Diagnostic Accuracy Of Clinically Accessible Force Sensing Insoles To Identify Underloaders During Gait Post Anterior Cruciate Ligament Reconstruction

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BACKGROUND

- 60-90% of individuals with anterior cruciate ligament reconstruction (ACLR) develop posttraumatic osteoarthritis (PTOA) in their lifetime with 36% developing the disease within a decade of surgery.[1]
- Individuals post-ACLR walk with aberrant movement[1] characterized by underloading (i.e., vertical ground reaction force impact peak (vGRF-IP)[2]
- Underloading gait patterns have been associated with poor knee joint health linked to PTOA development post-ACLR.[3,4]
- Loadsols® are clinically accessible force sensing insoles and valid tools for assessing vGRF-IP.[5]
- vGRF-IP <1.09 body weight (BW) during gait is a cut-point used to identifying underloaders in laboratory settings using force plates, but appropriate clinically applicable cut points for Loadsol® have not been established for use in clinical settings.

PURPOSE

To determine the diagnostic accuracy and determine clinically relevant cut points of Loadsols® to identify individuals post-ACLR with underloading walking patterns (i.e., vGRF-IP <1.09 xBW)

METHODS

- Individuals with a primary history of ACLR within the past 6 months to 5 years were included in the study
- Participants walked at habitual gait speed on a split-belt treadmill equipped with force plates while wearing Loadsols® to determine vGRF-IP during gait (Figure 1 and 2)
- Statistical analysis: ROC curves were used to determine the diagnostic accuracy of the loadsols to identify underloaders. Youden's Index, sensitivity, specificity, positive and negative predictive values were calculated to determine the most clinically applicable cut point to identify underloaders using the Loadsols ®

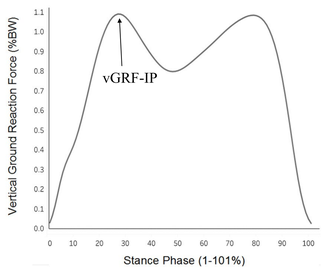


Figure 1. Underloading of the vertical ground reaction force impact peak (vGRF-IP) during the load phase of gait

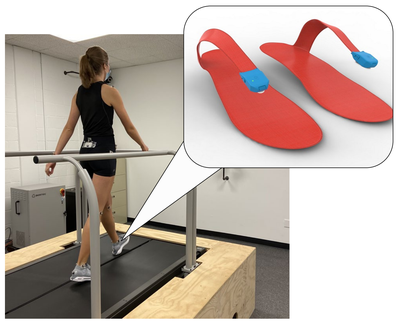
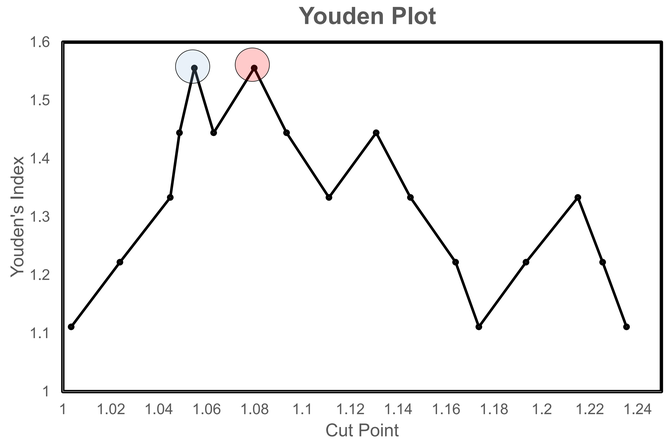


Figure 2. Collecting gait biomechanics while wearing insoles on treadmill with built-in force plates

RESULTS

Clinically accessible force sensing insoles demonstrate excellent diagnostic accuracy for identifying underloading walking patterns in individuals post-ACLR



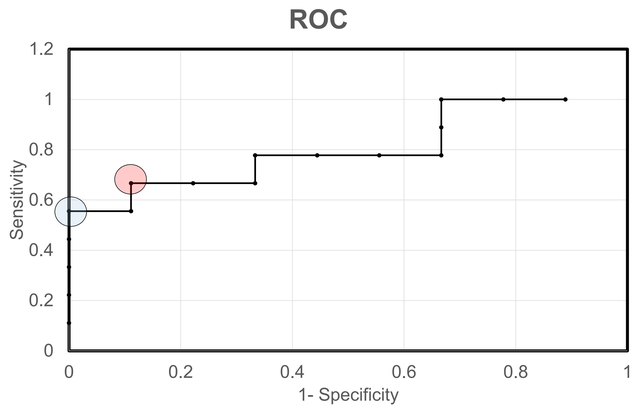


Table 1. Youden Index Statistics

Cut Point 1	1.06 (xBW)	Cut Point 2	1.08 (xBW)
Youden's Index	1.56	Youden's Index	1.56
Sensitivity	0.56	Sensitivity	0.67
Specificity	1.00	Specificity	0.89
PPV	100%	PPV	86%
NPV	69%	NPV	73%

Table 2. ROC and AUC Statistics

Area Under the Curve (AUC)	0.80
AUC 95% Confidence Interval	[0.59-1.00]

Table 3. Demographics

Participants	9 Female 9 Male
Age (years)	21.89 ± 4.35
Height (m)	1.78 ± 0.09
Weight (kg)	79.78 ± 14.58
BMI	25.57 ± 4.06
Time Post Op (months)	37.72 ± 16.13
Gait Speed (m/s)	1.26 ± 0.16
ACLR Graft Type	11 BPTB 6 HT 1 AG
Loadsol vGRF-IP	1.118 ± 0.078
Force Plate vGRF-IP	1.096 ± 0.058

DISCUSSION

- Loadsol® force-sensing insoles are clinically accessible and demonstrate adequate diagnostic accuracy in identify individuals with aberrant loading patterns post-ACLR in a clinical setting.
- Identifying individuals who underload post-ACLR in clinical setting during the rehabilitation process will aid clinicians' in implementing early and effective gait retraining intervention.
- A Loadsol® cut point of **1.06 BW** is recommended for use in **research** settings to identify underloaders for inclusion in gait-retraining clinical trials to maximize specificity and positive predictive values.
- A Loadsol® cut point of **1.08 BW** is recommended for use in **clinical** settings to identify underloaders to maximize sensitivity.
- Further studies with larger sample sizes are recommended to further refine these thresholds.

REFERENCES

1. Luc, B., Gribble, P. A., & Pietrosimone, B. G. (2014). Osteoarthritis prevalence following anterior cruciate ligament reconstruction: A systematic review and numbers-needed-to-treat analysis. *J Athl Train*, *49*(6), 806–819.
2. Davis-Wilson, H. C., Pfeiffer, S. J., Johnston, C. D., Seeley, M. K., Harkey, M. S., Blackburn, J. T., Fockler, R. P., Spang, J. T., & Pietrosimone, B. (2020). Bilateral Gait 6 and 12 Months Post-Anterior Cruciate Ligament Reconstruction Compared with Controls. *Med Sci Sports Exerc*, *52*(4), 785–794.
3. Pietrosimone B, Seeley MK, Johnston C, Pfeiffer SJ, Spang JT and Blackburn JT. Walking Ground Reaction Force Post-ACL Reconstruction: Analysis of Time and Symptoms. *Med Sci Sports Exerc.* 2019;51(2):246–54.
4. Pfeiffer S. Spang J, Nissman D, Lalush D, Wallace K. et al., (2019). Gait mechanics and T1rho MRI of tibiofemoral cartilage 6 months after ACL reconstruction. *Med Sci Sports Exerc.* 51(4),630-639.
5. Renner KE, Williams DSB, Queen RM. (2019). The reliability and validity of the Loadsol(®) under various walking and running conditions. *Sensors (Basel).* 19(2), 256.

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