# COMPARING PRINCIPAL COMPONENT AND DISCRETE METRICS FOR VARUS THRUST ASSESSMENT IN KNEE OSTEOARTHRITIS

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## Summary

This study examined the relationship between principal component-derived varus thrust (VT) metrics and discrete VT measures from motion capture, wearable sensors, and visual observation. While associations were generally weak, stronger relationships emerged in cases with high confidence in VT presence. Future research should explore optimal VT markers and assess their sensitivity across populations and surgical interventions.

## Introduction

Osteoarthritis (OA) is a degenerative joint disease primarily affecting the knee, with frontal plane biomechanics playing a key role in disease progression. The knee adduction moment is a key marker of medial compartment loading, but its reliance on motion capture and force plates limits clinical use. Varus thrust (VT) has emerged as a simplified proxy, assessed via visual inspection, motion capture, or wearable sensors [1]. However, discrete VT metrics may not fully capture movement patterns. This study aimed to compare PCA-derived VT measures to previously reported discrete VT markers and assess differences between surgical and non-surgical sides.

## Methods

Thirty-three patients with knee OA (Age: 64 ± 7 years; BMI: 33 ± 7 kg/m²) scheduled for total knee arthroplasty were recruited as part of a larger study at St. Joseph's Healthcare. Participants underwent gait assessment using a 10-camera markerless motion capture system (Theia Markerless Inc.) and wearable inertial sensors (Axivity AX6, 100 Hz) placed just below the knee on each tibia. VT measures were derived from motion capture data (knee adduction excursion in 0–30% stance), inertial sensors (peak lateral tibial acceleration in 0–30% stance), and visual ratings of VT presence for both knees [2]. A principal component analysis PCA) was applied to frontal plane knee angle data to extract principal components describing stance-phase knee adduction patterns. These PCA-derived components were compared to the three conventional VT metrics using linear and logistic regressions ($p < 0.05$).

## Results and Discussion

Visual assessment identified 35 knees as definitely or probably exhibiting VT, while 31 knees were classified as not having VT. Using a more conservative threshold, 18 knees were identified as definitely having VT, compared to 11 knees classified as definitely not having VT.

PCA of stance-phase knee adduction angles identified two principal components (PCs) explaining >95% of variance: PC1 (91%), representing the overall magnitude of knee adduction, and PC2 (4%), reflecting differences in adduction within the first 30% of stance (Figure 1). PC2 was deemed a potential VT pattern metric and assessed accordingly.

Linear regression revealed that PC2 was significantly associated with sensor-derived VT ($p = 0.04$; $R^2 = 0.07$).

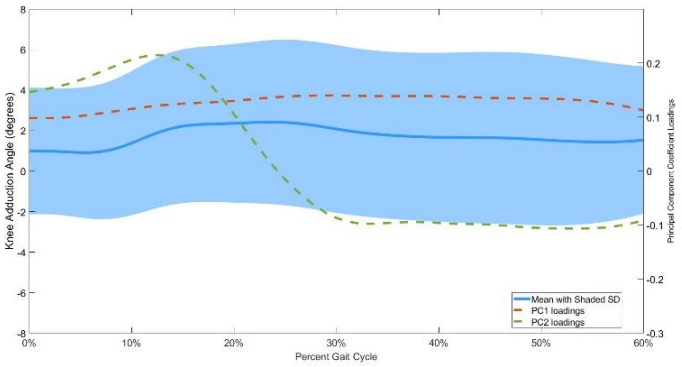


**Figure 1**: Ensemble average of knee adduction during stance (blue), with PC coefficient loading for PC1 (red) and PC2 (green).

Similarly, PC2 correlated with knee adduction excursion ($p = 0.02$, $R^2 = 0.08$). Logistic regression showed no significant association between PC2 and visual VT classification ($p = 0.41$). However, when restricting analysis to definite VT presence vs. absence, the relationship became significant ($p = 0.03$, $R^2 = 0.20$), suggesting a stronger association in more clearly classified cases.

## Conclusions

PC-derived VT metrics are associated with conventional VT measures from motion capture, wearable sensors, and visual observation. However, these associations are generally weak, except in cases with high confidence in VT presence. The optimal marker for VT and the most effective measurement approach remains unclear. Future research should investigate the sensitivity of these metrics across different populations and surgical interventions to enhance clinical applicability.

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## References

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