11º CONGRESSO NACIONAL DE BIOMECÂNICA
A. P. G. Castro, C. Pina, P. R. Fernandes, C. Santos, J. Folgado & A. Amaro (Eds)
Sesimbra, Portugal, 21-22 de Fevereiro, 2025

METHODOLOGY FOR ANALYZING DAILY LIVING ACTIVITIES BY INTEGRATING XSENS WITH ANYBODY SOFTWARE

Catarina Rocha[1], Diogo Sousa[1], João Lobo[2], Dulce Oliveira[1], Michael Andersen[3], Pedro Pereira[2], André Pinho[2], Joana Almeida[2] and Dulce Madeira[2]

[1] *Biomechanics and Health Unit, INEGI, Portugal*

[2] *Level I Trauma Centre, FMUP, Portugal*

[3] *Department of Materials and Production, AAU, Denmark*

cmrocha@inegi.up.pt; dssousa@inegi.up.pt; joao_2523@hotmail.com; doliveira@inegi.up.pt; msa@mp.aau.dk; pedroper@med.up.pt; arpcinco@hotmail.com; joana17almeida17@gmail.com; madeira@med.up.pt

KEYWORDS: Activities of daily living, Ground Reaction Force, Inertial Motion Capture, Inverse Dynamics, Musculoskeletal modeling

1 INTRODUCTION

The simulations based on musculoskeletal models' inverse dynamics are commonly used to analyze human movement [1]. This article presents a pipeline for obtaining ground reaction forces (GRF) from kinematic data to evaluate the impact of muscular overload on GRF during daily activities such as running applied to post-operative data from patients with anterior cruciate (ACL) and anterolateral ligament (ALL) reconstruction. Given the need for precise anatomical customization and accurate segment estimation in musculoskeletal modeling, the pipeline ensures the reliability of GRF estimates and addresses the challenges of model adjustment and interpretation [2].

2 METHODOLOGY

2.1 Data Collection

Kinematic data were recorded using Xsens inertial sensors integrated with the Xsens motion capture system (hardware and MVN Analyze software) during various physical activities. Trials with errors, like incorrect limb positioning, were excluded. The data was reprocessed in high definition to reduce noise, with a consistent starting position and the trial with the fewest frames used as a reference. The data was then exported in BVH format, ensuring the 'T-pose' option was disabled.

2.2 Data Processing and Analysis

The 'BVH-Xsens' model in AnyBody software (AnyBody Technology A/S, Aalborg, Denmark) was used to analyze movement dynamics, incorporating patient-specific parameters (e.g., height and weight) for better biomechanical accuracy. GRF components (medial-lateral, anterior-posterior, and vertical) were calculated, with transformations applied to the first two components to align them with joint axes.

2.3 Post-Processing

Using Spyder software, the GRF data was pre-processed, and relevant columns were selected. Gait cycles were identified based on changes in the vertical force signal, and the data was normalized to the patient's body weight. The average cycles for the three force components were calculated for both limbs. Graphs were then generated, enabling comparisons with literature data from healthy individuals to analyze biomechanical differences between groups. Figure 1 shows a schematic illustrating the stages of the process, from data collection to post-processing.

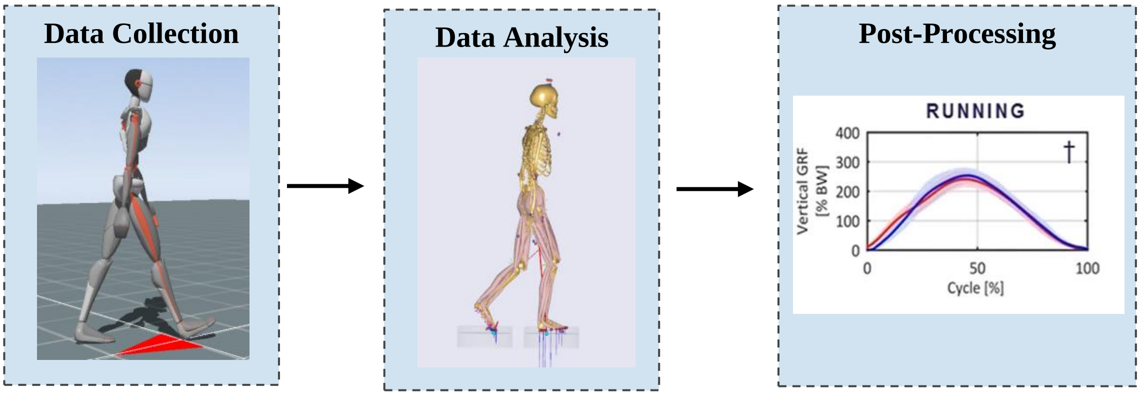

Figure 1- Diagram of the data collection and post-processing process.

3 RESULTS AND DISCUSSION

Preliminary analysis indicates an increased load on the non-operated limb during running in 15 patients, especially on the gastrocnemius. Adjustments to the parameters of the virtual force platforms were made to ensure accurate GRF measurements. When these adjustments did not resolve the overload, additional tests were suggested to explore other contributing factors. Comparisons with the literature showed that, for the vertical component, the observed values varied between 500-550 N, while the reference values are 840-1050 N. In the medial-lateral component, the force was 50-60 N, compared to 35-70 N in the literature, and in the anterior-posterior component, the values ranged from 20-70 N, while the literature presents values between 140-350 N. This difference may be associated with muscle overload, which justifies electromyography (EMG) tests to check compensatory muscle activity and further tests on force platforms for a more complete assessment.

4 CONCLUSION

This study investigates the use of musculoskeletal modeling and kinematic data to assess muscle overload's impact on GRF in post-operative ACL and ALL reconstruction patients. Preliminary results suggest that muscle overload primarily affects the non-operated limb, especially the gastrocnemius, during running. Although adjustments to GRF detection were beneficial in some cases, integrating EMG could provide deeper insights into compensatory muscle activity and its influence on joint moments and GRF. Further research is necessary to refine the analysis and identify other contributing factors, ultimately enhancing rehabilitation strategies.

ACKNOWLEDGEMENTS

The authors acknowledge the support from LAETA, under the project UIDB/50022/2020.

REFERENCES

[1] R. Fluit, M. S. Andersen, S. Kolk, N. Verdonschot, and H. F. J. M. Koopman, "Prediction of ground reaction forces and moments during various activities of daily living," *Journal of Biomechanics*, vol. 47, no. 10, pp. 2321–2329, Jul. 2014.

[2] S. H. L. Smith, R. J. Coppack, A. J. van den Bogert, A. N. Bennett, and A. M. J. Bull, "Review of musculoskeletal modelling in a clinical setting: Current use in rehabilitation design, surgical decision making and healthcare interventions," *Clinical Biomechanics*, vol. 83, no. 105292, Mar. 2021.