AN EXAMINATION OF TEMPORAL SPATIAL IN DIFFERENT GENDER YOUNG PEOPLE USING 3D MOTION ANALYSIS OF GAIT

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POLITEKNIK SULTAN SALAHUDDIN ABDUL
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POLITEKNIK SULTAN SALAHUDDIN
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2017

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I hereby declare that the work in the thesis is my own except for quotations and summaries which been duly acknowledged.

Signature : ....

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Date : 25 May 2017

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ABSTRACT

Gender plays an important role in social communication. Many social interactions depend greatly on correct gender perception. In addition, previously gait analysis applications have been used for an orthopaedist, physical therapist or kinesiology to evaluate affected individual gait which diagnosed disorders. Gait analysis has proved to be a tool of great utility for orthopaedics due to its importance for pathologies diagnosis and the evaluation of surgical treatments, of rehabilitation, and the use of prosthesis and orthosis. The purpose of this study to identify differences in temporal-spatial gait parameters across different children gender in age between 5 to 12 years old. Temporal-spatial gait parameter at lower limb have been collected using Vicon Nexus motion system and all data collection have been carried out at Human Motion and Gait Analysis Laboratory, Universiti Teknologi MARA (UiTM) Shah Alam. 32 healthy children consist of 16 boys and 16 girls participated in this study. An eight camera 100Hz Vicon MX motion capture system and two AMTI forces plates used to track the body motion of participant during walking. The analysis is performed using statistical techniques in reliability such as probability, cumulative distribution function, canonical correlation and cross-correlation are done via Matlab software. In addition, this study also uses t-test for identify significant different in selected temporal spatial parameter namely opposite foot off, opposite foot contact, foot off, single support, double support and stride time. The results show that there are significant differences between male and female for the variable. Results proven that statistical method matlab using software can effectively verified gait parameters between different genders. This research also use the Graphic User Interface (GUI) to show the result that was analyse using Matlab Software. Profiling walking gait pattern expected to help doctors and therapists to form structured intervention for further treatment and therapy for young people.

Keywords: analysis, gait, temporal-spatial, human motion, lower limb

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ABSTRAK

Jantina memainkan peranan yang penting dalam komunikasi sosial. Banyak interaksi sosial banyak bergantung kepada persepsi jantina. Selain itu, analisis sebelum ini gaya berjalan telah digunakan oleh ortopedik, ahli terapi fizikal atau kinesiology untuk menilai gaya berjalan individu yang di diagnosis. Analisis gaya berjalan telah terbukti menjadi alat utiliti yang besar untuk ortopedik kerana kepentingannya untuk diagnosis patologi dan penilaian rawatan pembedahan, pemulihan, dan penggunaan prostesis dan orthosis. Tujuan kajian ini untuk mengenal pasti perbezaan dalam parameter gaya berjalan temporal-spatial seluruh kanak-kanak yang berbeza jantina umur di antara 5 hingga 12 tahun. Temporal-spatial parameter gaya berjalan pada bahagian bawah badan manusia telah dikumpul menggunakan sistem gerakan Vicon Nexus dan pengumpulan data telah dijalankan di Motion Manusia dan Gait Analisis Makmal, Universiti Teknologi MARA (UiTM) Shah Alam. 32 kanak-kanak yang sihat terdiri daripada 16 lelaki dan 16 perempuan telah mengambil bahagian dalam kajian ini. Lapan kamera 100Hz Vicon MX sistem menangkap gerakan dan dua AMTI kuasa plat digunakan untuk mengesan gerakan badan peserta semasa berjalan. Analisis ini dilakukan dengan menggunakan teknik statistik dalam kebolehpercayaan termasuk kebarangkalian, fungsi taburan culmulative, korelasi kanonik dan merentas korelasi dilakukan melalui perisian Matlab. Di samping itu, kajian ini juga menggunakan ujian t untuk mengenal pasti perbezaan yang signifikan dalam parameter dipilih duniawi spatial iaitu bertentangan kaki off, hubungan kaki bertentangan, kaki off, sokongan tunggal, sokongan double dan masa tenang. Hasil kajian menunjukkan bahawa terdapat perbezaan yang signifikan antara lelaki dan perempuan untuk pembolehubah. Keputusan membuktikan bahawa kaedah statistik Matlab menggunakan perisian berkesan boleh mengelaskan parameter gaya berjalan antara jantina yang berbeza. Kajian ini juga menggunakan Antara Muka Pengguna Grafik (GUI) untuk menunjukkan hasil yang telah dianalisis menggunakan Matlab Software. Profil corak berjalan kaki gaya berjalan dijangka membantu doktor dan ahli terapi untuk membentuk campur tangan berstruktur untuk rawatan lanjut dan terapi untuk orang muda.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

There is a common perception that men and women walk differently psychologists, for example, have consistently noted that observers can identify the sex of a person from limited gait information [1]. As example, through the Olympic record male have the 9.58m/s for 100meter event but female have the record only 10.49m/s. It have different about 0.91m/s between male and female in running time for 100meter event. So, trough the Olympic record it show have the differences between male and female in running.

Therefore, through this study in gait analysis will expose the pattern of human walking between males and females. During the first years of life, humans learn to walk instinctively by experimenting with their own bodies until they find an individual walking style. Despite the individual nature of this process, there are sufficient similarities to develop a characteristic human walking pattern [2].

Gait, essentially is the walking pattern of a person. It is the ability of one to maintain balance and assume the upright position as well as the aptitude to initiate and sustain rhythmic stepping [3]. Other research also said that, gait analysis is the systematic study of human walking [4]–[6]. It requires measurements, analysis, and assessment of biomechanical features that are associated with the walking task. It involves the measurement of quantitative domains: temporal-spatial, kinematics and kinetics.

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According to the World Health Organisation's (WHO) 2013 World Health statistics report, 8% of Malaysia's population is well above 60 years old. The Malaysian Ministry of Health's annual report 2011 reported about 11% and 7.2% of children aged between 0 to 18 years are detected with physical and cerebral palsy disabilities. Gait disorders are not uncommon amongst the aforementioned percentiles and it also affects the range between the age groups [3].

In this study focused in the young people normally are the children. It is because nowadays, many diseases that occur to the children and it do not have the proper for the clinical study. Example of disease like, arthritis, leg injuries bone fractures infections that damage tissues in the legs, tendinitis, inner ear infections and nervous system disorders, such as cerebral palsy or stroke.

Gait requires input from the brain, spinal cord, peripheral nerves, muscular power and joint and cardiovascular health because all of these systems are required to coordinate gait, gait speed is an indicator of the health of many physiological systems in human body [2]. In this study, force plates that measure ground reaction forces and high-frequency infrared camera in Vicon motion system will be used to analyze that gait analysis.

Previous research [7]–[10] has shown gait are beneficial to individuals who are biomechanically challenged (e.g. flat foot, muscular imbalances and injuries). The results of gait analysis can then be used by physical therapists and doctors to improve the performance of athletes and also the quality of life for the general population, especially young people.

1.2 Problem Statement

It has been shown that between boys and girls have so many differences in age related to body size and character [11]. By using the temporal-spatial technique in gait analysis will examine the different gender of analysis of gait. Early diagnosis and intervention are very important to analyze walking pattern for normal people and it

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can affect children functional capabilities and quality of life. For this reason information on the causes of difference gait patterns in this different gender could help to diagnose normal children and identified gait asymmetries between them. Therefore, by using temporal spatial parameter this study will be done to identify a deficiency in walking gait pattern for normal children life in different gender for the general population especially young people [2][12].

1.3 Objectives

The main objectives of this project are:

- To identify differences in temporal-spatial gait parameters across different children gender in young people.
- To analyze temporal spatial parameter for different gender by using signal processing in Matlab application and Graphic User Interface (GUI).

1.4 Scope Of Project

The main works of this study will involve in data acquisition and analysis of gait parameters among normal children obtained from the experiment. Thirty two (n= 32) normal children aged between 5 to 12 years old will be participating in this study. All parameters will be used to establish whether which real differences in gait temporal-spatial exist between different gender male and female normal children. Opposite foot off (OFO), opposite foot contact (OFC), foot off (FO), single support (SS), double support (DS) and stride time (ST) as an example of spatial and temporal parameters will be measured from the study. Data collection will be conducted out at the Human Motion Analysis Research Laboratory, Faculty of Electrical Engineering, UiTM Shah Alam using Vicon Mcam motion capture system and force plates.

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1.5 Significant Of The Research

The proposed study could provide an understanding of all gait parameter in temporal-spatial for normal children different gender. It will also help towards to the enhancement of knowledge in gait studies as well as bring awareness to the public in order to take care the general population especially young people and support the government for intervention and treatment programs. To date, there is limited study has been done on analysis of gait pattern of normal children. The result hopefully provides usefulness on gait analysis of normal children that can improve diagnosis method of normal children based on gait analysis and then be used by physical therapists and doctors to improve performance and also the quality of life for the general population, especially young people.

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CHAPTER 2

LITERATURE REVIEW

2.1 Analysis of Gait

Nowadays, gait analysis is used in many research areas such as in biomedical, rehabilitations, sports biomechanics and for biometric system. Gait analysis provides information on functional anatomy, physiology, neurophysiology, biomechanics and another field that related. Walking is everyday activity in daily life; therefore studies in gait analysis may bring benefits in walking efficiency to avoid the risk of fall and to assist practitioners in training or rehabilitation process [13].

In addition, based previous research A. Moreno they said the gait analysis has prove to be a tool of great utility for Orthopedics due to its importance for pathologies diagnosis and the evaluation of surgical treatments, of rehabilitation, of balance and posture, and the use of prosthesis and orthesis [2]. Furthermore, through the analysis of gait it can make sure that the way to treat some of the disease especially about the cerebral palsy. It shown on the previous research Longwei Chen, the effective management of gait problems associated with CP requires detailed examination to guide decisions on treatment strategies. Both gait analysis and clinical measurements are significant factors in the evaluation and treatment of gait disorders in children with CP [7].

So, now it prove that through this gait of analysis the disease can be analyze with successfully. Besides that, not only a cerebral palsy disease that can be treat and analyze using the analysis of gait. Through the advent of an aging population, dementia and Alzheimer's disease (AD) becomes the main diseases of the adulttery.

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Gait disorders are common in patients with AD, which are may increase the risk of falls and reduce their mobility.

Based on research Pau Choo Chung, the AD patients presented a significantly shorter mean stride length and slower mean gait speed compared with the healthy controls. The variability in the percentage of the stance phase of the AD patients was slightly greater than that in the healthy controls with about 2%. The proposed wearable gait analysis device is worth of further in- depth research to identify gait parameters in mild AD patients. These gait parameters could not only be served as indicators for early diagnosis of AD, but also as predictive clinical factors of progression towards dementia in this population [14].

In addition, usually gait analysis was used in recognizing the deviations in gait between groups in the study [13]. Based on the previous research Ricard Borras, notice for instance, that gait analysis can be used for uniquely recognizing humans, but also for estimating their gender or age. Moreover, gait analysis can be applied in a non-intrusive way and it is accessible at large distance or at lower resolutions. These advantages of gait in front of other biometrics have raised expectations of their potential use in real applications [15].

Towards the advancement of the technologies, the gait analysis can be evaluated in quantitative analysis in differentiating the groups [13]. Normal gait definition is series of rhythmical , alternating movements of the trunk & limbs which result in the forward progression of the center of gravity and the body. As example Figure 2.1 below shown that one the how analysis by using gait. It shown the manner spatial temporal stride kinetic were derived.

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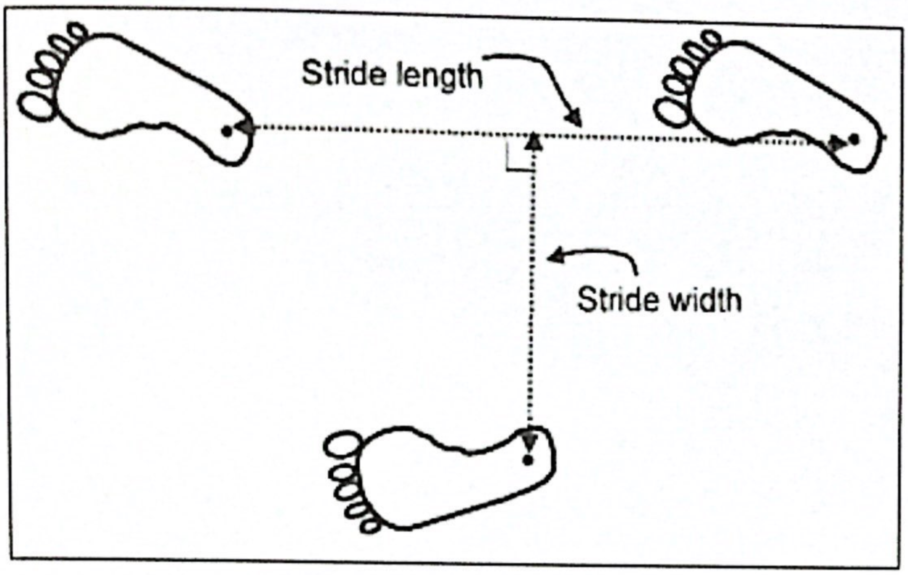

Figure 2.1: How The Analyze Used In Temporalspatial In Gait Analysis.[16]

In this study, will be a focus on the lower limb of the body. Gait analysis and classification using machine classifiers offer advantages for more potential applications in biomedical signal and image processing. Overall of the researcher got the succesfull result after use the analysis of gait especially when to treat and analyze the disease. It show that, through this way may can proved that analysis of gait as one important procedure for future. In addition, by used gait analysis surely got the succes result which were not have differences between the adult or young people. Both of this society got the result that extraordinary from the past result when used this way.

2.1.1 Gait Cycle

A gait cycle is the time period or sequence of events or movements during locomotion in which one foot contacts the ground to when that same foot again contacts the ground and involves forward propulsion of the center of gravity. A single gait cycle is also known as a stride. Each gait cycle or stride has two phases. Table 2.1 shows the differences between stance phase and swing phase.

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Table 2.1: Difference between Stance Phase and Swing Phase

Stance Phase	Swing Phase
The stance phase is that part of a gait cycle during which the foot remains in contact with the ground. For analyzing gait cycle, one foot is taken as reference and the movements of the reference foot are studied. It constitutes of 60 percent of the gait cycle.	The swing phase is that part of the gait cycle during which the reference foot is not in contact with the ground and swings in the air. It constitutes about 40% of the gait cycle.

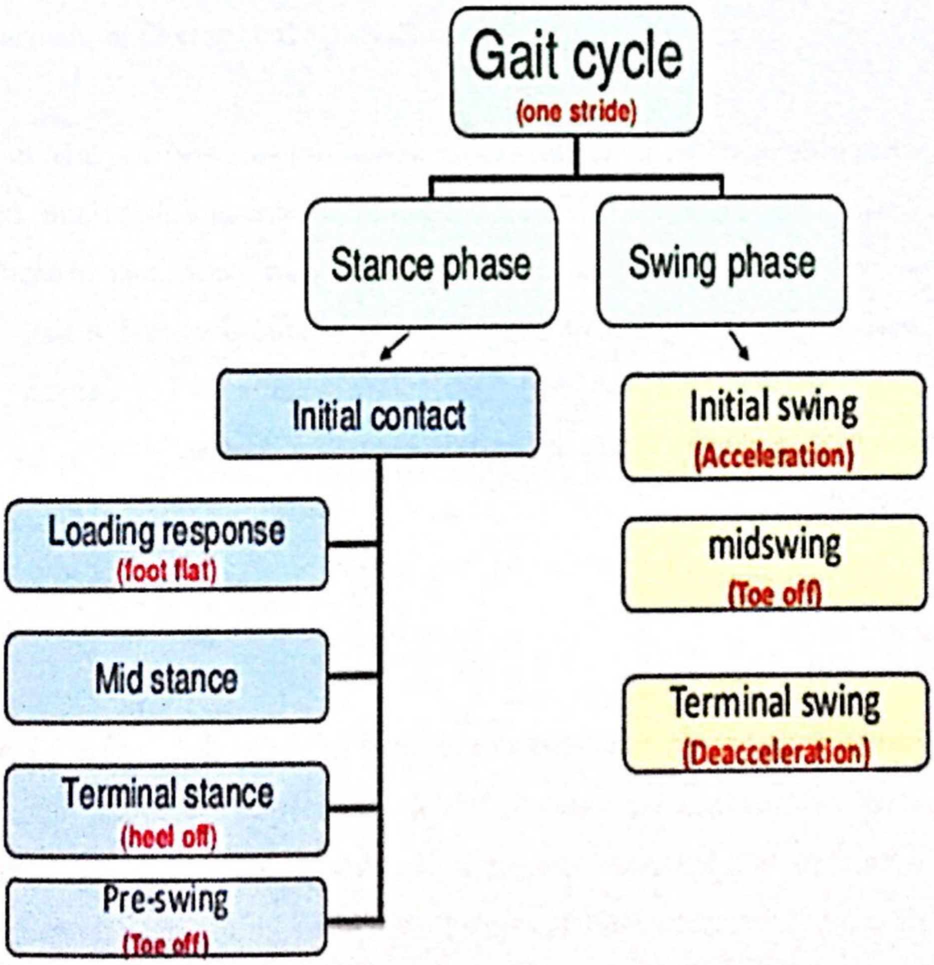

Figure 2.2: Phase of Gait Cycle

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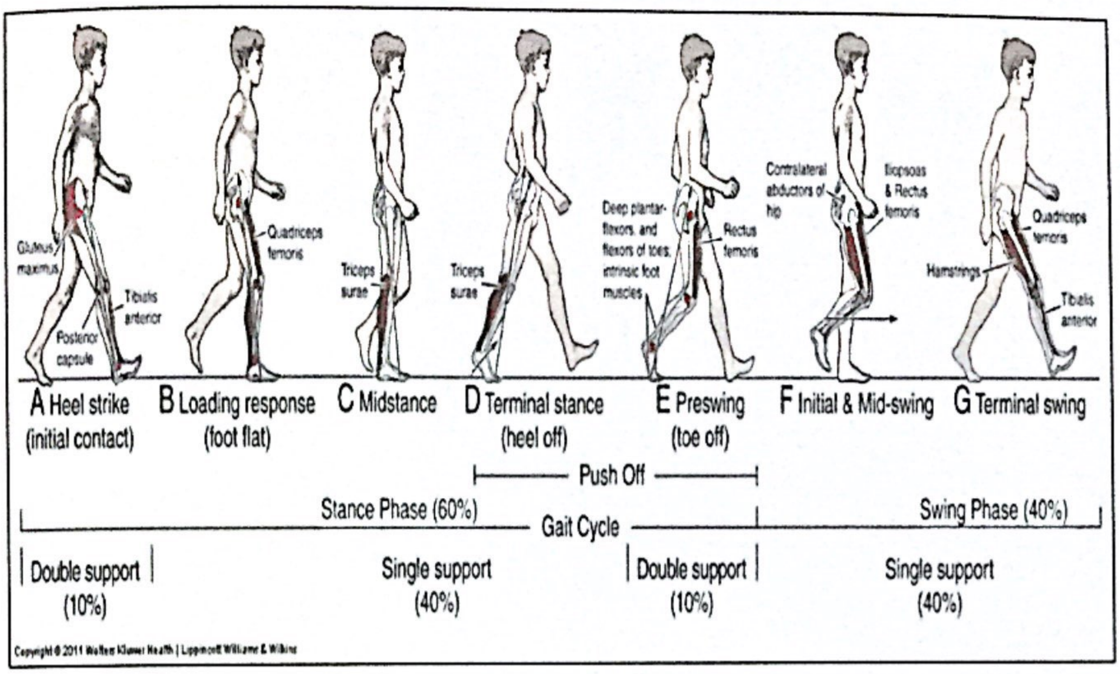

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Figure 2.3: Component of Gait Cycle

2.2 Technique (Temporal Spatial)

Gait analysis involves measurement,[17] where are measurable parameters that introduced, analyzed, and interpretation the data. Which were conclusions about the subject (health, age, size, weight, speed, etc.) are processed. In the gait analysis technique had a few technique that can be use to analyze the data. Which are the temporal spatial, kinematics, markerless gait capture, kinetics, and dynamic electromyography. However only three certain technique that usually researcher used, which are spatiotemporal, kinetics and kinematics. In this study we used the spatiotemporal technique. Temporal-spatial is a measurement that based on time and distance.

Temporal-spatial measures were computed for each gait cycle using the Vicon motion capture data [11]. Spatial means of distance parameters that include of step length and stride length. Temporal means time parameters that include of cadence, speed (velocity), single limb support. Temporal characterization occurs when you have a series of images taken at different time. Correlations between the images are often used to monitor the dynamic changes of the object. Spatial characterization applies when you are analyzing one image. The single gait cycle that most closely

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approximated the individual mean of all gait cycles on these three measures was selected as the trial for analysis [11].

Besides that, based on the research Longwei Chen, there temporal and spatial parameters are significant in clinical assessment. They are visualized and have better clinical explanation, and analysis on the parameters is simple. Therefore, they could be used well clinically. The study analyzed some clinically used indicators in temporal and spatial parameters in children with Cerebral Palsy and Normal children to evaluate walking ability of children with Cerebral Palsy [7]. Their result shown that have the consistent with the past research.

Which are, the average stride length, average left leg step length and right leg step length were 0.25m, 0.13m and 0.12m, which were far lower than 0.70m, 0.35m and 0.35m of ND children. Whereas, average double support phases with left and right leg forward were 26.27s and 27.00s respectively, which were far higher than 8.58s and 9.42s of ND children. It was consistent with other research, which revealed that the parameters could be used for gait analysis [7][10].

In addition, age-related differences in temporal–spatial parameters were expected due to differences in body size and proportion and walking strategies. It based on the late study, similarly, the present study did not find any age-related differences in the sagittal hip, knee, or ankle angles during gait [11]. There is need to use the temporal spatial as a technique for this study which are have many significant due to past research. In order to analyze more flexibility from parameter the spatiotemporal technique. In this study used only six parameter from the spatiotemporal. Which are as a main objective from this study to analyze which temporal-spatial parameter more significant for different gender in young people. Table 2.2 shows the parameter used for this study.

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Table 2.2: Spatiotemporal Parameter

VARIABLE NAME	DESCRIPTION MEAN
Opposite Foot Off (%)	Time of contralateral foot off.
Opposite Foot Contact (%)	Time of contralateral foot contact.
Foot Off (%)	Time of ipsilateral foot off.
Single Support (S)	Within the gait cycle during which the body mass is carried by a single limb; approximately 40% of gait cycle.
Double Support (S)	Approximately 20% of the gait cycle during which both feet are in ground contact.
Stride Time (S)	The time elapsed between the first contact of two consecutive footsteps of the same foot and is expressed in milliseconds.

There is lot of gait analysis experiment and study have been done before and most of them were studying on Temporal Spatial. And because of this, 3D Vicon Capture System on the top chart of method use like the study of "Relationship Between Temporal-Spatial Gait Parameters, Gait Kinematics, Walking Performance, Exercise Capacity, And Physical Activity Level In Peripheral Arterial Disease" by Crowther RG1, Spinks WL, Leicht AS, Quigley F, Golledge J .

Vicon is a typical motion capture space comprises an area the capture volume surrounded by a number of high-resolution cameras. There is some requirements for motion capture space that need to be study. Some of the information relates to the permanent set up, the rest will be useful whether the researcher are working in a permanent space or on location. The area will depend on many factors including:

- The space available – the capture space
- The Vicon system that have been chosen
- The type of motion capture the researcher wish to perform
- Whether they wish to capture analogue data such as Force Plate, EMG or audio

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2.3 Gender Differences

Gender plays an important role in social communication and many social interactions depend greatly on correct gender perception [18]. Which are many of the research focus on the different gender cause its may effect on the clinical application. When compared to males, females are almost twice as likely to sustain a running injury, such as patellofemoral pain syndrome, iliotibial band syndrome or gluteus medius injury [19]. It show that, have different between gender but trough this study hopefully will make the recognicision for early especially for children.

Based on research Dustin A. Bruening, gait differences between sexes are of interest in a variety of clinical applications. In instrumented gait studies, male and female subjects are often pooled for analysis or normative comparisons, yet there may be specific instances that warrant separation. Sex differences exist in many pathology incidence rates such as osteoarthritis, ACL tears, and low back pain. Some of these sex differences may be manifest in gait and thus influence treatment and rehabilitation strategies [20].

In addition, reported by Shiqi Yu, if a computer can recognize gender, it will be very helpful in many applications. For example, gender classification can improve surveillance systems intelligence, analyze customers for store managers, allow robots to perceive gender, etc. Automatic gender classification can be based on face, voice, or gait. Among these consider gait, which is a particular way or manner of walking, and has become an attractive biometric feature detectable at a distance [18]. However, in this study focussed about the gender differences by using the spatiotemporal technique that measured in certains parameter.

Recent studies had discussed in the differences of gait pattern between genders. Based on past research by Min et al., there was no significant difference between gender in cadence but found significant at greater muscle activity at tibialis anterior, higher ankle joint motion and greater vertical ground reaction force during loading response and pre-swing phase as compared to males [21][13]. Reported by, Dustin et al. found a significant difference at cadence

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where females tend to walk faster than males. Most notably, these studies suggested that males exhibit greater torso sway and females greater pelvic obliquity range of motion (ROM) [20][13].

Besides that, a different study by Seung et al. in obesity people had suggested that weight also affects the walking gait pattern. From the result, it is shown that the differences exist at spatiotemporal, range of motion at lower extremity joints as well as in a joint moment [13]. Which are known that between male and female have differents weight related to their habit of diet. Gait-based gender classification is a new and interesting topic. Some researchers have done pioneering work on gender classification [18].

Gait-based gender classification is still immature because of its unique advantages of being noncontact, noninvasive, and easily acquired at a distance, it is gaining increasing interest from researchers [18]. Furthermore, in this study also involved the gender differences between male and female, but more focussed on the gender differences between young people. Their age range between five to twelve years old and it had almost same range ange from past research [2][11].

2.4 Young People

In this study focussed the population of the young people range age between five to tweleve years old. It because based on the previous study A. Moreno, consider that toward the age of 5 and 7, the child gait pattern can have major maturity, some parameters will be modified in subsequent years due to the fact of height and weight increase [2]. It happen because the walking depending how the age increases and related to the height and weight of the human.

So, age the children means at seven years old as a correctly age to get the analyze of data. Based onn the results A. Moreno, he could say that children's gait patterns evolve individually. At about 7 years of age, the child will achieve the

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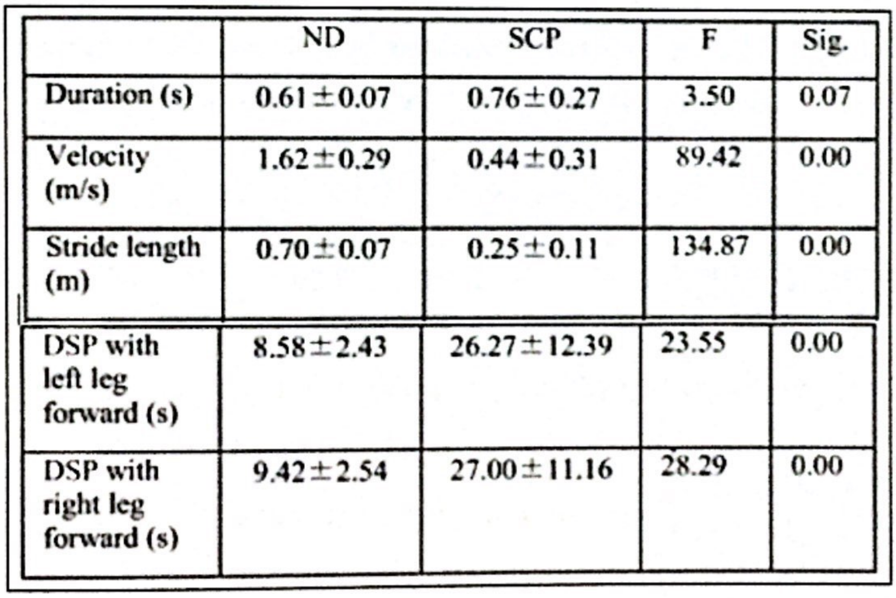
adequate initial heel contact, proper gait progression control, alternation of the pelvic area and synchronization of movement with the thoracic area [2].

The purpose of this study to the enhancement of knowledge in gait studies as well as bring awareness to the public in order to take care the general population especially young people and support the government for intervention and treatment programs. To date, there is limited study has been done on analysis of gait pattern of normal children. However, analysis of gait pattern of normal children very important because it needed to be compared in other analysis. For example, from study Longwei Chen, the average double support phases of children with SCP were 0.41s(left leg) and 0.46s(right leg), which were far more than 0.07s and 0.06s of normal children [7]. Table 2.3 below shows the example for the past result.

Table 2.3: Example past result Temporal Spatial parameter between Cerebral Palsy (SCP) and Normal Children (ND) in stable walking.[6]



	ND	SCP	F	Sig.
Duration (s)	0.61±0.07	0.76±0.27	3.50	0.07
Velocity (m/s)	1.62±0.29	0.44±0.31	89.42	0.00
Stride length (m)	0.70±0.07	0.25±0.11	134.87	0.00
DSP with left leg forward (s)	8.58±2.43	26.27±12.39	23.55	0.00
DSP with right leg forward (s)	9.42±2.54	27.00±11.16	28.29	0.00

Therefore, the doctor know that it was something wrong happen to the Cerebral Palsy children and they can find a strategies makesure the children to heal. So, the result of their research caused by high muscle tension, weak control and balance ability of limbs, low speed and accuracy of posture change for children with SCP, so they have to turn to compensatory mechanism, which is to decrease Single Support Phase and increase Double Support Phase to keep the balance of body, and

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decrease the risk of fall and coordinate next motion [7]. That shown the important of this study with normal children.

The result hopefully provides usefulness on gait analysis of normal children that can improve diagnosis method of normal children based on gait analysis and then be used by physical therapists and doctors to improve performance and also the quality of life for the general population, especially young people. In order to evaluate the specific characteristics of a certain pathological gait pattern, it is necessary to compare it to parameters studied in “normal” individuals, clinically healthy, for each type of population and according to age and gender according to the A. Moreno [2].

In addition, based on the result from the past research by Seung-uk Ko, the findings of this study support and expand evidence about sex differences in gait patterns to older adults. To maintain a normal mean gait speed of 1.1 m/s, older women were found to take shorter and narrower steps than men [22]. In order to analyze more about the gender differences, in this study focussed on the young people than adult.

Prior studies had used young and older population on gait study. Some used for healthy participants, rest consider for pathology gait. Numbers of study had focused on gait analysis for children in healthy participants and pathology studies. However, only a few study had discussed on children gait analysis based on genders' which limit to the gait references for future study [13].

On the other hand, the normal spatio-temporal pattern values reported for populations among 20 and 60 years old, do not coincide with the parameters obtained in this study, so they cannot be used for comparison purposes to analysis data on the gait of unhealthy children [1]. In conclusion, the values that were found in the pediatric gait evaluation are important because they prove that these data is needed to make automatic comparisons that give doctors an objective interpretation of the information displayed from the motion analysis equipments.

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2.5 3D Motion

Motion tracking has been employed by industry for many years but has remained an expensive and difficult process. Specialist equipment and the requirement for a highly controlled environment are obstacles stopping tracking from breaking into the consumer market. Motion capture, or Mocap, is one of the most widely used technologies in the gaming and film industry. It has been featured in a variety of films, such as the X-men series, Alice in Wonderland, and Iron Man and involves a number of lighting and camera specialists, as well as stuntmen to effectively bring the character to light. Figure 2.4 below shows the example 3D motion.

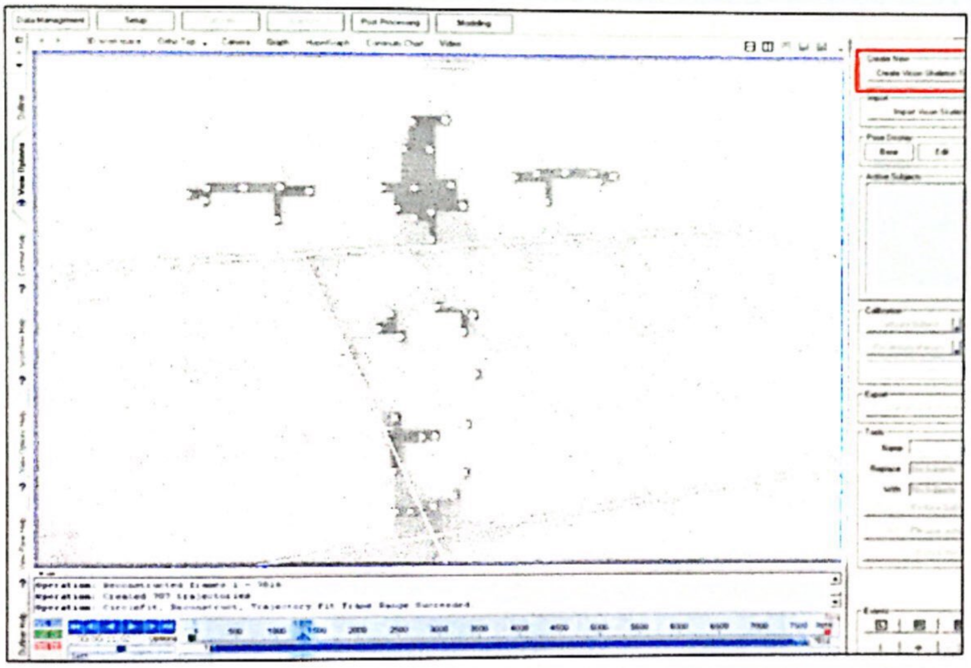

Figure 2.4: Example of 3D Motion analyzed using Vicon System

2.5.1 Motion Capture

It is a means of digitally recording movements or actions of a human being and using it to experiment with different design layouts and themes. Mocap involves taking images from several angles to create a 3D graphical representation of the movement. It was introduced in the mid 90's and has since become a major industry for 3D character design and video animations.

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The process of recording movements of a human being involves a stuntman or actor wearing a number of sensors and markers on a black bodysuit. Whenever the actor or stuntman makes a specific movement, cameras and lighting effects from multiple angles are used to render 2D of 3D figure on a screen. Motion capture is involves digitizing the facial features of an actor for filmmaking or 3D character design.

The actor or stuntman is required to give a variety of facial expressions to denote different emotions, which are then used to give a realistic rendering of the character in animations. In many films, an actor's facial features are used to give a realistic meaning to a character. In the Avengers movie, for instance, Mark Ruffalo's facial attributes, such as hair and cheekbones, were digitally imprinted on to the 3D Hulk rendering. As example shows on the Figure 2.5 , the 3D human motion walking through plane.

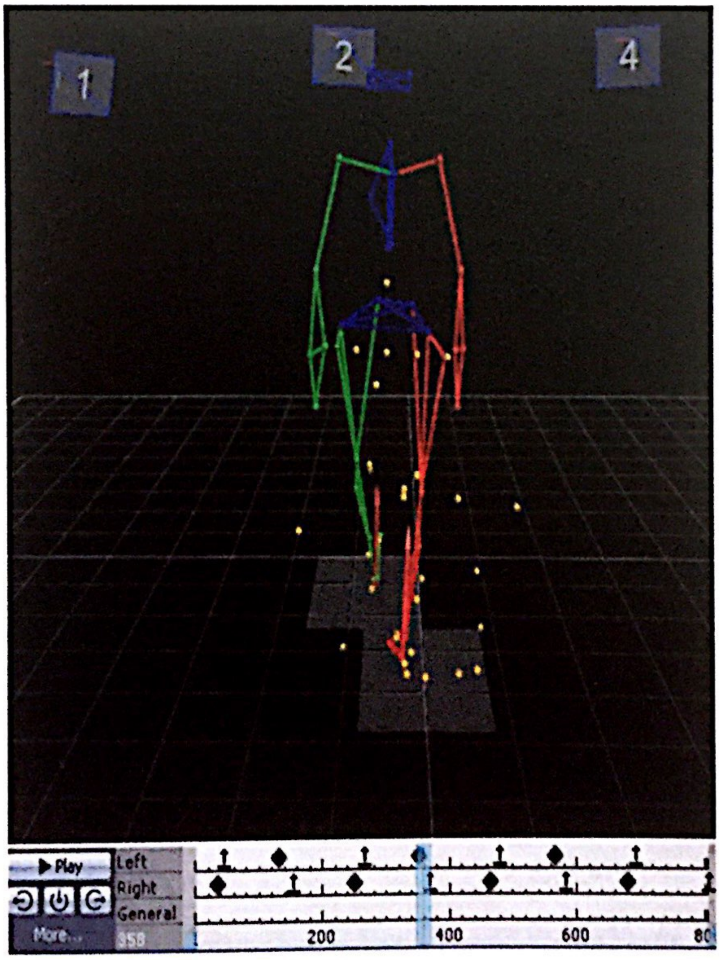

Figure 2.5: Example Of 3D Human Motion Walking Through Plane

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2.5.2 Advantages Of Motion Capture

Cost-Effectiveness
Real-Time Capture
Provides Realistic Animations

Motion capture is extremely cost-effectives as it is incredibly time efficient. This is particularly useful in an industry in which time is money, as the more time is required to make an animation; the more it costs developers. Through motion capture, a movement of an actor or stuntman can be captured only once that can then be changed using different themes and layouts. Usually, the motion capture project is conducted in dedicated studios in which colored walls are used to capture high quality graphical representations for up to multiple hours, thereby reducing costs over the long-term.

Motion capture technology has evolved considerably over the years. In the past, only 2D animations could be produced. But today, it allows developers and designers to capture the minute details of an actor's face, which leads to a duplicate 3D character design on the screen. Sophisticated lighting and camera effects are deployed to capture the dynamics, such as how shadows will appear under different lighting conditions and emotional states of a character.

When a character's facial features need to be captured in a realistic manner, the actor's images are taken from multiple camera angles all at once. This improves the rate at which quality animations could be produced. Additionally, it can also be uploaded on to the computer in real-time, also contributing to higher productivity. Although original technical limitations in clinical gait analysis have been resolved by improvements in modern instrumentation, limitations are still present in the current data collection and reduction protocols.

A newly developed protocol is proposed here, to suggest a potential solution to many of the current issues. This is particularly suitable for children, but it can also be used in adults. The markers necessary for the analysis can be mounted quickly, cause little distress to the subject, and are all tracked easily with five- to eight- camera

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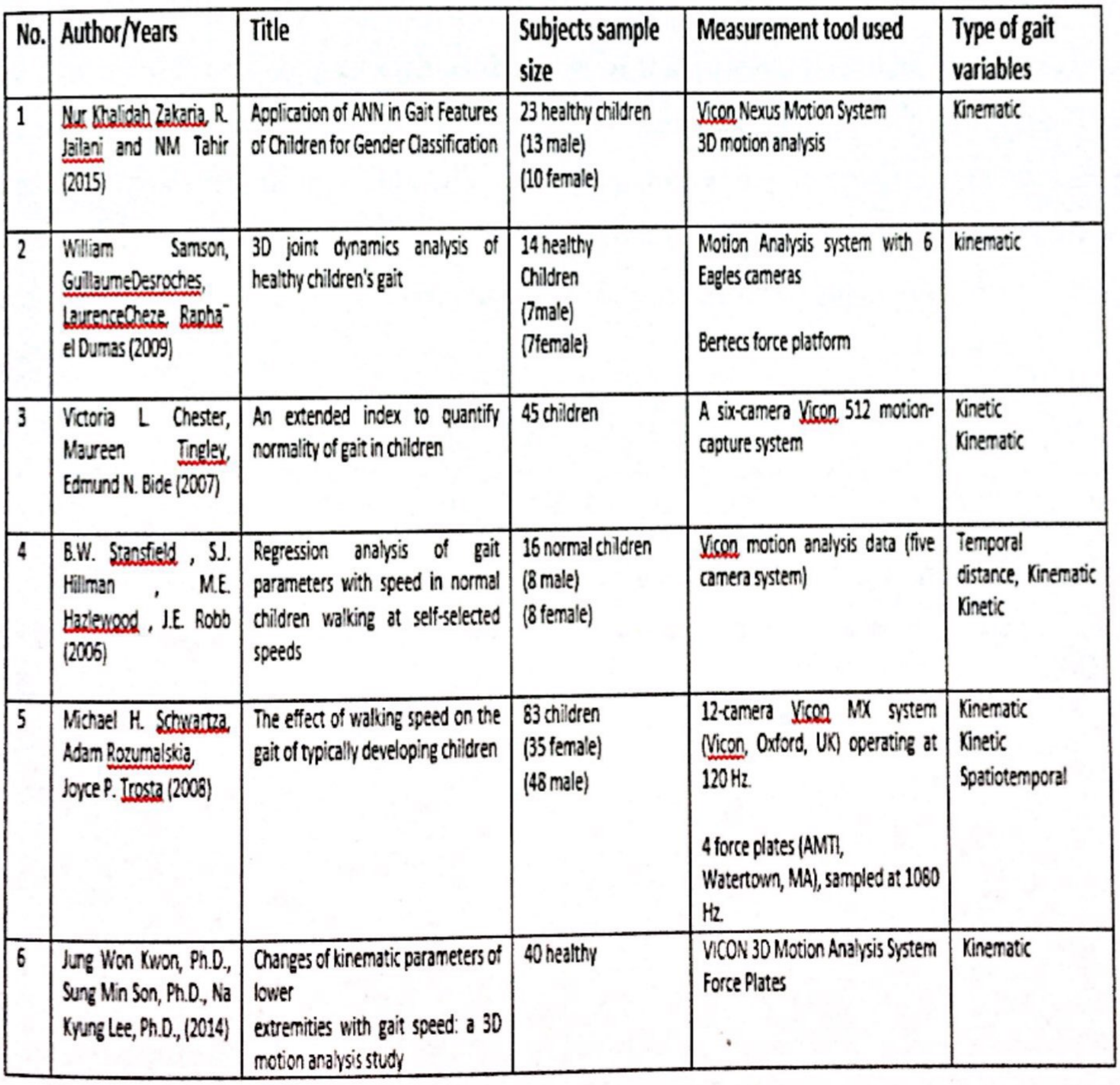
stereophotogrammetric systems. It appears to be also appealing to clinicians because of the familiarity of the skeletal model and marker-set.

As the protocol is based on the identification of anatomical landmarks only, examiner training would only include instructions for landmark palpation. Three-dimensional anatomically based segment and joint motion descriptors, including the foot, are adopted in accordance with recent recommendations. The present preliminary application in a population of healthy children supports its viable implementation in routine clinical gait analysis to a wide range of patient populations. The example shows on the Table 2.4.

Table 2.4: Past Research used the 3D Motion



No.	Author/Years	Title	Subjects sample size	Measurement tool used	Type of gait variables
1	Nur Khalidah Zakaria, R. Jailani and NM Tahir (2015)	Application of ANN in Gait Features of Children for Gender Classification	23 healthy children (13 male) (10 female)	Vicon Nexus Motion System 3D motion analysis	Kinematic
2	William Samson, GuillaumeDesroches, LaurenceCheze, Rapha¨el Dumas (2009)	3D joint dynamics analysis of healthy children's gait	14 healthy Children (7male) (7female)	Motion Analysis system with 6 Eagles cameras Bertecs force platform	kinematic
3	Victoria L Chester, Maureen Tingley, Edmund N. Bide (2007)	An extended index to quantify normality of gait in children	45 children	A six-camera Vicon 512 motion-capture system	Kinetic Kinematic
4	B.W. Stansfield , S.J. Hillman , M.E. Hazlewood , J.E. Robb (2006)	Regression analysis of gait parameters with speed in normal children walking at self-selected speeds	16 normal children (8 male) (8 female)	Vicon motion analysis data (five camera system)	Temporal distance, Kinematic Kinetic
5	Michael H. Schwartza, Adam Rozumalskia, Joyce P. Trosta (2008)	The effect of walking speed on the gait of typically developing children	83 children (35 female) (48 male)	12-camera Vicon MX system (Vicon, Oxford, UK) operating at 120 Hz. 4 force plates (AMTI, Watertown, MA), sampled at 1080 Hz.	Kinematic Kinetic Spatiotemporal
6	Jung Won Kwon, Ph.D., Sung Min Son, Ph.D., Na Kyung Lee, Ph.D., (2014)	Changes of kinematic parameters of lower extremities with gait speed: a 3D motion analysis study	40 healthy	VICON 3D Motion Analysis System Force Plates	Kinematic

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is described and explained about the process and the method for implementing this study with successful. The detail explanations of the methodology are explained in this chapter such as the flow of this project, how data collection was taken for this research, and how to analyze the data using the Matlab Software. The data was analyzed using probability function, histogram distribution, culmulative distribution function, canonical correlation, cross correlation and t-test. In addition, this study also do some of the Graphical User Interface (GUI) application.

3.2 Flow Chart

Flow Chart below had shown that the whole process of implementing this study and it has been described with detail explanation for every step of the process. The process include everything of all in this research.

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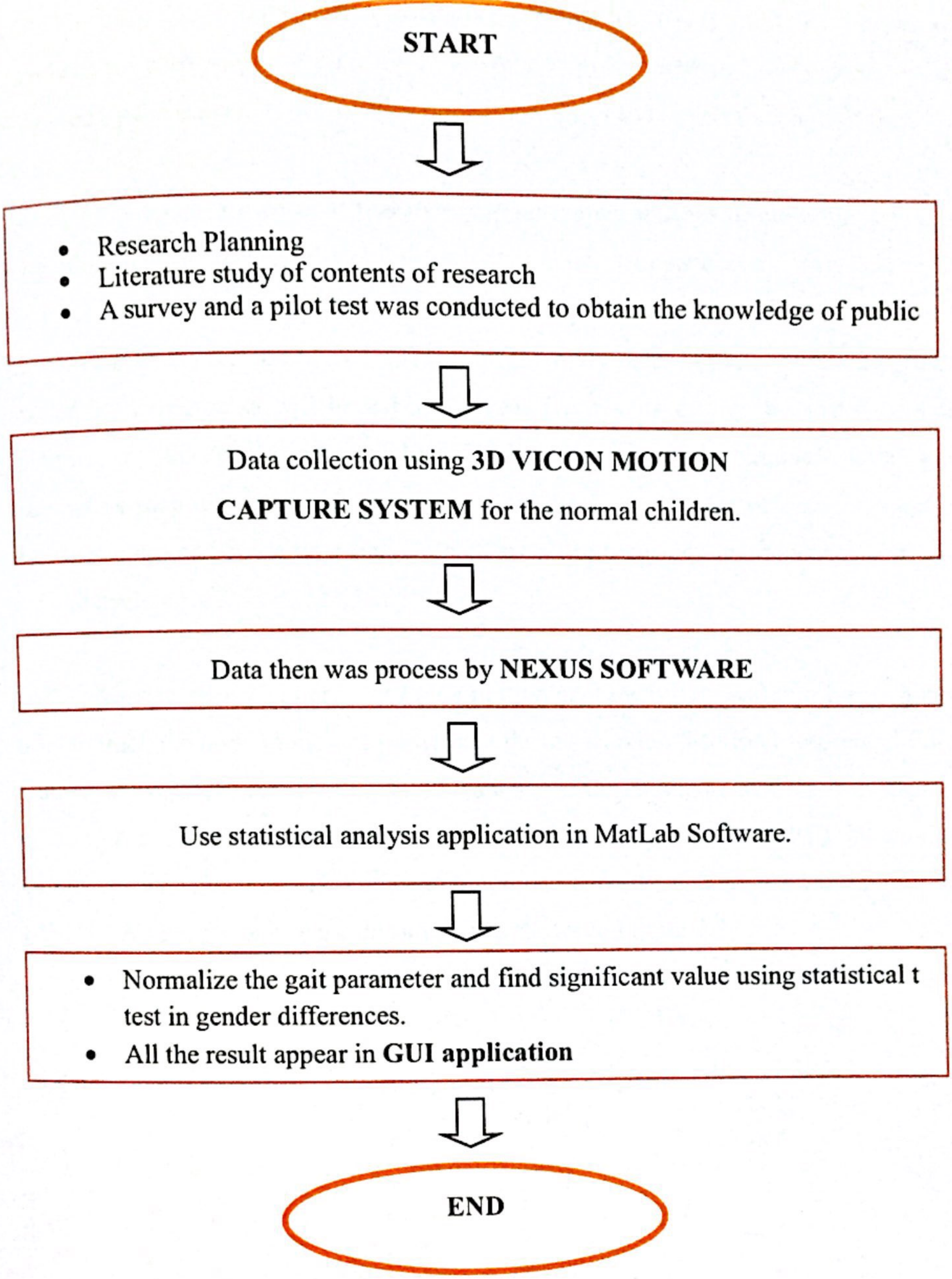

Figure 3.1: Flow Chart of Project

In this study, data collection will be conducted at the motion analysis lab. Temporal-spatial data at lower limb have been collected using Vicon Nexus motion system and all data collection have been carried out at Human Motion and Gait Analysis Laboratory, Universiti Teknologi MARA (UiTM) Shah Alam. 32 healthy

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children consist of 16 boys and 16 girls were participated in this study. All parents or guardians for each subject are informed the related procedures and study protocols as approved by the university Research Ethics Board prior to signing the consent form.

All subjects are ensured that there are no known injuries or abnormalities that may affect their gait. Basically, subject physiological data such as age (year), weight (kg) and height (cm) are measured before the experiments are carried out. Several reflective markers will be placed directly on the body of each participant's hip, knee and ankle. Participants will be asked to wear *lycra* suits during the experiment to minimize marker occlusion [11][23]. This study measured temporal-spatial gait parameters such as opposite foot contact, opposite foot off, foot off, single support, double support and stride time only. Which are more focussing on the stance phace of the gait cycle.

After that, an eight camera *Vicon* motion capture system and two forces plates used to track the body motion of participant during walking. Motion capture and force plate data were collected using eight cameras, 100Hz Vicon MX motion capture system, and two AMTI force plates. Ground reaction forces (GRF) lateral Fx, horizontal Fy, and vertical Fz were recorded using two force sensing platforms (AMTI). All the procedure for this study has shows in Figure 3.2.

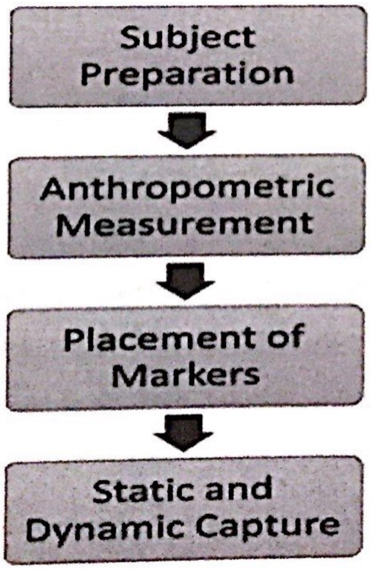

Figure 3.2: Overview of Experiment Procedure Using Vicon 3D Motion Capture System

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After the practice trials, participants were asked to walk at pathway given for about 3 meters without any help from others. A three-dimensional image of lower limb tracks by motion capture cameras. There will be a need to preprocessing walking gait data that gathered from the experiment in order to remove unwanted noise. It also can exclude missing or invalid data. By using Nexus Software, that is a data processing engine has been completely re-engineered to significant speed and accuracy improvements when processing data.

The new data processing engine also allows real-time subject calibration feedback and automatically initializes labeling subject. As a result, data that presented not bias and reliability to use for the next analysis. The Matlab Software will be used to analyze the data of this study. Advanced signal processing techniques will be used to analyze data obtained after the preprocessing procedure. Then statistical analysis will be applied to evaluate the distribution of the data obtained.

3.3 3D Vicon Capture System

A typical motion capture space comprises an area the capture volume surrounded by a number of high-resolution cameras. Each camera has a ring of LED strobe lights fixed around the lens. The T10 offers an impressive resolution of 1 megapixel, captures 10-bit grayscale using 1120 x 896 pixels and can capture speeds of up to 2,000 frames per second.

Not only that, the T10 is capable of capturing 250 frames per second at full frame resolution (1 megapixel), offering a significantly improved performance over its predecessor. The subject, whose motion is to be captured, has a number of reflective markers attached to their body, in well-defined positions. As the subject moves through the capture volume, light from the strobe is reflected back into the camera lens and strikes a light sensitive plate creating a video signal. The example of LED light shows on the Figure 3.3.

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Figure 3.3: LED Camera Used For Captured Motion

The Vicon Data station controls the cameras and strobes and also collects these signals, along with any other recorded data (sound or analog signals from force plates for gait analysis). It then passes them to a computer on which the Vicon software suite is installed. Motion capture is the process of recording the movement of objects or people. The technology originated in the life science market for gait analysis but is now used widely by sports therapists, neuroscientists and for validation and control of computer vision and robotics. The Figure 3.4 below shows the block diagram of the 3D Vicon System. Then, the Figure 3.5 shows the orthogonal 3D view.

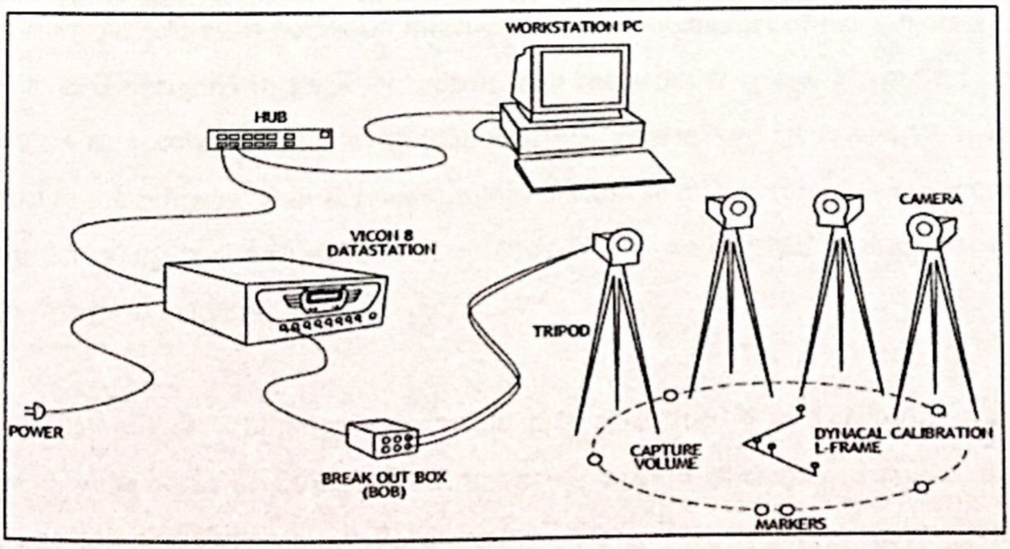

Figure 3.4: Block diagram of the 3D Vicon system.

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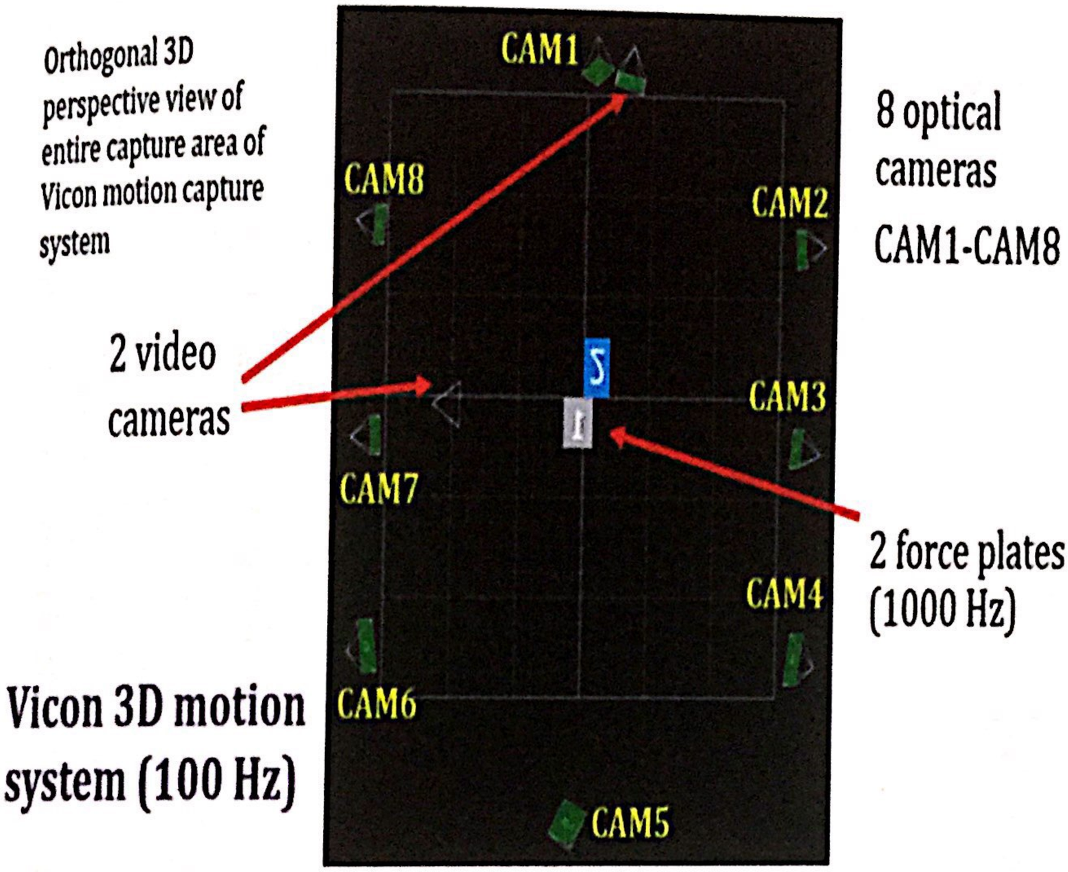

Figure 3.5: Orthogonal 3D Perspective View of Entire Capture Area Of Vicon Motion Capture System

3.4 Marker Placement

The spheres coated in the retro-reflective tape are known as markers. We use them as visual reference points on different parts (or segments) of the subject's body and Vicon is designed to track and reconstruct them in 3D space. Movement of the walking was recorded using a motion analysis system via 16 reflective markers adhered to the subjects' skin at lower limb joints and segments (hip, knee, and ankle). Where necessary, we will differentiate between real and virtual (simulated within Vicon software) markers.

They rely on calibration movements to be performed before capturing walking data and some form of fitting of the measured marker positions to an underlying model of how the body moves [9]. By using Optical-Passive, this technique used to

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retroreflective markers that are tracked by infrared cameras. The Figure 3.6 shows the example in the marker placement and the Figure 3.7 shows the example of retro reflective marker.

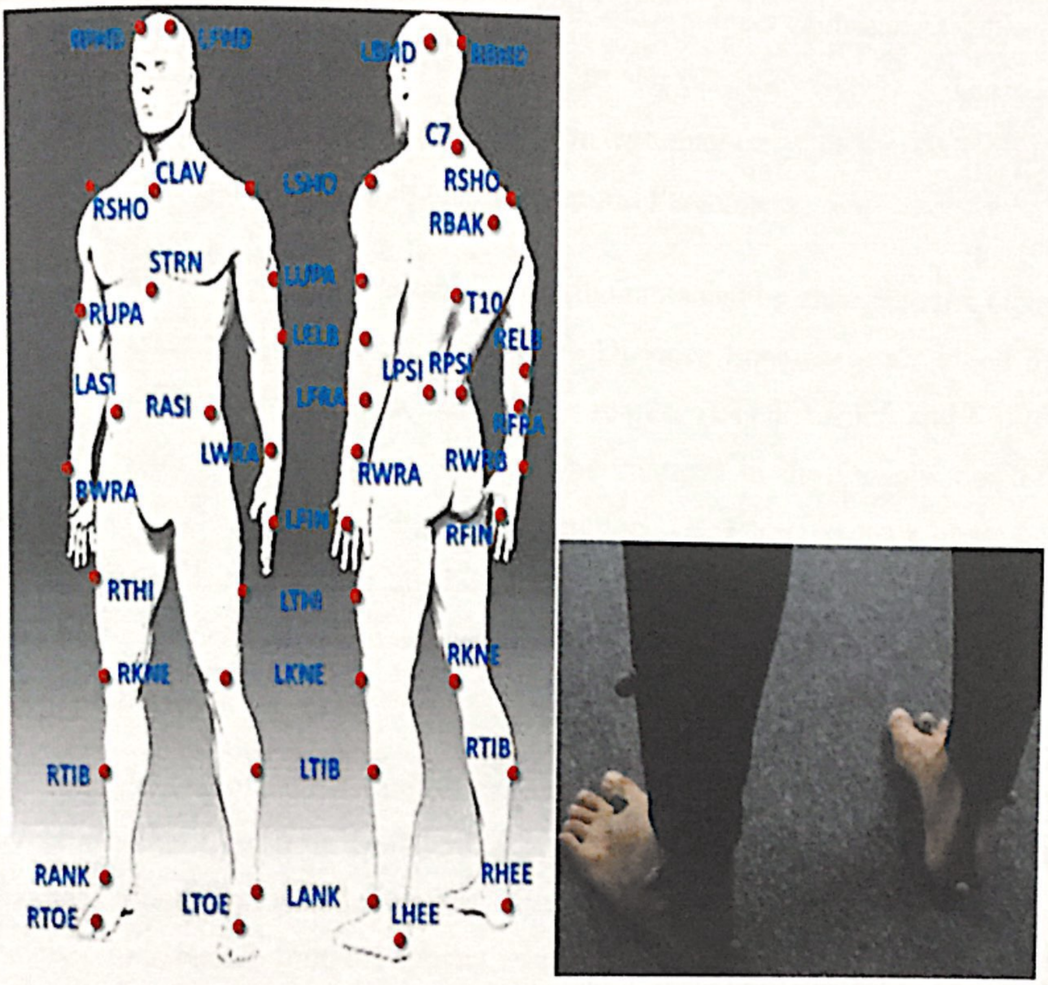

Figure 3.6: Example of Marker Placement

Figure 3.7: Example of Retro Reflective Marker Used in This Study

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3.5 Nexus Software System

Nexus Software is the data processing engine has been completely re-engineered to significant speed and accuracy improvements when processing data. The new data processing engine also allows real-time subject calibration feedback and automatically initializes labelling subject. In Nexus the Generate Gait Cycle Parameters Pipeline Operation can be used in conjunction with the Gait events to calculate standard Gait Cycle Spatial and Temporal Parameters.

These Parameters and available units (the units can be change in the Generate Gait Cycle Parameters Options box) are: The Distance Parameters are based in the marker position at the time, by default the toe marker (LTOE for left and RTOE for right) is used for the calculation. This can be changed in the Options box of the Generate Gait Cycle Parameters Pipeline Operation. The Parameters are based on the first cycle for each side where all the necessary events are found. Polygon can re-calculate the parameters and can define the parameters in the first cycle or the average of all defined cycles.

Foot contact/off events are all expressed relative to the ipsilateral gait cycle, either as absolute time from ipsilateral foot contact or as %GC, as per the Polygon preference. Single and double support calculations are only valid for walking, i.e. when the contralateral foot off/contact events happen within the ipsilateral stance phase.

i. **Stride time:** time between successive ipsilateral foot strikes.
ii. **Foot off:** time of ipsilateral foot off.
iii. **Opposite foot contact:** time of contralateral foot contact.
iv. **Opposite foot off:** time of contralateral foot off.
v. **Single support:** time from contralateral foot off to contralateral foot contact.
vi. **Double support:** time from ipsilateral foot contact to contralateral foot off plus time from contralateral foot contact to ipsilateral foot off.

All distance and speed measurements use a reference marker on each foot, by default the LTOE/RTOE markers, but this can be changed in the preferences. The

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marker's position is evaluated in 3D at the time of the events. Figure 3.8 below shows the example of 3D images of lower limb.

Four 3D points are defined:

i. IP1 is the ipsilateral marker's position at the first ipsilateral foot contact.
ii. IP2 is the ipsilateral marker's position at the second ipsilateral foot contact.
iii. CP is the contralateral marker's position at the contralateral foot contact.
iv. CPP is CP projected onto the IP1 to IP2 vector.

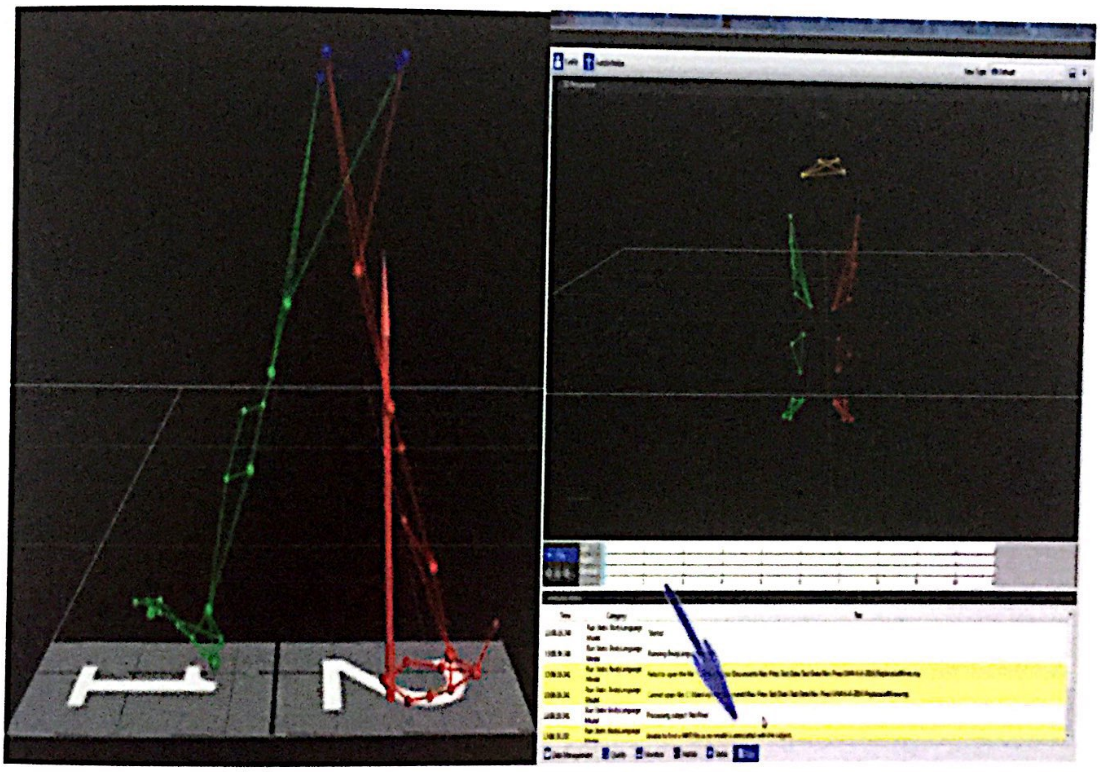

Figure 3.8: Three-Dimensional Image of Lower Limb Tracks By 3D Motion Capture Camera.

3.6 Matlab Software

The MATLAB high-performance language for technical computing integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include :

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i. Math and computation
ii. Algorithm development
iii. Data acquisition
iv. Modeling, simulation, and prototyping
v. Data analysis, exploration, and visualization
vi. Scientific and engineering graphics
vii. Application development, including graphical user interface building

MATLAB or known as a matrix laboratory, is a multi-paradigm numerical computing environment and fourth-generation programming language. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing abilities. MATLAB is the easiest and most productive software for engineers and scientists. Whether you're analyzing data, developing algorithms, or creating models, MATLAB provides an environment that invites exploration and discovery. It combines a high-level language with a desktop environment tuned for iterative engineering and scientific workflows.

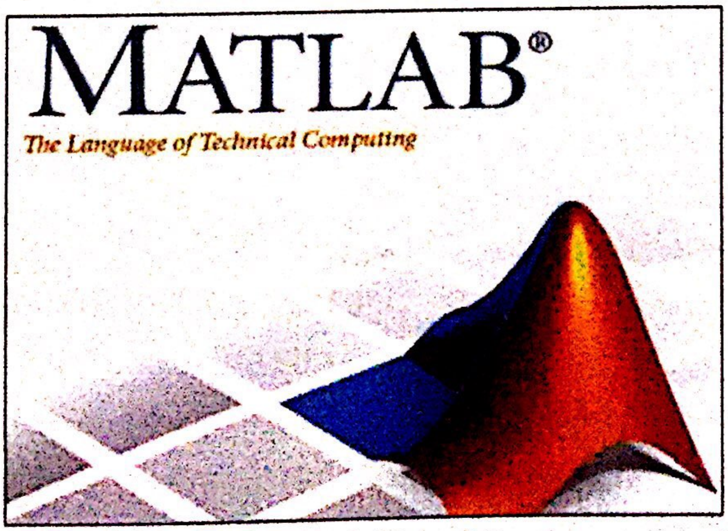

Figure 3.9: Matlab Software

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An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems. MATLAB supports developing applications with graphical user interface (GUI) features. MATLAB includes GUIDE (GUI development environment) for graphically designing GUIs. It also has tightly integrated graph-plotting features. In addition, in this study will be used the Matlab Software to do the programming for analyze the data and do some the GUI application.

3.7 Pilot Test

A pilot study or test is usually carried out on members of the relevant population, but not on those who will form part of the final sample. This is because it may influence the later behavior of research subjects if they have already been involved in the research. A pilot test is often used to test the design of the full-scale experiment which then can be adjusted. It is a potentially valuable insight and should anything is missing in the pilot test it can be added to the full-scale (and more expensive) experiment to improve the chances of a clear outcome.

Often in engineering applications, pilot experiments are used to sell a product and provide quantitative proof that the system has the potential to succeed on a full-scale basis. Pilot experiment are also used to reduce cost, as they are less expensive than full experiments. If there is not enough reason to provide full-scale applications, pilot studies can generally provide this proof. In this research, the pilot test was used to know the relevant issues like costing and the number of subject. So, it will relevant to continue this study with large number of subject.

3.8 METHOD FOR DATA ANALYSIS

In this research, for data analysis used the reliability test and validity test. Reliability refers to the repeatability of findings. If the study were to be done a second time. If so, the data are reliable. If more than one person is observing behavior or

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some event, all observers should agree on what is being recorded in order to claim that the data are reliable. In order to get the data that reliable, this research used the reliability test which are to evaluate the data obtained is stable and consistent. For the reliability test, histogram distribution, probability plot and culmulative distribution functions was used.

Besides that, validity refers to the credibility or believability of the research. In order to do the good research, the validity test used. Which are the validation test used to find effectiveness the research through the parameter measured. For validity test, cross correlation and canonical correlation was used.

3.8.1 Histogram Distribution

The histogram distribution function used to check the reliability test. Purpose of the histogram to roughly assess the probability distribution of a given variable by depicting the frequencies of observations occurring in certain ranges of values. A histogram is a plot that lets discover, and show, the underlying frequency distribution (shape) of a set of continuous data. This allows the inspection of the data for its underlying distribution (e.g., normal distribution), outliers, or skewness.

A histogram is a graphical representation of the distribution of numerical data. It is an estimate of the probability distribution of a continuous variable (quantitative variable) and was first introduced by Karl Pearson. It is a kind of bar graph. In order to construct a histogram from a continuous variable, firstly the data needed to split the data into intervals, called bins. For the data set, the frequencies in each bin have been tabulated along with the scores that contributed to the frequency in each bin. Histograms are sometimes confused with bar charts. A histogram is used for continuous data, where the bins represent ranges of data, while a bar chart is a plot of categorical variables.

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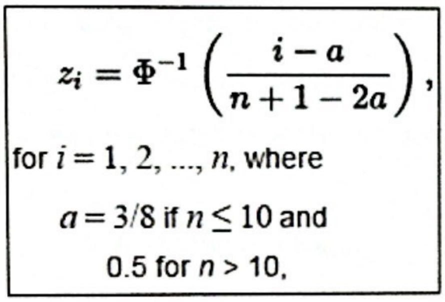
3.8.2 Probability Plot

In statistics, a probability plot is a graphical technique for comparing two data sets, either two sets of empirical observations, one empirical set against a theoretical set, or (more rarely) two theoretical sets against each other. A probability plot is graph that can use to evaluate the fit of a distribution to data, estimate percentiles, and compare different sample distributions.

The normal probability plot is formed by plotting the sorted data versus an approximation to the means or medians of the corresponding order statistics; see rankit. Some users plot the data on the vertical axis and others plot the data on the horizontal axis. Different sources use slightly different approximations for rankits. The formula used by the "qqnorm" function in the basic "stats" package in R (programming language) is as follows shows on the Figure 3.10.



$$z_i = \Phi^{-1}\left(\frac{i-a}{n+1-2a}\right),$$

for $i = 1, 2, \ldots, n$, where

$a = 3/8$ if $n \leq 10$ and

0.5 for $n > 10$.

Figure 3.10: Equation for Probability Plot

If the data are consistent with a sample from a normal distribution, the points should lie close to a straight line. As a reference, a straight line can be fit to the points. The further the points vary from this line, the greater the indication of departure from normality. If the sample has mean 0, standard deviation 1 then a line through 0 with slope 1 could be used. With more points, random deviations from a line will be less pronounced.

Normal plots are often used with as few as 7 points, e.g., with plotting the effects in a saturated model from a 2-level fractional factorial experiment. With fewer points, it becomes harder to distinguish between random variability and a substantive deviation from normality. Probability plots for distributions other than the normal are

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computed in exactly the same way. The normal quantile function $\Phi-1$ is simply replaced by the quantile function of the desired distribution.

In this way, a probability plot can easily be generated for any distribution for which one has the quantile function. With a location-scale family of distributions, the location and scale parameters of the distribution can be estimated from the intercept and the slope of the line. For other distributions the parameters must first be estimated before a probability plot can be made.

3.8.3 Culmulative Distribution Functions

The cumulative distribution function (CDF) of a random variable is another method to describe the distribution of random variables. The advantage of the CDF is that it can be defined for any kind of random variable (discrete, continuous, and mixed). In probability theory and statistics, the cumulative distribution function (CDF) of a real-valued random variable X, or just distribution function of X, evaluated at x, is the probability that X will take a value less than or equal to x. The cumulative distribution function (cdf) is the probability that the variable takes a value less than or equal to x. That is :

$$F(x)=Pr[X\leq x]=\alpha$$

For a continuous distribution, this can be expressed mathematically as

$$F(x)=\int x-\infty f(\mu)d\mu$$

For a discrete distribution, the cdf can be expressed as

$$F(x)=\sum xi=0f(i)$$

The following is the plot of the normal cumulative distribution function. The horizontal axis is the allowable domain for the given probability function. Since the vertical axis is a probability, it must fall between zero and one. It increases from zero to one as we go from left to right on the horizontal axis. The concept of the cumulative distribution function makes an explicit appearance in statistical analysis in two (similar) ways. Cumulative frequency analysis is the analysis of the frequency of occurrence of values of a phenomenon less than a reference value.

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The empirical distribution function is a formal direct estimate of the cumulative distribution function for which simple statistical properties can be derived and which can form the basis of various statistical hypothesis tests. Such tests can assess whether there is evidence against a sample of data having arisen from a given distribution, or evidence against two samples of data having arisen from the same (unknown) population distribution.

3.8.4 Cross Correlation

Cross-correlation is a measure of similarity of two series as a function of the displacement of one relative to the other. This is also known as a sliding dot product or sliding inner-product. Thus, we can also implement cross correlation with convolution. Auto-correlation is a measure of similarity of a function to itself at time-lag and t is commonly used for searching a long signal for a shorter, known feature. The term cross-correlations is used for referring to the correlations between the entries of two random vectors X and Y, while the correlations of a random vector X are considered to be the correlations between the entries of X itself. It is a time domain analysis useful for determining the periodicity or repeating patterns of a signal. Figure 3.11 shows the formula of the cross correlation.

$$\boxed{r_{xy} = \frac{\sum_{i=1}^{n}(x(i)-\bar{x})(y(i)-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x(i)-\bar{x})^2 \sum_{i=1}^{n}(y(i)-\bar{y})^2}}}$$

Figure 3.11: Formula for Cross Correlation

3.8.4 T-test

A t-test is a hypothesis test of the mean of one or two normally distributed populations. An important property of the t-test is its robustness against assumptions of population normality. In other words, t-tests are often valid even when the assumption of normality is violated, but only if the distribution is not highly skewed. This property makes them one of the most useful procedures for making inferences

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about population means. However, with nonnormal and highly skewed distributions, it might be more appropriate to use nonparametric tests.

Paired Sample T-Test

The paired sample t-test, sometimes called the dependent sample t-test, is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. In a paired sample t-test, each subject or entity is measured twice, resulting in pairs of observations. Common applications of the paired sample t-test include case-control studies or repeated-measures designs.

One approach it might consider would be to measure the performance of a sample before and after completing the research, and analyze the differences using a paired sample t-test. Paired sample t-test on their mean length with the following hypotheses:

H 0: $\mu = 0$ (the mean length of all parts meets the target value)
H 1: $\mu \neq 0$ (the mean length of all parts does not meet the target value)

i. **Null Hypothesis**

In a statistical test the hypothesis that there is no significant difference between specified populations, any observed difference being due to sampling or experimental error.

ii. **P-value.**

The P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is a t statistic, use the t Distribution Calculator to assess the probability associated with the t statistic, having the degrees of freedom computed above.

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Paired Sample t-Test using Matlab Software

In this research the paired sample t-test was used to analyze the data of Temporal-Spatial between males and females for young people. The t-test was calculate by using the Matlab Software. The command for the t-test using the Matlab Software shown as below in Table 3.1.

```
load('OVERALLPARAMETER1.mat')
x = OVERALLPARAMETER1(:,1);
y = OVERALLPARAMETER1(:,2);
[h,p]= ttest(x,y)
```

Table 3.1: Example Command Used In Matlab Programming For T-Test

Command	Meaning
h =ttest(x,y)	Returns a test decision for the null hypothesis that the data in x – y comes from a normal distribution with mean equal to zero and unknown variance, using the paired-sample t-test.
[h,p] = ttest(___)	Returns the *p*-value, p, of the test, using any of the input arguments from the previous syntax groups.

Statistical Significance

Statistical significance is determined by looking at the p-value. The p-value gives the probability of observing the test results under the null hypothesis. The lower the p-value, the lower the probability of obtaining a result like the one that was observed if the null hypothesis was true. Thus, a low p-value indicates decreased support for the null hypothesis.

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However, the possibility that the null hypothesis is true and that we simply obtained a very rare result can never be ruled out completely. The cutoff value for determining statistical significance is ultimately decided on by the researcher, but usually a value of .05 or less is chosen. This corresponds to a 5% (or less) chance of obtaining a result like the one that was observed if the null hypothesis was true.

3.9 Graphic User Interface (GUI)

A graphical user interface (GUI) is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable and predictable manner, so that a user knows what to expect when he or she performs an action.

For example, when a mouse click occurs on a pushbutton, the GUI should initiate the action described on the label of the button. A graphical user interface provides the user with a familiar environment in which to work. This environment contains pushbuttons, toggle buttons, lists, menus, text boxes, and so forth, all of which are already familiar to the user, so that he or she can concentrate on using the application rather than on the mechanics involved in doing things.

However, GUIs are harder for the programmer because a GUI-based program must be prepared for mouse clicks (or possibly keyboard input) for any GUI element at any time. Such inputs are known as events, and a program that responds to events is said to be event driven. The three principal elements required to create a MATLAB Graphical User Interface are components. Which each item on a MATLAB GUI (pushbuttons, labels, edit boxes, etc.) is a graphical component.

The types of components include graphical controls (pushbuttons, edit boxes, lists, sliders, etc.), static elements (frames and text strings), menus, and axes. Graphical controls and static elements are created by the function uicontrol, and menus are created by the functions uimenu and uicontextmenu. Axes, which are used

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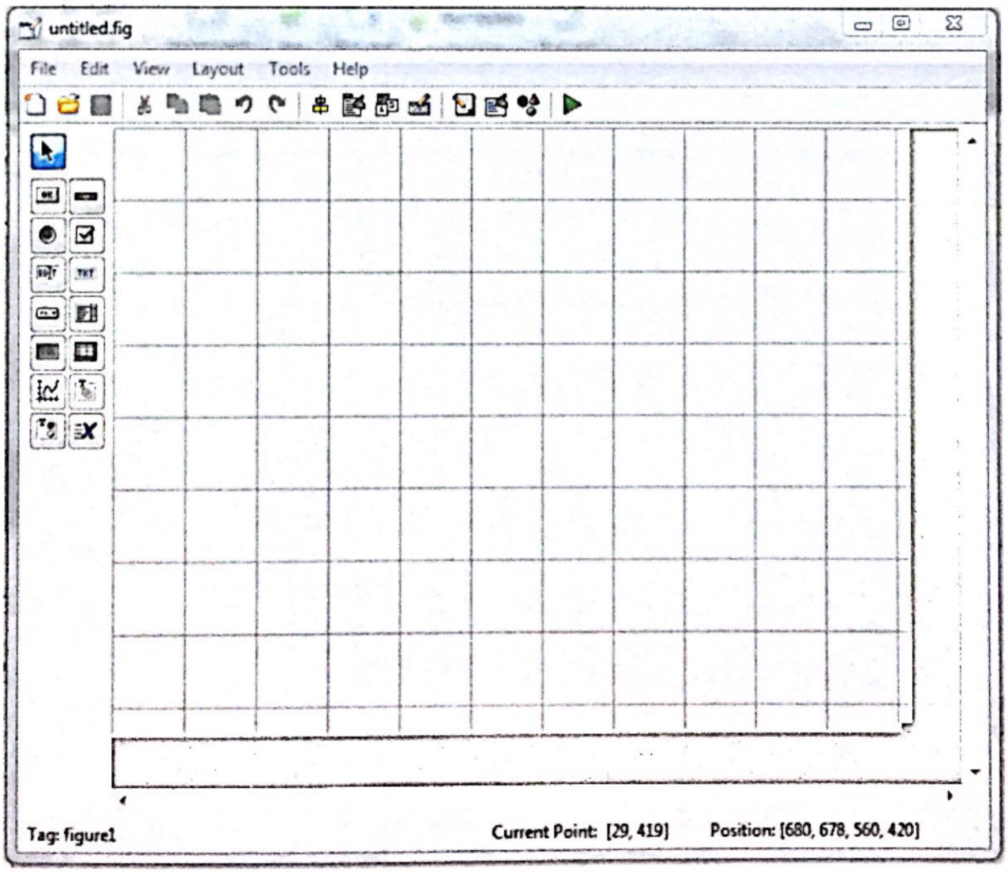
to display graphical data, are created by the function axes. After that the figues, as a components of a GUI must be arranged within a figure, which is a window on the computer screen. In the past, figures have been created automatically whenever we have plotted data. However, empty figures can be created with the function figure and can be used to hold any combination of components.

Finally callback, which used there must be some way to perform an action if a user clicks a mouse on a button or types information on a keyboard. A mouse click or a key press is an event, and the MATLAB program must respond to each event if the program is to perform its function. For example, if a user clicks on a button, that event must cause the MATLAB code that implements the function of the button to be executed. The code executed in response to an event is known as a call back. There must be a callback to implement the function of each graphical component on the GUI. As example Figure 3.12 shows the GUI in Matlab Application.



Tag: figure1

Current Point: [29, 419]

Position: [680, 678, 560, 420]

Figure 3.12: Example of Graphic User Interface (GUI) in Matlab Application

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So, for this study the GUI application used to appear the result of all data subject. In order to make the easiest way to show the result to the people. Graphic User Interface have the advantage which are is that it works without prior knowledge. For example, when do the programming need to know certain keywords of a language but in GUI just click the button only and its show the result. Besides that, GUIs allow to steer focus. Humans react to certain visual cues, for example focusing on movement. This allows to highlight important information. It is important to find the easiest way nowday.

3.10 Costing Of The Research

The costing of the project overall about RM500.00 for rented the Human Motion Analysis Research Laboratory for this study.

Table 3.2: Cost of the Research

BIL	DESCRIPTION	PRICE (RM)
1	Rent of Human Motion Analysis Research Laboratory, Faculty of Electrical Engineering, UiTM Shah Alam	RM500.00

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CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter covers the the findings, analysis and discussion of the data/testing. It shown the result from our collected data such as questionnaire and the data is analysed and generated graph by using Microsoft Excel and Matlab Software. The data was analyzed using probability function, histogram distribution, culmulative distribution function, canonical correlation, cross correlation and t-test. In addition, this study also do some of the Graphical User Interface (GUI) application. Then the result that analysed is discussed in this chapter.

4.2 Questionnaire

Through this part, the questionnaire is conducted among fifty public respondent area of TTDI Jaya Shah Alam and Section 13 Shah Alam. Apart from that, all the data in the survey form is tabulated in graph bar below. As overall, through the data collected from this questionnaire showed positive feedback in this study. The result of the questionnaire shown on the Figure 4.1 and Figure 4.2.

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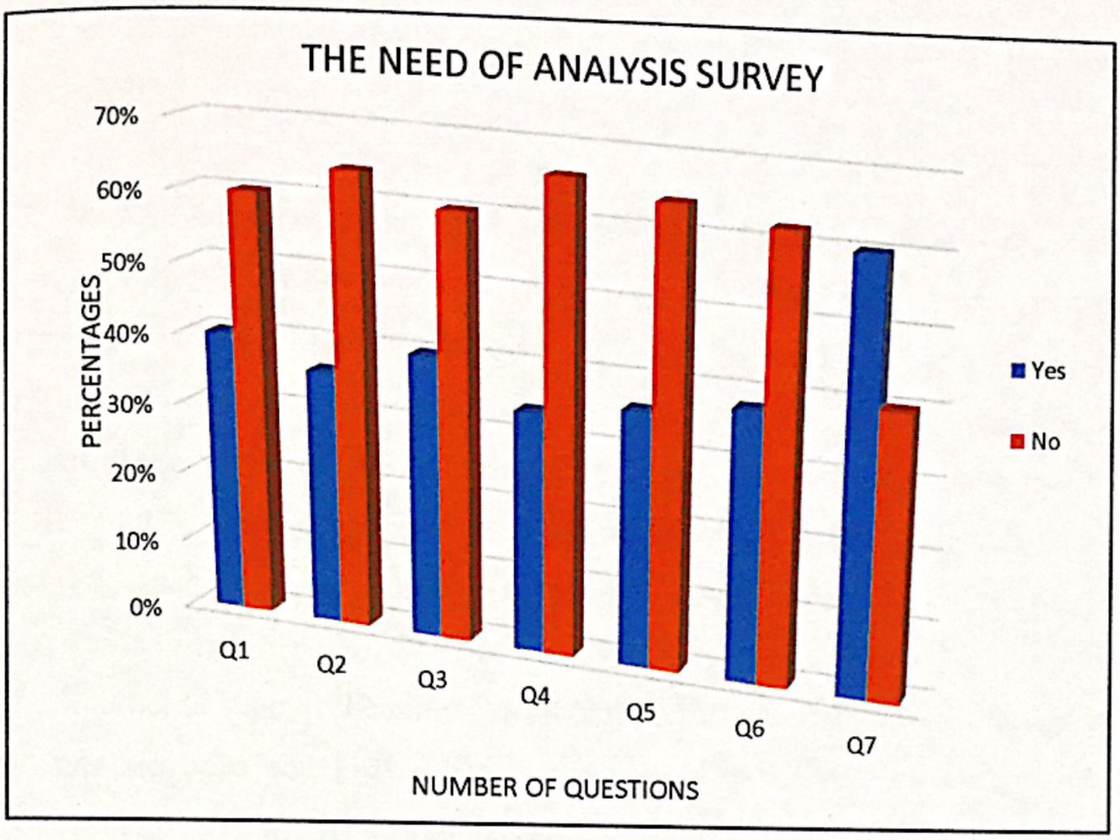

Figure 4.1: Graph the Need of Analysis Survey

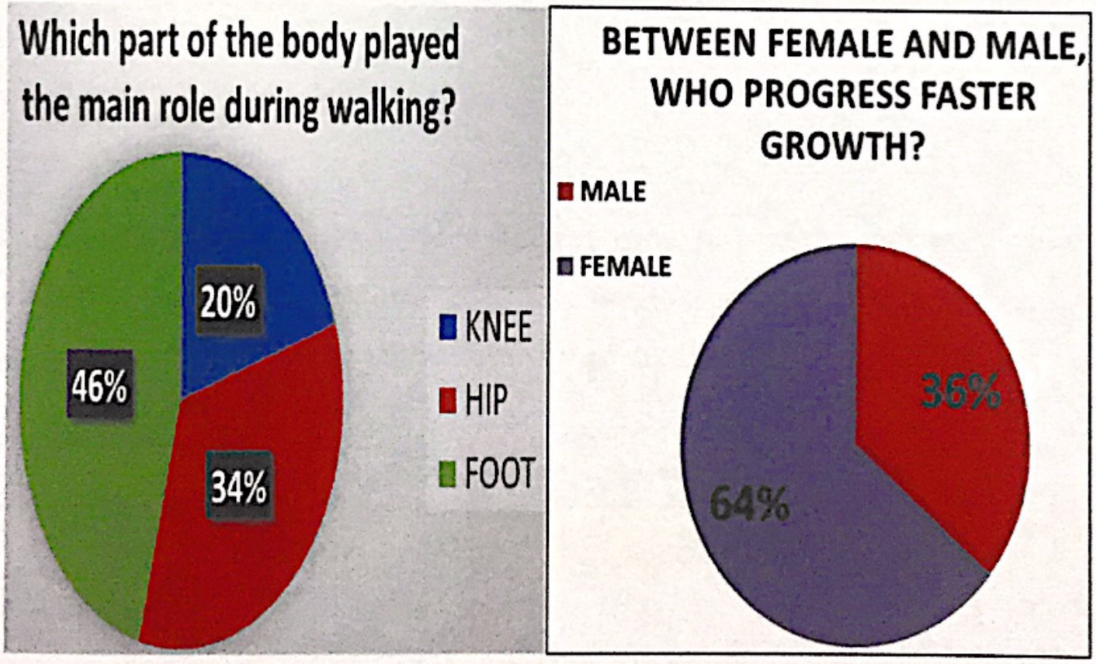

Figure 4.2: Graph of Questionnaire

Based on data collection that had answered from the public respondent. The average respondent answered the questions as expected. Most respondents did not know about methods and techniques in this research. This indicates that the current

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knowledge on the methods, technologies and ways of this study are less (66%). This shows that the importance of this research to help children in order to ensure their future growth.

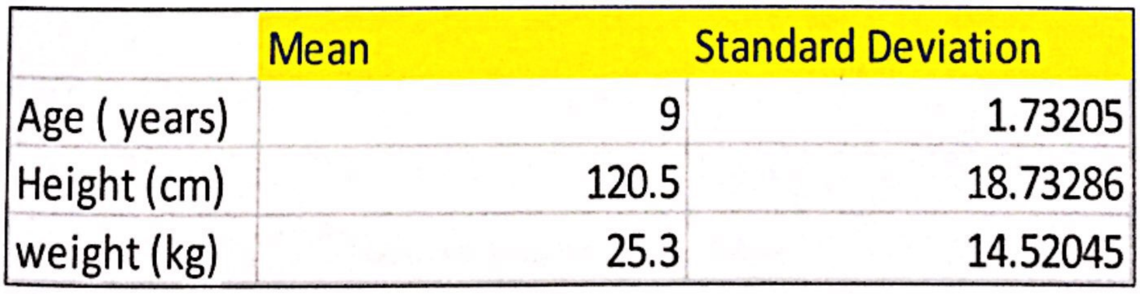
Through the answers answered by respondents, they think of men and women pace of growth in favor of women 64% than men 36% in the early stages. As for the answer to the best way to teach children is that they prefer the use of baby walkers. Where children walk with the aid of a supporting device for babies. Next, to which the main part of the body's main role during the walking. Almost half of the respondents chose the foot 46% that is on top of the ankle and below. It supports the study where it is a more focused way to measure the current in the lower body.

In order to support the main objective from this research, through the question about that are boys and girls differ in the gait pattern. Thus, an average of the respondent answered no. It showed that almost of the respondent did not know about this different gait pattern between genders.

4.3 Pilot Analysis

In this pilot test, only three subject used to analyze and make sure the significant of parameter same or almost same due to past research. The subjects mean, height and weight had shown in the Table 4.1 of demographic for pilot analysis.

Table 4.1: Demographic of Subject for Pilot Test



	Mean	Standard Deviation
Age (years)	9	1.73205
Height (cm)	120.5	18.73286
weight (kg)	25.3	14.52045

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4.3.1 Subjects Data for Pilot Test

Subject 1

Table 4.2: Subject 1 Parameter Data

Parameter	Opposite Foot Off (%)	Opposite Foot Contact (%)	Foot Off (%)	Single Support (s)	Double Support (s)	Stride Length (m)
Left	10.10101	52.525253	57.575756	0.42	0.15	1.026559
Right	5.154639	48.453609	56.701027	0.42	0.13	1.091559
Mean	7.6278245	50.489431	57.1383915	0.42	0.14	1.059059

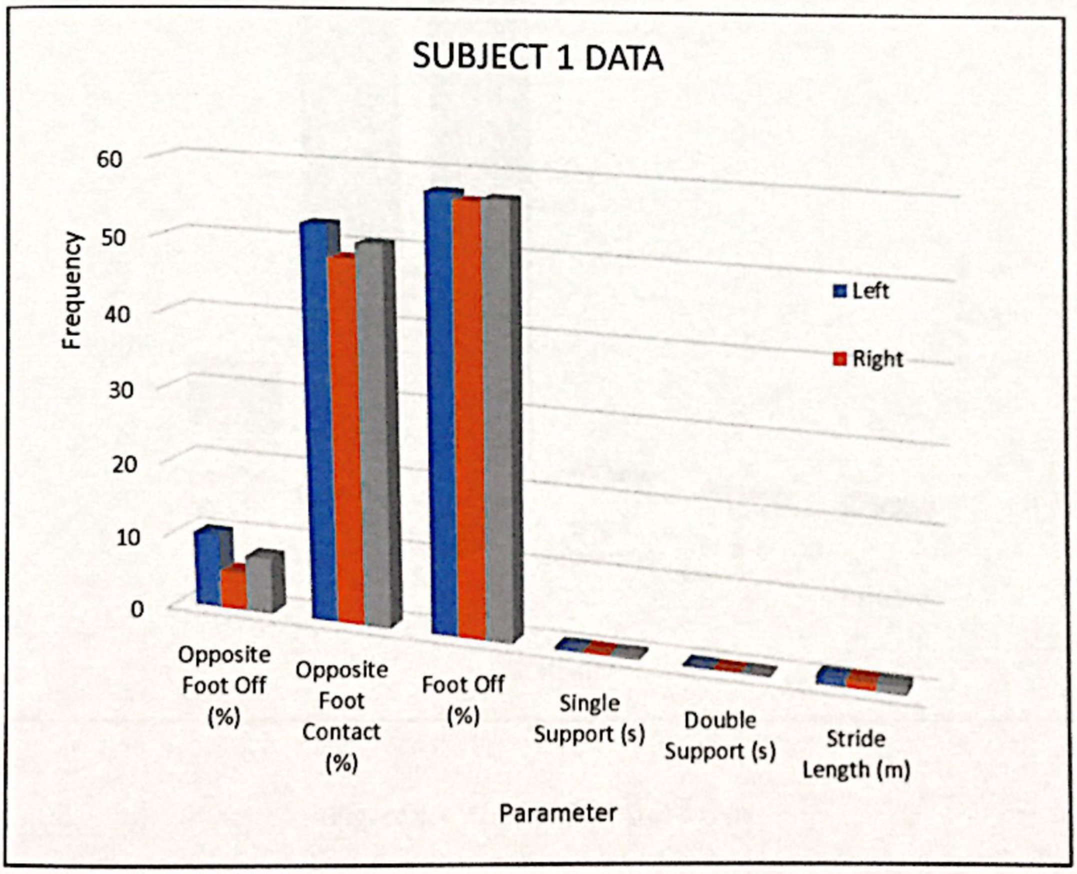

Figure 4.3: Graph of Subject 1 Data

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Subject 2

Table 4.3: Subject 2 Parameter Data

Parameter	Opposite Foot Off (%)	Opposite Foot Contact (%)	Foot Off (%)	Single Support (s)	Double Support (s)	Stride Length (m)
Left	7.954545	50	56.81818	0.37	0.13	1.107262
Right	7.865169	50.561798	58.42697	0.38	0.14	1.10002
Mean	7.909857	50.280899	57.62258	0.375	0.135	1.103641

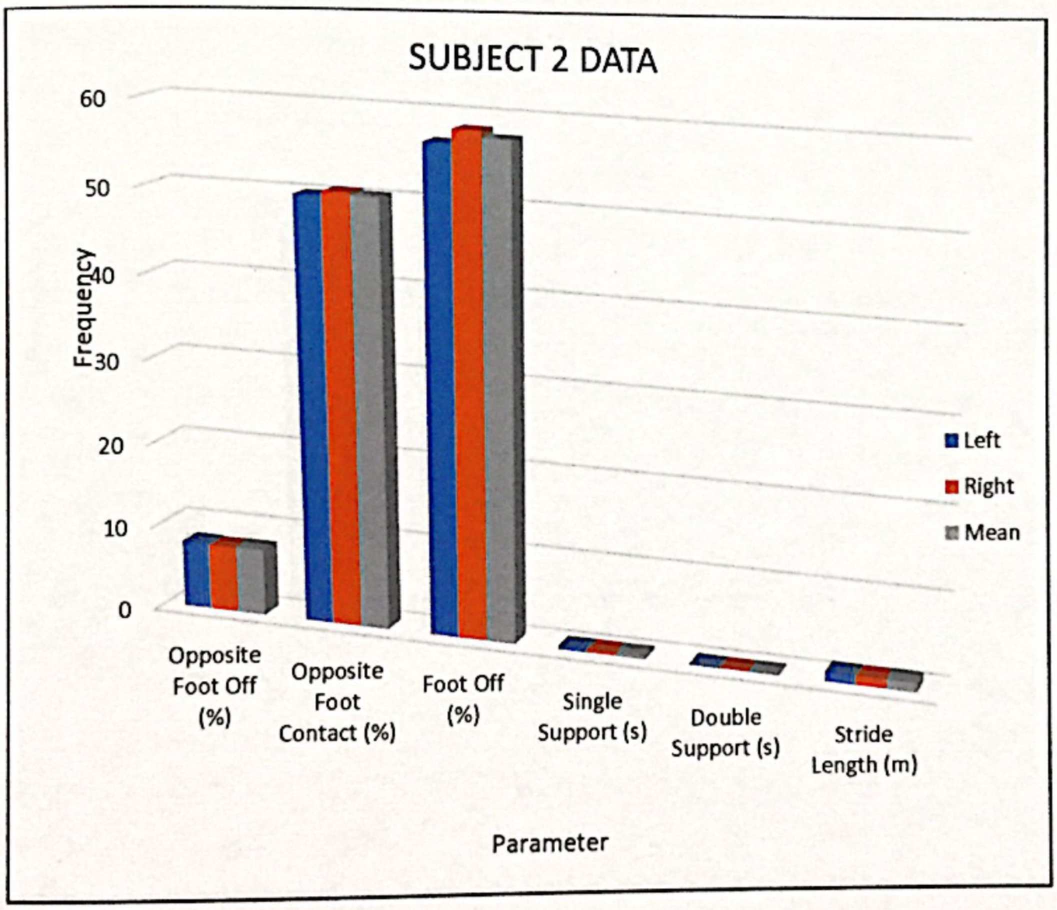

Figure 4.4: Graph of Subject 2 Data

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Subject 3

Table 4.4: Subject 3 Parameter Data

Parameter	Opposite Foot Off (%)	Opposite Foot Contact (%)	Foot Off (%)	Single Support (s)	Double Support (s)	Stride Length (m)
Left	10.185185	49.074074	59.25926	0.42	0.22	1.151843
Right	7.619048	49.523811	60	0.44	0.19	1.127846
Mean	8.9021165	49.2989425	59.62963	0.43	0.205	1.139845

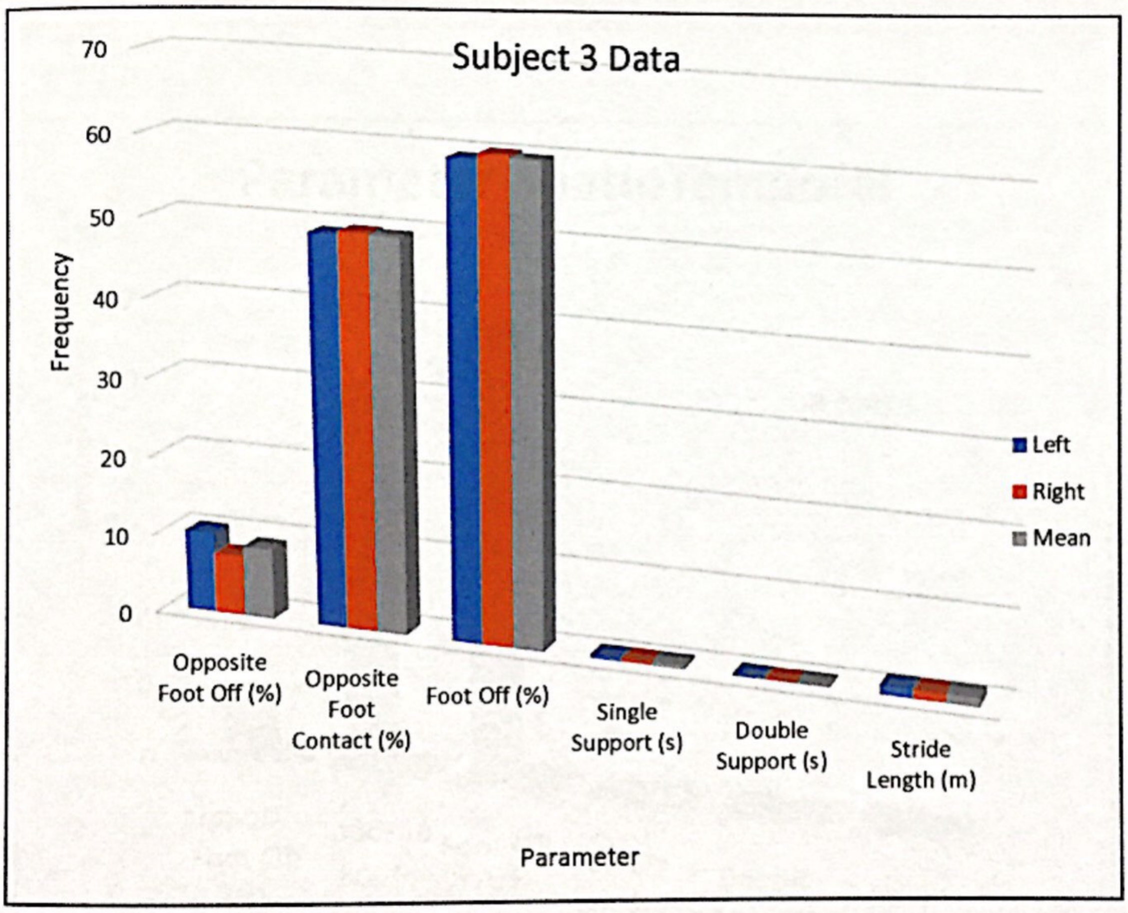

Figure 4.5: Graph of Subject 3 Data

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4.3.2 Full Data Pilot Analysis

Table 4.5: Parameter Data

Parameter	Mean	Standard Deviation
Opposite Foot Off (%)	8.14659933	0.66932
Opposite Foot Contact (%)	50.0230908	0.63574
Foot Off (%)	58.13019933	1.32092
Single Support (s)	0.40833333	0.03215
Double Support (s)	0.16	0.04072
Stride Length (m)	1.1008481	0.04047

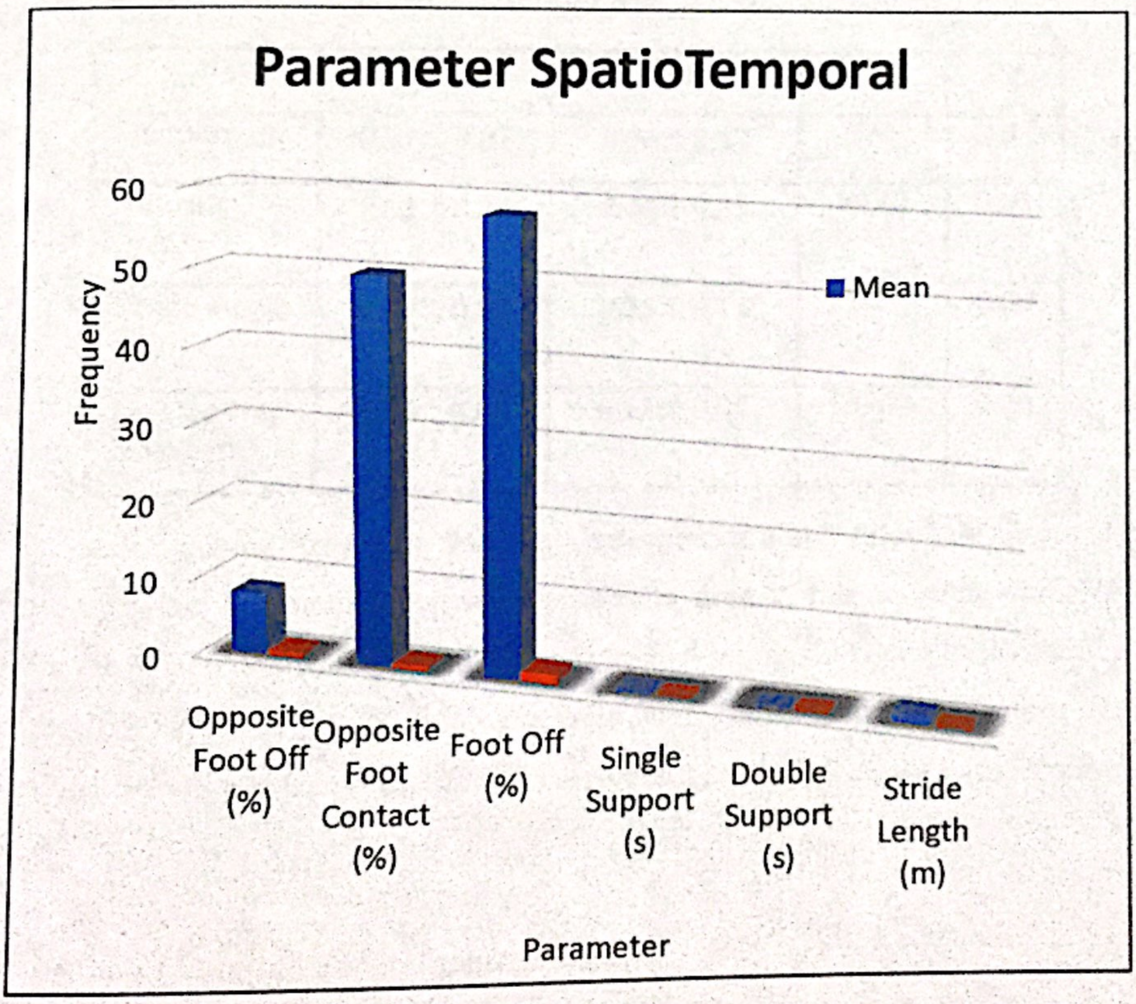

Figure 4.6: Graph of Full Data Pilot Test

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4.3.3 Result and Discussion for Pilot Analysis

Paired-Sample T Test on data of SCP group demonstrated significant difference in stride length, single support phase and double support phase between bilateral lower limbs. According to Longwei Chen, the parameter stride length for normal children is 0.70 ± 0.07 and for cerebral palsy children 0.25 ± 0.11. That is average stride length 0.70m for normal is higher than 0.25m for cerebral palsy[7], and related to my finding it show that 1.10m for the stride length. therefore, the reading its not far and showed that its true. Table 4.6 below shows the past research study.

Table 4.6: Temporal And Spatial Parameter Of ND Children And Children With SCP Instable Walking

	ND	SCP	F	Sig.
Duration (s)	0.61±0.07	0.76±0.27	3.50	0.07
Velocity (m/s)	1.62±0.29	0.44±0.31	89.42	0.00
Stride length (m)	0.70±0.07	0.25±0.11	134.87	0.00
Left leg step length (m)	0.35±0.05	0.13±0.05	109.76	0.00

After gaining the result from both questionnaire and Pilot Test, it could be analyse whether the methodology and procedure used in this research was able to obtain the parameter that required in the next actual research. After all the result been tabulated, it is proven that the finding is valid while the equipment was robust to use to evaluate result and the procedure was correct before conducting an actual research.

4.4 Data Collection For Actual Research

A sample of 34 individuals was gathered but only 32 individual data was analyzed because want the balance of males and females. The final analyzed sample was of 32 subjects (16 males and 16 females) between the ages of 5 and 12 years old. The demographic data was taken for all the subject include age, weight and height.

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The mean age for all 32 subject is 9.62 ± 0.23 years old. In other that, for the males is 9.63 ± 0.23 years old and for females is 9.61 ± 0.24 years old. The mean weight of all subject is 29.17 ± 1.36 kg and for males is 30.50 ± 1.48 kg, females is 27.98 ± 1.27 kg.

After that, for mean height all subject is 128.26 ± 1.62 cm and for males is 130.10 ± 1.57 cm, females is 126.63 ± 1.67 cm. The mean age for males and females subject is not to far for each other but, the mean weight and mean height for males shown that higher than females. It consistants with other research that show females are more lighter than males [24]. The results of the demographic subject mentioned below are shown in the Table 4.7.

Table 4.7: Demographic Data For All Subject

	MEAN	STANDARD DEVIATION
Age (years)	9.62	1.86
Height (cm)	128.27	12.95
Weight (kg)	29.17	10.91

4.4.1 Full Data Collection Subject

Table 4.8: Full Data Subject Of Temporal-Spatial Parameter.

PARAMETER	MEAN	STANDARD DEVIATION
Opposite Foot Off (%)	8.12	1.95
Opposite Foot Contact (%)	49.8	1.13
Foot Off (%)	58.59	2.93
Single Support (s)	0.43	0.04
Double Support (s)	0.18	0.07
Stride Time (s)	1.04	0.11

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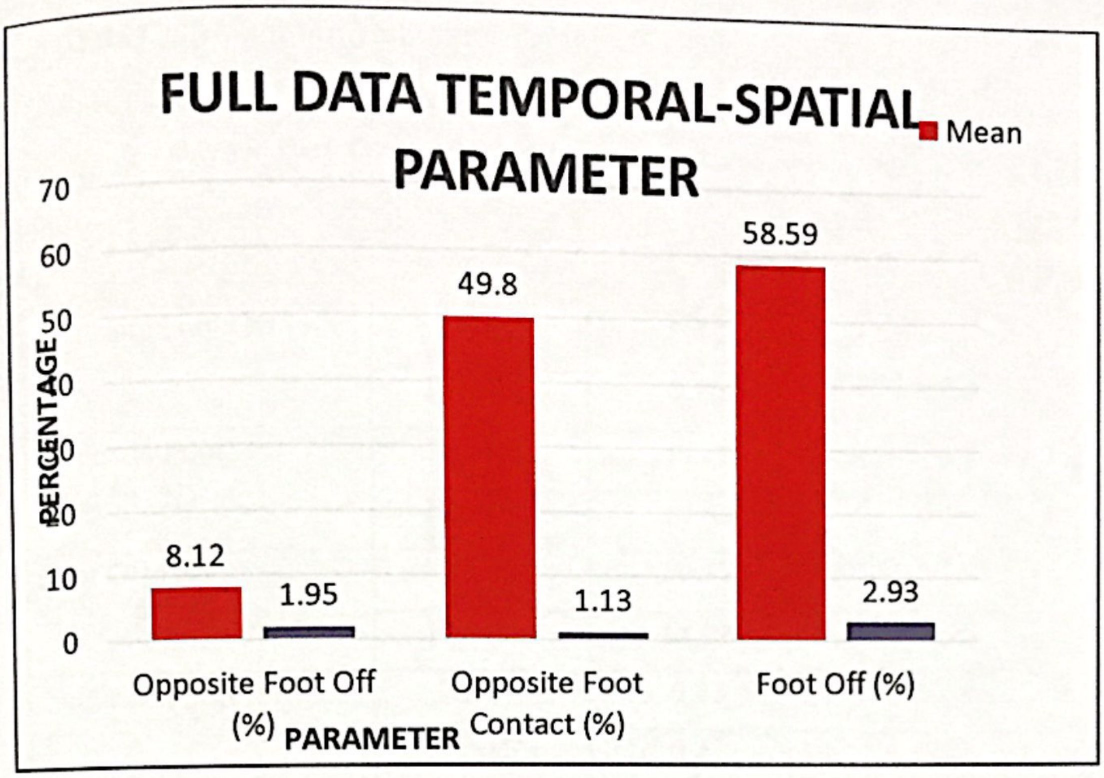

Figure 4.7: Graph of data subject Temporal-spatial parameter for OFO,OFC and FO.

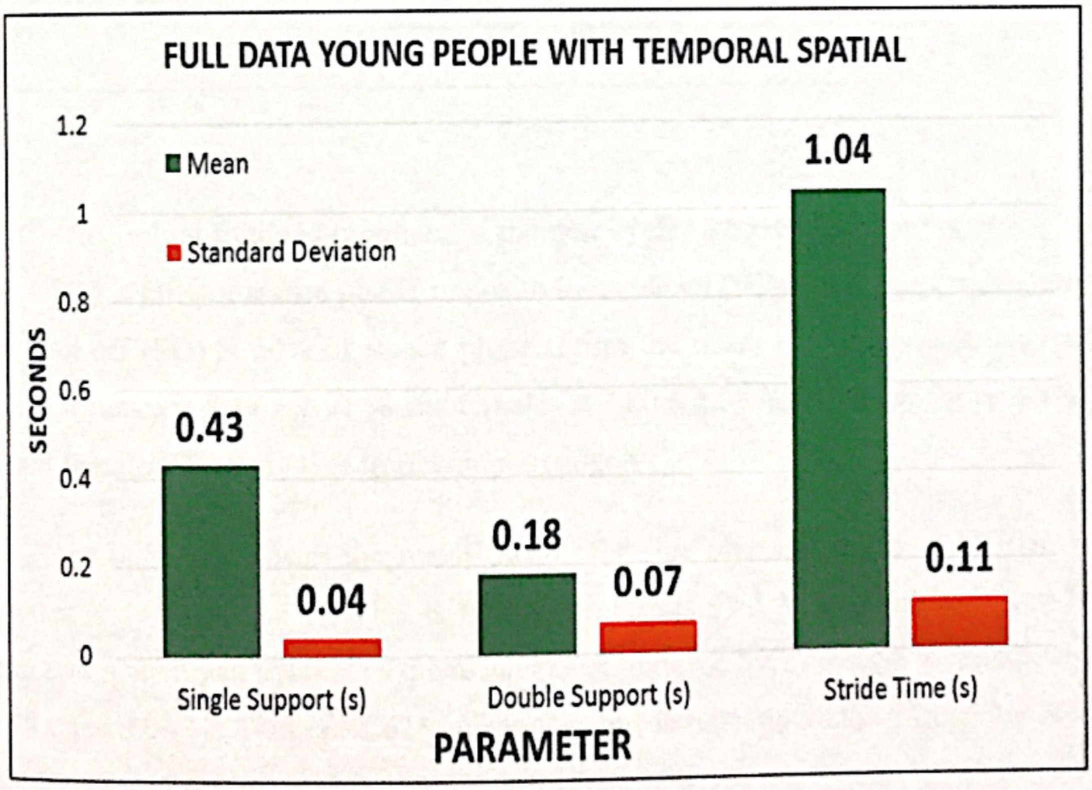

Figure 4.8: Graph of data subject Temporal-spatial parameter for SS, DS and ST.

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4.4.2 Data Collection for Males and Females Subject

Table 4.9: Data Temporal-Spatial For Males And Females Subject.

PARAMETER	GENDER	MEAN	STANDARD DEVIATION
Opposite Foot Off (%)	Males	8.47	1.91
	Females	7.80	1.99
Opposite Foot Contact (%)	Males	49.75	1.56
	Females	49.85	0.55
Foot Off (%)	Males	59.17	3.66
	Females	58.08	2.06
Single Support (s)	Males	0.43	0.04
	Females	0.43	0.03
Double Support (s)	Males	0.19	0.08
	Females	0.17	0.06
Stride Time (s)	Males	1.06	0.11
	Females	1.02	0.10

According to the component of the gait cycle, we know that the opposite foot off (OFO) is 60% of stance phase, opposite foot contact (OFC) is 10% of stance phase and foot off (FO) is 50% of stance phase. From the result of this reseach, the mean OFO for males is 8.47 ± 1.91 % and females is 7.80 ± 1.99 % . That are for males 84.7 % and females 78 % of OFO from component gait cycle.

In other that, from the result mean OFC for males is 49.75 ± 1.56 % and females is 49.85 ± 0.55 %. That is for OFC males is 99.5 % and females is 99.7 % from component gait cycle. For the mean FO of males is 59.17 ± 3.66 % and females is 58.08 ± 2.06 %. That is 98.62% for males and females is 96.80% from the FO of component gait cycle.

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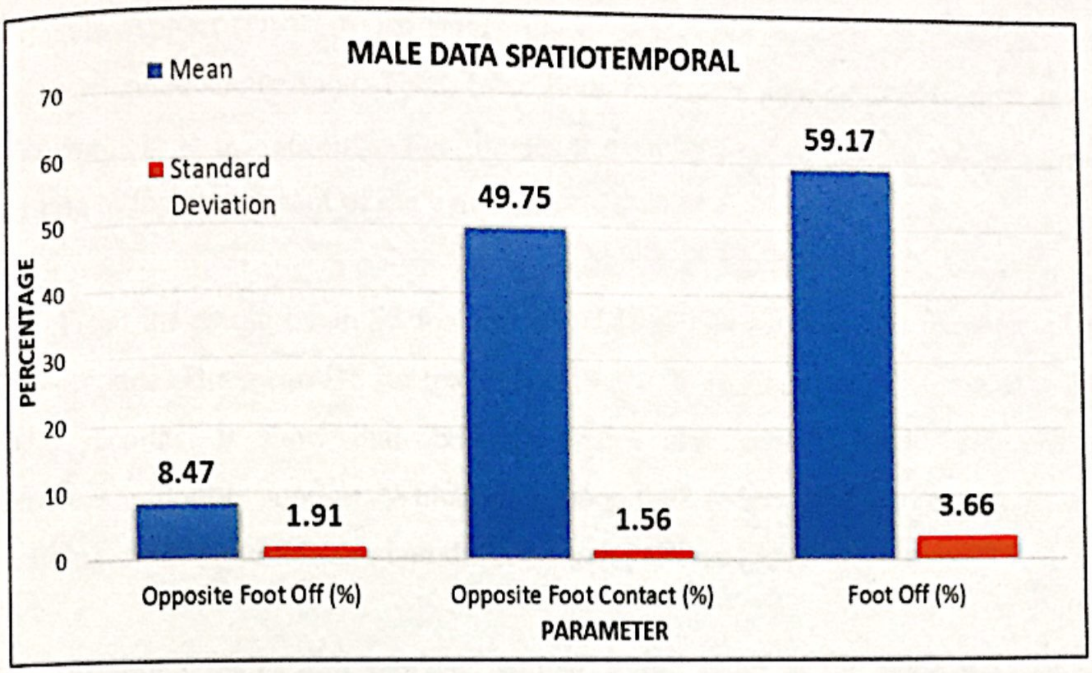

Figure 4.9: Graph of male data Spatiotemporal for OFO,OFC and FO.

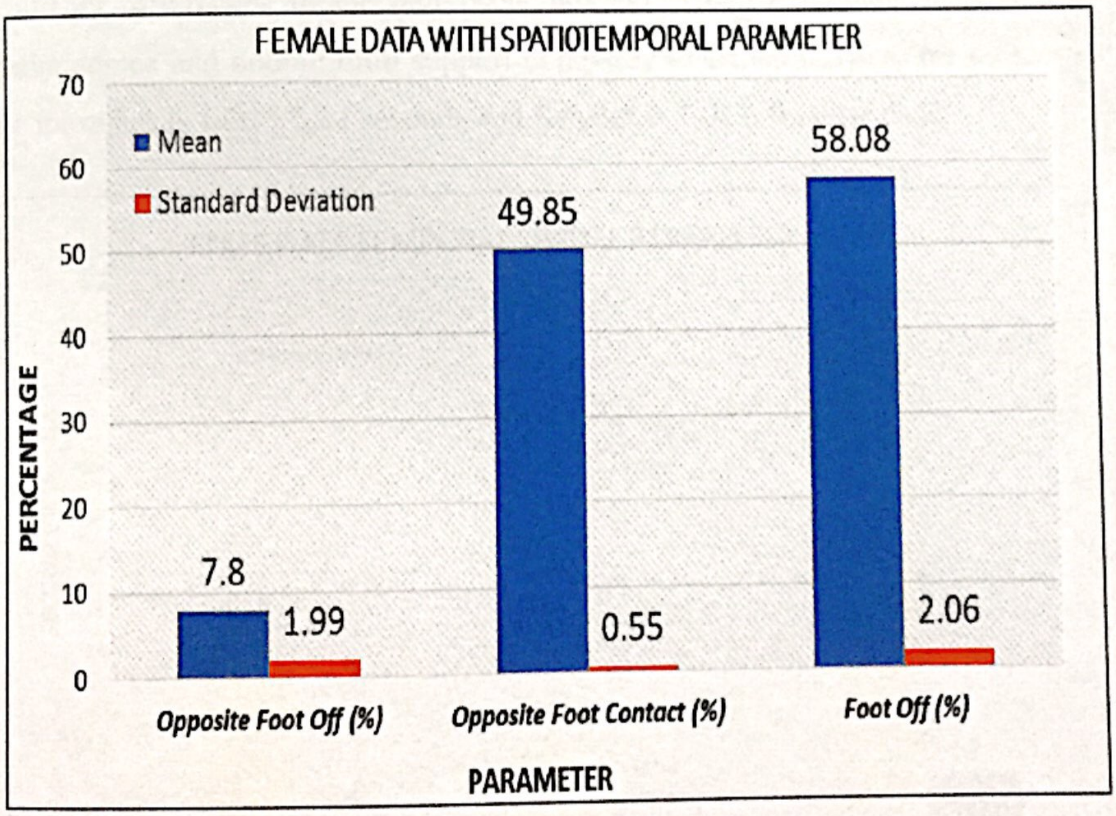

Figure 4.10: Graph of female data Spatiotemporal for OFO, OFC and FO.

According to the component gait cycle, we know that gait cycle is single sequence of functions by one limb, begins when references foot contacts the ground and ends with subsequent floor contact of the same foot. Single support (SS) is 40%

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and double support (DS) 20% of stance phase of the gait cycle. That is 60% of the stride time called stance time. Then, in seconds for single support is 0.4 seconds and double support is 0.2 seconds. For the stride time is one second in the gait cycle according to the component of the gait cycle.

From the result, mean SS for males is 0.43 ± 0.04 seconds and females is 0.43 ± 0.03 seconds. The mean DS for males is 0.19 ± 0.08 seconds and for females is 0.17 ± 0.06 seconds. It show that, between males and females have 0.02 seconds differences in double support. Which males stop 0.02 longer than females in the way of walking. Males and females had different gait patterns [25].

Although males and females walked at the same in the opposite foot off, opposite foot contact, foot off, single support, and stride time, they presented no significant differences in the gait cycle phases. However, males walked with a smaller stance and double limb support compared to females. Then, for mean stride time for males is 1.06 ± 0.11 seconds and females is 1.02 ± 0.10 seconds.

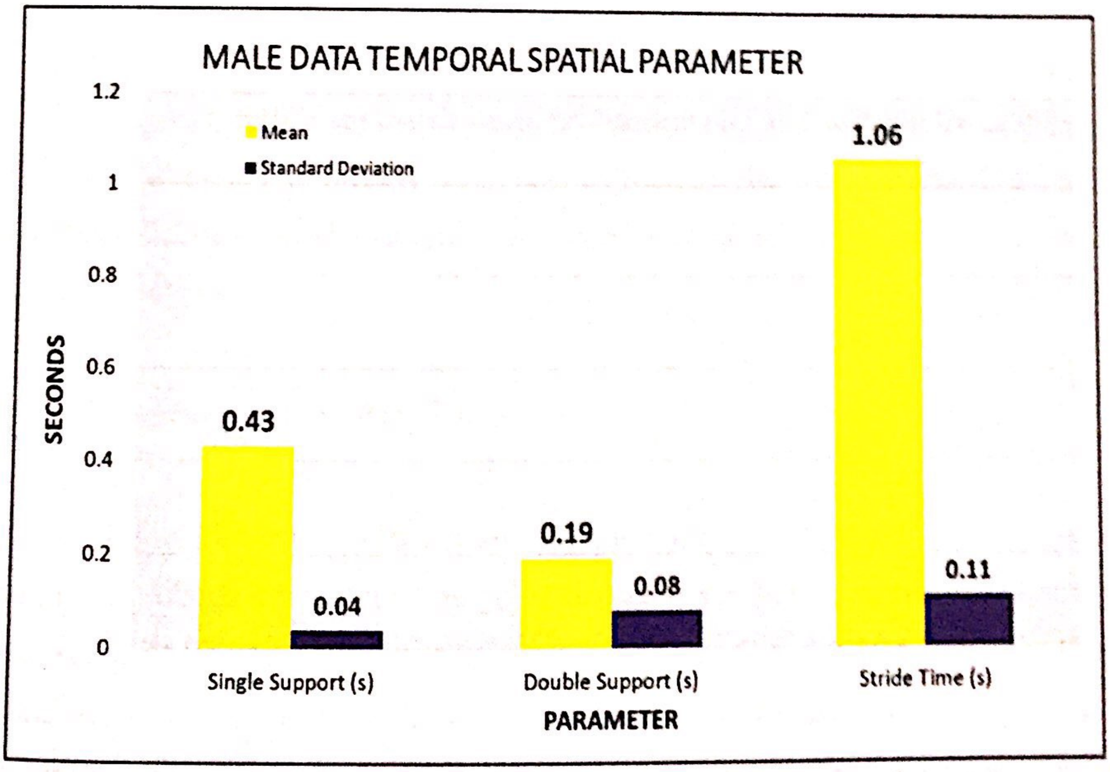

Figure 4.11: Graph of male data Spatiotemporal for SS, DS and ST.

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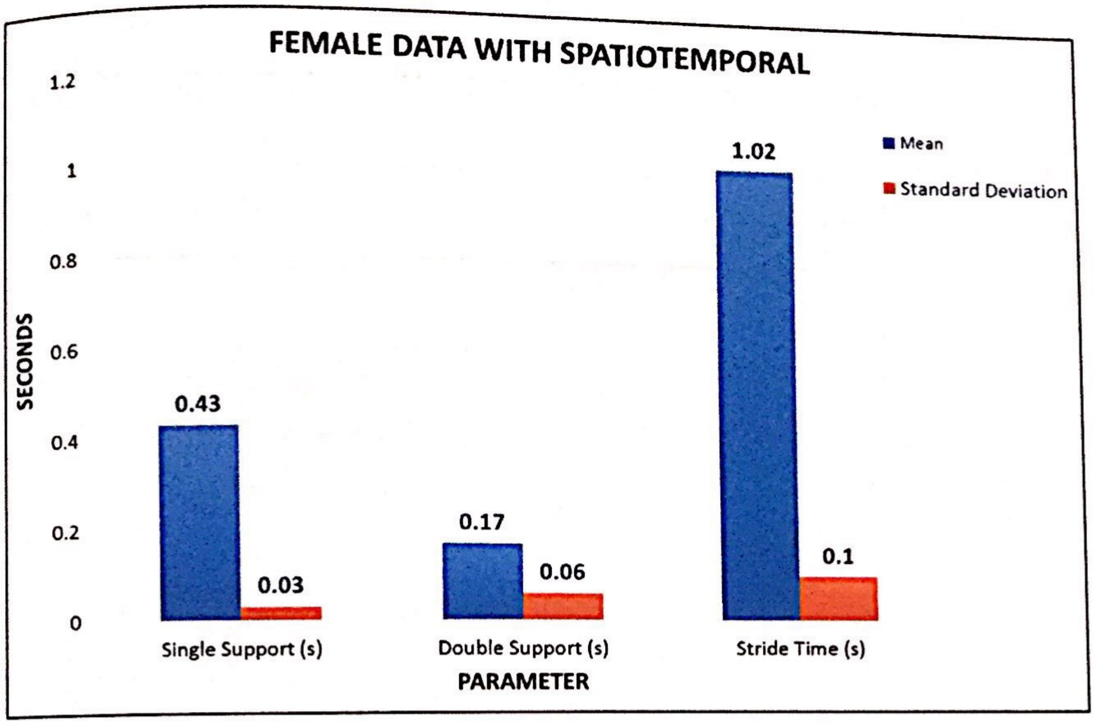

Figure 4.12: Graph of female data Spatiotemporal for SS, DS and ST.

4.5 Reliability Test and Validity Test

In this research, for data analysis used the reliability test and validity test. For the reliability test, histogram distribution, probability plot and culmulative distribution functions was used. For validity test, cross correlation and canonical correlation was used. The reliability test and validity test needed because of want to make sure that the data that is balance.

4.5.1 Histogram Distribution Result

For the histogram distribution, the data for all parameter was in normal distribution. Which are in the histogram the data that have the normal symmetric histogram with most of the frequency counts bunched in the middle and with the counts dying off out in the tails. From a physical science and engineering point of view, the normal distribution is that distribution which occurs most often in nature (due in part to the central limit theorem). Not any of data show that the histogram show the way of skeewed of binomial.

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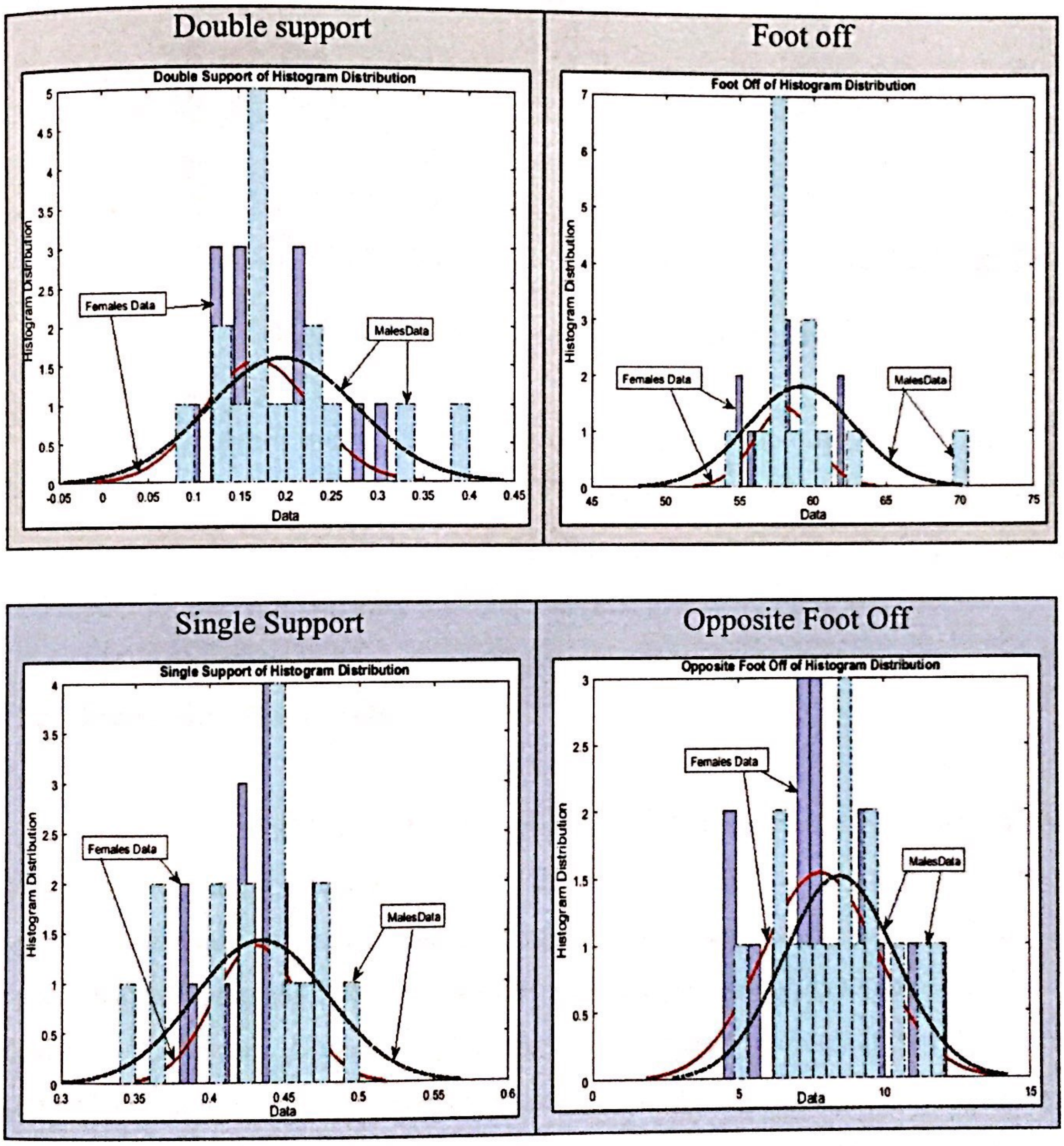
In addition, the parameter for each data between males and females show that, only the opposite foot off, double support and stride time show the data in truely in normal distribution histogram. However, all the parameter of the data like opposite foot contact, single support and foot off still in normal distribution histogram. Figure 4.13 shows the result of all parameter in histogram distribution.



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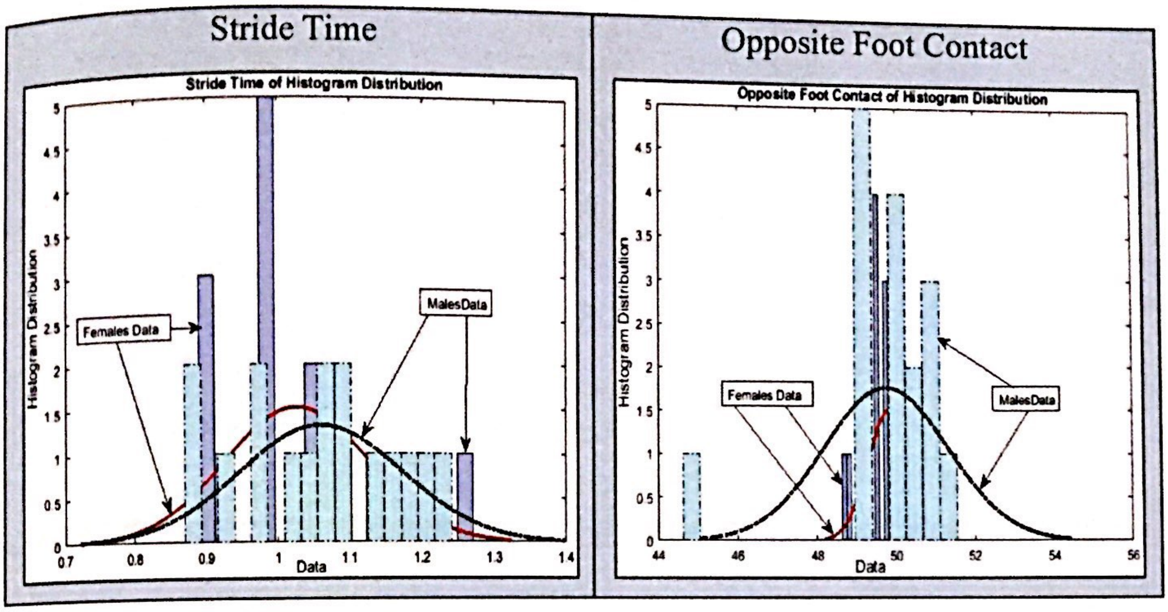

Figure 4.13: Graph of data for Histogram Distribution

If the histogram indicates a symmetric, moderate tailed distribution, then the recommended next step is to do a normal probability plot to confirm approximate normality. If the normal probability plot is linear, then the normal distribution is a good model for the data. So, after that, the p normal probability plot was plotted.

4.5.2 Probability Plot Result

The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed. The data are plotted against a theoretical normal distribution in such a way that the points should form an approximate straight line. Departures from this straight line indicate departures from normality. The normal probability plot is a special case of the probability plot. From the result it show that the normal probability plot shows a strongly linear pattern. There are only minor deviations from the line fit to the points on the probability plot. Figure 4.14 shows the result for all parameter in probability plot.

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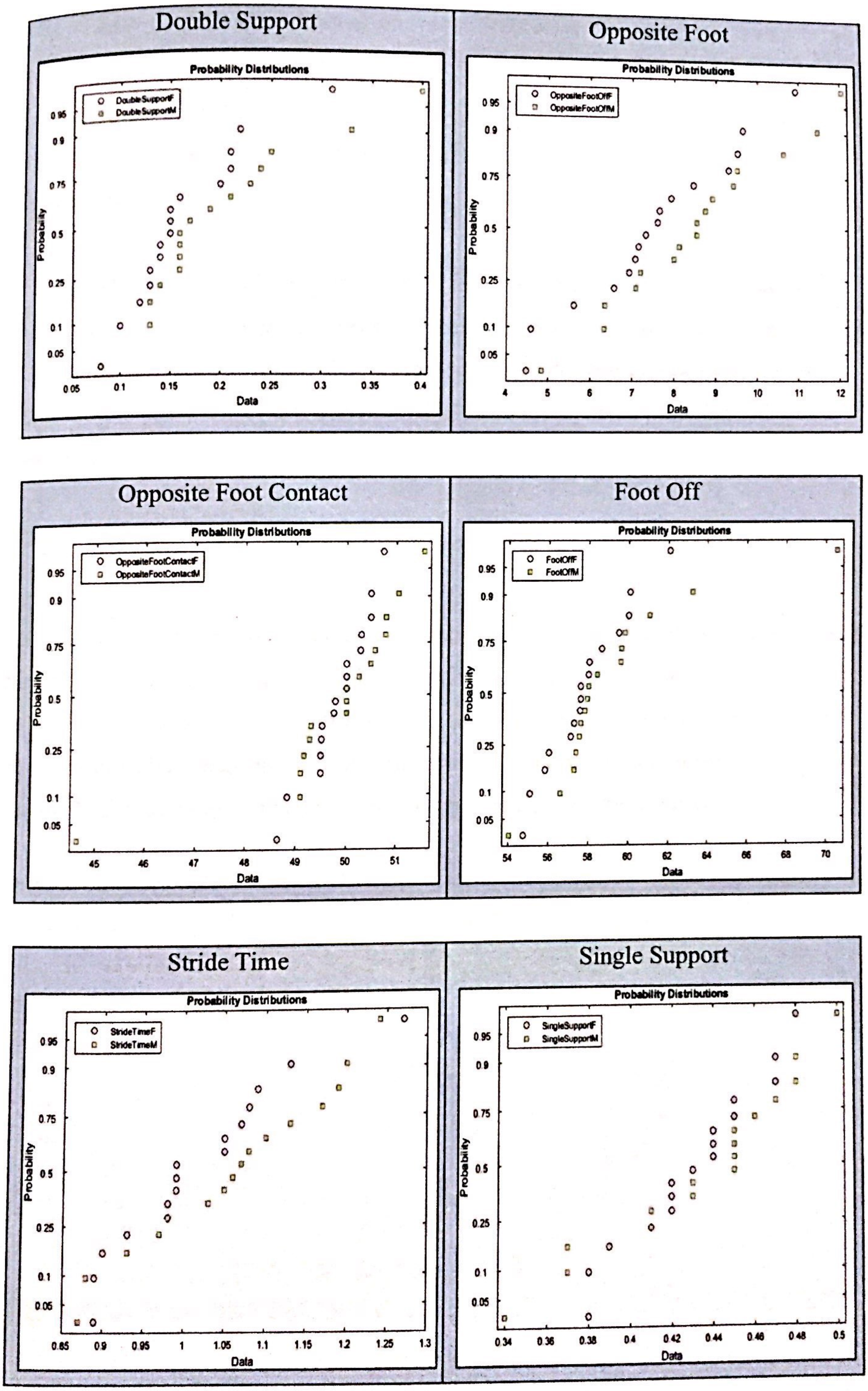

Figure 4.14: Graph of data for Probability Plot

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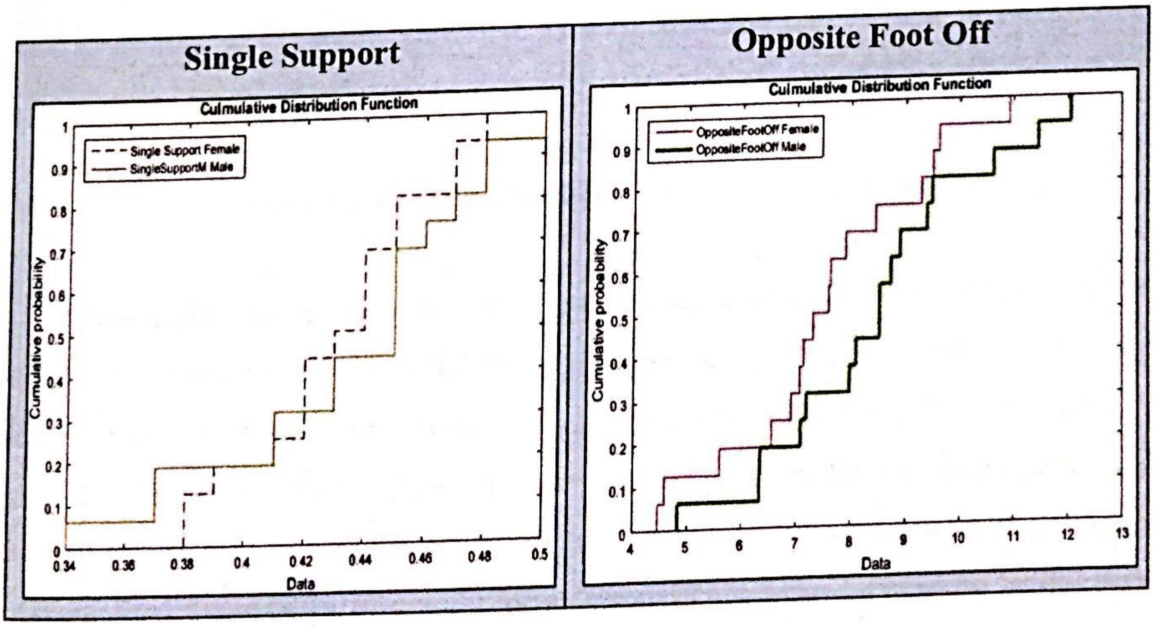
From the result a normal probability plot of a sample from a normal distribution it looks fairly straight, at least when the few large and small values are ignored. The all of the parameter of this study show that, as a reference, a straight line can be fit to the points. The points vary from this line, the greater the indication of departure from normality.

The sample of all parameter shown that had mean 0, standard deviation 1 then a line through 0 with slope 1 which are could be used. The normal probability plot shows a strongly linear pattern. There are only minor deviations from the line fit to the points on the probability plot. The normal distribution appears to be a good model for these data.

4.5.3 Culmulative Distribution Functions Result

The horizontal axis is the allowable domain for the given probability function. Since the vertical axis is a probability, it must fall between zero and one. It increases from zero to one as we go from left to right on the horizontal axis. As show in this study, culmulative distribution functions also as a empirical culmulative distribution. Figure 4.15 shows the all parameter for culmulative distribution functions.



Single Support

Opposite Foot Off

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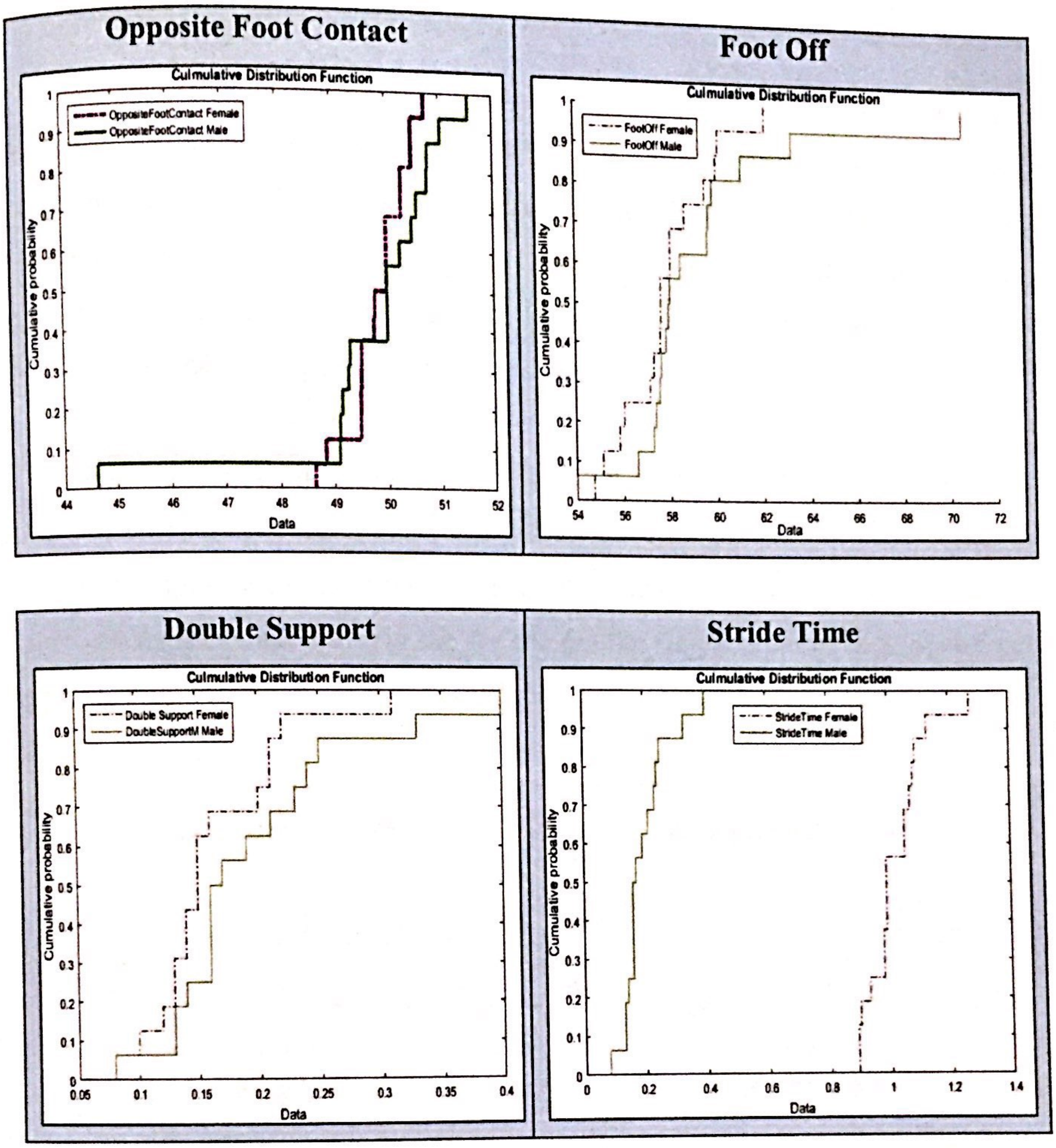

Opposite Foot Contact

Foot Off

Double Support

Stride Time

Figure 4.15: Graph of data for Culmulative Distribution Functions

The CDF completely describes the distribution of a discrete random variable. Which are in this study show all the parameter have the culmulative distribution function but only stride time between males and females have the gap for this study in the CDF. However, all the data set for the parameter can be use as a culmulative distributions functions because the CDF still in the range of zero to one. It can be conclude that, the data for this study for all the parameter can be used as follow it are reliable.

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4.5.4 Cross Correlation Result

The term cross-correlations is used for referring to the correlations between the entries of two random vectors X and Y, while the correlations of a random vector X are considered to be the correlations between the entries of X itself. It is a time domain analysis useful for determining the periodicity or repeating patterns of a signal. Crross correlation can be state that for r = 1 as a perfect correlation, r = 0 as a no correlation and r = -1 perfect anti correlation.

From the result in Figure 4.16, it show that, the correlation coefficient of a sample is denoted by r, and the correlation coefficient of a population is denoted by ρ or R. Then Figure 4.17 show the all parameter show have the similiarities between males and females data but only the for the double support that have a gap between the parameter. Its show that are the double support as a perfect anti correlation.

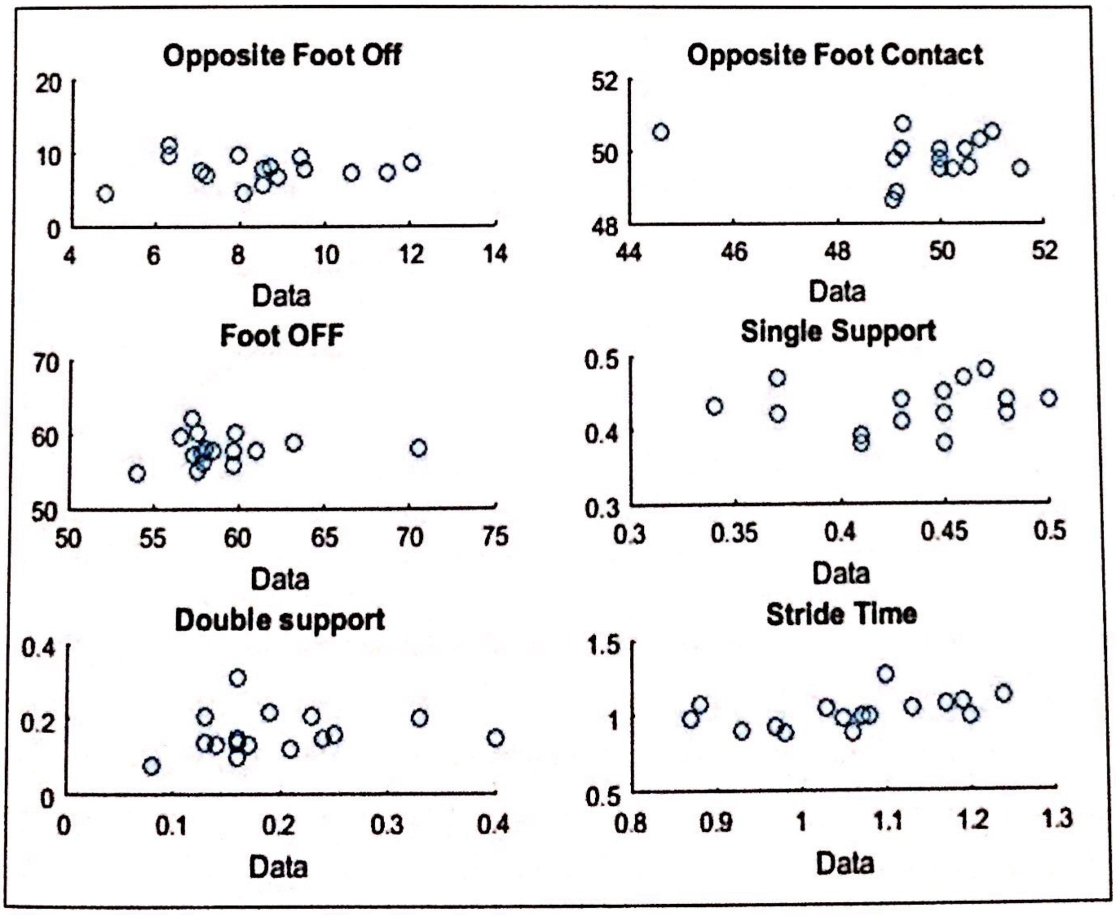

Figure 4.16: Graph of Raw Data for Cross Correlation

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When the slope of the line in the plot is negative, the correlation is negative; and vice versa. The strongest correlations (r = 1.0 and r = -1.0) occur when data points fall exactly on a straight line. The correlation becomes weaker as the data points become more scattered. If the data points fall in a random pattern, the correlation is equal to zero. Correlation is affected by outliers. Compare the first scatterplot with the last scatterplot. The stride time show the correlation as a strong positive correlation, r = 0.8. after that, all the parameter show the cross correlation into the positive because still in the range one to zero.

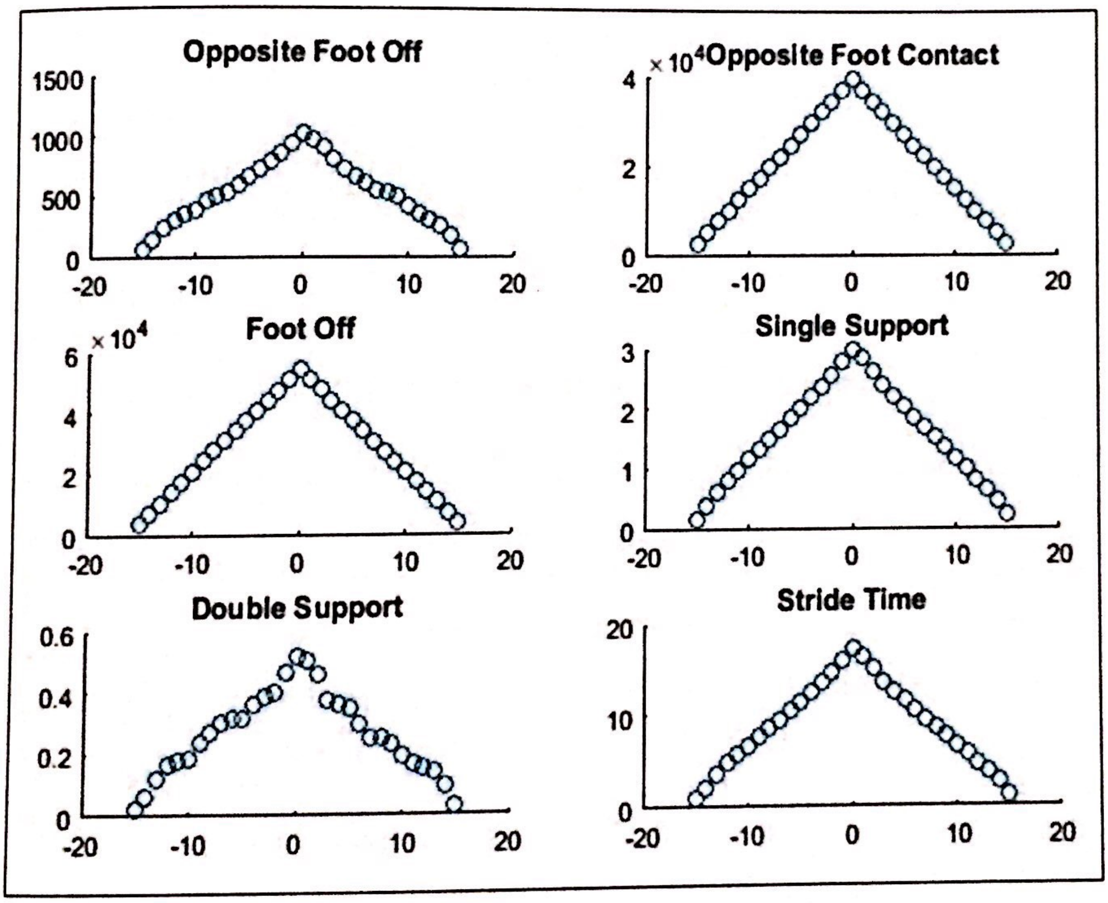

Figure 4.17: Graph of Result Cross Correlation for All Parameter

The single outlier in the last plot greatly reduces the correlation (from 1.00 to 0.71). However, a correlation of 0 does not mean zero relationship between two variables; rather, it means zero linear relationship. It is possible for two variables to have zero linear relationship and a strong curvilinear relationship at the same time.

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4.6 T-test Result

A paired-samples t-test was conducted to compare the six parameter in the Temporal-Spatial technique in the gait analysis between males and females subject. In this study show that, for the opposite foot off, opposite foot contact, foot off, single support and stride time parameter there were the P-values is less than the significance level. It show that no significant difference between males and females for this five parameter choosen.

Table 4.10: Gait Parameter T Test Results Between Males And Females.

GAIT PARAMETER	Mean And Standard Deviation T Test Result			
	Males	**Females**	**P-value**	**H value**
Opposite Foot Off (%)	8.47 (± 1.91)	7.80 (± 1.99)	0.1591*	0
Opposite Foot Contact(%)	49.75 (± 1.56)	49.85 (± 0.55)	0.8490*	0
Foot Off (%)	59.17 (± 3.66)	58.08 (± 2.06)	0.1947*	0
Single Support (S)	0.43 (± 0.04)	0.43 (± 0.03)	0.7667*	0
Double Support (S)	**0.19 (± 0.08)**	**0.17 (± 0.06)**	**4.2717e-09***	**1**
Stride Time (S)	1.06 (± 0.11)	1.02 (± 0.10)	0.1564*	0

However, there was a significant difference in the double support parameter for males (M = 0.19, SD = 0.08) and females (M = 0.17, SD=0.06) conditions; H = 1, p-value = 4.2717e-09 . These results suggest that have the significant value for double support parameter between males and females. Accorrding to the past research, there are significant gender differences in most of the spatio-temporal gait parameters of patients with knee knee osteoarthritis (OA), specifically in all of the gait cycle phases

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(stance, swing, double limb support and single limb support) and in the foot placement angle.[25]

However, through this study for differences gender, in range age 5 to 12 years old children only double support have the significant. Specifically, our results suggest this parameter that show the differences between male and female are efficient to know the gender recognition especially in the gait analyis.

In addition, a past researcher [7] also used the paired sample t-test to know that have the differences between normal and cerebral palsy children. It show that this method is relevant to use as a method to the the differences between two variable. Which are this study want to know the differences between gender.

4.7 Graphic User Interface (GUI) Application

From this research, all the data was set into the Graphic User Interface (GUI) in order to make the easiest way show the result. The good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. In this research the GUI application show the result of histogram distribution, probability plot, culmulative distribution and cross correlation. The user just only have to click and the result for this research will appear.

By using the GUI component the three principal elements required to create a MATLAB Graphical User Interface are components, figures and callback. Components in the MATLAB GUI (pushbuttons, labels, edit boxes, etc.) is a graphical component. The types of components include graphical controls (pushbuttons,edit boxes, lists, sliders, etc.), static elements (frames and text strings), menus, and axes. The pushbuttons include the tittle of analysis that used in this research. The Figure 4.18 below shows the menu of the GUI for this study by the title name of each result that was analyzed.

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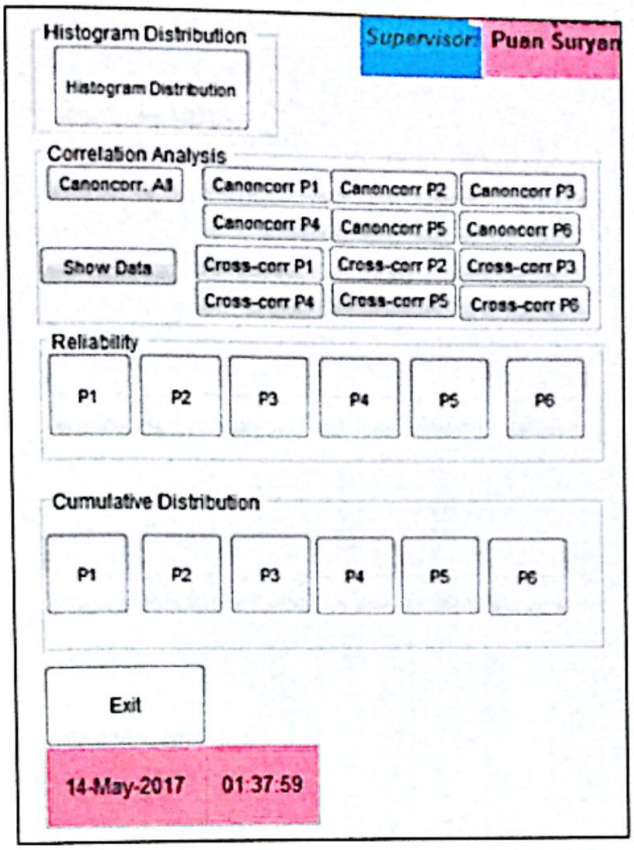

Figure 4.18: Pushbutton For The Tittle Of The Result Analysis

Graphical controls and static elements are created by the function uicontrol, and menus are created by the functions uimenu and uicontextmenu. Then, axes, which are used to display graphical data, are created by the function axes. It is appears of the result for this study, which are histogram, probability and cross correlation. In addition figures are the components of a GUI must be arranged within a figure, which is a window on the computer screen.

In the past, figures have been created automatically whenever we have plotted data. This research use the reliability data and probability data to do the analysis. Finally, call back there must be some way to perform an action if a user clicks a mouse on a button or types information on a keyboard. A mouse click or a key press is an event, and the MATLAB program must respond to each event if the program is to perform its function. The Figure 4.19 below shows full the result of this study by using the GUI application.

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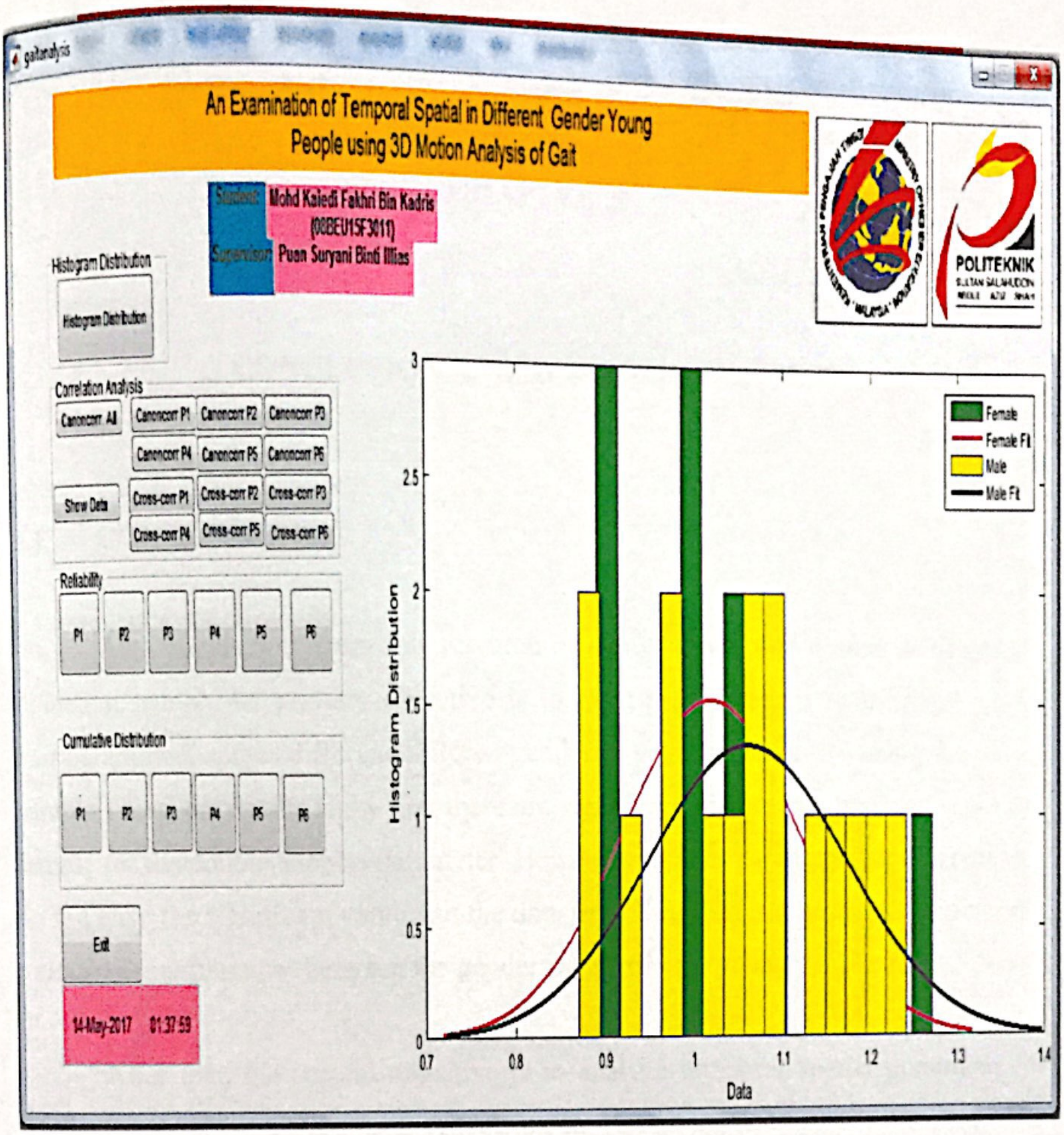

An Examination of Temporal Spatial in Different Gender Young People using 3D Motion Analysis of Gait

Student: Mohd Kaiedi Fakhri Bin Kadris (08BEU15F3011)

Supervisor: Puan Suryani Binti Illias

14-May-2017 01:37:59

Figure 4.19: Result of Graphic User Interface (GUI)

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion, from this research or study shown that it have achieved the objective, which the primary objective is to identify differences in temporal-spatial gait parameters across different children gender in young people. By using the paired sample t-test, the results show that there are significant differences between male and female for the double support parameter. However, another parameter for this research do not have the significant value, but the data from the t-test can be use as a references to know the differences between the gender especially for young people.

After that, the second objective is to analyze temporal spatial parameter for different gender by using signal processing in Matlab application and Graphic User Interface (GUI). Through the statistical method, for the relibility test and validity test it show the data for this study are balance for both of it. In order to find the effectiveness and the consistent data the statistical method was used. It is show the succesfull result.

Results proven that statistical method matlab using software can effectively verified gait parameters between different gender. After that, by using the Graphic User Interface (GUI) all the result was shown in the platform in order to show the easiest way for known the result. In addition, by profiling walking gait pattern expected to help doctors and therapists to form structured intervention for further treatment and therapy for young people.

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Other than that, it will also help towards to the enhancement of knowledge in gait studies as well as bring awareness to the public in order to take care the general population especially young people and support the government for intervention and treatment programs. Lastly,the result hopefully provides usefulness on gait analysis of normal children that can improve diagnosis method of normal children based on gait analysis and then be used by physical therapists and doctors to improve performance and also the quality of life for the general population, especially young people.

5.2 RECOMMENDATION

As a recommendation, for further study in this research hopefully can do more research and analyze with all technique for the Gait Analysis such as temporal spatial, kinetic and kinematic technique. It is because with all this technique gait analysis surely can make more succesfull result and analysis for children. Besides that, hopefully another researcher can do the research with more range age for the subject. As example, differences between gender in the older range age. Then, hopefully another researcher can make the profilling data for asian people versus europe people in order to know the differences between this people.

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APPENDIX A : GANTT CHART OF THE PROJECT

GANTT CHART FOR BEU 5173 / BEU 6225

YEAR	SESI 1 2016/2017														SEM 2 2016/2017													
MONTH	SEPT				OCT				NOV				DEC		FEB	MARCH					APRIL				MAY			
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
RESEARCH PROPOSAL	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
• Title declaration	X	X	X	X	X	X																						
• Finalize research proposal					X	X	X	X	X	X																		
LITERATURE REVIEW																												
• Gait Analysis	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
• Temporal Spatial	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
• 3D Vicon System / AMTI Force Plate / Marker Placement	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
• Different Gender	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
DATA COLLECTION																												
• Distributing questionnaire / Pilot Test					X	X	X	X																				
• Collect Data at Uitm																X	X	X	X									
ANALYSIS DATA																												
• Analyze Questionaire / Analyze Pilot Test									X	X																		
• Analyze Large Scale Data																				X	X	X						
• Interpret data																					X	X	X	X	X			
PUBLICATION																												
• Journal /Conference Proceeding																								X				
• Review Paper											X																	
THESIS WRITING																												
• CHAPTER 1 – Introduction	X	X	X	X																								
• CHAPTER 2 – Literature Review					X	X	X	X																				
• CHAPTER 3 – Methodology									X	X	X	X	X	X	X	X	X	X	X	X	X	X						
• CHAPTER 4 – Data analysis / finding															X	X	X	X	X	X	X	X	X	X				
• CHAPTER 5 – Conclusion																								X	X	X		
• Submit final draft																							X					
• Submit thesis																										X		
ASSESSMENT																												
• VIVA																											X	
• Thesis (Chapter 1 – 5)																												

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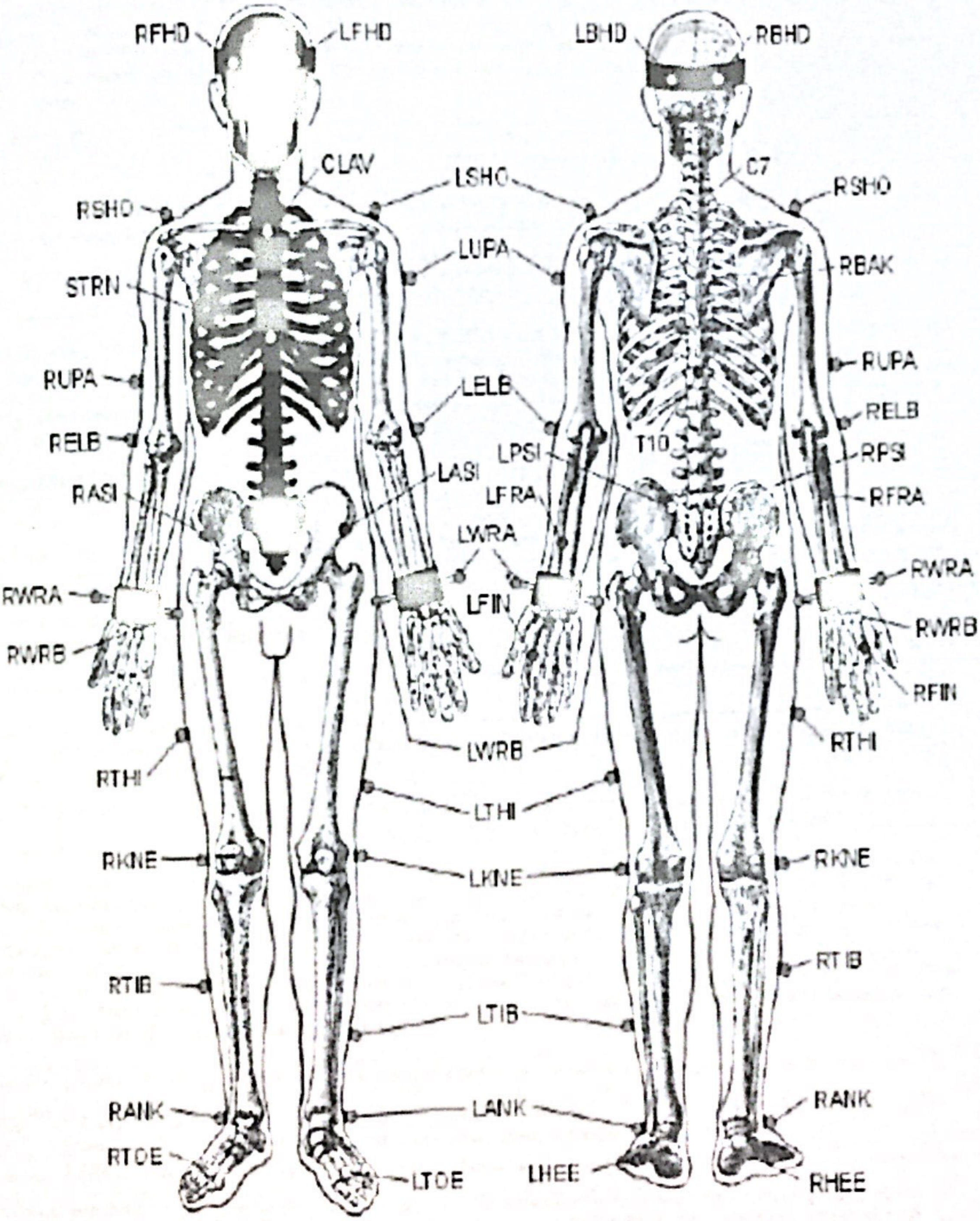
APPENDIX B: PLUG GAIT MARKER PLACEMENT

Plug-in-Gait Marker Placement



The following describes in detail where the Plug-in-Gait markers should be placed on the subject. Where left side markers only are listed, the positioning is identical for the right side.

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Lower Body

Pelvis

LASI	Left ASIS	Placed directly over the left anterior superior iliac spine
RASI	Right ASIS	Placed directly over the right anterior superior iliac spine

The above markers may need to be placed medially to the ASIS to get the marker to the correct position due to the curvature of the abdomen. In some patients, especially those who are obese, the markers either can't be placed exactly anterior to the ASIS, or are invisible in this position to cameras. In these cases, move each marker laterally by an equal amount, along the ASIS-ASIS axis. The true inter-ASIS Distance must then be recorded and entered on the subject parameters form. These markers, together with the sacral marker or LPSI and RPSI markers, define the pelvic axes.

LPSI	Left PSIS	Placed directly over the left posterior superior iliac spine
RPSI	Right PSIS	Placed directly over the right posterior superior iliac spine

LPSI and RPSI markers are placed on the slight bony prominences that can be felt immediately below the dimples (sacro-iliac joints), at the point where the spine joins the pelvis.

SACR	Sacral wand marker	Placed on the skin mid-way between the posterior superior iliac spines (PSIS). An alternative to LPSI and RPSI.

SACR may be used as an alternative to the LPSI and RPSI markers to overcome the problem of losing visibility of the sacral marker (if this occurs), the standard marker kit contains a base plate and selection of short "sticks" or "wands" to allow the marker to be extended away from the body, if necessary. In this case it must be positioned to lie in the plane formed by the ASIS and PSIS points.

Leg Markers

LKNE	Left knee	Placed on the lateral epicondyle of the left knee

To locate the "precise" point for the knee marker placement, passively flex and extend the knee a little while watching the skin surface on the lateral aspect of the knee joint. Identify where knee joint axis passes through the lateral side of the knee by finding the lateral skin surface that comes closest to remaining fixed in the thigh. This landmark should also be the point about which the lower leg appears to rotate. Mark this point with a pen. With an adult patient standing, this pen mark should be about 1.5 cm above the joint line, mid-way between the front and back of the joint. Attach the marker at this point.

LTHI	Left thigh	Place the marker over the lower lateral 1/3 surface of the thigh, just below the swing of the hand, although the height is not critical.

The thigh markers are used to calculate the knee flexion axis location and orientation. Place the marker over the lower lateral 1/3 surface of the thigh, just below the swing of the hand, although the height is not critical. The antero-posterior placement of the marker is critical for correct alignment of the knee flexion axis. Try to keep the thigh marker off the belly of the muscle, but place the thigh marker at least two marker diameters proximal of the knee marker. Adjust the position of the marker so that it is aligned in the plane that contains the hip and knee joint centers and the knee flexion/extension axis. There is also another method that uses a mirror to align this marker, allowing the operator to better judge the positioning.

LANK	Left ankle	Placed on the lateral malleolus along an imaginary line that passes through the transmalleolar axis
LTIB	Left tibial wand marker	Similar to the thigh markers, these are placed over the lower 1/3 of the shank to determine the alignment of the ankle flexion axis

The tibial marker should lie in the plane that contains the knee and ankle joint centers and the ankle flexion/extension axis. In a normal subject the ankle joint axis, between the medial and lateral malleoli, is externally rotated by between 5 and 15 degrees with respect to the knee flexion axis. The placements of the shank markers should reflect this.

Foot Markers

LTOE	Left toe	Placed over the second metatarsal head, on the mid-foot side of the equinus break between fore-foot and mid-foot
LHEE	Left heel	Placed on the calcaneous at the same height above the plantar surface of the foot as the toe marker

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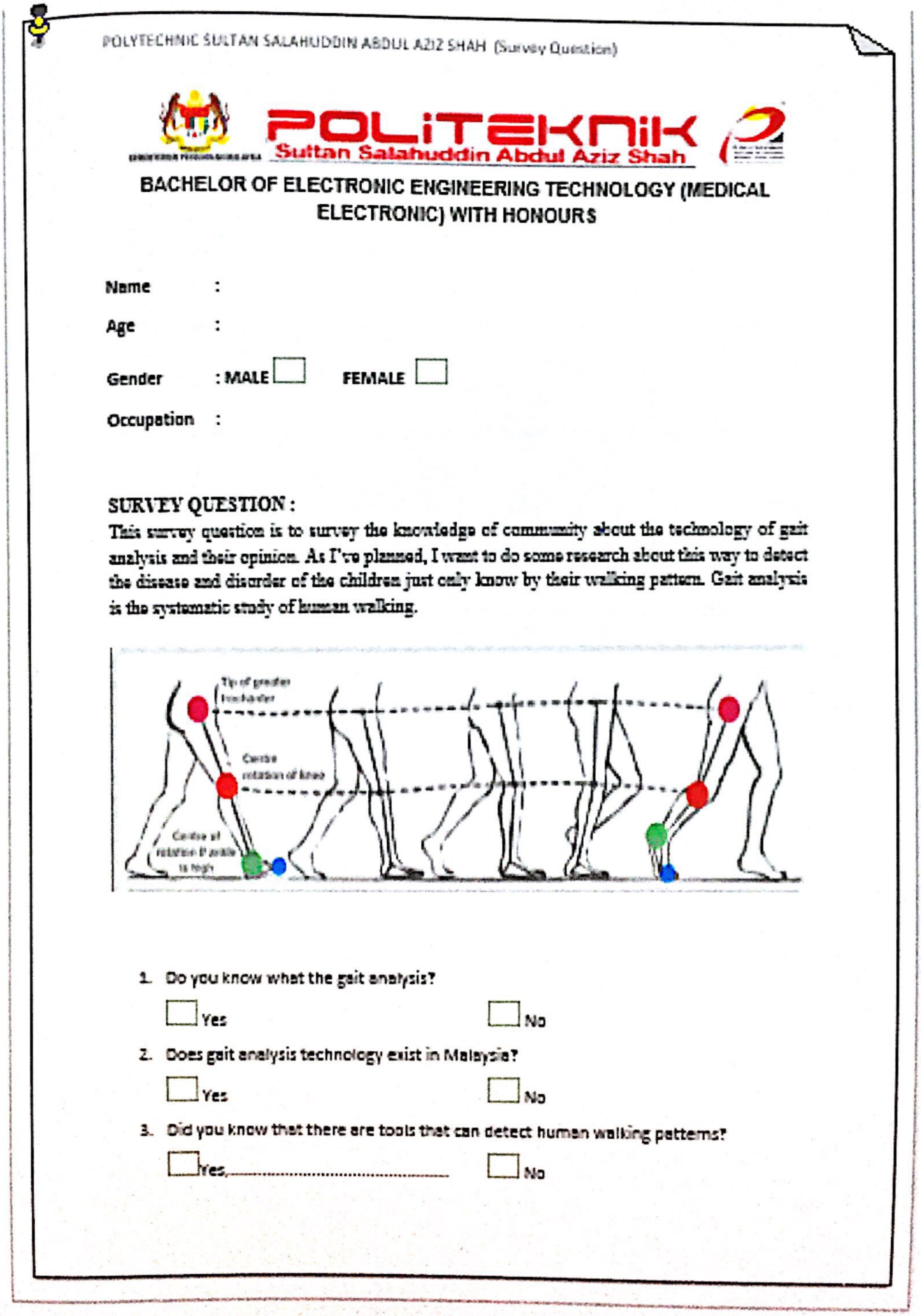
APPENDIX C: QUESTIONNAIRE



POLYTECHNIC SULTAN SALAHUDDIN ABDUL AZIZ SHAH (Survey Question)

POLITEKNIK
Sultan Salahuddin Abdul Aziz Shah

BACHELOR OF ELECTRONIC ENGINEERING TECHNOLOGY (MEDICAL ELECTRONIC) WITH HONOURS

Name :

Age :

Gender : **MALE** ☐ **FEMALE** ☐

Occupation :

SURVEY QUESTION :

This survey question is to survey the knowledge of community about the technology of gait analysis and their opinion. As I've planned, I want to do some research about this way to detect the disease and disorder of the children just only know by their walking pattern. Gait analysis is the systematic study of human walking.

1. Do you know what the gait analysis?

☐ Yes ☐ No

2. Does gait analysis technology exist in Malaysia?

☐ Yes ☐ No

3. Did you know that there are tools that can detect human walking patterns?

☐ Yes,.. ☐ No

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4. Did you know that the method used to detect human walking patterns?

☐ Yes,.. ☐ No

5. Did you know that through this technology we can detect and analyze diseases that affect the human body's pattern systems?

☐ Yes ☐ No

6. Did you know that boys and girls differ in the gait pattern?

☐ Yes ☐ No

7. Nowadays, the patterns of human walking are only examined more for adults rather than for children?

☐ Yes ☐ No

8. In your opinion, if the comparison between female and male, who progress faster growth?

☐ Yes ☐ No

9. In your opinion, which part of the body played the main role during walking?

☐ Knee ☐ Hip ☐ Foot

10. In your opinion, how is the best way to train your child to walk properly?

....

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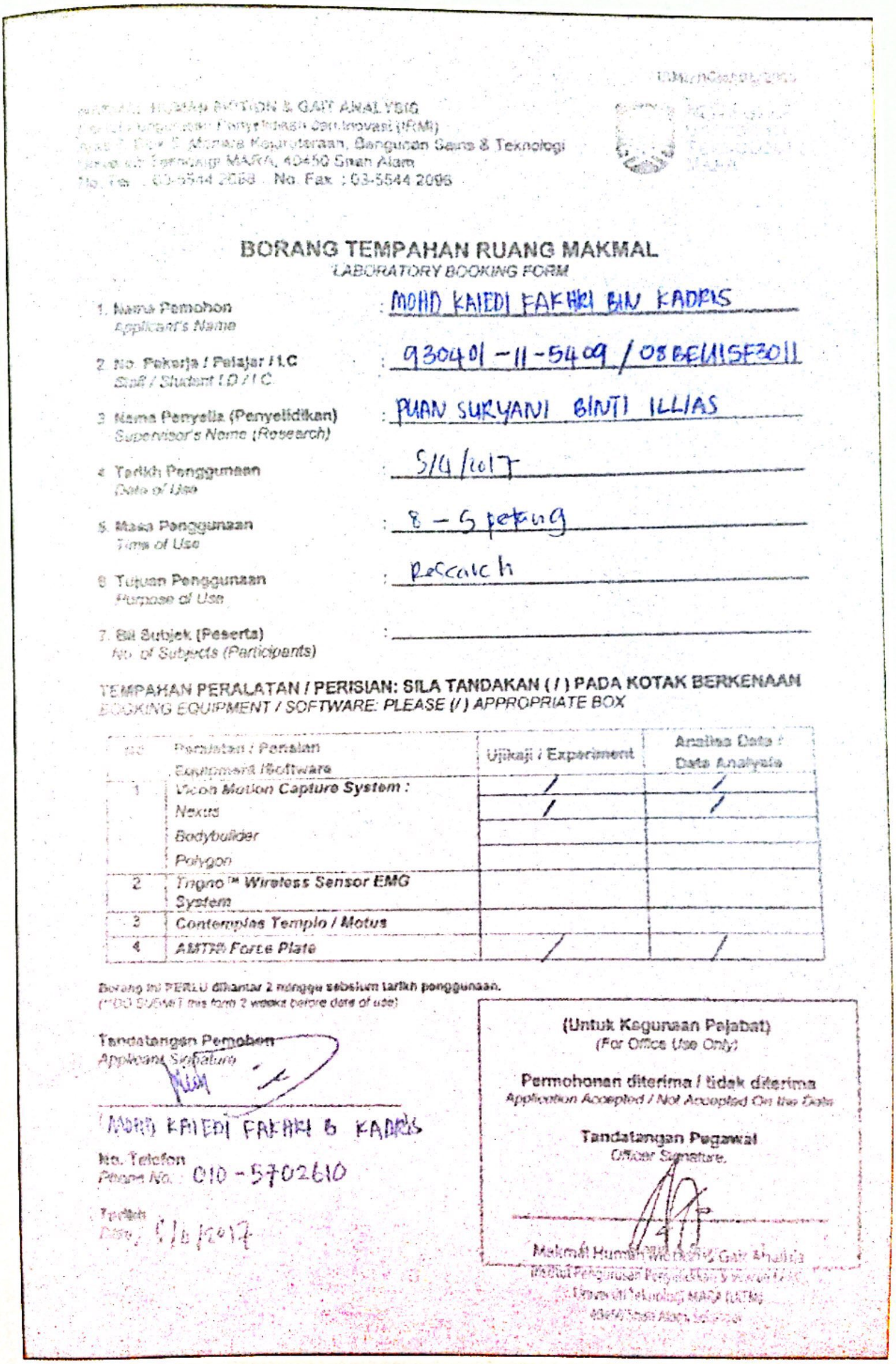
APPENDIX D: LABORATORY BOOKING FORM



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MAKMAL HUMAN MOTION & GAIT ANALYSIS
Institut Pengurusan Penyelidikan dan Inovasi (IRMI)
Aras 7, Blok 5, Menara Kejuruteraan, Bangunan Sains & Teknologi
Universiti Teknologi MARA, 40450 Shah Alam
No. Tel : 03-5544 2068 . No. Fax : 03-5544 2096

BORANG TEMPAHAN RUANG MAKMAL
LABORATORY BOOKING FORM

1. Nama Pemohon *Applicant's Name* : MOHD KAIEDI FAKHRI BIN KADRIS
2. No. Pekerja / Pelajar / I.C *Staff / Student I.D / I.C* : 930401-11-5409 / 08BEU15F3011
3. Nama Penyelia (Penyelidikan) *Supervisor's Name (Research)* : PUAN SURYANI BINTI ILLIAS
4. Tarikh Penggunaan *Date of Use* : 5/4/2017
5. Masa Penggunaan *Time of Use* : 8 - 5 petang
6. Tujuan Penggunaan *Purpose of Use* : Research
7. Bil Subjek (Peserta) *No. of Subjects (Participants)* :

TEMPAHAN PERALATAN / PERISIAN: SILA TANDAKAN (/) PADA KOTAK BERKENAAN
BOOKING EQUIPMENT / SOFTWARE: PLEASE (/) APPROPRIATE BOX

Bil	Peralatan / Perisian *Equipment / Software*	Ujikaji / Experiment	Analisa Data / Data Analysis
1	*Vicon Motion Capture System :*	/	/
	Nexus	/	/
	Bodybuilder		
	Polygon		
2	*Trigno™ Wireless Sensor EMG System*		
3	*Contemplas Templo / Motus*		
4	*AMTI® Force Plate*	/	/

Borang ini PERLU dihantar 2 minggu sebelum tarikh penggunaan.
(*DO SUBMIT this form 2 weeks before date of use)

Tandatangan Pemohon
Applicant Signature

MOHD KAIEDI FAKHRI B KADRIS

No. Telefon
Phone No. : 010-5702610

Tarikh
Date : 5/4/2017

(Untuk Kegunaan Pejabat)
(For Office Use Only)

Permohonan diterima / tidak diterima
Application Accepted / Not Accepted On the Date

Tandatangan Pegawai
Officer Signature.

Makmal Human Motion & Gait Analysis
Institut Pengurusan Penyelidikan & Inovasi (IRMI)
Universiti Teknologi MARA (UiTM)
40450 Shah Alam, Selangor

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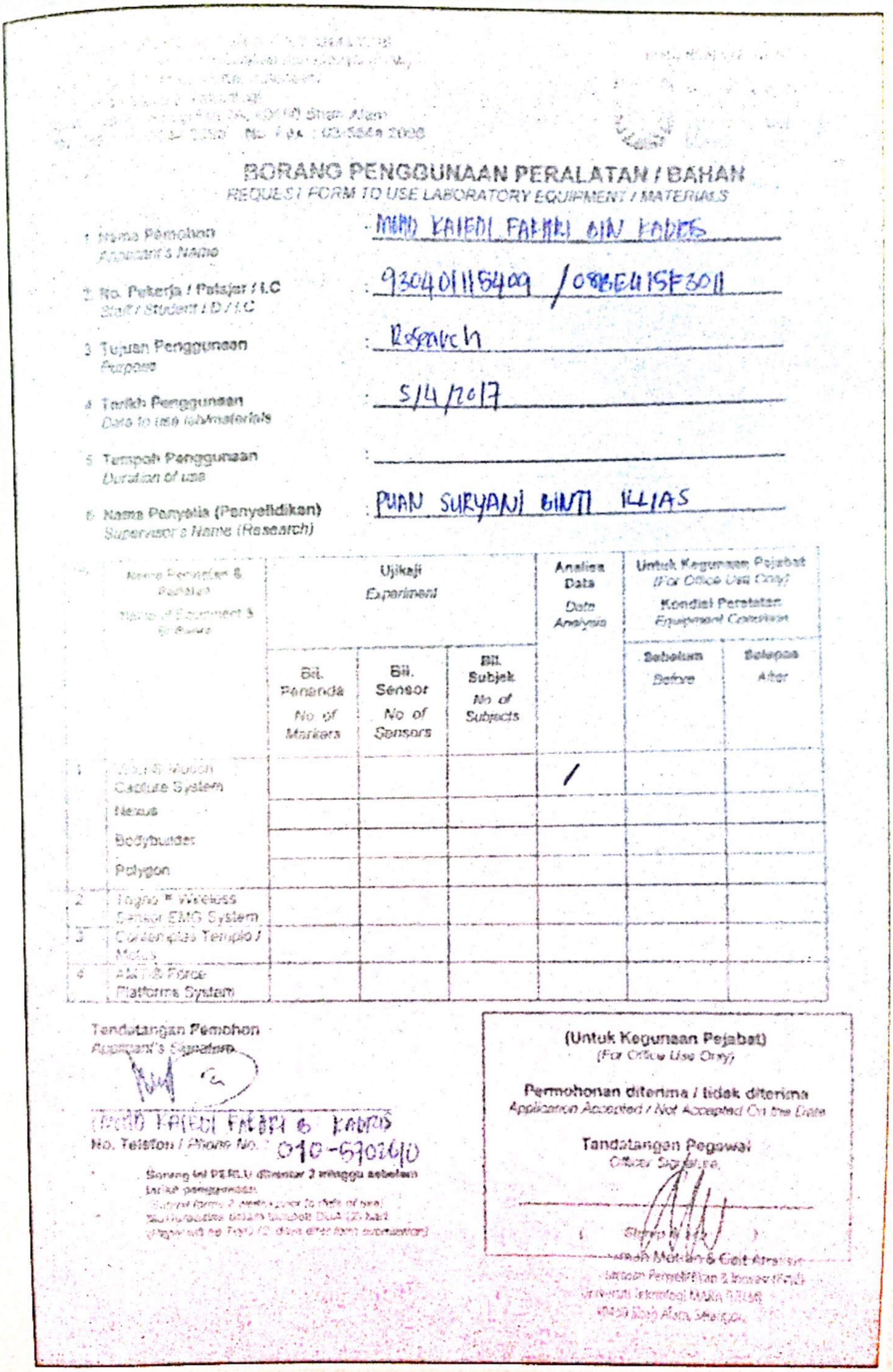
APPENDIX E: REQUEST FORM TO USE LABORATORY EQUIPMENT



[illegible]
[illegible] Shah Alam
[illegible] No. Fax : 03-5544 2006

BORANG PENGGUNAAN PERALATAN / BAHAN
REQUEST FORM TO USE LABORATORY EQUIPMENT / MATERIALS

1. Nama Pemohon *Applicant's Name* : MOHD KAIEDI FAHMI BIN KADES
2. No. Pekerja / Pelajar / I.C *Staff / Student I.D / I.C* : 930401115409 / 08BE415F3011
3. Tujuan Penggunaan *Purpose* : Research
4. Tarikh Penggunaan *Date to use lab/materials* : 5/4/2017
5. Tempoh Penggunaan *Duration of use* :
6. Nama Penyelia (Penyelidikan) *Supervisor's Name (Research)* : PUAN SURYANI BINTI ILLIAS

	Nama Peralatan & Bahan *Name of Equipment & Software*	Ujikaji *Experiment*			Analisa Data *Data Analysis*	Untuk Kegunaan Pejabat *(For Office Use Only)* Kondisi Peralatan *Equipment Condition*	
		Bil. Penanda *No of Markers*	Bil. Sensor *No of Sensors*	Bil. Subjek *No of Subjects*		Sebelum *Before*	Selepas *After*
1	Vicon® Motion Capture System				/		
	Nexus						
	Bodybuilder						
	Polygon						
2	Trigno ™ Wireless Sensor EMG System						
3	Contemplas Templo / Motus						
4	AMTI® Force Platforms System						

Tandatangan Pemohon
Applicant's Signature

(MOHD KAIEDI FAHMI B. KADRIS)
No. Telefon / *Phone No.* : 010-5702610

Borang ini PERLU dihantar 2 minggu sebelum tarikh penggunaan.
Submit forms 2 weeks prior to date of use.
Sah/keputusan dalam tempoh DUA (2) hari
(Approved in TWO (2) days after form submission)

(Untuk Kegunaan Pejabat)
(For Office Use Only)

Permohonan diterima / tidak diterima
Application Accepted / Not Accepted On the Date

Tandatangan Pegawai
Officer Signature,

(Stamp & Sign)

Makmal Motion & Gait Analysis
Institut Penyelidikan & Inovasi
Universiti Teknologi MARA (UiTM)
40450 Shah Alam, Selangor.

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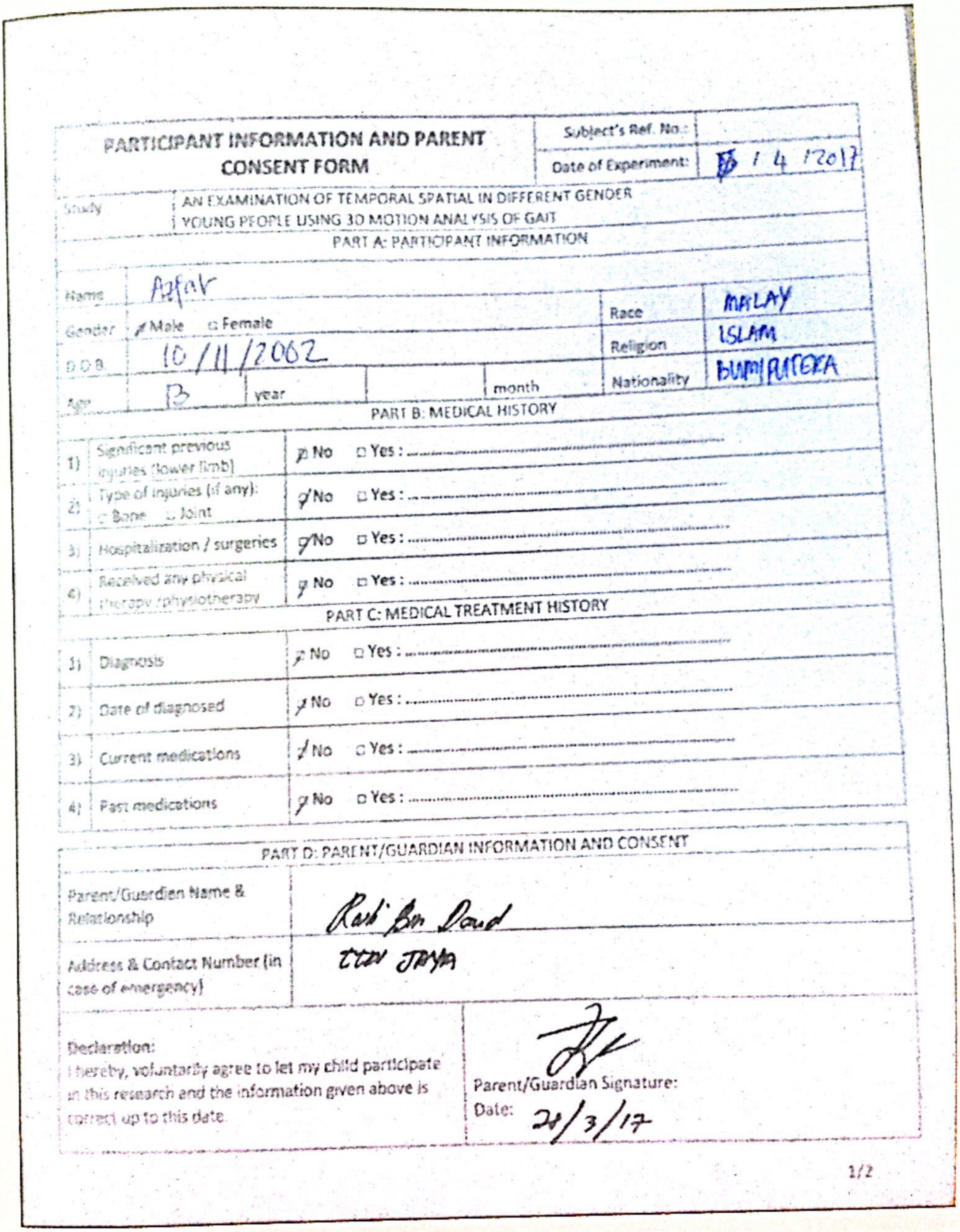
APPENDIX F: PARTICIPANT INFORMATION AND PARENT CONSENT FORM



PARTICIPANT INFORMATION AND PARENT CONSENT FORM	Subject's Ref. No.: Date of Experiment: [illegible] / 4 /2017
Study	AN EXAMINATION OF TEMPORAL SPATIAL IN DIFFERENT GENDER YOUNG PEOPLE USING 3D MOTION ANALYSIS OF GAIT

PART A: PARTICIPANT INFORMATION

Name	Azfar				
Gender	☒ Male ☐ Female			Race	MALAY
D.O.B.	10/11/2002			Religion	ISLAM
Age	13	year	month	Nationality	BUMIPUTERA

PART B: MEDICAL HISTORY

1)	Significant previous injuries (lower limb)	☒ No ☐ Yes : ....
2)	Type of injuries (if any): ☐ Bone ☐ Joint	☒ No ☐ Yes : ....
3)	Hospitalization / surgeries	☒ No ☐ Yes : ....
4)	Received any physical therapy /physiotherapy	☒ No ☐ Yes : ....

PART C: MEDICAL TREATMENT HISTORY

1)	Diagnosis	☒ No ☐ Yes : ....
2)	Date of diagnosed	☒ No ☐ Yes : ....
3)	Current medications	☒ No ☐ Yes : ....
4)	Past medications	☒ No ☐ Yes : ....

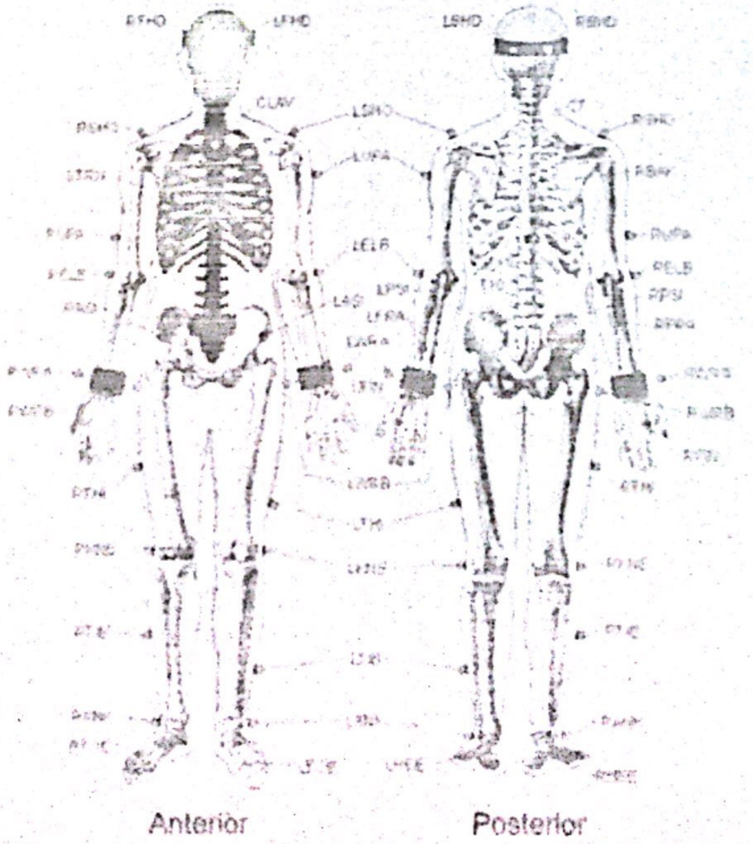
PART D: PARENT/GUARDIAN INFORMATION AND CONSENT

Parent/Guardian Name & Relationship	Rasi Bin Daud
Address & Contact Number (in case of emergency)	TTDI JAYA
Declaration: I hereby, voluntarily agree to let my child participate in this research and the information given above is correct up to this date.	Parent/Guardian Signature: Date: 28/3/17

1/2

APPENDIX G: ANTHROPOMETRIC MEASUREMENTS

ANTHROPOMETRIC MEASUREMENTS		Subject's Ref. No.:	
		Category:	N / P
Body Mass	33.9	kg	
Height	148.7	mm	
ITEM	LEFT	RIGHT	DESCRIPTION
Leg Length	839 mm	831 mm	Full leg length, measured between ASIS marker and the medial malleolus, via the knee joint. Measure with subject is standing.
Knee Width	77.33 mm	76.84 mm	The medio-lateral width of the knee across the line of the knee axis. Measure with subject is standing.
Ankle Width	63.95 mm	64.40 mm	The medio-lateral distance across the malleoli. Measure with patient standing.
Shoulder Offset	_______ mm	_______ mm	Vertical offset from the base of the acromiom marker to shoulder joint center.
Elbow Width	_______ mm	_______ mm	Width of elbow along flexion axis (roughly between the medial and lateral epicondyles of the humerus).
Wrist Width	_______ mm	_______ mm	Anterior/posterior thickness of wrist.
Hand Thickness	_______ mm	_______ mm	Anterior/posterior thickness between the dorsum and palmar surfaces of the hand.



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APPENDIX H: SOME BASIC GUI COMPONENTS

Table 10.1 Some Basic GUI Components

Element	Created By	Description
Graphical Controls		
Pushbutton	`uicontrol`	A graphical component that implements a pushbutton. It triggers a callback when clicked with a mouse.
Toggle button	`uicontrol`	A graphical component that implements a toggle button. A toggle button is either "on" or "off," and it changes state each time that it is clicked. Each mouse button click also triggers a callback.
Radio button	`uicontrol`	A radio button is a type of toggle button that appears as a small circle with a dot in the middle when it is "on." Groups of radio buttons are used to implement mutually exclusive choices. Each mouse click on a radio button triggers a callback.
Check box	`uicontrol`	A check box is a type of toggle button that appears as a small square with a check mark in it when it is "on." Each mouse click on a check box triggers a callback.
Edit box	`uicontrol`	An edit box displays a text string and allows the user to modify the information displayed. A callback is triggered when the user presses the `Enter` key.
List box	`uicontrol`	A list box is a graphical control that displays a series of text strings. A user can select one of the text strings by single- or double-clicking on it. A callback is triggered when the user selects a string.
Popup menus	`uicontrol`	A popup menu is a graphical control that displays a series of text strings in response to a mouse click. When the popup menu is not clicked on, only the currently selected string is visible.
Slider	`uicontrol`	A slider is a graphical control to adjust a value in a smooth, continuous fashion by dragging the control with a mouse. Each slider change triggers a callback.
Static Elements		
Frame	`uicontrol`	Creates a frame, which is a rectangular box within a figure. Frames are used to group sets of controls together. Frames never trigger callbacks.
Text field	`uicontrol`	Creates a label, which is a text string located at a point on the figure. Text fields never trigger callbacks.
Menus and Axes		
Menu items	`uimenu`	Creates a menu item. Menu items trigger a callback when a mouse button is released over them.
Context menus	`uicontextmenu`	Creates a context menu, which is a menu that appears over a graphical object when a user right-clicks the mouse on that object.
Axes	`axes`	Creates a new set of axes to display data on. Axes never trigger callbacks.

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APPENDIX I: CODING MATLAB FOR HISTOGRAM DISTRIBUTION

```
figure,
load('DoubleSupports1.mat')
x = DoubleSupports1(~isnan(DoubleSupports1))
BinNo=length(x);
R=histfit(x,BinNo);
hold on
load('DoubleSupports2.mat')
x = DoubleSupports2(~isnan(DoubleSupports2))
BinNo=length(x);
H=histfit(x,BinNo)
hold off
load('FootOff1.mat')
x = FootOff1(~isnan(FootOff1))
BinNo=length(x);
figure, histfit(x,BinNo)
mn = mean(x);
sd = std(x);
ptiles = prctile(x,[16 50 84]);
figure;
hold on;
hist(x,BinNo);
ax = axis;
h1 = plot([mn mn], ax(3:4),'r-','LineWidth',2);
h2 = plot([mn-sd mn-sd],ax(3:4),'r-','LineWidth',2);
h3 = plot([mn+sd mn+sd],ax(3:4),'r-','LineWidth',2);
h4 = [];
for p=1:length(ptiles)
h4(p) = plot(repmat(ptiles(p),[1 2]),ax(3:4),'g-
','LineWidth',2);
end
legend([h1 h4(1)],{'Mean and std dev' 'Percentiles'});
xlabel('Value');
ylabel('Frequency');
```

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APPENDIX J: CODING MATLAB FOR PROBABILITY PLOT

```
figure;
clf;
hold on;
LegHandles = []; LegText = {};
probplot('normal'); title('');
hLine = probplot(gca,OppositeFootContactF,[],[],'noref');
set(hLine,'Color',[0.333333 0 0.666667],'Marker','o',
'MarkerSize',6);
xlabel('Data');
ylabel('Probability')
LegHandles(end+1) = hLine;
LegText{end+1} = 'OppositeFootContactF';
hLine = probplot(gca,OppositeFootContactM,[],[],'noref');
set(hLine,'Color',[0.333333 0.666667 0],'Marker','o',
'MarkerSize',6);
xlabel('Data');
ylabel('Probability')
LegHandles(end+1) = hLine;
LegText{end+1} = 'OppositeFootContactM';
box on;
hold off;
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical',
'Location', 'NorthWest');
set(hLegend,'Interpreter','none');
```

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APPENDIX K: CODING MATLAB FOR CULMULATIVE DISTRIBUTION

```
figure;
clf;
hold on;
LegHandles = []; LegText = {};
 [CdfY,CdfX] = ecdf(StrideTimeF,'Function','cdf');  %
hLine = stairs(CdfX,CdfY,'Color',[0.333333 0
0.666667],'LineStyle','--', 'LineWidth',1);
xlabel('Data');
ylabel('Cumulative probability')
LegHandles(end+1) = hLine;
LegText{end+1} = 'StrideTime Female';
 [CdfY,CdfX] = ecdf(StrideTimeM,'Function','cdf');
hLine = stairs(CdfX,CdfY,'Color',[0.333333 0.666667
0],'LineStyle','--', 'LineWidth',1);
xlabel('Data');
ylabel('Cumulative probability')
LegHandles(end+1) = hLine;
LegText{end+1} = 'StrideTime Male';
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
box on;
hold off;
hLegend = legend(LegHandles,LegText,'Orientation',
'vertical', 'Location', 'NorthWest');
set(hLegend,'Interpreter','none');
```

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APPENDIX L: CODING MATLAB FOR CROSS CORRELATION

```
figure,
subplot(3,2,1)
scatter(Males(:,1),Females(:,1))
title('Opposite Foot Off')
[acor,lag] = xcorr(Males(:,1),Females(:,1));
Fs=11025;
[~,I] = max(abs(acor));
lagDiff = lag(I)

timeDiff = lagDiff/Fs


figure,
subplot(3,2,1)
scatter(lag,acor)
a3 = gca;
a3.XTick = sort([-3000:1000:3000 lagDiff]);
title('Opposite Foot Off')
```

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