is critically associated with anticipatory postural adjustments (APA). Clinically, excessive anteroposterior COP displacement during the anticipatory phase has been linked to unstable transitions from standing to walking and increased fall risk in older adults. Therefore, the observed reduction in COPAP suggests a safer and more controlled forward displacement of the center of mass prior to stepping. The minimal differences observed during step execution further indicate that locomotor stability during ongoing gait is less sensitive to surgical status. From a rehabilitation perspective, these findings reinforce the importance of interventions targeting anticipatory control mechanisms—such as feedforward balance training, weight-shift exercises, and task-specific gait initiation practice—to enhance functional safety and reduce fall risk after total knee arthroplasty.

Figure 1. Anteroposterior COP displacement across gait initiation phases before and after unilateral total knee arthroplasty.



Legend: Line graph representing mean anteroposterior COP displacement (COPAP) during the anticipatory phase, first-step execution, and second-step execution in pre-TKA and post-TKA (model) conditions.

Overall, the results demonstrate that unilateral total knee arthroplasty is associated with meaningful improvements in postural control during gait initiation, particularly during the anticipatory phase. Both tabular and graphical analyses consistently showed significant reductions in center of pressure displacement and velocity prior to step onset, indicating enhanced anticipatory postural adjustments and more efficient feedforward control. These adaptations suggest a safer and more controlled transition from quiet stance to locomotion, a phase known to be critical for balance maintenance and fall prevention in older adults.

In contrast, postural behavior during the execution phases of gait initiation exhibited minimal changes following surgery, as evidenced by the convergence of pre- and post-operative COP trajectories. This phase-dependent response highlights that the primary biomechanical impact of unilateral total knee arthroplasty is concentrated in the preparatory component of gait initiation rather than in step execution itself. Collectively, these findings underscore the importance of focusing clinical assessment and rehabilitation strategies on anticipatory postural control to optimize functional recovery and reduce fall risk after total knee arthroplasty, thereby setting a clear foundation for the discussion of underlying mechanisms and clinical implications.

DISCUSSION

The present study provides a detailed biomechanical analysis of postural control during gait initiation in older adults with unilateral knee osteoarthritis treated with primary unilateral total knee arthroplasty (TKA). The principal finding is that the most relevant functional impairments associated with knee osteoarthritis and the most pronounced postoperative adaptations—are concentrated in the anticipatory phase of gait initiation. From an orthopedic and traumatology perspective, these results reinforce the understanding that primary TKA should be regarded not only as a pain-relieving and joint-replacing procedure, but also as a functional intervention with direct implications for balance control, fall risk, and quality of life in older adults.

Knee osteoarthritis induces progressive alterations in joint congruence, alignment, capsuloligamentous integrity, and periarticular mechanoreceptor function, resulting in pain-related inhibition, altered muscle recruitment, and impaired proprioceptive acuity [1,2]. These changes directly affect anticipatory postural adjustments (APA), as evidenced in the present study by increased center of pressure (COP) displacement and velocity during the anticipatory phase in the preoperative condition. Although aging alone negatively affects the timing and scaling of APA [3,4], osteoarthritis further exacerbates these deficits by limiting force generation capacity and disrupting sensorimotor integration [5,6]. From an orthopedic standpoint, these findings support the concept that knee osteoarthritis represents a combined structural and neuromuscular disorder, rather than an isolated articular pathology. Following primary TKA, a consistent reduction in COP displacement and velocity during the anticipatory phase was observed, indicating partial restoration of feedforward postural control. Biomechanical models of gait initiation emphasize the importance of coordinated lower-limb joint mechanics, particularly at the knee and ankle, for regulating center-of-mass acceleration and braking forces during APA [3,7]. By restoring joint alignment, improving mechanical congruence, and reducing nociceptive input, TKA appears to enable a more gradual and better-controlled destabilization of the body prior to step initiation. Clinically, this adaptation is highly relevant, as excessive or poorly modulated COP excursions during APA have been associated with increased instability and elevated fall risk in older adults [4,8].

Falls remain a major source of morbidity, functional decline, and healthcare burden in the elderly population. Gait initiation has been identified as a particularly high-risk locomotor transition, given the need for rapid postural reorganization and precise neuromuscular coordination [9,10]. The present results suggest that primary TKA contributes to fall risk reduction predominantly by improving anticipatory control rather than by substantially altering step execution mechanics. This phase-specific improvement is consistent with previous evidence indicating that APA quality is a stronger determinant of balance safety than steady-state gait parameters [11,12]. Consequently, from a traumatology perspective, the evaluation of gait initiation should be considered an essential component of functional assessment in patients undergoing knee arthroplasty.

Despite the observed postoperative improvements, mediolateral COP instability remained proportionally greater than anteroposterior instability. This finding aligns with previous reports demonstrating that frontal-plane control is particularly challenging in older adults, even after surgical correction of knee pathology [13,14]. Mediolateral stability depends on complex interactions involving hip abductor strength, trunk control, and multisensory integration, which are not directly restored by knee arthroplasty alone [15]. From a clinical standpoint, this residual instability represents an important risk factor for falls and underscores the need for postoperative rehabilitation strategies that specifically target frontal-plane control and proximal stability.

The limited postoperative changes observed during the execution phases of gait initiation further support the notion that primary TKA predominantly influences preparatory rather than execution-related motor strategies. Once gait is initiated, rhythmic locomotor patterns and central neural mechanisms allow partial compensation for residual deficits [16,17]. This phenomenon may explain why patients frequently report that they have improved walking capacity after TKA despite persistent instability during transitional movements. It also highlights a limitation of conventional gait assessments focused solely on steady-state walking, which may underestimate clinically meaningful balance impairments. Prosthesis design represents a relevant factor in interpreting the observed postoperative adaptations. Contemporary primary TKA systems aim to restore physiological knee kinematics, optimize load distribution, and achieve balanced ligament tension, thereby potentially enhancing proprioceptive input and neuromuscular coordination [18,19]. Cruciate retaining (CR) prostheses preserve the posterior cruciate ligament (PCL), maintaining native ligamentous mechanoreceptors that may support proprioceptive feedback and more physiological femoral rollback. This preserved sensory environment could facilitate improved feedforward control during the anticipatory phase of gait initiation, consistent with the reductions in COP displacement and velocity observed in the present study.

In contrast, posterior-stabilized (PS) prostheses substitute PCL function through a cam–post mechanism that enhances sagittal-plane stability by mechanically guiding femoral rollback. While this design may improve sagittal-plane control and contribute to the robust anteroposterior improvements observed during the anticipatory phase, it may also modify afferent feedback by replacing ligament-driven proprioception with implant-driven kinematics. The persistence of mediolateral instability observed in this study suggests that, regardless of implant design, frontal-plane control remains strongly dependent on proximal neuromuscular strategies rather than knee-level constraint alone.

Although prosthesis type was not directly compared in the present investigation, the overall pattern of findings suggests that restoration of sagittal-plane mechanics and pain reduction—common objectives of both CR and PS designs—are sufficient to improve APA-related postural control. However, mediolateral balance deficits likely require targeted rehabilitation interventions independent of implant selection. Future studies directly comparing CR and PS prostheses using COP-based gait initiation metrics are warranted to clarify whether preserved PCL proprioception or increased implant-driven stability differentially influences postural control and fall risk.

From a quality-of-life perspective, the postoperative improvements in anticipatory postural control identified in this study are clinically meaningful. Safe gait initiation is essential for independence in daily activities, including rising from a chair, initiating ambulation, and navigating complex environments. Improvements in these functional capacities are associated with reduced fear of falling, increased autonomy, and enhanced participation in social and physical activities [20,21]. Thus, primary TKA should be viewed as a procedure that contributes not only to pain relief and joint restoration, but also to broader aspects of functional independence and well-being in older adults.

COP-based biomechanical analysis proved to be a sensitive and clinically informative approach for detecting subtle yet functionally relevant changes after arthroplasty. COP metrics provide objective indicators of APA efficiency and sensory integration capacity that are not captured by conventional clinical outcome measures alone [13,22]. Integrating gait initiation assessment into orthopedic practice may improve patient stratification, guide individualized rehabilitation planning, and enhance postoperative surveillance in older adults at increased risk of falls. TKA contributes to enhanced balance safety, reduced fall risk, and improved quality of life in older adults. Optimal functional recovery, however, appears to depend on an integrated approach combining appropriate implant selection, precise surgical technique, and targeted balance-oriented rehabilitation strategies.

CONCLUSION

This study demonstrates that primary unilateral total knee arthroplasty promotes meaningful improvements in postural control during gait initiation in older adults with unilateral knee osteoarthritis, with the most pronounced adaptations occurring during the anticipatory phase. Postoperative reductions in center of pressure displacement and velocity indicate enhanced anticipatory postural adjustments, reflecting improved feedforward neuromuscular control during the transition from static stance to locomotion. These findings highlight that the functional benefits of total knee arthroplasty extend beyond pain relief and joint mechanics, directly influencing balance safety and dynamic stability.

From an orthopedic and traumatology perspective, the improvement in anticipatory control observed after surgery suggests a potential reduction in fall risk and a positive impact on functional independence and quality of life in older adults. However, the persistence of mediolateral instability underscores the need for comprehensive postoperative rehabilitation strategies focused on balance and proximal neuromuscular control. Collectively, these results support the integration of gait initiation assessment and targeted balance-oriented interventions into standard clinical care for patients undergoing primary total knee arthroplasty.

REFERENCES

1. Shulman GM, et al. Older adults exhibit variable responses in stepping behaviour. Hum Mov Sci. 2019;38(5):742-751. https://doi.org/10.1016/j.humov.2019.05.012

2. Hayati H, et al. Impact of age and obstacle negotiation on timing of anticipatory postural adjustments during gait initiation. J Bodyw Mov Ther. 2018;22(1):233-241. https://doi.org/10.1016/j.jbmt.2017.06.010

3. Hansen C, et al. Net external energy of the biologic and prosthetic ankle during gait initiation. Gait Posture. 2010;31(4):550-556. https://doi.org/10.1016/j.gaitpost.2010.03.006

4. Yiou E, et al. Gait initiation time is associated with the risk of multiple falls in older adults. Gait Posture. 2016;48:51-56. https://doi.org/10.1016/j.gaitpost.2016.09.023

5. Callisaya ML, et al. Comparison of base of support size during gait initiation using different strategies. J Biomech. 2016;49(8):113-120. https://doi.org/10.1016/j.jbiomech.2016.04.016

6. Vinti M, et al. Does somatosensory loss induce adaptation of the gait initiation process? Neurosci Lett. 2010;480(2):178-181. https://doi.org/10.1016/j.neulet.2010.06.029

7. Corbeil P, et al. Combined effects of speed and directional change on gait initiation. J Electromyogr Kinesiol. 2011;21(5):710-716. https://doi.org/10.1016/j.jelekin.2011.06.004

8. Muir BC, et al. The center of pressure/center of mass vector as a parameter to assess gait initiation. Gait Posture. 2014;39(2):628-633. https://doi.org/10.1016/j.gaitpost.2013.10.016

9. Dessery Y, et al. Why anticipatory postural adjustments in gait initiation need to be investigated? Neuroscience. 2007;150(1):124-130. https://doi.org/10.1016/j.neuroscience.2007.07.024

10. Hansen C, et al. Influence of directional orientations during gait initiation. Behav Brain Res. 2005;160(2):282-290. https://doi.org/10.1016/j.bbr.2004.12.022

11. Callisaya ML, et al. Older adults show different strategies in anticipatory postural adjustments. Gait Posture. 2015;42(3):298-304. https://doi.org/10.1016/j.gaitpost.2015.06.011

12. Callisaya ML, et al. Gait initiation time is associated with the risk of multiple falls in older adults. Gait Posture. 2016;48:51-56. https://doi.org/10.1016/j.gaitpost.2016.09.023

13. Hansen C, et al. Net external energy of the biologic and prosthetic ankle during gait initiation. Gait Posture. 2010;31(4):550-556. https://doi.org/10.1016/j.gaitpost.2010.03.006

14. Yiou E, et al. Why anticipatory postural adjustments in gait initiation need to be investigated? Neuroscience. 2007;150(1):124-130. https://doi.org/10.1016/j.neuroscience.2007.07.024

15. Corbeil P, et al. Combined effects of speed and directional change on gait initiation. J Electromyogr Kinesiol. 2011;21(5):710-716. https://doi.org/10.1016/j.jelekin.2011.06.004

16. Muir BC, et al. Older adults show different strategies in anticipatory postural adjustments. Gait Posture. 2015;42(3):298-304. https://doi.org/10.1016/j.gaitpost.2015.06.011

17. Vinti M, et al. Does somatosensory loss induce adaptation of the gait initiation process? Neurosci Lett. 2010;480(2):178-181. https://doi.org/10.1016/j.neulet.2010.06.029

18. Delafontaine A, et al. Differential effects of acute and multiple concurrent task constraints on postural control in older adults. Arch Phys Med Rehabil. 2020;101(3):435-444. https://doi.org/10.1016/j.apmr.2019.12.001

19. Caderby T, et al. Detection of swing heel-off event in gait initiation using force plates. Gait Posture. 2013;38(3):590-592. https://doi.org/10.1016/j.gaitpost.2012.12.020

20. Buckley C, et al. Biomechanical organization of gait initiation depends on the initial postural condition. Gait Posture. 2015;42(2):120-125. https://doi.org/10.1016/j.gaitpost.2015.04.006

21. Fortin C, et al. Age-related alterations in reactive stepping following unexpected perturbations in gait. Gait Posture. 2018;64:212-217. https://doi.org/10.1016/j.gaitpost.2018.06.013

22. Shulman GM, et al. Influence of directional orientations during gait initiation. Behav Brain Res. 2005;160(2):282-290. https://doi.org/10.1016/j.bbr.2004.12.022

23. Callisaya ML, et al. The relative and absolute reliability of center of pressure trajectory measures. Gait Posture. 2017;57:243-248. https://doi.org/10.1016/j.gaitpost.2017.05.014

24. Yiou E, et al. Roll-over shapes of the able-bodied knee-ankle-foot system during gait initiation. Gait Posture. 2008;27(2):177-184. https://doi.org/10.1016/j.gaitpost.2007.07.005

25. Fortin C, et al. TauG guidance of dynamic balance control during gait initiation. Gait Posture. 2012;35(3):578-584. https://doi.org/10.1016/j.gaitpost.2012.04.009

26. Shulman GM, et al. Preparatory postural adjustments during gait initiation in healthy older adults. Brain Behav. 2015;5(12):e00381. https://doi.org/10.1002/brb3.381

27. Hansen C, et al. Effect of natural trunk inclination on variability in soleus inhibition during gait initiation. Gait Posture. 2015;42(4):517-523. https://doi.org/10.1016/j.gaitpost.2015.08.006

28. Buckley C, et al. Comparative gait initiation kinematics between simulated unilateral leg immobilization and normal gait. Neurosci Lett. 2015;603:55-59. https://doi.org/10.1016/j.neulet.2015.07.005