

## Original Research Article

# Factors associated with contralateral limb knee pain in unilateral lower limb amputees: a cross-sectional analysis of 531 patients

Shashi B. Sahu<sup>1</sup>, K. Gouri Prasad<sup>2</sup>, Rajiv Kaul<sup>3\*</sup>, Vishwavijet Mopagar<sup>4</sup>

<sup>1</sup>Department of Surgery, Artificial Limb Subcentre/Base Hospital Delhi Cantt, Delhi, India

<sup>2</sup>Department of Surgery, Base Hospital Delhi Cantt, Delhi, India

<sup>3</sup>Department of Orthopaedics, Base Hospital Delhi Cantt, Delhi, India

<sup>4</sup>Department of Community Medicine, Armed Forces Medical College, Pune, Maharashtra, India

**Received:** 25 September 2026

**Revised:** 17 October 2026

**Accepted:** 24 October 2026

### \*Correspondence:

Dr. Rajiv Kaul,

E-mail: [drrajivkaul@gmail.com](mailto:drrajivkaul@gmail.com)

**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

## ABSTRACT

**Background:** Lower limb amputation results in substantial biomechanical alterations during gait, frequently leading to asymmetrical loading of the contralateral limb. Chronic overloading of the sound extremity has been implicated in the development of secondary musculoskeletal complications, including knee pain and osteoarthritis. However, the factors associated with contralateral joint pain among amputees remain incompletely understood. The objective of the study was to estimate the prevalence of patient-reported contralateral knee pain among unilateral lower limb amputees and identify demographic and clinical factors associated with its presence.

**Methods:** A cross-sectional observational study was conducted using a clinical database of 531 adult unilateral lower limb amputees undergoing prosthetic rehabilitation from 2016 to 2021. Contralateral knee pain was recorded as a patient-reported binary outcome (yes/no) during clinical assessment. Demographic variables, amputation characteristics, time since amputation, time to first prosthetic fitting, body weight, and walking distance were analysed. Continuous variables were compared between pain and no-pain groups using independent-samples t-tests, and categorical variables using chi-square tests where applicable.

**Results:** Contralateral knee pain was reported by 64 of 531 participants, giving an overall prevalence of 12.1% (95% CI 9.6-15.1%). Participants with knee pain were older than those without pain (54.9 versus 48.9 years;  $p=0.009$ ) and had a longer duration since amputation (20.1 versus 13.5 years;  $p=0.018$ ). Body weight ( $p=0.48$ ), daily walking distance ( $p=0.26$ ), and time to prosthetic fitting ( $p=0.25$ ) were not significantly different between groups.

**Conclusions:** Contralateral knee pain was present in approximately one in eight unilateral lower limb amputees in this cohort. Increasing age and longer duration since amputation were associated with the presence of contralateral knee pain. Because this cross-sectional study used a patient-reported binary pain outcome and did not include a validated knee functional score, the findings should be interpreted as associations rather than causal or independent predictive effects.

**Keywords:** Amputation, Contralateral limb, Knee pain, Osteoarthritis, Prosthesis, Gait asymmetry, Rehabilitation, Joint degeneration

## INTRODUCTION

Lower limb amputation is a life-altering event that affects mobility, independence, and quality of life. Despite significant advancements in prosthetic technology,

restoration of normal gait remains challenging because of the loss of anatomical structures responsible for force generation, proprioception, and shock absorption.<sup>1</sup> Consequently, unilateral amputees frequently develop compensatory movement patterns characterized by

increased reliance on the intact extremity. Numerous biomechanical investigations have demonstrated increased ground reaction forces, prolonged stance times, and elevated joint moments in the contralateral limb during gait.<sup>2</sup> These abnormalities may subject the intact knee and hip joints to chronic repetitive loading beyond physiological limits. Over time, such abnormal loading has been hypothesized to contribute to pain, cartilage degeneration, and osteoarthritis.<sup>3</sup> Burke et al first reported a significantly increased prevalence of osteoarthrosis in the contralateral knee among lower limb amputees.<sup>1</sup> Subsequent studies further suggested that asymmetrical gait mechanics and increased loading of the intact limb contribute to degenerative changes and symptomatic osteoarthritis.<sup>2,3</sup> Traumatic amputees reportedly exhibited substantially greater rates of knee pain and symptomatic osteoarthritis compared with non-amputees.<sup>4</sup> The prevalence of knee osteoarthritis is reported to be around 27% among traumatic lower limb amputees.<sup>5</sup> However, more recent evidence has questioned the universality of these findings. Latest findings suggest a lower prevalence of osteoarthritis than expected, and proposed that activity levels and lifestyle factors may significantly influence disease development.<sup>6</sup> Given these conflicting observations, further investigation into the factors associated with contralateral joint pain remains warranted. The present study aimed to estimate the prevalence of patient-reported contralateral knee pain among unilateral lower limb amputees and to examine demographic and clinical factors associated with its presence.

## METHODS

A cross-sectional observational study was performed using a clinical database of unilateral lower limb amputees undergoing prosthetic rehabilitation at a tertiary-care prosthetic rehabilitation centre. A total of 531 participants were included over a 5-year period from 2016 to 2021. The institutional ethics committee granted a formal waiver for ethical approval because the survey/database was anonymous and contained non-sensitive data. Inclusion criteria were age  $\geq 18$  years, unilateral lower limb amputation, independent ambulation using a prosthesis, and availability of complete clinical information required for the present analysis.

Patients with bilateral amputations, neurological gait disorders, inflammatory arthritis, or incomplete clinical records were excluded. Variables extracted from the database included age, sex, height, weight, cause and level of amputation, time since amputation, time to first prosthetic fitting, daily walking distance, and presence of contralateral knee pain.

Amputation level was classified as below-knee/trans tibial, above-knee/trans femoral, through-knee, Syme's, or Chopart's amputation. The cohort included 241 trans tibial, 113 trans femoral, 120 through-knee, 24 Syme's, and 33 Chopart's amputations.

## Outcome assessment

The primary outcome was the presence of contralateral knee pain. Pain was reported directly by the patient during clinical assessment and recorded as a binary yes/no variable. No visual analogue scale, numerical rating scale, radiographic criterion, or validated knee-specific functional outcome score was used. Accordingly, the outcome represents patient-reported knee pain rather than radiographic osteoarthritis or quantified functional impairment.

## Statistical analysis

Statistical analysis was performed using statistical package for the social sciences (SPSS) version 26.0. Continuous variables were summarized as mean  $\pm$  standard deviation (SD) and compared between participants with and without contralateral knee pain using independent-samples t-tests. These variables included age, time since amputation, body weight, daily walking distance, and time to first prosthetic fitting. Categorical variables were summarized as frequencies and percentages and were compared using chi-square tests where applicable. The independent-samples t-test was selected for comparison of continuous measurements between two independent groups; its use assumes independence of observations, approximate normality within groups, and appropriate consideration of variance equality. The chi-square test was selected for associations between categorical variables and assumes independent observations and adequate expected cell frequencies. A two-sided p value  $< 0.05$  was considered statistically significant. Sex and level of amputation were recognized as potentially relevant confounding or effect-modifying variables. However, only 4% of the cohort were female, and level-specific knee-pain counts were not available in the analysed dataset. Therefore, reliable stratified estimates by sex or amputation level and adjusted multivariable effect estimates could not be generated without risking unstable or unsupported inference. The analysis is consequently interpreted as unadjusted association testing rather than a predictive model.

## RESULTS

A total of 531 unilateral lower limb amputees were included. Contralateral knee pain was reported by 64 participants; the numerator for prevalence was therefore 64 participants with patient-reported contralateral knee pain and the denominator was all 531 eligible participants. The overall prevalence was 12.1% (64/531; 95% CI 9.6-15.1%). The cohort was predominantly male (96%). By amputation level, 241 (45.4%) were trans tibial, 113 (21.3%) trans femoral, 120 (22.6%) through-knee, 24 (4.5%) Syme's, and 33 (6.2%) Chopart's amputations (Table 1). The study population consisted predominantly of male patients with a broad spectrum of ages, and causes of amputation (Figure 1). The study cohort represented a heterogeneous amputee population with a broad age distribution and varying durations since amputation.

Patients were divided into two groups according to the presence or absence of contralateral lower limb joint pain. Participants with contralateral knee pain were significantly older than those without pain (54.9 versus 48.9 years;  $p=0.009$ ) and had lived with their amputation for a longer period (20.1 versus 13.5 years;  $p=0.018$ ). Mean body weight was  $68.27\pm6.45$  kg in the pain group and  $69.00\pm6.43$  kg in the no-pain group ( $p=0.48$ ). Mean daily walking distance was  $3.77\pm2.23$  km/day versus  $3.10\pm1.51$  km/day ( $p=0.26$ ). Time to first prosthetic fitting was  $4.36\pm2.62$  months versus  $3.20\pm1.90$  months ( $p=0.25$ ) (Table 2).

**Table 1: Demographic and amputation-level characteristics of the study population.**

| Variable                                     | Overall cohort (n=531), N (%) |
|----------------------------------------------|-------------------------------|
| Age (years), mean $\pm$ SD                   | 50.3 $\pm$ 14.2               |
| Male sex                                     | 96%                           |
| Female sex                                   | 4%                            |
| Weight (kg), mean $\pm$ SD                   | 65.4 $\pm$ 12.2               |
| Time since amputation (years), mean $\pm$ SD | 15.8 $\pm$ 9.7                |
| Below-knee/transtibial                       | 241 (45.4)                    |
| Above-knee/transfemoral                      | 113 (21.3)                    |
| Through-knee                                 | 120 (22.6)                    |
| Syme's                                       | 24 (4.5)                      |
| Chopart's                                    | 33 (6.2)                      |
| Prosthetic users                             | 100%                          |

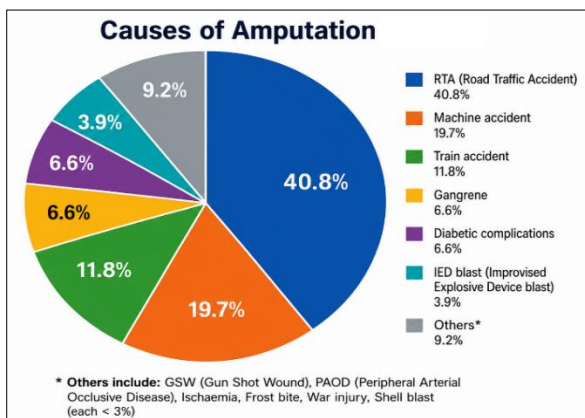


**Figure 1: Causes of amputation.**

On unadjusted analysis, age and duration since amputation were associated with the presence of contralateral knee pain, whereas body weight, walking distance, and time to prosthetic fitting were not. No claim of independent prediction is made because adjusted effect estimates (odds ratios with 95% confidence intervals) were not available for verification (Table 3). The present findings were compared with previously published studies evaluating contralateral joint degeneration in amputees, and are summarized (Table 4).

**Table 2: Comparison of patients with and without contralateral knee pain.**

| Variable                            | Knee pain        | No knee pain     | P value |
|-------------------------------------|------------------|------------------|---------|
| Age (years)                         | 54.9             | 48.9             | 0.009   |
| Time since amputation (years)       | 20.1             | 13.5             | 0.018   |
| Weight (kg)                         | 68.27 $\pm$ 6.45 | 69.00 $\pm$ 6.43 | 0.48    |
| Walking distance/day (km/day)       | 3.77 $\pm$ 2.23  | 3.10 $\pm$ 1.51  | 0.26    |
| Time to prosthetic fitting (months) | 4.36 $\pm$ 2.62  | 3.20 $\pm$ 1.90  | 0.25    |

**Table 3: Unadjusted comparisons of factors associated with contralateral knee pain.**

| Variable                   | Unadjusted finding            | P value |
|----------------------------|-------------------------------|---------|
| Age                        | Higher age in pain group      | 0.009   |
| Time since amputation      | Longer duration in pain group | 0.018   |
| Weight                     | Not significant               | 0.48    |
| Walking distance/day       | Not significant               | 0.26    |
| Time to prosthetic fitting | Not significant               | 0.25    |

**Table 4: Comparison of present study findings with major published studies.**

| Study               | Sample Size      | Outcome                 | Key Findings                                                                 |
|---------------------|------------------|-------------------------|------------------------------------------------------------------------------|
| Burke et al, 1978   | 42               | OA prevalence           | Increased contralateral knee OA                                              |
| Fisher et al, 1994  | Elderly amputees | Gait biomechanics       | Increased knee loading                                                       |
| Norvell et al, 2005 | Veteran amputees | Symptomatic OA          | Increased knee pain and OA                                                   |
| Struyf et al, 2009  | 78               | OA prevalence           | Knee OA prevalence 27%                                                       |
| Welke et al, 2019   | 1,569            | OA prevalence           | Lower OA prevalence than expected                                            |
| Present Study       | 531              | Contralateral knee pain | Older age and longer duration since amputation are associated with knee pain |

## DISCUSSION

The most important finding of this study was the significant association between increasing age, longer duration since amputation, and development of contralateral lower limb joint pain. Our findings support the concept that cumulative exposure to altered gait biomechanics contributes substantially to musculoskeletal degeneration in unilateral amputees. Older patients demonstrated a significantly higher prevalence of joint pain. This finding is consistent with established osteoarthritis literature indicating that age is among the strongest predictors of cartilage degeneration (Figure 2).<sup>1</sup> The Framingham Osteoarthritis Study demonstrated increasing incidence of symptomatic and radiographic osteoarthritis with advancing age.<sup>1</sup> Similar age-related mechanisms may contribute to pain development in amputees.

The association between longer duration since amputation and joint pain likely reflects prolonged exposure to abnormal loading conditions. Several biomechanical studies have demonstrated increased forces acting on the contralateral limb during gait.<sup>2</sup> Lemaire and Fisher reported significantly increased knee joint reaction forces among long-term prosthetic users.<sup>3</sup> Norvell et al similarly suggested that chronic overloading contributes to secondary joint degeneration.<sup>7</sup> Our findings support these observations and suggest that cumulative biomechanical stress may represent an important mechanism underlying joint pain development.

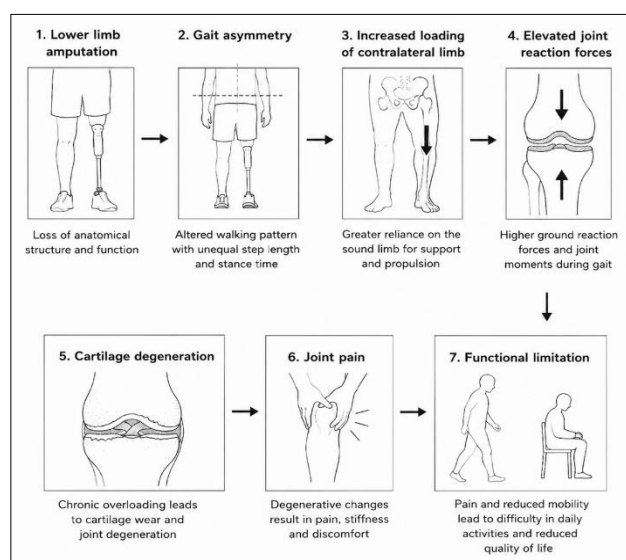


**Figure 2: Biomechanical pathway linking lower limb amputation to contralateral knee joint degeneration.**

Contrary to expectations, body weight was not significantly associated with joint pain in our cohort. Although obesity is a recognized risk factor for osteoarthritis in the general population, the effect of altered gait mechanics may outweigh the contribution of body weight in amputees.<sup>3,5</sup> Daily walking distance was

not significantly associated with pain. This finding suggests that the quality of loading may be more important than the absolute quantity of loading.<sup>2</sup> Delay in prosthetic fitting did not significantly influence pain development. This may indicate that long-term biomechanical adaptations are more important determinants than early rehabilitation variables.<sup>3</sup> Our findings are consistent with similar studies by Burke et al, Morgenroth et al, Norvell et al, and Struyf et al, which reported increased prevalence of pain and degenerative changes in the contralateral limb.<sup>4,6-8</sup> However, they differ somewhat from those of Welke et al, who observed a lower prevalence of osteoarthritis among transfemoral amputees. Differences in patient demographics, activity levels, and outcome measures may explain these discrepancies.<sup>9</sup> Amputation level is biomechanically important because transtibial, transfemoral, through-knee, Syme's, and Chopart's amputations cannot be assumed to impose equivalent loading patterns. The present cohort included all five levels, but level-specific knee-pain counts were unavailable; therefore, the relationship between amputation level and contralateral knee pain could not be validly tested.

## Clinical implications

Contralateral knee pain may impair mobility and independence among prosthesis users. Routine clinical review should therefore include enquiry regarding intact-limb knee symptoms, with attention to gait, prosthetic optimization, strengthening, weight management, and timely referral when symptoms persist.

## Limitations

Several limitations should be acknowledged. First, knee pain was assessed only as a patient-reported yes/no outcome; symptom severity, duration, and clinically important thresholds were not quantified. Second, no validated knee-specific functional instrument (for example, KOOS or WOMAC) was administered. Pain was selected because it was consistently available in the clinical dataset and is a clinically relevant symptom, but absence of a validated functional score prevents assessment of the effect of pain on knee function and limits comparison with studies using standardized patient-reported outcome measures. Third, radiographic imaging was not uniformly available, so the study estimates prevalence of knee pain rather than osteoarthritis. Fourth, although amputation level was recorded, level-specific knee-pain counts were unavailable, preventing stratified analysis across transtibial, transfemoral, through-knee, Syme's, and Chopart's amputations. Fifth, the cohort was predominantly male (96%), limiting sex-specific inference. Finally, comprehensive gait analysis and prosthetic component/alignment variables were not available. Future prospective studies should incorporate standardized pain severity measures, validated knee functional scores, radiographic assessment where appropriate, gait analysis, prosthetic variables, and

adequately powered stratification by sex and amputation level.

## CONCLUSION

Patient-reported contralateral knee pain was present in 12.1% (64/531; 95% CI 9.6-15.1%) of unilateral lower limb amputees in this cross-sectional cohort. Older age and longer duration since amputation were associated with knee pain on unadjusted analysis, whereas body weight, daily walking distance, and time to first prosthetic fitting were not. Because pain was recorded as a binary patient-reported outcome and stratified/adjusted analyses by amputation level and sex were not available, the findings should be interpreted as exploratory associations rather than independent predictive effects.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the Institutional Ethics Committee*

## REFERENCES

1. Hoque ME, Zawad MS, Rasel NMA. Lower-Limb Amputation and Gait Abnormalities: Exploring Challenges and Technological Innovations. In: Rehabilitation Engineering - Advances and Applications. IntechOpen; 2025.
2. Donnelly K, Davis C, Liotta N, Perkins A, Agrawal V, Highsmith MJ, et al. Assessing ground reaction forces and degenerative changes of sound limb in unilateral lower extremity amputees: a systematic review. *Acta Sci Orthop*. 2022;5(9):10.
3. Farrokhi S, Mazzone B, Yoder A, Grant K, Wyatt M. A narrative review of the prevalence and risk factors associated with development of knee osteoarthritis after traumatic unilateral lower limb amputation. *Mil Med*. 2016;181(Suppl 4):38-44.
4. Burke MJ, Roman V, Wright V. Bone and joint changes in lower limb amputees. *Ann Rheum Dis*. 1978;37(3):252-4.
5. Morgenroth DC, Gellhorn AC, Suri P. Osteoarthritis in the disabled population: a mechanical perspective. *PM R*. 2012;4(5 Suppl):S20-7.
6. Morgenroth DC, Medverd JR, Seyedali M, Czerniecki JM. The relationship between knee joint loading rate during walking and degenerative changes on magnetic resonance imaging. *Clin Biomech*. 2014;29(6):664-70.
7. Norvell DC, Czerniecki JM, Reiber GE, Maynard C, Pecoraro JA, Weiss NS. The prevalence of knee pain and symptomatic knee osteoarthritis among veteran traumatic amputees and nonamputees. *Arch Phys Med Rehabil*. 2005;86(3):487-93.
8. Struyf PA, van Heugten CM, Hitters MW, Smeets RJ. The prevalence of osteoarthritis of the intact hip and knee among traumatic leg amputees. *Arch Phys Med Rehabil*. 2009;90(3):440-6.
9. Welke B, Jakubowitz E, Seehaus F, Daniilidis K, Timpner M, Tremmer N, et al. The prevalence of osteoarthritis: Higher risk after transfemoral amputation? A database analysis with 1,569 amputees and matched controls. *PLoS One*. 2019;14(1):e0210868.
10. Anderson AS, Loeser RF. Why is osteoarthritis an age-related disease? *Best Pract Res Clin Rheumatol*. 2010;24(1):15-26.
11. Felson DT, Naimark A, Anderson J, Kazis L, Castelli W, Meenan RF. The prevalence of knee osteoarthritis in the elderly. The Framingham Osteoarthritis Study. *Arthritis Rheum*. 1987;30(8):914-8.
12. Hurley GR, McKenney R, Robinson M, Zadavec M, Pierrynowski MR. The role of the contralateral limb in below-knee amputee gait. *Prosthet Orthot Int*. 1990;14(1):33-42.
13. Lemaire ED, Fisher FR. Osteoarthritis and elderly amputee gait. *Arch Phys Med Rehabil*. 1994;75(10):1094-9.
14. Robbins SM, Birmingham TB, Callaghan JP, Jones GR, Chesworth BM, Maly MR. Association of pain with frequency and magnitude of knee loading in knee osteoarthritis. *Arthritis Care Res*. 2011;63(7):991-7.
15. Esposito ER, Wilken JM. Biomechanical risk factors for knee osteoarthritis when using passive and powered ankle-foot prostheses. *Clin Biomech*. 2014;29(10):1186-92.

**Cite this article as:** Sahu SB, Prasad KG, Kaul R, Mopagar V. Factors associated with contralateral limb knee pain in unilateral lower limb amputees: a cross-sectional analysis of 531 patients. *Int J Res Orthop* 2026;12:1973-7.