# Comparison of the magnitude differences in resultant knee joint reaction force when modelling with and without muscles

**Jonas Enqvist**[1], L. Joakim Holmberg[2], Toni Arndt [1,3]

[1] Department of physiology, nutrition and biomechanics, Swedish School of Sport and Health Sciences (GIH), Stockholm, Sweden

[2] Solid Mechanics, Department of Management and Engineering, Linköping University, Linköping, Sweden

[3] Department of Clinical Science, Intervention and Technology, Karolinska Institute, Stockholm, Sweden

Email: jonas.enqvist@gih.se

## Summary

The current study evaluated and compared knee joint reaction forces (KJRF) during countermovement jumps with Visual 3D (V3D; C-motion, Germantown, MD, USA) and the AnyBody Modelling System (AMS; AnyBody Technology, Aalborg, Denmark). KJRF from AMS, which incorporated internal muscle forces, were 4.6-6.2 times higher than V3D estimates. The findings emphasize that excluding muscle contributions when calculating KJRF underestimates joint loads and presumably injury risk and tissue loading.

## Introduction

Some software used in biomechanical research provides pipelines to calculate a net joint force, without considering the internal forces that the definition of joint reaction force depends on, most importantly due to muscles. The use of the net joint force in studies investigating joint loading may lead to underestimated joint reaction forces and thus underestimation of the risk of tissue failure [1]. The current study aims to compare the magnitude of resultant knee joint reaction forces (KJRF[R]) derived from two different calculation methods.

## Methods

Eleven uninjured male participants (mean age 25.5 years) performed countermovement jumps on dual force plates (Kistler GmbH, Winterthur, Switzerland) and kinetics and kinematics were registered in Qualisys Track Manager (Qualisys, Göteborg, Sweden). KJRF[R] was calculated independently in V3D (Net force: muscle forces excluded), and AMS (Reaction force: muscles forces included).

## Results and Discussion

KJRF[R] calculated with AMS was 4.6-6.2 times higher than KJRF[R] calculated in V3D (Table 1).

**Table 1** Resultant knee joint reaction forces [N/BW] calculated using different methods during the end of the eccentric phase (EccEnd) and at the concentric peak of countermovement jumps (ConPeak).

| | EccEnd | ConPeak |
|---|---|---|
| GRF[R] | 2.32±0.45 | 2.14±0.2 |
| KJRF[R] V3D | 2.19±0.44 | 1.89±0.18 |
| KJRF[R] AMS | 13.34±4.52 | 8.81±2.15 |
| MeanDiff AMS-V3D | 11.15 | 6.92 |

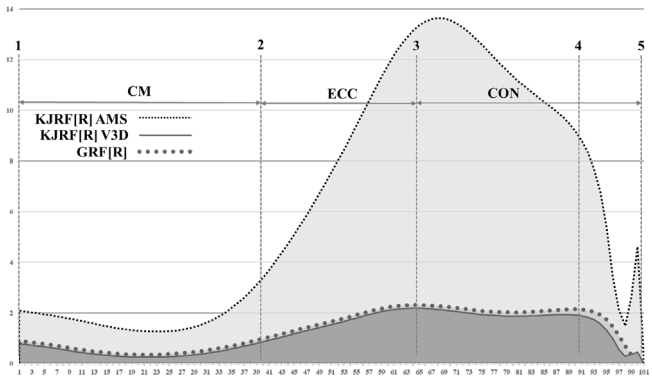


**Figure 1** Normalized force time curve. Grey line = Resultant ground reaction force (GRF[R]), discontinuous line = KJRF[R]AMS and black line = KJRF[R]V3D. Vertical lines show events 1 = Start of countermovement (CM), 2 = Start of eccentric phase (ECC) 3 = End of ECC, 4 = Concentric peak force and 5 = takeoff.

Previous calculations of KJRF using musculoskeletal models have shown similar KJRF to direct measurements in an instrumented knee [2]. The current study clearly showed that net force computed by V3D underestimated KJRF[R] due to the exclusion of muscle forces on KJRF (Figure 1 & Table 1). Using a net force in biomechanical investigation of knee joint loading may lead to a misinterpretation of the loads [1]. The application of a musculoskeletal model is therefore necessary for accurately answering questions regarding joint loading.

## Conclusions

This study emphasizes the need for musculoskeletal modelling when assessing joint loading and presents limitations of using a net force in biomechanical investigations.

## Acknowledgments

Financial support for the project was provided by the Swedish School of Sport and Health Sciences (GIH) and Ski Team Sweden Alpine.

## References

[1] Vigotsky, A.D., et al. (2019) "Mechanical misconceptions: Have we lost the “mechanics” in “sports biomechanics”? " Journal of Biomechanics 93: 1-5. 93, 1-5

[2] Marra, M.A., et al. (2015) "A subject-specific musculoskeletal modeling framework to predict in vivo mechanics of total knee arthroplasty " Journal of biomechanical engineering 137(2): 020904. 137, 020904