The Influence of Task Selection on Limb Symmetry in Individuals 1–5 Years Post-ACL Reconstruction

Harry S. Battersby[1], Judson S. Moorhouse[1], Max D. Smith[1], Derek N. Pamukoff[1]
Institution: Western University[1]
Email: hbatters@uwo.ca

Summary

This study examined how task difficulty affects limb symmetry after ACL reconstruction and if quadriceps strength predicts symmetry in walking, hopping, and jumping. More dynamic tasks, such as drop vertical jumps and hop length, exhibited greater asymmetry than walking or hop force production. Quadriceps strength symmetry was associated with jump symmetry but accounted for only a small portion of the variance. Other factors, like limb coordination and psychological readiness, may also contribute to movement asymmetry.

Introduction

Limb symmetry is a key component of return-to-sport following anterior cruciate ligament (ACL) reconstruction. However, many clinical assessments use quadriceps strength to assess rehabilitation progression, and many individuals still demonstrate task-dependent asymmetry after ACL reconstruction and return to sport [**1**]. It is unclear if asymmetry exists in everyday tasks or is exacerbated during more dynamic movements. These residual asymmetries may contribute to poor loading mechanics and reinjury risk. While quadriceps strength symmetry is commonly used as a return-to-sports criterion, its relationship with biomechanical symmetry in functional tasks remains unclear. The purpose of this study was to: 1) examine the effect of task on limb symmetry following ACL reconstruction and 2) determine the association between quadriceps strength and limb symmetry during jumping, hopping, and walking.

Methods

Twenty-one individuals with unilateral ACL reconstruction participated (12 females, 9 males, age: 20.62±1.89 years, time since surgery: 29.01±13.64 months, meniscal surgery=12, BMI= 23.84±2.45, graft type: hamstring=5, patella tendon=11, quadriceps tendon=5). Isokinetic knee extensor strength was assessed using a dynamometer at 90°/sec over 5 consecutive repetitions. 3-Dimentional motion analysis for jumping and hopping was recorded using 8 cameras (200Hz) and 2 force plates (2000 Hz). Gait biomechanics were collected over 5 minutes on a split-belt force-instrumented treadmill at a self-selected speed. Five trials of 10s were collected at the end of each minute after a 5-minute war-up period. In the single-leg hop test, participants performed a forward hop from a force plate, landing on the same leg, with heel-to-heel jump distance measured. A successful trial was deemed if the participant landed on one leg and held for 3 seconds, with 3 trials recorded. Drop vertical jumps (DVJ) were performed from a 30-cm box placed half the participants' height away onto two force plates, followed by a maximal vertical jump. Three trials were recorded. Peak torque was recorded for strength and peak ground reaction force (GRF) was extracted for all movement tasks. The average distance was recorded for hop tests. A limb asymmetry index (LSI) was calculated for each measure by dividing the value of the measure for the injured limb by the uninjured and multiplying by 100. Repeated measures ANOVA compared LSIs across tasks, and Tukey's HSD was used for post-hoc comparisons. Linear regression assessed associations between strength LSI and movement LSIs.

Results

There was a significant main effect of task on LSI ($F_{1\text{-}20}$ =5.970, $p<0.01$, $\eta p^2 = 0.23$). Post hoc pairwise comparisons showed that DVJ GRF LSI (87.18±18.03) was lower than both treadmill GRF LSI (100.19±2.50), ($p<0.01$) and hop GRF LSI (100.91±9.86), ($p<0.01$). Hop length LSI (93.09±12.63) was lower than treadmill GRF LSI and hop GRF LSI. A higher strength LSI value was associated with a higher DVJ LSI value (R^2=0.19, p=0.049). There were no other associations between strength LSI and other task LSIs (R^2 = 0.02-0.08, p=0.31-0.89).

Conclusion

Task influences limb symmetry, and more dynamic tasks (DVJ and hop length) revealed greater asymmetry than walking or hop force production. Individuals may favour their contralateral limb when the task requires higher impact forces and more joint coordination. When perceptions of task demand and risk are low, individuals may be more likely to adopt a symmetrical loading strategy. Quadriceps strength symmetry was associated with DVJ symmetry but only explained 19% of the variance. This suggests that other underlying deficiencies such as limb coordination or psychological movement barriers may contribute to movement asymmetry despite return to sport. [**2,3]** Other tasks (hop GRF, treadmill walking) may be less sensitive to strength differences, possibly due to compensatory strategies or lower neuromuscular demand [**4**]. Future studies should explore additional factors influencing movement asymmetry, such as limb coordination and psychological readiness, to better understand their role in task-specific limb symmetry.

Acknowledgments

Canadian Foundation for Innovation John R. Evans Leader Fund (Project ID: 42110, PI: DN Pamukoff)

References

1) Castanharo et al. (2011). J Orthop Sci 16, 531-535.
2) Dennis et al. (2024) Sports Biomech, 1-16.
3) Nagelli et al. (2019). Clin Biomech, 68, 104-108.
4) Smeets et al. (2021). Gait Posture, 83, 44-51.