Artikel Penelitian

Data References of Indonesian Walking Pattern at Low, Medium and High Speeds on Treadmills

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Abstract

Introduction: *Gait analysis is the study about how to move. However, the normal gait reference which is currently used is the normal gait of Europeans. The body proportions, leg length, and height between Europeans and Indonesians are different.*
Methods: *The samples were 44 Indonesian aged 18 – 26 years which was divided into 22 males and 22 females. Samples used legging and socks that had been marked with a color at a certain point. The research sample walked on a treadmill at low, medium and high speeds and recorded from the back and sides. Based on the video, the angles of the hip joint, knee join was assessed.*
Results: *In male subjects, the joint angles of low, medium and high speed walking: maximal thigh joint (21.30°, 21.77°, 22.67°), minimal thigh joint (-7.05°, -7.74°, 8.66°), maximal knee joint (55.25°, 57.00°, 60.04°), minimal knee joints (9.63°, 10.13°, 10.50°). In female subjects, the joint angles of low, medium and high speed walking: maximal thigh joint (24.02°, 24.43°, 24.99°), minimum thigh joint (-3.25°, -3.86°, -4.22°), maximal knee joint (53.60°, 56.80°, 58.99°), minimal knee joints (11.12°, 12.94°, 12.83°).*
Conclusion: *The faster walking speed, the greater angle of thigh joint and knee joint.*

Keywords: *Gait Analysis, Kinematic Parameter, Treadmill*

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Data Refrensi Pola Berjalan Orang Indonesia pada Kecepatan Rendah, Sedang dan Tinggi di Atas Treadmill

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Abstrak

Pendahuluan: *Gait analisis adalah ilmu yang mempelajari cara berjalan. Namun, refrensi gait normal yang digunakan hingga sekarang adalah gait normal orang Eropa. Padahal ukuran proporsi tubuh, panjang tungkai, tinggi antara orang Eropa dan Indonesia berbeda.*
Metode: *Sampel terdiri dari 44 orang Indonesia usia 18-26 tahun yang terbagi menjadi 22 laki-laki dan 22 perempuan. Sampel menggunakan legging dan kaos kaki yang telah diberi tanda dengan warna pada titik tertentu. Sampel berjalan di atas treadmill pada kecepatan rendah, sedang dan tinggi serta direkam dari belakang dan samping. Berdasarkan video, sudut sendi paha dan sendi lutut dinilai.*
Hasil: *Pada subjek laki-laki, besar sudut pada kecepatan rendah, sedang dan tinggi: sendi paha maksimal (21.30°, 21.77°, 22.67°), sendi paha minimal (-7.05°, -7.74°, 8.66°), sendi lutut maksimal (55.25°, 57.00°, 60.04°), sendi lutut minimal (9.63°, 10.13°, 10.50°). Pada subjek perempuan, besar sudut pada kecepatan rendah, sedang dan tinggi: sendi paha maksimal (24.02°, 24.43°, 24.99°), sendi paha minimal (-3.25°, -3.86°, -4.22°), sendi lutut maksimal (53.60°, 56.80°, 58.99°), sendi lutut minimal (11.12°, 12.94°, 12.83°).*
Kesimpulan: *Semakin tinggi kecepatan berjalan, maka sudut sendi paha dan sendi lutut akan semakin besar.*

Kata kunci: *Gait Analysis, Parameter Kinematik, Treadmill*

Introduction

Gait analysis is the study about moving, in particular studying how humans move by using observations and researchers' way of thinking, which can be clarified or assisted by using tools to calculate body movements, body mechanics, and muscle activity.[1]

There are several abnormal gait conditions, including hemiplegic gait, diplegic gait, neuropathic gait (steppage gait, equine gait), myopathic gait, choreiform gait (hyperkinetic gait), ataxic gait (cerebellar), parkinsonian gait, and sensory gait.[2]

There are tools to assess gait analysis including videotaping, three-dimensional motion analysis, dynamic electromyograms, and force plates.[3]

Gait analysis is a profitable tool for identifying a person's fitness. More specifically, gait analysis can show the area or phase of the gait cycle in a patient where the problem lies. This can be done by following the movements of the different joints and comparing them with the gait parameters of a healthy person of the same gender, age and gait parameters.[4]

There are 3 parameters that are generally assessed in gait analysis including spatio-temporal parameters, kinematic parameters, and kinetic parameters.[5] Kinematic parameter is one of the parameters that is often used. This parameter assesses the change in degree of angle in each joint followed during 1 cycle of the running phase (initial contact - loading response - midstance - terminal stance - pre swing - initial swing - mid swing - terminal swing - initial contact).[6]

The obtained gait measurement results are compared with existing normal gait references to determine whether the individual has a normal or abnormal gait range. However, the reference of normal gait that is used currently is a normal gait of the Europeans. In fact, the body proportions, leg length, height between Europeans and Indonesians is different. Thus, the normal gait between Europeans and Indonesians must be different. However,

the normal gait reference values for Indonesians still does not exist. It is important to use this reference to normal Indonesian gait to be used as a reference for assessing the quality of gait for Indonesians who are undergoing ongoing rehabilitation therapy.

Methods

This study was an analytical observational study with a cross-sectional design. The study was conducted from February to November 2020 in CBIOM3S, Diponegoro University. Ethical approval was obtained from The Health Research Ethics Committee Faculty of Medicine Diponegoro University No. 229/EC/KEPK/FK-UNDIP/X/2020. All subjects gave informed consent before participation.

Study Population

The research samples were obtained by using simple random sampling method. The samples were 44 Indonesian people aged 18-26 years which was divided into 22 males and 22 females with normal qualitative observations in the city of Semarang who met the inclusion and exclusion criteria.

The inclusion criteria in the study are: 1) Having normal gait qualitatively. Qualitative assessment was carried out by 3 general practitioners and 1 orthopedic specialist. Gait is said to be normal indicated by a regular and symmetrical gait cycle without any additional movement and without any form of complication in complex gait maneuvers such as stopping, reversing direction, jumping with one and both legs and walking back and forth, 2) Has a complete number of limbs, 3) Can run on the treadmill smoothly, 4) Willing to be a research subject and follow research procedures, 5) Indonesian, aged 18-26 years who do not have a mixture of genes from outside Indonesia.

The exclusion criteria in this study are: 1) Has trouble and walking difficulty, 2) Have a history of head trauma that causes neurological symptoms, 3) Have had lower limb surgery, 4) Have experienced trauma that causes a change in the shape or function of the lower limbs.

Intervention

1. Individuals who met the inclusion and does not have any exclusion criteria, and agreed to take part in the study were included.

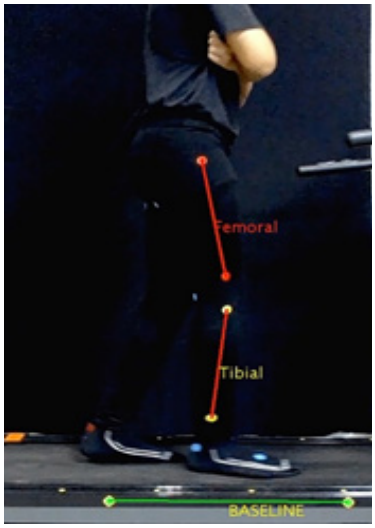

Figure 1. Marker Placement and Recording

2. The research sample was recorded gender, age, and measured body weight, height and body mass index.
3. The research sample used leggings and socks and then a colored paper marker was attached on the hip joint and knee joint. Markers were attached to the right leg on the outside and the left foot on the inside.
4. The research sample ran on a treadmill at low, medium and high speeds for 10 phases of walking for each speed. While walking, the gait of samples was recorded using 2 cameras located on the right side and the back of the treadmill. Marker placement and recording can be seen in figure 1.
5. Based on the gait video, the angles in the hip joint and knee joint were assessed at each speed, then the average value and standard deviations were found.

Statistical Analysis

To obtain a database or standard, the mean and standard deviation of all the data obtained were sought. This is done so that the data represented by a value could be used as a reference standard for making comparisons with the normal European reference standard. Standard deviation stated the distribution or variation of data from the mean value. The standard deviation used was the study sample data, not the entire study population.

Kinematic parameters were tested by using the Independent T-test and Pearson test to determine the relationship between the normal European reference standard and the data obtained from the Indonesian gait.

Results

An assessment of kinematic parameter was carried out on the gait of 22 male and 22 female subjects at low, medium and high speeds so that the following results were obtained. Based on table 1, it can be seen that the faster speed of the treadmill, the wider range of motion of the joints. This can be seen from the increase in the max hip angle, the greater positive value which indicates the higher thigh flexion. In the min hip angle, a more negative value is obtained, which indicates that the thigh movement is further extended backwards. At the max knee angle, the value is more positive which indicates more knee bending or flexion. Finally, at the min knee angle, a more positive value is obtained which indicates that the knee joint is not fully straightened because it is preparing to perform further knee flexion.

Table 1. Normal Gait Indonesian People

Max Hip Angle			Min Hip Angle			Max Knee Angle			Min Knee Angle		
Slow	Natural	Fast	Slow	Natural	Fast	Slow	Natural	Fast	Slow	Natural	Fast
22.66° ± 3.96°	23.10° ± 3.99°	23.83° ± 4.02°	-5.15° ± 4.58°	-5.80° ± 4.65°	-6.44° ± 4.48°	54.42° ± 5.8°	56.90° ± 5.46°	59.51° ± 5.96°	10.37° ± 5.39°	11.54° ± 5.35°	11.66° ± 5.75°

In this study, the body mass index of the sample was also carried out. Correlation test was conducted to find the relationship between changes in walking speed and changes in body mass index to changes in the angle of thigh and knee. So that the following results were obtained.

The statistical tests found a relationship between the changes in velocity and the angle of the thigh and knee joints in male and female subjects. At the maximum hip angle, there was a very low and unidirectional level of relationship (p= 0.120) to the increase in walking speed with no significant difference (p = 0.172). In the minimum hip angle, there was a very low and opposite level of relationship (p = -0.116) to the increase in walking speed with no significant difference (p = 0.187). At the maximum knee angle, there was a low and

Table 2. Normal Male Gait Indonesian People

Max Hip Angle			Min Hip Angle			Max Knee Angle			Min Knee Angle		
Slow	Natural	Fast	Slow	Natural	Fast	Slow	Natural	Fast	Slow	Natural	Fast
21.30° ± 4.32°	21.77° ± 4.51°	22.67° ± 4.28°	-7.05° ± 4.17°	-7.74° ± 4.33°	-8.66° ± 4.12°	55.25° ± 6.12°	57.00° ± 6.24°	60.04° ± 5.61°	9.63° ± 6.39°	10.13° ± 5.98°	10.50° ± 6.25°

A separation between the angle of thigh and knee between male and female was carried out so that the following results were obtained

Table 2 specifically shows the normal gait of Indonesian male obtained from this study. It shows that the faster the treadmill speed, the wider the range of motion, which is indicated by the increase in the angle at each joint.

unidirectional level of relationship (p = 0.343) to the increase in walking speed with a significant difference (p <0.001). At the minimum knee joint, there was a very low and unidirectional level of relationship (p = 0.096) to the increase in walking speed with no significant difference (p = 0.273).

The results of statistical tests linked the body mass index to changes in the angle of the thigh joint and knee joint in male and

Table 3. Normal Female Gait Indonesian People

Max Hip Angle			Min Hip Angle			Max Knee Angle			Min Knee Angle		
Slow	Natural	Fast	Slow	Natural	Fast	Slow	Natural	Fast	Slow	Natural	Fast
24.02° ±3.10°	24.43° ±2.93°	24.99° ±3.46°	-3.25° ±4.23°	-3.86° ±4.19°	-4.22° ± 3.70°	53.60° ± 5.49°	56.80° ± 4.69°	58.99° ± 6.38°	11.12° ± 4.19°	12.94° ± 4.33°	12.83 ° ± 5.07 °

Table 3 specifically shows the normal gait of Indonesian female obtained from this study. Similarly like the male angle, the faster the treadmill speed, the wider the range of female subjects. At the maximum hip angle, there was a very low and unidirectional level relationship (p = 0.086) to the increase in body mass index with no significant differ-

ence (p = 0.326). In the minimum hip angle, there was a very low and opposite level of relationship (p = -0.068) to an increase in body mass index with no significant difference (p = 0.435). At the maximum knee angle, there was a very low and opposite level of relationship (p = -0.001) to the increase in body mass index with no significant difference (p = 0.992). At the minimum knee angle, there was a very low and unidirectional level of relationship (p = 0.130) to an increase in body mass index with no significant difference (p = 0.137).

Discussion

Walking speed affects almost all existing gait parameters. The angle of the thigh joint and knee joint are significantly affected by the increase in gait velocity.[7] In both male and female subjects, in general, an increase in walking speed will increase the range of motion of the thigh joint and knee joint. The research data shows that the higher the walking speed, the higher the thigh flexion that occurs to the front, the greater the value of the thigh extension towards the back, and the greater the value of the knee flexion. However, the higher the walking speed, the tendency of the knee to do maximum extension will decrease. This occurs because the knee joint immediately prepare for further knee flexion.

Body mass index increment will result in increasing the angle of the maximum hip angle, minimum hip angle and maximum knee angle. However, an increase in body mass index does not have a strong relationship with the minimum knee joint size. The increase in the maximum angle of the knee joint occurs due to flexion of the thigh which increases its position. A minimum increase in the angle of the thigh occurs in a different direction, so that the correlation test is negative. This means that the extension of the thigh that occurs will be further towards the back of the body. The maximum increase in the knee joint results from increased knee flexion. An increase in body mass index did not have a strong correlation with a minimum increase in knee joint size. The minimum increase in the size of the knee joint can occur due to knee extension that occurs not fully performed, meaning that when knee extension occurs, the knee joint is still in a bent position.

Male subjects had greater value of minimum angle of the hip joint and a maximum angle of the knee joint than female subjects. Meanwhile, female subjects had greater value of a maximum angle of the thigh joint and a minimal angle of the knee joint than the male subjects. This occurs because male subjects generally have a larger size of the gluteal muscle and hamstring muscles than women. Women have more active femoral quadriceps muscle activity than men, but men have more active hamstring activity than women.[8] The gluteal muscle functions in the extension of the thighs, while the hamstring muscles function in knee flexion movements. The enlargement of these two muscles occurs as a result of being stimulated through daily activities.

Conclusions

Normal gait of Indonesians at low, medium and high speeds generally shows a significant difference to normal gait of Europeans. The higher the walking speed, the greater the angle of the thigh joint and the knee joint, so that it is closer to the angle of the European thigh and knee joints. Gender and body mass index affect the angle of the thigh joint, and knee joint.

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