Biomechanical Characteristics of Transfemoral Prosthetic Gait: A Scoping Review Protocol

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Introduction

Depending on a functional artificial limb (prosthesis) is crucial for restoring locomotion in people with amputation. The ability to use a prosthesis becomes more difficult for those with amputation above the knee (transfemoral) due to the loss of the anatomic knee joint function. For prosthesis users, biomechanical inefficiencies during gait, such as increased energy expenditure, risk of imbalance and falls, and required movement compensations of the body, can result in long-term pain and musculoskeletal complications [1]. These biomechanical inefficiencies affect mobility, daily activities, and quality of life in people with lower-limb amputation [1]. Optimizing gait biomechanics is important to address these inefficiencies.

Understanding healthy gait is crucial for clinicians to evaluate the gait characteristics of people with lower-limb amputations [2]. Instrumented gait analysis is an objective way to measure walking performance through the collection of quantitative data of the gait cycle. It consists of investigating kinematic, spatiotemporal, kinetic, and electromyography (EMG) data and is used to identify pathologic gait [3]. Kinematic data describes the movement of the joints without regard to force generation [2], and it includes displacement and orientation of body segments, joint angles, and spatiotemporal gait parameters [4]. In contrast, the magnitude of the ground reaction forces and its relationship to joint centers and lower-limb joint mechanical moments and powers are the

factors that determine moments or torque about a joint, which represent the magnitude and direction of the kinetic data [2]. EMG within instrumented gait analysis analyzes the muscle activation patterns during the gait cycle by obtaining the timing and action of muscles that contribute to walking.

The aim of this review is to scope the literature for studies that use instrumented gait analysis and report on kinematics, spatiotemporal features, kinetics, and EMG activation data for persons with transfemoral amputation who use traditional socket-suspended prosthetic devices.

Review Questions

What are the main differences in gait between people with transfemoral amputation who use socket-suspended prostheses and those who have not undergone amputation of the lower limb (healthy individuals)? Specifically, what are the main differences in kinematics, spatiotemporal, kinetics, and EMG data between transfemoral prosthetic ambulation and healthy ambulation on level walking surfaces as reported by instrumented gait analysis?

Inclusion Criteria

Participants

In this scoping review, we will include studies that report on participants who are adults, i.e., over the age of 18 years who are healthy or have an transfemoral amputation and walk with a socket-suspended prosthesis.

Concept

This scoping review will focus on the kinematics, spatiotemporal features, kinetics, and EMG data reported for transfemoral socket-suspended prosthesis users and healthy individuals.

Context

There are no contextual limitations. Articles from all settings will be included.

Methods

Search Strategy

The purpose of the search strategy is to determine all eligible studies regardless of the year of publication. This scoping review will include study designs that use quantitative methods including grey literature (peer-reviewed scientific abstracts/conference presentations in academic conferences). Studies available in English in the following databases will be reviewed: Medline, PubMed, Embase, SportDISCUS, Scopus, and Web of Science. A preliminary search was conducted in Medline based on the text words contained in the titles and abstracts of relevant studies (see Appendix 1). A more elaborate search strategy will be employed in consultation with a librarian to search for relevant literature in the above noted databases. Lastly, the reference lists of included articles will be searched for additional sources. Authors of primary sources will be contacted for further information if necessary.

Articles that will be excluded from this scoping review are those that are based on animal models, radiographic or microbiological investigations, ramp or inclined walking, the investigation of gait quality without identification of biomechanical features, or studies based on systems other than optical motion capture systems. Articles that meet the inclusion criteria will also be excluded from this review if they are general learning articles or review articles.

Data Extraction

Data will be extracted from the studies included in the scoping review by two independent reviewers. A spreadsheet will be developed that will be included the specific details from the included studies regarding the author(s), year of publication, origin/country of origin (where the

source was published or conducted), aims/purpose, study population and sample size within the source of evidence, methodology/methods, details of any intervention (if applicable), outcomes and details of how the outcomes are measured (if applicable), and key findings that are relevant to the objectives of this scoping review. This will be revised as needed and any deviations from this protocol will be documented in the final scoping review.

Data Analysis

Upon extracting data from included articles, we will collate information about each of the biomechanical variables of gait reported and provide a descriptive summary of the evidence that aligns with the purpose of this review. Similarities and inconsistencies in the outcomes reported in the included studies will be discussed. Additionally, differences between the biomechanical variables of gait in users of socket-suspended prosthesis and those with healthy gait will also be noted and discussed.

Data Presentation

The extracted data from the papers will be collated by each of the biomechanical variables of gait and presented in a tabular format.

References

[1] R. Gailey, K. Allen, J. Castles, J. Kucharik, M. Roeder, Review of secondary physical conditions associated with lower-limb amputation and long-term prosthesis use, J. Rehabil. Res. Dev. 45 (2008) 15–30. https://doi.org/10.1682/JRRD.2006.11.0147.

[2] A. Esquenazi, Gait analysis in lower-limb amputation and prosthetic rehabilitation, Phys. Med. Rehabil. Clin. N. Am. 25 (2014) 153–167. https://doi.org/10.1016/j.pmr.2013.09.006.

[3] B.J. Darter, J.B. Webster, Principles of Normal and Pathologic Gait, Fifth Edit, Elsevier Inc., 2019. https://doi.org/10.1016/B978-0-323-48323-0.00004-4.

[4] T. Lencioni, I. Carpinella, M. Rabuffetti, A. Marzegan, M. Ferrarin, Human kinematic, kinetic and EMG data during different walking and stair ascending and descending tasks, Sci. Data. 6 (2019) 1–10. https://doi.org/10.1038/s41597-019-0323-z.

Appendix 1

Concept 1 - Gait analysis

Gait

Gait Analysis/

Locomotion

Walking

Biomechanics

Kinematics

((Gait or motion or biomechanic* or locomotion or walking or kinematic*) adj2 (analysis or evaluation* or assessment*))

Concept 2 - Transfemoral prosthetic

Knee joint/su AND amputation/

Knee joint/su AND artificial limbs/

((Transfemoral or above-knee or “above knee”) adj2 (prosthe* or amputat* or amputee* or limb-loss))

Search: ((Gait or motion or biomechanic* or locomotion or walking or kinematic* or kinetics* or spatio temporal or EMG or Electromyography*) adj2 (analysis or evaluation* or assessment*) adj2 (Transfemoral amp* or above knee amp*))