Journal CoE: Health Assistive Technology
Volume 1, Number 1, Tahun 2023, pp. 41-44
DOI: 10.36082/jchat.v1i1.1013
Open Access: https://ejournal.poltekkesjakarta1.ac.id/index.php/jchat

Comparison Analysis of Gait on Transfemoral Patient using Four-bar Linkage Friction and Pneumatic Swing Phase Control

Cendana Sardiman[1*], Burlian Mughnie[2], Tri Riana Lestari[3]

[1] Back Vor Good Clinic, Jakarta, Indonesia
[2,3] Prosthetic and Orthotics Department, Polythecnic of Health Jakarta I, Jakarta, Indonesia

ARTICLE INFO

Article history:
Received: March 1, 2023
Revised: March 9, 2023
Accepted: March 15, 2023
Available online: March 21, 2023

Keywords:
Transfemoral, four-bar linkage friction swing phase control, four-bar linkage pneumatic swing phase control.

ABSTRACT

Various kinds of artificial knee joints continue to develop over time in the prosthetic world, for example, the four-bar linkage friction and four-bar linkage pneumatic. The knee joint mechanism differs between four-bar linkage friction and pneumatic swing phase control, which can affect the transfemoral patient's gait. Artificial knee joints, four-bar linkage friction, and four-bar linkage pneumatic are rarely used in the clinical laboratory of Orthotics and Prosthetics because clinical only provides the simple type of knee joint (manual lock knee). There were 84 transfemoral patients recorded in the clinic laboratory Orthotics Prosthetics Department for this research. None of them ever use these two types of knee joint four-bar linkage knee joints. Four transfemoral amputees were recruited in this research. They were asked to walk comfortably to investigate the gait function with a 10-meter walking test (10 MWT) using two types of the knee joint: four-bar linkage friction and four-bar linkage pneumatic. After that, differences in cadence, step length, and walking speed with two knee joint was tested and analyzed by independent t-test and chi-square. The spatiotemporal gait parameters comparison result between four-bar linkage pneumatic and four-bar linkage friction were: walking speed was 59.2 m/min compared to 54.2 m/min (p-value = 0.000). Cadence was 87.6 step/min compared to 72.5 steps/min (p-value = 0.000), and step length was 1.14 cm compared to 0.96 cm (P-value = 0.000). The gait analysis of the knee joint compare to normal gait showed that the odds ratio (OR) Cadence was 4,2 (p-value = 0.000), Step length was 3,5 (P-value = 0.000), ad walking speed was 4 (p-value = 0.000). There are significantly different spatiotemporal gait parameters between four-bar linkage friction and pneumatic swing phase control. The cadence, step length, and walking speed result from the four-bar linkage pneumatic is closer to mimicking normal gait.

INTRODUCTION

Various kinds of artificial knee joints continue to develop over time in the prosthetic world, for example, the four-bar linkage friction and four-bar linkage pneumatic. The knee joint mechanism differs between four-bar linkage friction and pneumatic swing phase control. This type of knee joint can affect the transfemoral patient's gait. Artificial knee joints, four-bar linkage friction, and four-bar linkage pneumatic are rare to be used in the clinical laboratory of Orthotics and Prosthetics because clinical only provides the simple type of knee joint (manual lock knee). There are 84 transfemoral patients recorded in the clinic laboratory Orthotics Prosthetics Department Polytechnic of Health Ministry of Health Jakarta I from 2012 until 2017. None of them ever use these two types of knee joint four-bar linkage knee joints.

Transfemoral or amputation above the knee partially cuts the femur bone. A transfemoral prosthesis supports those who have amputations above the knee (transfemoral). A transfemoral prosthesis has a modular or exoskeletal design. Modular designs are more easily fit against transfemoral amputations than exoskeletal designs Taheri and Karimi14. Of all of the transfemoral components, the part on the knee is one of the most complex parts. Prescription for knee joint should suit the patient's age, weight, and activity. The advanced type of knee joint is only sometimes suitable for the patient. It is essential to select a knee joint to increase balance when patients walk and improve their gait pattern. In the knee joint, the four-bar linkage polycentric friction has the advantage of the mechanism. The benefit is shortened mechanical prosthesis during the swing phase and sitting position, and the knee joint mechanism is similar to the knee joint in human mechanism.

*Corresponding author.
E-mail addresses: cendanas@gmail.com

Suppose the 0° center of rotation of the knee mechanism is located behind the straight line connecting the femoral head to the heel. In that case, a 4-bar linkage knee mechanism is intrinsically extension-stable, causing free from an extension of residual limb force. The polycentric pneumatic artificial knee joint has a tube and a piston inside. Inside its tube contains air (pneumatic) or liquid (hydraulic). It will provide resistance to movement, and when the resistance increases with the speed of walking, it will control the difference of the user variables when walking or running.

METHOD

The method used is described in detail, for unusual methods a reference must be included. Contains the design or research design used, research objectives, data collection techniques and instruments that describe data analysis techniques.

Four transfemoral amputees were recruited in this research. The inclusion criteria for selecting the patients were: 1) having no contraindication for standing and walking with prosthesis, 2) using the current prosthesis for at least five hours per day, and 3) had been amputee at least one year ago. The following parameters were evaluated in this research project: The knee joint mechanism is different between four-bar linkage friction and pneumatic swing phase control); The spatiotemporal gait parameters (walking speed, cadence and step length)

Concern form given to respondent, if the patient does not agree to be the respondent then the researcher will not continue the next step and check the patient again according to the inclusion criteria of the patient to be respondent. If the patient agrees to be a respondent then the researcher proceeds to the next stage. First stage is assessment and casting observed directly by the clinical supervisor, second is fabrication starting from rectification, draping, grinding and smoothing. Third is the bench alignment that is the first stage to determine the alignment of a prosthesis where the socket, artificial knee joint, shank and foot are assembling into a prosthesis observed directly by the clinical supervisor, the fourth is static fitting is a prosthesis first using by the patient at this stage usually alignment and height of a prosthesis will change from the bench alignment to be observed directly by the clinical supervisor, and then last is dynamic fitting the subjects were asked to walk with a comfortable speed for one hour with the prosthesis, with a four-bar linkage friction joint and four-bar linkage pneumatic joint, figure 1. The alignment of the prosthetic components with this type of knee joint was controlled by the clinical supervisor. Then the subjects were asked to walk at a comfortable speed along the clinic. The spatiotemporal test is on four subjects by using a 10-meter walking test (10MWT).

Figure 1. Four-bar linkage friction and four-bar linkage pneumatic by Regal company

The difference between the gait performance of the subject while walking with four-bar linkage friction and four-bar linkage pneumatic joints, was determined by the use of Independent t-test. Which knee joint closing mimics normal gait used Chi-Square. The significant level was chosen as $p<0.05$.

RESULT

The mean values of the spatiotemporal gait parameters while walking with both knee joints are presented in table 1. The walking speed of four bar linkage pneumatic was significantly higher than four-bar linkage friction, 59,23 and 54,25 m/min, respectively, (P-value = 0,000). Cadence four-bar linkage pneumatic was significantly more than four-bar linkage friction, 87,64 and 72,58 step/min, respectively, (P-value = 0,000). Step length four-bar linkage pneumatic was significantly higher than four-bar linkage friction, 1,1 and 0,9 cm, respectively, (P-value = 0,000). The gait analysis of knee joint compared to normal gait showed, that odds ratio (OR) in cadence was 4,2 (P-value = 0.000), Step length was 3,5 (P-value = 0.000) and walking speed was 4 (P-value = 0.000).

Table 1. The spatiotemporal while walking with both type of knee joints

Parameters	Cadence (step/men)	Step length (cm)	Walking Speed (m/min)	p_value
Four-bar linkage friction	72.58	.960	54.25	0.000
Four-bar linkage pneumatic	87.64	1.146	59.23	0.000

DISCUSSION

Various types of prosthetic components have been designed to improve the performance of the subjects while walking and standing. However, the function of the knee joint is most important and effective in contrast to other components. Probably, no other component of artificial limbs has received as much attention from designers as the knee joint. Various types of the knee joint have been designed to fulfill a dual function of stability during stance phase and mobility during swing phase. Although the designs of the knee joint have been improved significantly in contrast to the traditional designs, the patients experience some problems during walking.

Results of analysis data on Cadence, walking speed and step length using artificial knee joint Four-bar linkage Pneumatic close normal gait compared to using Four-bar linkage friction knee joint. Results of analysis data on Cadence, walking speed and step length using artificial knee joint Four-bar linkage friction and Four-bar linkage pneumatic not mimic like normal gait. Independent result values (p-value <0.05) showed significant differences in cadence, walking speed and step lengths in the Four-bar linkage friction and Four-bar linkage pneumatic joints.

CONCLUSION

Spatiotemporal gait parameter on transfemoral patients using artificial knee joint Four-bar linkage Pneumatic swing phase control closing mimic to normal gait compared to knee joint Four-bar linkage friction swing phase control. There are significant differences in cadence, walking speed and step length in transfemoral amputation patients when using Four-bar Linkage Pneumatic knee joint compared to Four-bar Linkage friction knee joint. Average cadence, walking speed and step length in transfemoral patients are not the same as a normal gait, but transfemoral patients are able to perform better during walking. Different mechanisms of artificial knee joints give different results to Cadence, Length of step and patient walking speed. The length of the stump gives effect on transfemoral patient gait using Four-bar linkage Pneumatic and the Four-bar linkage friction.

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