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A STUDY ON GAIT PATTERN OF MALAY SUBJECTS

Dissertation submitted in partial fulfillment for the Degree of Bachelor of Science (Health) in Forensic Science

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CERTIFICATE PAGE

CERTIFICATE

This is to certify that the dissertation entitled

"A Study on Gait Pattern of Malay Subjects"

is the bonafide record of research work done by

Ms. Rina Haryani Osman Basah

during the period of January 2006 to April 2006

under my supervision.

Signature of supervisor: .....

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ABSTRACT

Gait pattern is also known as walking pattern. The gait pattern of each individual is unique. The various terms and factors used in gait pattern analysis include direction line, step length, step width, gait angle, gait line or gait length, foot angle, foot length, foot width and also presence of any peculiarities in the foot or gait pattern. This research involves the study of individual's walking pattern. The individuality is observed by measuring the variables stated above. The frequency, mean, standard deviation and standard error of mean are calculated. The results show the variety and distribution of data in the frequency table. In this study all variables are discussed separately. Based on the measurements and its calculation, this study reveals the identification of the individual.

Recognizing people by their gait is a biometric of increasing interest. Recently, analysis has progressed by the evaluation of few techniques on small databases with encouraging results to large databases and still with encouraging results. The potential of gait as a biometric was encouraged by the considerable availability of evidence, especially in biomechanics and literature.

In this study, gait pattern provides useful information in number of ways. The most frequent and important use of gait pattern is to identify the originator. Bare foot prints are highly individualistic in nature like fingerprint. In the same way the study of gait pattern also reveals the individual identification. This gait pattern research also indicates a mean to establish sex, and height of the person to some extent. By careful analysis of the gait pattern, we can also indicate the presence of deformity, speed and also any possibility of fraudulent

act by criminals. For this research study, I have collected one hundred samples of gait pattern from Malay population and conducted my study and recorded the findings.

INTRODUCTION

"Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as silent evidence against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen that he deposits or collects - all these and more bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual evidence. Physical evidence cannot be wrong; it cannot perjure itself; it cannot be wholly absent. Only its interpretation can err. Only human failure to find it, study and understand it, can diminish its value" (Kirk, 1953).

Walking is an important attribute of man's superiority over the others in animal kingdom. Mode of walking has changed gradually since hominids achieved erect bipedalism. As human species proliferated all over the world as the only surviving subspecies of home, it was quite natural in the course of evolution that walking had undergone modifications in the gait pattern.

Before a person known, well approaches closely enough to recognize their facial features, their identity is revealed by unique attributes in their gait. Most of us were taken for granted this way of recognizing a person. Even when we identify someone by these means, we are unconscious of the details that allowed us to reach our conclusion. Not only is the gait of each individual different but also the features of gait. Before we try to examine those footprints, as an examiner we must have a good working knowledge of foot that wear the

shoe and make the walking prints. This includes knowledge of the bones of the feet and an understanding how each bone functions in making an impression. The uniqueness of the human foot may be described based on their morphological aspect, biomechanical aspect and the papillary ridge formations. In morphological aspect, the examiner must have knowledge about the visible form and structure of the foot. Biomechanical aspect is all about the function of the foot. The papillary ridge formation is like the fingerprint, the components that can provide positive identification based on the formation and unit relationship of the ridges. Above all, the structural and functional components of the foot are composed of highly refined interrelated segments which provide a stable base for supporting the body while standing, running, walking and jumping. Each step begins with the weight supported for the trailing foot. We swing the striding foot forward and begin to transfer our weight forward to the heel. Our weight rolls toward the toes as our momentum carries us forward, and we begin to swing the alternate leg forward.

From forensic point of view, one can relate gait pattern is unique to the individual. Barefoot walking, use of footwear and load carrying habit will condition human walking pattern. As forensic investigators, they tend to retrieve as much personal information as possible from the foot prints or walking prints.

Napier (1997) has discussed about length on human walking in evolutionary perspective, which is more on anthropological interest. Nath (1993) stressed the forensic implications of various anthropometric items. Quamara et al (1980), Guiles and Vallangdigam (1991), Jasuja and Manjula (1993) have indicated the possibility of estimating stature from foot prints and Robins (1986) tried to estimate not only height but also body weight from foot prints. Ghoshmaulik (1993) attempted to correlate stride length with

different somatometric features including stature (As quoted by Bijan Kumar Tripathy, 2004).

In gait pattern, many researchers have attempted to find the probability consideration in the individualization of gait pattern. Gait pattern or walking pattern is a series of consecutive foot prints found in a crime scene. From the gait analysis, the manner of walking of the person could be deduced. Gait pattern is put under the track mark evidence, just like shoe mark, wheel mark, hoof and paw mark and other trails (Sharma, 1977). They include two dimensional prints as well as three dimensional impressions. Both prints and impressions are found in the crime scene. Gait pattern analysis can help to reveal some valuable information that is useful to the crime scene investigator. As we all know, all crimes involve men and places. At the crime scene, the criminals must reach, stay and then leave the crime scene. Usually they must leave their foot prints or series of foot prints i.e. walking pattern in the process. This evidence should theoretically be available in most of the crimes. This evidence can form an important link between crimes, criminal, the crime scene and also the victim. Why the walking pattern or track marks evidence is important in crime scene investigation? Actually, track marks occur in most of the crimes but many investigators do not know the importance because they do not have knowledge about the track marks. Hence the track mark analysis is usually ignored by the investigators. Walking pattern also provides a positive link between criminal and crime scene. The presence of a foot print at a crime scene can clearly identify or indicate his or her presence in that crime scene. The most important factor is that gait pattern can help investigator to reconstruct the crime scene as they provide useful investigation lead.

Much information can be obtained from the analysis of the gait pattern. Gait pattern can indicate the number of persons involved based on different walking pattern seen at the crime scene. They also can indicate the age of the person, whether the person is child, young or old, based on the features or size of the marks, sometimes to some extent the sex of the person. Based on the gait pattern, we can estimate the height of the person. The mode of entry and exit as well as their behaviour in the scene such as they were standing, moving slowly, walking fast or running can also be deduced. The state of mental health of the person whether the person is normal, ill, injured or suffered from deformity can also be deduced by means of gait pattern. By examining the gait pattern, we also can assess the state of mental health whether the person was drunk, under the influence of drugs or was suffering from some mental disease. In addition, we also can know whether the person was carrying some load or whether the woman who left the trail was pregnant. Sometimes we also can detect whether there is any frauds in gait pattern.

The gait pattern of each individual is unique. The individuality of the gait is based upon the study of the gait line, foot line, step length, gait length, gait angle, foot angle, foot length, step width and foot width. A unique advantage of gait as a biometric is that it offers potential for recognition at a distance or at low resolution, when other biometrics might not be perceivable (Nixon et al., 1999). Further, it is difficult to disguise gait without hampering progress, which is of particular interest in scene of crime analysis. Recognition can be based on the (static) human shape as well as on movement, suggesting a richer recognition cue. Further, gait can be used when other biometrics is obscured – criminal intent might motivate concealment of the face, but it is difficult to conceal and/or disguise motion as this generally

impedes movement. There is much evidence to support the notion of using gait to recognize people (Nixon et al., 2003).

A person can perform his or her walking pattern in a fairly repeatable and characteristic way, sufficiently unique that it is possible to recognize a person at a distance by their gait (Winter, 1991). Similar observations can be found elsewhere, even in contemporary literature. Murray et al., (1964) established many of the basic tenets of gait analysis. These studies again suggested that gait appeared unique to subjects. Studies in psychology have progressed from establishing how humans can recognize subjects' motion (Johannson, 1973), to recognizing friends. Early approaches used marker-based technology, but a later one used video imagery (Stevenage et al., 1999), also showing discrimination ability in poor illumination conditions. As such there is much support for the notion of gait as a biometric.

REVIEW OF LITERATURE

Few studies have been made regarding the gait analysis. My research here involving 100 subjects clearly indicated that gait pattern of a person is unique based on the observation of all the parameters and no two gait patterns are identical. The parameters are step length, step width, gait angle, foot length, foot width and foot angle.

Early approaches were limited in using more standard techniques processing silhouettes. These included analyzing subjects' trajectories (Niyogi and Adelson, 1994), principal components analysis (PCA) (Murase and Sakai, 1996), moments (of flow) (Little and Boyd, 1998) and a combination of PCA with canonical analysis (CA) (Huang et al., 1999). Only one approach used a model to analyze leg movement (Cunado et al., 2003).

There is a high correlation between step length and height of a person (Murray et al. 1964), which indicates that step length could differ between subjects if there are differences in height. Step width may give information about the conditions of a person. An increased step width could be related with stabilization problems (Gary 1990). Other type of parameters for identification purposes had been used by Menno Merlijn, 2004. The parameters used for the his study include hip joint angle, knee and ankle joint angle, thigh angle, the step length, step width, walking speed, cycle time and foot angle. The subjects have worn underwear and shoes. The subjects were asked to walk with their favourite walking speed along the cameras. For each subject, seven trials were made for data analysis. The subjects were asked to look at a piece of paper, which hang at 1.5 m height in front of them. This makes the subjects walk straight up and avoid distract thinking while walking.

The subject walked about 7 meters straight, after 2.5 meters the subject was filmed till about 6 meters. After the 7 meters the subject turned to the right and walked back for the next trial. In his study, by using the gait parameters, he found significant gait difference between subjects and it is an evident that gait pattern is unique. The parameter that show significant differences between the subjects include foot angle (64 % - 73 % of the maximal attainable significant differences), followed by the time average hip joint angle (58 %) and the step length (45 %). The other parameters score less than 25 %, which is poor for identification purposes.

The study of Mr. Bijan Kumar is the observation on stepping pattern and correlates stride length or step distance with selected morphometric features viz. stature, height trochanter, height tibiale, bitrochanter breadth, foot length, foot breadth and foot index. Except for the foot index, correlation values in all other cases are negative, observation on stepping linearity reveals predominant occurrence of divergent type of steps while the first step covering a distance larger than the following steps is observed in majority of cases.

Kocsis, et al., (1999), focuses on the presentation of a new 3D motion analysis technique for treadmill walking. An ultrasound-based 3D measurement system and a developed measuring arrangement were used to measure and determine gait parameters during treadmill walking. The model considers each limb segment to be a rigid body, linked to each other by a joint. This paper also presented a new 3D motion analysis software package for treadmill walking and introduces the Data Manager developed. They studied knee kinematics and temporal-distance gait measurement parameters (step length, stride length, stride width, etc.) obtained from treadmill walking. These measurements were highly correlated with and not significantly different to those in literature. Treadmill walking allows

for the analysis of several cycles of each subject. On the basis of the analysis the standard deviation of temporal-gait parameters and the knee kinematics data of each subject can be established. The 3D movement analysis system presented is a suitable and standardized procedure for quick gait analysis.

OBJECTIVE OF THE STUDY

1. To understand the uniqueness of gait pattern.
2. To study the extend of uniqueness of gait pattern of individual.
3. To understand how characteristic of the gait pattern may be identified.
4. To understand that standardized photographic techniques used for recording and accurate comparison purposes for the gait pattern.
5. To study gait pattern analysis with reference to Malay population.
6. To study and measure the parameters that are essential in gait pattern analysis.

MATERIALS AND METHOD

MATERIALS

1. Foot print kit
2. Foot print roller
3. Foot print plate
4. Mahjung paper (34 inc x 34 inc)
5. Foot print ink or duplicating ink
6. Scale
7. Blackboard ruler
8. Digital camera
9. Cellophane tape
10. Scissors
11. Protractor
12. Square

METHODOLOGY

Sample Collection:

Inked walking impressions were collected from 100 Malay subjects. Walking impressions were taken without wearing shoes, which means barefoot impressions. The subjects were asked to step with bare feet on an inked foot print plate and then to leave six steps with a normal walk on a spread mahjung paper and thus recorded the gait pattern. They are properly numbered and preserved for analysis. The samples were collected only in Malay population.

Fig 1: Collection of the gait pattern samples.

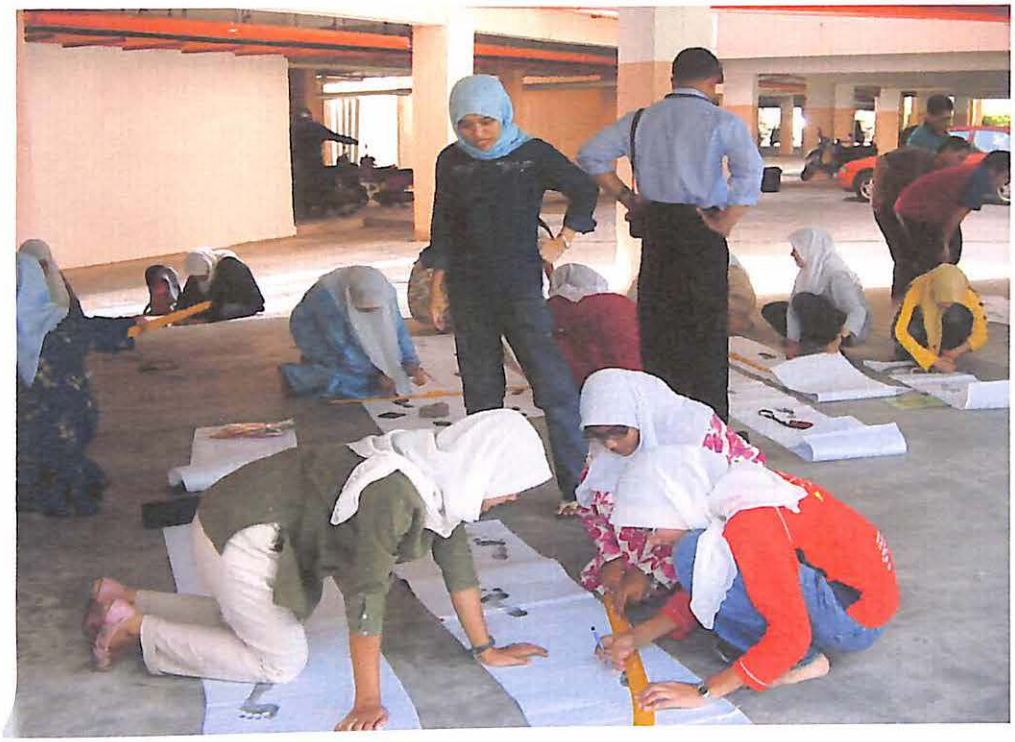

Fig 2: Measurement of the gait pattern.

Fig 3: Measurement of foot angle and gait angle.

The following parameters used for gait measurements were recorded.

- step length
- step width
- gait angle
- left foot angle
- left foot length
- left foot width
- right foot angle
- right foot length
- right foot width
- gait length
- any peculiarities present

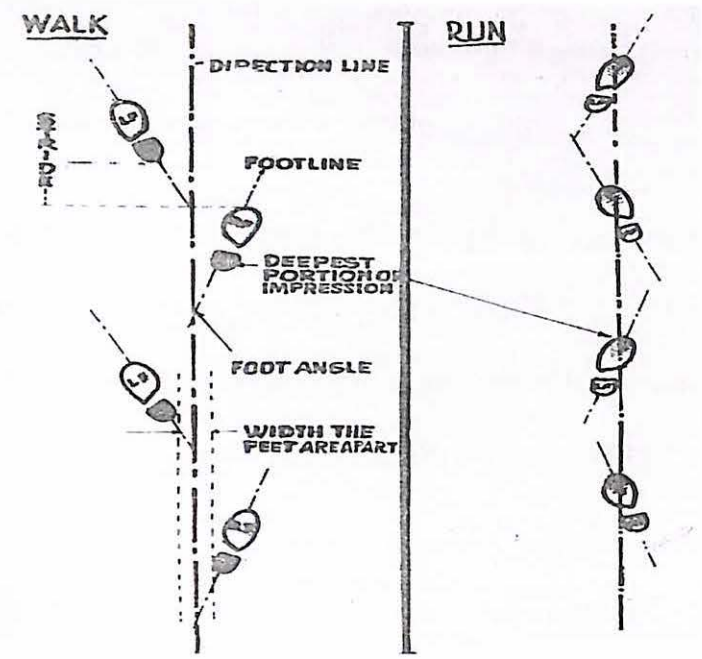

Fig 4: Illustrates the components of the gait pattern

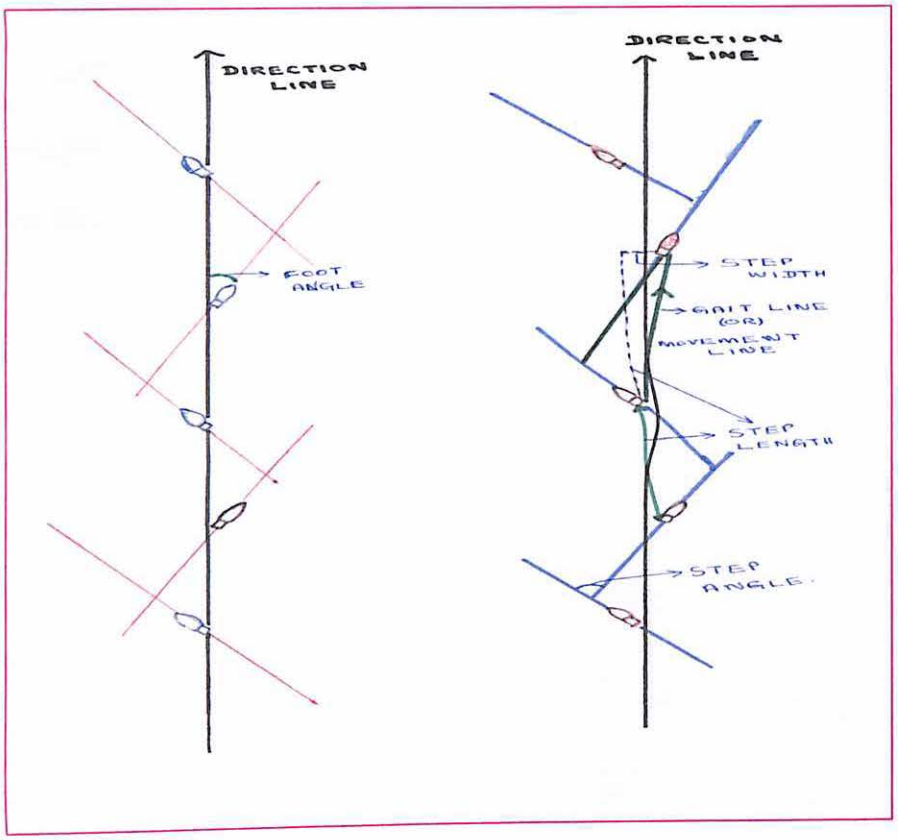

Fig 5: Measurement of different parameters for recording gait pattern

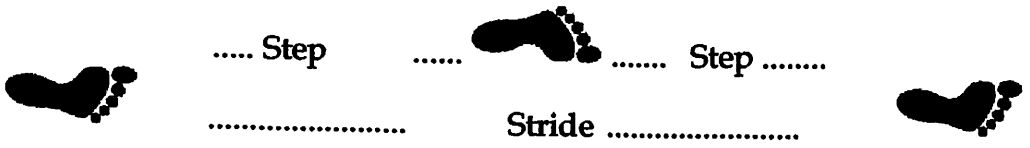

Fig 6: Difference between stride length and step length.

Step Length is the distance from one foot strike to the next (left to right or right to left) is about 0.75 m for normal adults. Stride Length (one gait cycle) is two successive steps (by both left and right feet - about 1.5 m for normal adults) (Kirtley, 1998).

Recording of the Gait Pattern:

Recording of gait pattern has been attempted successfully by Muller. The equipment needed consists of two squares and a protractor. The arms of the square are hinged at right angles. One of the squares carries scale on both arms. For measuring step length or step width, the two square encase two consecutive foot or footwear marks, the longer sides of the squares touching the outer sides of the marks and the shorter sides of the squares touching the heel and toe tip. The reading from the scale gives length and width of the step.

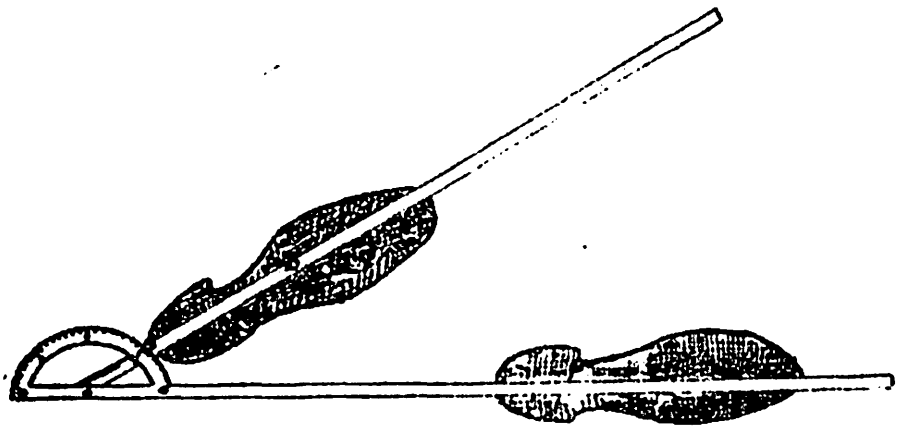

Fig 7: The measurement of the step angle is made easy by the device shown in the figure. The two arms of the device must be placed in the centers of the two marks.

The step angle or gait angle is measured with the help of the protractor. One arm is placed along the longitudinal axis of one foot or footwear mark and the other arm is placed along the longitudinal axis of the other foot or footwear mark. The angle subtended by the two arms of the compass gives the step angle. Foot angles are measured by taking the angle between direction and foot line. Sizes of the foot or footwear, damage, tear or deposit are also taken into account. All above measurements are recorded. This kind of recording gait pattern is attempted by Muller.

In my research, for measurement, I used two long rulers and a big protractor. Direction line is an imaginary line along the centre of the path followed by the subject. Gait line is the line actually followed. It is obtained by joining the centers of the heel marks. Foot length is measured by distance from heel to the longest toe. Gait length is measured by the distance of the centers of the consecutive heel marks.

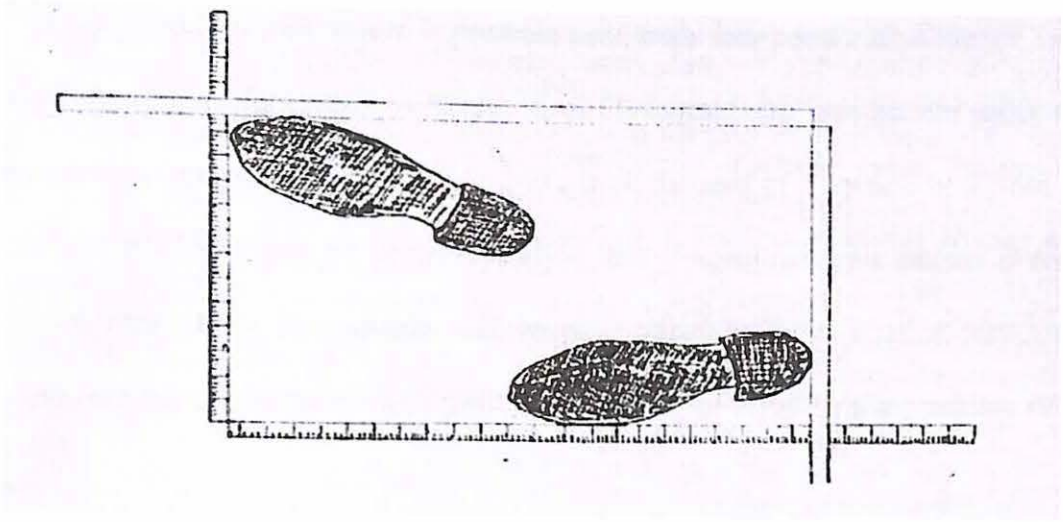

Fig 8: Above illustration indicates the easy way in which step length and the step width can be measured. The reading of the longer arm of the square gives the length of the step, while reading on the shorter arm indicates the step width.

Gait angle is the angle between the consecutive foot lines and it is equal to the sum of the two foot angles. Foot angle is the angle between the foot line and the direction line. Step length is determined by measure the distance between the two consecutive heel marks. Step width is obtained by measured the distance between the tangents to the inner edges of the two feet. Foot width is determined by measure the breadth of the foot.

Photography:

Fig 9: One of the gait pattern samples.