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2D-MOTION ANALYSIS: KNEE JOINT ANGULATION OF TRANSTIBIAL AMPUTEE PATIENT WHO USE SACH FOOT AT CLINIC LABORATORY OF PROSTHETICS AND ORTHOTICS DEPARTMENT IN POLYTECHNIC OF HEALTH MINISTRY OF HEALTH JAKARTA 1

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Abstract

The neutral foot position of the prosthetic SACH foot has a higher hindfoot area compared to the forefoot area with 1cm heel height. When the patient wears the shoes, foot and shank alignment is at 90 degrees. Thus, when the patient does not use the shoe, the prosthesis will tilt backward especially when the foot is mid-stance and will force the pressure of the knee toward the extension of the knee joint which can cause damage to the knee joint structure. Therefore, knee joints will be measured at the time of the patient's use and not wearing shoes during mid-stance. ***Objective:*** To find out if there are significant differences in knee joint degree during mid-stance when using and not using shoes with 1cm heel height. ***Methods*** Quantitative comparative by observation of 2-dimensional motion in transtibial amputation patients using shoes and not using shoes with cross-sectional study design. ***Result :*** The degree of knee joints generated during mid-stance by patients with transtibial amputation when using shoes was 10.8^{o} of flexion (p = 0.004) while at the time of not using the resulting knee boots was 4.5^{o} of flexion (p = 0,000), normal degree of knee joint during mid- stance is 10^{o}-20^{o} of flexion. The results of paired t-test showed that there were significant differences in knee joint degree from standard degree, but when using the shoe showed a result of 0.8^{o} larger than the lowest normal range while when not using shoes the resulting degree of 6.3^{o} is smaller than lowest normal range.

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Introduction

According to a report on the incidence of cases of lower extremity amputation at the Orthotic Prosthetics Laboratory of the Health Polytechnic of the Health Ministry of Jakarta 1 to 2017. The clinic is a placement clinic for final-year students of Orthotic Prosthetic. Orthotics Prosthetics is a branch of science consisting of how to make a motion aid and making a device to allow someone to do ambulation.

The lower extremity amputation below of the knee that cut through the tibia and fibula bones is called transtibial amputation. People with lower extremity amputations are often feeling very difficult when walking or moving from one place to another, so to make the move or doing ambulation requires motion aids such as a walker, wheelchair, or device to replace the leg also known as prosthesis.

The prosthesis is made in such a way as to resemble the shape of the leg at the sound-side. Prosthesis for below knee amputation serves to share the weight to be divided into two legs or not only on one leg (the leg on the side that is not amputated). The prosthesis used for below knee amputation is a transtibial prosthesis, mostly weight bearing is put on the patella tendon because it is a very tolerant area for weight gain.

A good prosthesis has an appropriate alignment following guidance, emphasized to improve comfort to the stump walking comfort in people with lower extremity amputations (Pinzur et al., 1995). A good alignment of prosthesis can also reduce the patient's energy consumption, so they will feel more comfortable and better for their ability to perform their normal activities (Ripatti, 2015). In the alignment it will position the prosthesis on the arrangement in a straight line, the arrangement is the socket (the cavity for the limb residual) will be connected to the shank (the connecting pole between the sockets with the artificial foot) in the vertical position, then the shank will be connected to the foot. Mis-alignment on the prosthesis will increase loading at all positions those are in 10^{o} flexion, extension, varus, and valgus. At this stage, a prosthetist and orthotist will positioning the prosthesis in the optimal alignment so that it will be adjusted to the shoes owned by the patient because alignment is essential if the prosthesis is positioned in the wrong position will make the muscle work increased and fatigue will be easier to occur (Pinzur et al., 1995).

The prosthetic users require a footwear for daily activities if the shoe is used as a shoe that will be used for prosthesis and has a certain heel height, then only those shoes that can be used to perform activities, if patient wants to use different shoes patients must be convinced that the replacement shoe has the same heel height, not higher or lower in order to maintain an optimal alignment position. Heel height measurement can be done by measuring the difference between the outsole thickness on the heel and the front of the shoe. This becomes a problem when a patient uses a prosthesis with a predefined alignment using shoes that have a certain heel height and then change shoes with different heel height. The degree of knee joints when the mid-stance phase is strongly influenced by the footwear being used and when not wearing footwear, the resulting degree of knee joint is not nearly normal (Salis, 2014).

Humans appear to automatically adjust their ankle joints to more plantar flexion when wearing high heels (Hansen & Childress, 2009). There are many types of foot for the prosthesis, one of which is the SACH Ankle Cushion Heel (SACH) is a type of prosthetic foot that has no ankle joints so the foot cannot be adapted to the shoe following the heel height or to the uneven surface on the floor, this will be difficult for the patient to walk on uneven surfaces, unlike the prosthetic foot that have ankle joints because the feet of the type can perform passive movements in accordance with the direction of the body load that patient given. The SACH prosthetic foot has a higher hindfoot area compared to the metatarsal line, the SACH foot has a height difference of 1 cm so it should be put on the shoes with the same height. In addition to SACH foot, there is a type

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of prosthetic rubber foot with a flat surface of the foot so this type of foot is very suitable if the patient has shoes with 0 cm heel height and often do activities without using shoes, because alignment at the time of using or not using shoes will remain the same. This does not occur in the SACH prosthetic foot because alignment will be different when using and not using shoes because the type of foot has a higher heel portion than the metatarsal line, so on the use of that type of foot when the patient takes off the shoe then walk will position the sole on the floor and will make the shank on the prosthesis tilted toward the back will put pressure on the knee joint towards the extension.

Pressure on the knee joint for long term towards the extension can cause soft tissue damage, swelling, and potentially to tear or strain the MCL, LCL, ACL, or PCL. This occurs because of a femoral or patellar drive and excessive pressure on one or more major ligaments within the joint, the resulting effect leading to knee joint motion, can cause the ACL to become tensioned or torn. The position of the extension is not optimal and will affect the degree of knee joint. Muscle work increases and causes fatigue to occur more easily, the findings suggest that proper prosthetic alignment is essential for normal activity in stump muscle (Fang, Jia, & Wang, 2007).

Methods

The research design in this research is comparative quantitative research. Comparative is a type of study used to compare the degree of knee joints when using and not using shoes with standard knee joints at mid-stance. After getting the difference, the researchers made a comparison of the degree of which knee joints are closer to the normal gait. Type of research in this research is cross - sectional by approach of observation or collecting data at once.

A. Population and Sample

Population in this research is a below knee amputation level which is transtibial unilateral and the sample will be a model of five patients for students in Clinic Laboratory Prosthetics and Orthotics Department Polytechnic of Health Ministry of Health Jakarta 1 in 2017. The criteria for the respondents for this research: Respondent who has a muscle strength level of at least 4 on stump according to Oxford Muscle Scale, Prosthesis user., Have used a prosthesis for one year, Use a prosthesis inside the house.

B. Instruments

In data collection techniques researchers use special software hudl technique to analyze the degree of motion or kinematic of knee joints, using only one camera to record every movement produced by the patient. The kinematic measurement is measured in the sagittal plane. Another questionnaire for foot size and muscle strength.

C. Procedure

The camera was placed on a tripod and positioned right at 90^{o} from the standing patient position, on the camera screen reaching the sagittal area from head to toe. Patients used prosthesis and prepared markers on the hip joints of the knee joint and ankle joints on the side using the prosthesis to facilitate calculation of knee joint degree in software. The recording was taken from the side of the foot using a prosthesis. The patient walked on a 10-meter track that had been prepared. Patient was instructed to walk through the track to finish at normal speed. The video recorded each patient walking back and forth in track three times when using and three times when not using shoes. After the video is completed the measurements will be taken by seven observers.

Results

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This research was conducted with a sample of five respondents with male gender with age range 30-43 years old. In the measurement by using hudl technique, each patient will be measured by seven observers so that it will produce 35 data.

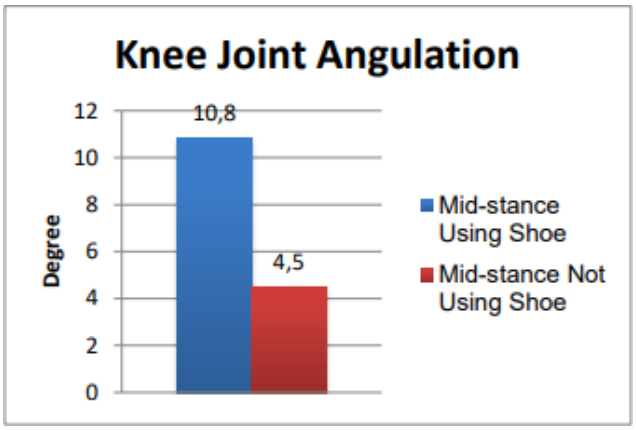

Figure 1. Graphic Difference Angulation of Knee Joint When Using and Not Using Shoes

Based on figure 1 the average results of knee joint measurements on five respondents performed by seven observers, the result of knee joint flexion range of degrees when using shoes 5º to 15º and on average the degree of knee joints when Mid-Stance using shoe is 10.3º while when not using the shoes is 4,5º. Measuring the degree of knee joints during mid-stance when the patient is not wearing the shoes is the leg on the amputation side of the stand and the legs on the other side are swinging through standing legs but at the time the heel that is standing is slightly raised.

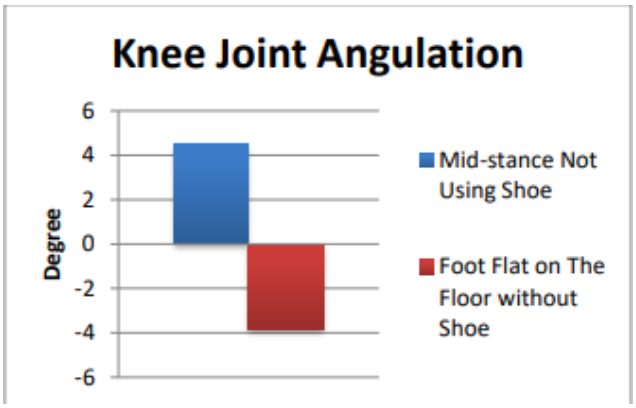

Figure 2. Graphic Difference Angulation of Knee Joint When Mid-Stance and Foot Flat Without Shoes

In another univariate test that focuses on when feet flat to the floor but the other side not through standing feet and according to the result of average degree of knee joint which yielded is -3,8º, minus means knee extension movement.

After knowing independent variables and dependent variables, researchers continue bivariate analysis. This study used paired t-test analysis to determine whether there is a significant difference in mean degree of knee joints when patients use and do not use shoes compared to normal degree.

Table 1. Result of Paired T-Test Knee Joint Angulation Compared Angulation Normal

	Mid-Stance Using Shoes	*Mid-Stance* Without Shoes	Foot Flat on Floor Without Shoes
Mean	10,8°	4,5°	-3,8°
Std. D	1.49678	1.9610	1.69923
Std. E	.25300	.3315	.28722
N	35	35	35
p_value	0,04	0,000	0,000
Information	**Significant**	**Significant**	**Significant**

Based on the results of bivariate analysis, p <0.05 could mean that this study showed a significant difference in the degree of knee joints produced during mid-stance using shoes and mid-stance when not wearing shoes when compared to the degree of normal knee joints. Find the degree of knee joints when the surface of the foot flat on the floor. This phase occurs before mid-stance and the resulting knee joint degree is -3,8^0 the degree is the degree of knee extension.

Discussion

SACH prosthetic foot has a lightweight, waterproof, durable, relatively inexpensive and can adjust on that shoe that has a heel height of 1 cm, but on the basis of this study it is shown that the degree of knee joint

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generated depends heavily on the use of the shoe, if the patient does not use the degree shoes produced when the midstance is significantly different from the normal degree, the degree is likely to extend due to the SACH prosthetic foot having a higher heel surface from the front of the foot (metatarsal line). The position of the foot will be compensated in the shoe with heel height 1 cm, but when the patient does not use the shoes will position the foot flat on the floor, This can make the alignment of the prosthesis tilted backward and will affect the degree of knee joints in the mid-stance phase. This can be seen from the degree of knee joints when the mid-stance is generated by five patients with transtibial amputations when using and not using shoes. The result of degree measurement is obtained by using software performed by seven observers.

The knee joint will move twice flexion and twice the extension in the gait style. At the time before the initial contact knee joint is in almost full extension position, flexion at loading response and early mid-stance, then back extension at late mid-stance after that again flexion to reach initial swing to prevent foot dragging to floor[13]. Mid- stance can be defined when the mid-swing leg is right on the leg standing side by side, while mid-swing is a phase when the next leg is in a standing phase (Levine, David, Jim D Richards, n.d.).

The mid-stance is a period in a walking cycle when the legs on the other side are swinging through standing legs[13], based on observations using the hudl technique, when using a shoe there is a phase where one side stands and the other is right swinging on one leg standing but not when the patient is not wearing shoes. This happens because the prosthesis actually uses a prosthetic foot that has a neutral position with a higher heel position compared to the front of the foot or metatarsal line. At the time of using shoes neutral foot position has been supported by compensation in accordance with its neutral position in the shoe but at the time the patient does not use nothing to support 1 cm heel height shoes or neutral foot position, so that the patient automatically move the knee joint to position the foot in position Which is neutral but the resulting degree is still far from the normal degree of knee joints during mid-stance. According to the average result of the degree of knee joints produced, it can be concluded that at the time of using shoes the resulting knee joint degree entered in the normal degree of 10.8^{o} of flexion but not when the patient did not wear shoes that is 4.5^{o} (figure 1) even Degrees far from the normal number generated when the prosthetic foot is flat on the floor of 3.8^{o} extension (figure 2).

Based on the average grade of knee joints generated during mid-stance when wearing shoes is 10.8^{o} knee flexion. Statistically, the value of p value produced is 0.004 thus the result p value <0.05 means there is a significant degree of knee joint distances from normal numbers. At the time of mid-stance the knee joint will move flexion and start for back extension and knee joint degree generated i.e 10^{o}-20^{o} flexion of knee. In this study using the lowest range of 10^{o}, there is a difference of 0.8^{o} greater than the lowest range but not exceeding the highest range so it can be concluded that the degree of knee joints during mid-stance when using shoes in the normal range (Levine, David, Jim D Richards, n.d.).

At mid-stance when not wearing shoes, the prosthetic feet position is not completely flat on the floor; this is caused by the prosthetic foot surface which has a higher heel surface than the metatarsal line (Hansen & Childress, 2009; Salis, 2014). The position occurs because the patient does the compensation to achieve the optimal position. Normally when a mid-stance GRF from the field sagittal will be located in the middle of the foot and the back of the knee joint to produce movements of flexion of the knee, because the patient did compensate by positioning the heel slightly raised position the Ground Reaction Force (GRF) is more forward forefoot make degrees The resulting flexion is less, so the degree of knee joints generated is 4.5^{o} knee flexion, the resulting degree is smaller than the lowest range. If the

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focus on prosthetic feet is flat on the resulting degree floor is -3.8˚, the minus number defines the extension so that it can be concluded that the degree of knee joints generated further away from normal numbers toward the extension. Statistically the value of p value generated at mid-stance and the average prosthetic foot on the floor is 0,000 thus p value <0.05, it means that there is a significant difference when compared with the standard number of knee joint degree produced but when the prosthetic foot flat on the floor resulting precisely further away from the normal numbers so that if the patient does not use the shoe can occur knee joint encouragement toward the extension continuously this will make the structure in the knee joint is not good. The resulting impacts according to [10] can cause extension movement of the knee joint, may cause the ACL to become tensioned or torn and if too much pressure forces the knee toward the extension, the joint may extend further than the actual range of motion, causing soft tissue damage, swelling, and potentially tearing or straining MCL, LCL, ACL, or PCL (Saito et al., 2015).

The results of this study are in line with the hypothesis that researchers have made that there is no difference in knee joint degree during mid-stance when using shoes and there are significant differences in knee joint degree during mid-stance when patients do not use the shoes, but the results are different from the research beforehand, the degree of knee joints generated when the patient was wearing shoes on average was 7,67º flexion and 1,63º extension when the patient walked without shoes while the instrument used to measure the degree of knee joints in the study was a goniometer by capturing the video at mid- stance phase in the computer then do the measuring (Dingwell, Cusumano, Rylander, & Wilken, 2021; Jonkergouw, Prins, Buis, & Wurff, 2016). Different from this research that is using hudl technique software, the advantages of the software is that it can change the video to be slower movement so it can get more accurate measurement position, besides can make the measurement of degree at once so that degree is more accurate that produced. Other than that, this software ever done to do research in a large measure of the degree of knee joint valgus on female footballers (Cesario, Hubbard, Marella, & Knisely, n.d.), although the software is low cost but can be applied to conduct assessment process (Milbrath, Stoepker, & Krause, 2016) Hudl technique can collect videos from specific activities, analyze the captured video to collect the measurements of the clinical gait in question and also the tool can be used in clinical practice (Abu-Faraj, Harris, Smith, & Hassani, 2015).

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