THE EFFECT ON BALANCE TRAINING EXERCISE FOR TEMPORAL SPATIAL GAIT PARAMETERS IN YOUNG ADULT

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ENDORSEMENT

I hereby acknowledge that I have read this report and I find that its contents meet the requirements in terms of scope and quality for the award of the Bachelor Of Electronic Engineering Technology (Medical Electronic) With Honours

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DECLARATION

I hereby declare that the final year project book is an authentic record of my own work carried out of one year Final Year Project for the award of Bachelor Of Electronic Engineering Technology (Medical Electronic) With Honours, Under the guidance of Pn Suryani Binti Illias from 6 September 2016 to 15 May 2017.

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ABSTRACT

Gait analysis allows the measurement and assessment of walking biomechanics, which facilitates the identification of abnormal characteristics and recommendation of treatment alternatives for lower limb. It is acknowledged for quantifying gait disorders and clinical evaluation of patients. In routine gait analysis, temporal spatial is recorded by motion capture. The temporal spatial can be applied to discriminate normal and pathological gait well as pre- and post-treatment conditions. The present study aimed at testing the application of machine learning to discriminate temporal spatial gait pattern between normal subjects and for normal young people involved in balance training exercise. Due to its high-dimensionality, temporal-dependence, high variability and correlated nature gait data is analyse for normal young people involved in balance training exercise. Therefore, examining the temporal spatial which is cadence, walking speed, stride time, step time, stride length, and step length data is expected to be more effective for identifying specific locomotion characteristics of lower limb movements. The predominant methods for this analysis include the tracking of external markers placed on the subject and the monitoring of subject interaction during gait is done by VICON MX system. Understanding the ethology of any abnormalities or changes allows the formulation of a treatment plan that may involve physical therapy, bracing or surgery. This research also use the Graphic User Interface (GUI) to show the final result that was analyze using Matlab Software.

ABSTRAK

'Gait analysis" atau Analisa Gaya Berjalan adalah pengukuran dan penilaian biomekanik berjalan, yang memudahkan mengenal pasti ciri-ciri yang tidak normal dan cadangan alternatif rawatan untuk anggota badan bawah pinggang. Ia diakui untuk mengukur gangguan gaya berjalan dan penilaian klinikal pesakit. Dalam rutin analisis gaya berjalan, 'Temporal Spatial' dirakamkan dengan menangkap gerakan seseorang. 'Temporal Spatial' boleh digunakan untuk membezakan gaya berjalan normal dan patologi serta keadaan sebelum dan selepas rawatan. Kajian ini bertujuan untuk menguji aplikasi pembelajaran mesin untuk membezakan corak gaya berjalan spatial temporal untuk anak-anak muda yang normal yang terlibat dalam Latihan Keseimbangan. Oleh kerana kematraan yang tinggi, kebergantungan-sementara, kepelbagaian yang tinggi dan pengkaitan data gaya berjalan digunakan sebagai analisis data untuk golongan muda biasa yang terlibat dalam Latihan Keseimbangan. Oleh itu, pemeriksaan Temporal Spatial iaitu irama, kelajuan berjalan, masa langkah, langkah masa, panjang langkah dan data langkah panjang dijangka menjadi lebih berkesan untuk mengenal pasti ciri-ciri pergerakan tertentu pergerakan anggota badan bawah pinggang. Kaedah utama untuk analisis ini termasuk pengesanan penanda luaran diletakkan pada subjek dan pemantauan interaksi tertakluk pada gaya berjalan dilakukan oleh sistem VICON MX. Memahami apa sahaja ethology keabnormalan atau perubahan membolehkan penggubalan pelan rawatan yang mungkin melibatkan terapi fizikal, perembatan atau pembedahan. Kajian ini juga tutut menggunakan Graphic User Interface (GUI) untuk memaparkan keputusan akhir yang dianalisa oleh prisian Matlab.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Balance training is training for the ability to recover balance or base of support (BOS) from postural sway, body movement over your BOS, following a destabilizing stimulus caused by objects, self-motion or the environment.[1] This means that because the human body is naturally equipped to be in balance, the whole concept and goal of balance training and the training protocol lies in the state of going from unbalanced back to balanced, otherwise known as balance recovery. There are three types of balance training.[2] The first is "Dynamic Balance." This is commonly known as "Dynamic Balance Recovery". The second is "Static Balance." The static (stationary) ability to recover from an out of balance situation created by an unstable environment. This is "Static Balance Recovery." The third is "Dynamic/Static Counterbalance" the ability to oppose and counter an equal or greater weight or force and maintain or recover balance. This is also referred to as "Perturbation Training." Example, football player preventing a blocker from moving him or a hockey player avoiding a check. Balance training, to be most effective must be performed using the same type of full body motion and equipment in a destabilizing environment as the intended activity itself.[3]

In this study, by using Gait Analysis, force plates that measure ground reaction forces and high frequency infrared camera in vision motion system will be used to analyze the beneficial to young individuals who are bio-mechanically challenged (e.g. flat foot, muscular imbalance and injuries). Previous research of gait analysis show the ability of general population on how to improve their performance and quality of life especially for young individuals.[4]

1.2 Problem Statement

In order to continue with the study, it is necessary to understand the difference in temporal spatial gait in young adult. It is very important to analyses the walking patterns or normal people as it maybe differ from the young and the result will effect this study.[5] For this reason the information of the effect of balance training exercise in gait pattern for young will be used to differentiate between both young people who do exercise and those who don't. It has been shown that balance training (BT) has the potential to promote postural control, strength of the lower extremities, and jumping performance in healthy young, middle-aged, and old subjects. BT have good effects on postural sway, leg extensor strength, and jumping height in a cohort of adolescent high school students.[3] Four weeks of BT implemented in physical education (PE) induced significant decreases in postural sway, increases in jumping height, and rate of force development (RFD) of the leg extensors. Therefore, this study, by using the temporal spatial parameter in walking gait for normal population especially for young will differentiate the difference between people that are involve in balance training exercise and those who do not.

1.3 Objectives

The main objectives of this project are:

- To identify the effect on balance training in temporal spatial gait parameter among young adult.

- To use advanced signal processing for gait using temporal spatial parameters in investigate if there any difference in people who do exercise and those who don't.

1.4 Scopes of Projects

The main works of the study will involve in data acquisition and analysis of gait parameters among normal children obtain from the experiment. 10 (n=10) young normal adult age from 18-25 years old will take part in this study. They will be divided in groups of two. The first group will be a group of children that will do the balance training exercise, and the second group will be filled with young adult who do not take the exercise. There are 11 in temporal spatial parameters will be used to establish whether which real temporal spatial gait exist after the balance training between the young.[6] Velocity, duration, single support phase (SSP), double support phase (DSP), stride length, step length, first step length, first step time, first step velocity, and first step DSP are the example of spatial and temporal parameters[4] will be measured from the study. But only four of it that will be extracted. Data collection and experiment will be conducted at Human Motion Analysis Research Laboratory, Faculty of Engineering, UiTM Shah Alam using 3D Vicon Mcam Motion Capture System and force plate.

1.5 Significant Of the Research

This study will be used as a result to understand the gait parameters in temporal spatial for the effect of balance training in young adult. The study also will added more knowledge in gait study as it will uplifting the knowledge and awareness among the population.[7] The result of this study hopefully will provide usefulness of using gait analysis in improving the diagnosis method and to improve performance and quality of life among the young adult. Nowadays, the usefull of gait was wide. It evolve from rehabilitation to such a wide area of prospects including computer software and gaming devices such as Kinects.[8][9] hopefully, this study will continue the enhancing of that wide development of gait. Other than that, there is limited study on gait analysis among normal children. Thus, the result also hopefully will give support to the government for intervention and treatment programs in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Gait Analysis

Gait analysis is the methodical of the human motion and all the particularly of investigation of the human movement.[10] It's utilizing the measuring body. It's utilizing the measuring body developments, body mechanics, and the action of the muscles. Gait examination is utilized to survey, plan, and treat the people with conditions influencing their capacity to walk. It is likewise usually utilized as a part of sports biomechanics to help athletes to run more effectively and to distinguish posture-related or movement-related problems in people with injuries.[11] The appropriate muscle force increases walking efficiency. As the body moves forward, one limb typically provides support while the other limb is advanced in preparation for its role as the support limb. Figure 2.1 shows the component of gait cycle for normal people. The gait cycle (GC) in its simplest form is comprised of stance and swing phases.

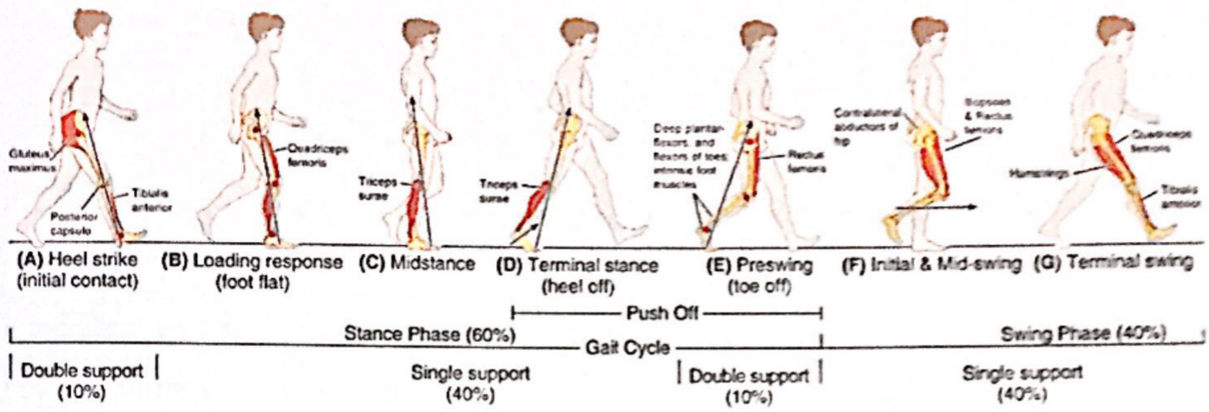


Figure 2.1: Component of Gait Cycle.

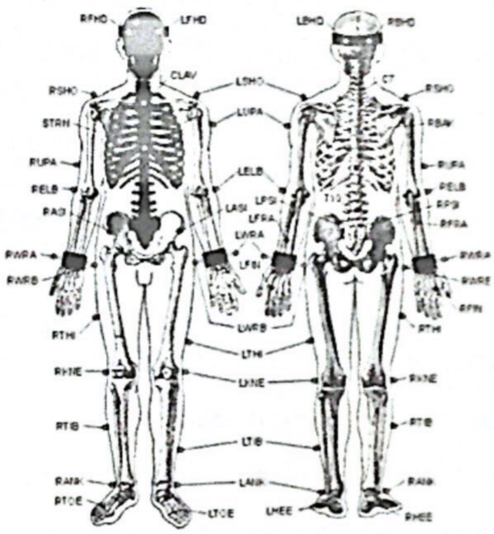


Figure 2.2: Plug-in-Gait markers Placement.

2.2 Temporal Spatial

Normal gait is described as a series of rhythmical, alternating movements of the trunk and limbs which result in the forward progression of the centre of gravity and the body.[12] Gait analysis is used for clinical identification of deviations from normal gait. Kinematic gait analysis is concerned with the description of gait components.[12] It deals with movement as opposed to kinetic which deals with the forces acting on or exerted by the body. For this it is considered in, distance (spatial) and time (temporal) parameters. A brief outline of some of the different spatial and temporal parameters as in Spatial Parameters.[6] (Distance parameters) include it will including mainly step length and stride length. While for Temporal Parameters (Time parameters) include Cadence, speed, and Single limb support.[13] So as for temporal spatial, it is the parameters of cadence, speed, and single limb support factored by step and stride length.

2.3 Balance Training Exercise

Each year, more than one-third of people age 65 or older fall.[8] Falls and fall-related injuries, such as hip fracture, can have a serious impact on an older person's life. If a person fall, it could limit the activities or make it impossible to live independently. Balance exercises, along with certain strength exercises, can help prevent falls by improving the ability to control and maintain body's position, whether when are moving or still.[9] Thus in this study, a routine of balance exercise will be executed in young adult people to gain if there any different before doing the exercise and after.

2.4 Subjects

A research have been done before for a specific subject to identify the temporal spatial. Crowther RG1, Spinks WL, Leicht AS, Quigley F, Golledge J. have done a research on "Relationship Between Temporal-Spatial Gait Parameters, Gait Kinematics, Walking Performance, Exercise Capacity, And Physical Activity Level In Peripheral Arterial Disease" on 2007. They have stated their previous research which found that temporal-spatial gait parameters do not discriminate between PAD-IC patients and control subjects during normal and maximal walking even though PAD-IC patients have decreased physical function characteristic of the disease. Impaired physical function is a feature of patients with peripheral arterial disease (PAD) who present with symptoms of intermittent claudication (PAD-IC). This study examined the hypothesis that patients with PAD-IC would demonstrate decreased temporal-spatial gait parameters, gait kinematics, walking performance, physiologic responses to exercise, and physical activity level compared with control subjects. The aim was to examine the temporal-spatial gait parameters and gait kinematics of individuals with PAD-IC and to determine the relationship between these variables and walking performance, exercise capacity, and physical activity level in these individuals.

They came out with a conclusion IC subjects walk with a shuffling gait pattern indicated by reduced joint angular displacement, velocities, and accelerations that results in reduced walking performance and physiologic responses and physical activity compared with controls matched for age, mass, and physical activity. And as for this study of "The Effect on Balance Training Exercise for Temporal Spatial Gait Parameters in Young Adult", the subject were normal young adult without any visible physical injury. The only thing that will or maybe become the manipulated data is the difference of them doing the balance training, and those who do not. Thus, there is no data on this difference before, this study will came out with a data on that specific subject. The is also the condideration done on focusing on gender of the subjects.[14][15]

2.5 Method

There is lot of gait analysis experiment and study have been done before and most of them were studying on Temporal Spatial.[5][16][6] 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.

"Analysis of Temporal and Spatial Gait Parameters in Children with Spastic Cerebral Palsy" study was done by Longwei Chen, Jue Wang, Shuwei Li, Lin Gao, Hongxia Li, Zhimin Wang and Zhengxiang Zhang which the objective was to obtains gait feature of children with spastic cerebral palsy (SCP) by analysis of temporal and spatial parameters in stable walking and gait initiation (GI). 24 children with SCP and 18 normally-developing (ND) children were tested by three-dimensional gait analysis system with normal walking speed. Velocity, duration, single support phase (SSP), double support phase(DSP), stride length, step length, first step Length, first step time, first step velocity, first step DSP were selected as spatial and temporal parameters. Finally, they also came out with a result stated there was significant difference between SCP group and ND group in velocity, stride length, step length, DSP, first step length, first step velocity, first step DSP ($P<0.05$).

The lab at Human Motion And Gait Analysis Laboratory(Hmga), Universiti Teknologi Mara, Shah Alam, have already installed all the equipment needed and also the system that will be used to analyse and collect all the data and came out with a result.

2.6 Parameter

For Temporal Spatial in Gait Analysis, there is some parameter that will become the measurement of the data. These parameter need to be concerned on and be the highlight of the study. A journal of "Basic gait parameters: Reference data for normal subjects, 10-79 years of age" by Tommy Oberg, have study the basic gait parameters were extracted from 233 healthy subjects—116 men and 117 women, 10 to 79 years of age.[17] On their study, initially, they stated that "The basic gait parameters most frequently used are velocity, step length, and step frequency. Many reports are concerned with pathological gait, but such data must be compared with valid normal reference data to be interpretable. Their subject was two hundred and forty healthy subjects initially, then some have been excluded due to certain cases.

Table 2.1: Age and sex characteristics of the subject.

		Number	
Age group, years	Men	Women	Total
10-19	27	27	54
20-29	15	15	30
30-39	15	15	30
40-49	15	15	30
50-59	15	15	30
60-69	15	15	30
70-79	14	15	29
Total	116	117	239

Then the study was conducted in Biomechanics Laboratory, University of California, Berkeley, California. The gait laboratory has a walkway about 10 m long, including acceleration and deceleration distances. Two photocells with 5 .5 m intervals, self-aligning electrogoniometers, a computer, and a plotter constitute the equipment used. Basic temporal gait parameters (gait speed, step length, and step frequency) were collected during slow, normal, and fast gait. The subject had to walk between the photocells 13 times—10 times without goniometers, and 3 times with goniometers. The mean of the 10 measurements was calculated for each gait parameter without goniometers. The results of one- and two-way ANOVA are presented in Table 2.2 and Table 2.3. The results of regression analysis are presented in Table 2.4

Table 2.2: The results of Gait parameters. One-way analysis of varience

		p-value	
		Age group	sex
Gait speed	Slow gait	N.S	<0.001
	Normal gait	<0.01	<0.001
	First gait	<0.001	<0.001
Step length	Slow gait	N.S.	<0.001
	Normal gait	N.S.	<0.001
	Fast gait	<0.05	<0.001
Step frequency	Slow gait	N.S.	N.S.
	Normal gait	N.S.	<0.001
	First gait	N.S.	<0.001
N.S.=Not significant(p>0.05)			

Table 2.3: The results of Gait parameters. Two-way analysis of varience

		p-value		
		Age group	sex	Age*Sex
Gait speed	Slow gait	N.S	<0.001	N.S.
	Normal gait	<0.01	<0.001	N.S.
	First gait	<0.001	<0.001	N.S.
Step length	Slow gait	N.S.	<0.001	<0.05
	Normal gait	N.S.	<0.001	<0.05
	Fast gait	<0.05	<0.001	N.S.
Step frequency	Slow gait	N.S.	N.S.	N.S.
	Normal gait	N.S.	<0.001	N.S.
	First gait	N.S.	<0.001	N.S.
N.S.=Not significant(p>0.05)				

Table 2.4: The results of Gait parameters and age. Regression analysis. Test for significant slope of regression line.

		p-value	
		Men	Women
Gait speed	Slow gait	N.S.	<0.05
	Normal gait	<0.05	N.S.
	First gait	<0.05	<0.01
Step length	Slow gait	N.S.	<0.01
	Normal gait	N.S.	<0.01
	Fast gait	N.S.	<0.001
Step frequency	Slow gait	N.S.	N.S.
	Normal gait	<0.001	N.S.
	First gait	<0.05	N.S.
N.S.=Not significant(p>0.05)			

From their study, the changes of the basic gait parameters most frequently seen with advancing age are a reduction of gait speed and step length, but only small changes of the step frequency. In their study they found statistically significant age-related changes in gait speed at normal and fast gait and of step length at fast gait in the one-way ANOVA, and almost the same results were found in the two-way ANOVA, where also interaction effects were evaluated.[18] In the two-way ANOVA there were no age variations with respect to step frequency. The magnitude of age-related reduction of gait velocity reported in the literature varies between 0.1 percent/year and 0 .7 percent/year. Such differences between different studies may be due to differences between the examined groups and differences in technique as well. In the two-way ANOVA model, they also found significant interaction effects of age and sex in the step length parameter. In old age groups (over 70 years), Dahlstedt found slow pedestrians with a normal gait speed of only 0.9 m/s, a high speed of 1 .1 m/s, and very high speed of 1 .3 m/s. However, in their study, they had only few people of these old ages, and none over the age of 80.

Thus, this study of balance training exercise will only consist of 10 young adult from 5 to 12 without excluding any of them because there will be no cases of such disability or physically impaired. This study also will only take out a certain parameter which is cadence (steps/min), walking speed (m/s), and stride time (s), step time (s), stride length (m), step length (m).

2.7 Research Study

When writing a research, it is crucial and important to take a look at numerous previous researches. For this research, a research based on children and gait analysis was been studied properly . William Samson, Guillaume Desroches, Laurence Cheze, Rapha¨ el Dumas writes a study on "3D Joint Dynamics Analysis of Healthy Children's Gait.[19] In their research, fourteen healthy children which is 7 males and

7 females were included in the study. Independent walking was acquired between 10 and 18 months and medical examination did not reveal any orthopaedic or neurological disorder. Parents gave their informed consent for their child to participate in the study. The average age, height and mass were 3.1±1.4 years old, 0.96±0.13m and 14.5±4.0 kg respectively.

This research was also used retro-reflective markers.and after done doing the statistical and analytical analysis, the result was obtain. The 3D joint dynamics which is moment, power and 3D angle between moment and velocity vectors, it seems to be a good approach to investigate gait dynamic strategies of children. They seems to confirm that children may have an alternative strategy that is mainly ankle stabilization and hip propulsion compared to adults, mainly ankle resistance and propulsion and hip stabilization. They proposed, in the future, the same 3D angle analysis should be applied to different age groups for better describing the evolution of the 3D joint dynamics strategies during the growth. Looking back to this research, the next research, which is this research was done by increasing the age average by to young adult, age 18 to 25.

There is also a study on "A comparison of kinetic gait parameters for 3–13 year olds". This research was done by Victoria L. Chester, Maureen Tingley, Edmund N. Biden.[20] They stated that there is already a studies done which done examining pediatric kinetic gait data have reported adult-like kinetic patterns by the age of 5 years (O˜ Unpuu et al., 1991) and 7 years or older (Cupp et al., 1999; Ganley and Powers, 2005). These studies have varied greatly in terms of the ages of children included and whether between-age comparisons were made. For example, O˜ Unpuu et al. (1991) examined, qualitatively, the gait patterns of children aged 5–16 years and compared the results to previously reported adult values. No between-age comparisons were provided as part of this study. Ganley and Powers (2005) observed significant differences in the ankle kinetics of 7 year olds versus adults. However, no other age groups were included in the study. In contrast, Cupp et al. (1999) subdivided 23 children into three age groups (4–5 years, 6–7 years, and 8–10 years) and compared the results to a control group consisting of five adults aged 18–21 years. The results of this study suggested that progressive changes occur in ankle gait kinetics after the age of 7 years.

In their research, forty-seven (n = 47) children aged 3–13 years old were recruited to participate in the study. Four groups of children children were formed based on the following age divisions: (1) children aged 3–4 years (n = 13); (2) children aged 5–6 years (n = 10); (3) children aged 7–8 years (n = 12); and (4) children aged 9–13 years (n = 12). Group characteristics are provided in Table 2.1.

Table 2.5: Participant characteristics for each age group

Age Group Characteristic	3-4 Years Old		5-6 Years Old		7-8 Years Old		9+ Years Old	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	3.73	0.39	5.6	0.51	7.6	0.53	11.00	1.24
Height (m)	1.01	0.06	1.16	0.06	1.29	0.09	1.48	0.08
Weight (KG)	16.35	2.04	21.96	2.62	27.86	6.03	42.77	10.75
Number of participants (n=47)	13		10		12		12	
Gender (m = male, F= female)	9m, 4f		5m, 5f		6m, 6f		7m, 5f	

Ethical approval for this study was obtained from the University of New Brunswick Ethics Committee. Parental consent and child assent was obtained prior to each child's participation in the study. Parents voluntarily completed a questionnaire designed to identify possible injuries or diseases that could affect their child's walking skills. No children were eliminated from the study based on these responses.

The type of apparatus used was also quite similar and will be used for this "The Effect On Balance Training Exercise For Temporal Spatial Gait Parameters In Young Adult". Instrumentation and apparatus were six-camera Vicon 512 motion capture system (Vicon Peak, Oxford, UK) was used to track the three-dimensional trajectories of reflective markers placed on the subjects skin. Motion data was sampled at a frequency of 60 Hz. Three embedded force plates (Kistler 9281CA, Kistler 9281B11, Kistler Instruments, Winterthur, Switzerland and AMTI BP5918, Advanced Mechanical Technology, Incorporated, Newton, MA, USA) measured the three dimensional forces and moments during each gait cycle at a sampling frequency of 600 Hz. Two digital cameras, a weight scale, and calipers were used to obtain anthropometric measures from each subject. The reability of this type of measurement makes it realiable to use for the next study or research.

Again, after data analysis and statisticl analysis was done, a result was obtain. It concluded that, except for the ankle joint, children attain adult-like gait kinetics by five years of age. Age-related differences in ankle joint moments and power were consistent with previous studies and suggest that children lack the neuromuscular maturity to produce adult-like ankle patterns. This study identified mature sagittal kinetic patterns at the ankle by approximately 9 years of age and older.

Also, there is a research done to extend the original index, incorporating kinematic and kinetic data from multiple planes, while allowing for correlations between component measures.[21] The research was done by Victoria L. Chester, Maureen Tingley, Edmund N. Biden entitled "An Extended Index To Quantify Normality Of Gait In Children".

Ethical approval for this study was obtained from the University of New Brunswick Ethics Committee. Forty-five children aged 3–13 years old were recruited from the Fredericton area. Then parental consent and child assent were obtained prior to each child's participation in the study. Parents voluntarily completed a questionnaire designed to identify of any possible injuries or diseases that could affect their child's walking pattern. No children were eliminated from the study based on those responses.

After that, data collection took place at the motion analysis laboratory at the University of New Brunswick (UNB). Six-camera, Vicon 512 motion capture system (Oxford Metrics Ltd.), sampling at 60 Hz, was used to track the three dimensional trajectories of reflective markers placed on the subjects' skin. Two force plates (Kistler 9281B21, Kistler Instruments, Winterthur, Switzerland and AMTI BP5918, Advanced Mechanical Technology, Incorporated, Newton, MA, USA), embedded at the center of the 6.7 m×0.9 m wooden walkway, measured three-dimensional forces and moments. Two digital cameras, a weight scale, and calipers were used to obtain anthropometric measures from each subject.

As for the procedure on how the study was done, all of the participants were asked to wear minimal clothing during data collection. This was to reduce any extra movement from the markers that will effect the reading or recording from Vicon infrared camera.[16] Twenty reflective markers were placed directly on the skin of each participant, according to the UNB protocol outlined in Chester et al. (2005). After that, several 'warm-up' trials were conducted to allow the participants to adjust to the markers and the walkway, and then children were encouraged to perform at least 20 trials. Following completion of the gait trials, the reflective markers were removed and a new segment inertia marker set was applied. Participants were then asked to stand in the anatomical position within a calibration frame, while simultaneous front and side digital photographs were taken. Anthropometric data such as joint width, height and mass were also measured during this time.

After the data analysis was done, there is a step of calculation of gait indices which consist of seven-dimensional indices of gait, three kinematics and four kinetic. During this, the focus was on sagittal index of gait (N = 82, 11-dimensional input), six new indices of gait, trunk index of gait (N = 72, nine-dimensional input), kinematic extra index of gait (N = 83, 18-dimensional input), Four kinetic indices of gait (N = 60, 8/10 dimensional input), and overall one-dimensional index of normality (N = 53, seven-dimensional input).

This paper concluded that large volumes of gait data can be reduced to a small set of physically meaningful, one dimensional indices of normality. They were sagittal angle patterns which is the most established measures of gait, trunk kinematics that not available at all labs, other kinematic variables that is knee varus or valgus while the availability may vary laboratory to laboratory, and finally four kinetic measures which is moment or the power for stance and also swing phase.

There is a lot more previous research that have been studied before and during the completion of this research. This is a step to understanding the wide variety of possible result. The other components that need to be studied were such as the reduction of gait clinic which is to provide quantified assessments of human locomotion which assist in the orthopaedic management of various pediatric gait pathologies.[22] Then there is also the study of if there were any injuries of the subject such as shoulder dislocation.[23]

2.8 VICON

A vicon system is a suite of networked motion capture cameras, hardware devices such as Vicon Lock+ for synchronization of third-party devices, and software applications, which provide real-time and offline digital-optical motion capture data.

There is a several study that use Vicon. The study such as the study of the subject of cerebral palsy kids while use Vicon as the instrument.[24][25] Then, the understanding of the Vicon procedure is needed. Then in this research, other tiny knowledge was gain such as Retro-reflective markers come in various sizes from 25mm spheres down to 3mm hemispheres which used for facial or small subject captures. Also included are soft hemispherical markers, useful for movements where subjects may contact each other, the floor or other hard surfaces.[26]

2.9 GUI

A GUI usually pronounced GOO-ee is a graphical rather than purely textual user interface to a computer. When as such a person opens a tab on the Google or any other browser, any application on the computer, basically they are looking at the GUI or graphical user interface of a particular Web browser or application interface.[27] The term came into existence because the first interactive user interfaces to computers were not graphical, they were text-and-keyboard oriented and usually consisted of commands that need to remember and computer responses that were infamously brief. The command interface of the DOS operating system which a person can still get to from Windows operating system is an example of the typical user-computer interface before GUIs arrived. An intermediate step in user interfaces between the command line interface and the GUI was the non-graphical menu-based interface, which let peoples interact by using a mouse rather than by having to type in keyboard commands.[28]

Why use GUI in this research? Then it is needed to understand the advantages of this interesring system. Basically, GUI's make it easy to place more information within a single program, Web page or computer home screen without the need to clutter it with text. With the right graphics, people are able to use complex programs with ease. GUIs are not simple though, and they are difficult to make. Additionally, a poorly designed interface makes things more difficult, rather than easier, for the user which is human, normal people that have no clue about any of the programming.[28]

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is described and explained about the process and the method for implementing this study with successful result. 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 analyse the data.

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.

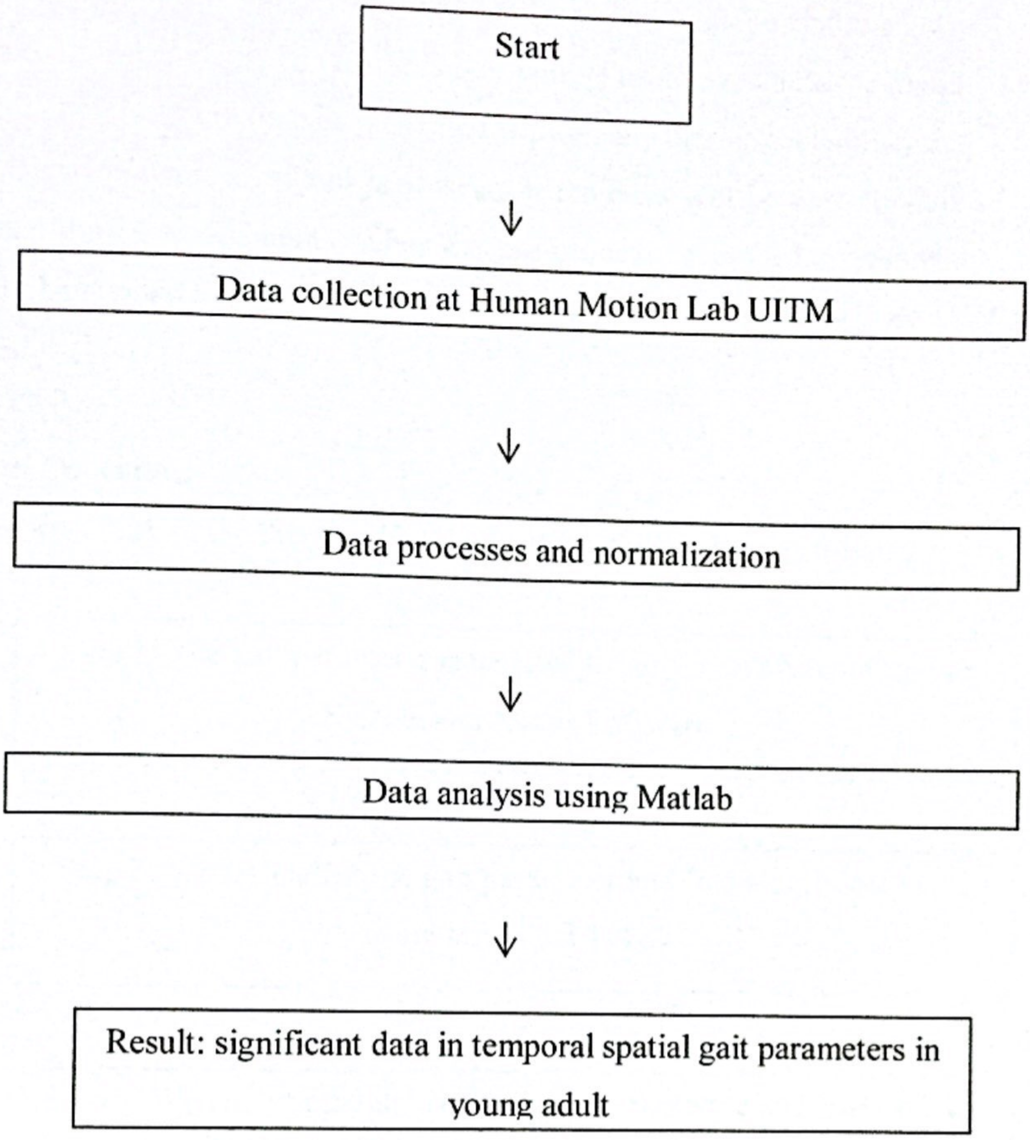


Figure 3.1: Flow Chart

This study will be conducted at the motion analysis lab. All data will be collected at the time of the experiments. 16 reflective markers will be placed directly on the hip, knee and ankle of each of the participant's body as shown in Figure 2. During experiment participant will be wearing year suits to minimize marker occlusion. The study will measured the temporal spatial gait parameters such as velocity, duration, single support phase (SSP), double support phase (DSP), stride length, step length, first step length, first step time, first step velocity, first step DSP. There will be eight camera Vicon motion capture system and two forces plates will be used to track the body motion of the participant during the walking After 3 times of practices and trials, participant will be asked to walk at pathway for about 3 meters without any help from others. There will be pre-processing walking gait data will be gathered from the experiment to remove unwanted noises. It also will be used to exclude the missing and invalid data. The result will then be presented without any bias and reliability to use for the next analysis. Advanced signal processing techniques will be used to analyse all data obtained during experiments. After the pre-processing procedure, the statistical analysis will be applied to evaluate the distribution of the data being obtained.

3.3 Data Collection

The procedure of the proposed method can be summarized as follows:

Step 1: The gait parameter calculated using Vicon Motion Capture System and Nexus Software.

↓

Step 2: We normalize the gait parameter and find significant value using statistical T-Test

↓

Step 3: We analyse the data using Matlab Software and made a GUI application.

Figure 3.2: The procedure of the proposed method

Figure 3.2 show the procedure that was done on this study. Each of the step have to be followed to make sure that the data will not be hard to analyse. The data that came out following this flow chart was then be tested and analysed using several step of data analysing.

3.4 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 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 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.

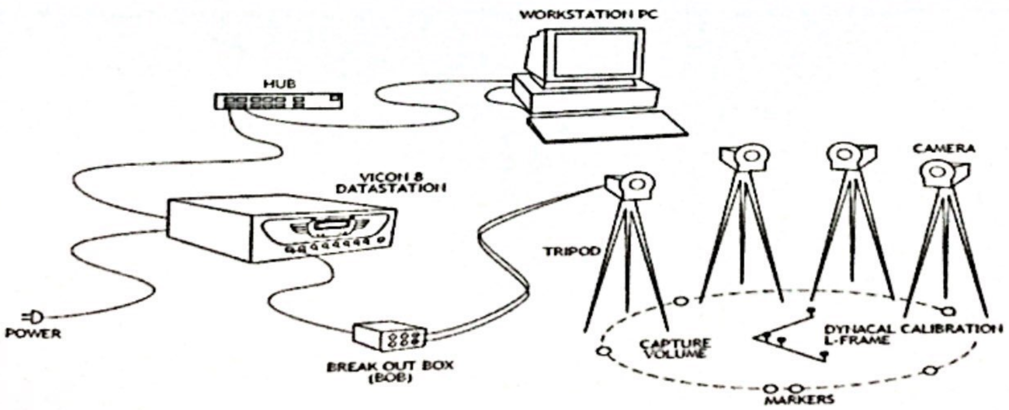


Figure 3.3: Block diagram of the 3D Vicon system

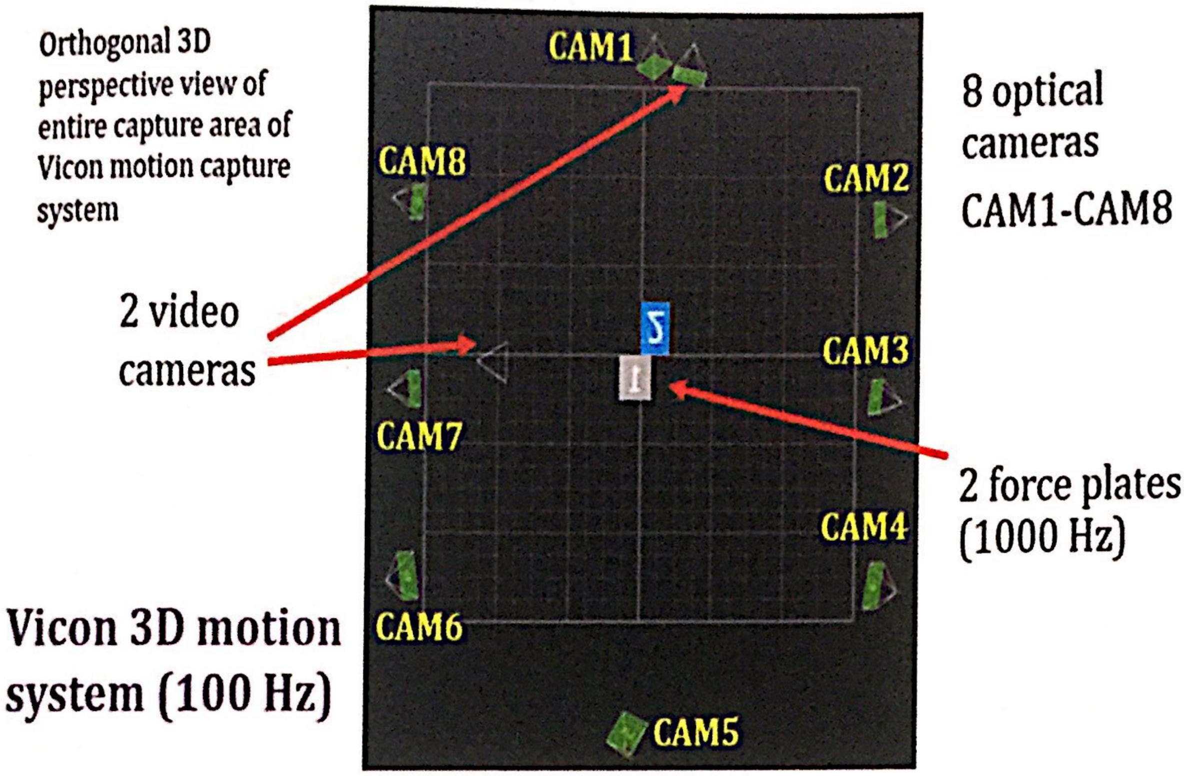


Figure 3.4: Orthogonal 3D perspective view of entire capture area of Vicon motion capture system at Human Motion Lab UITM, Shah Alam, Selangor

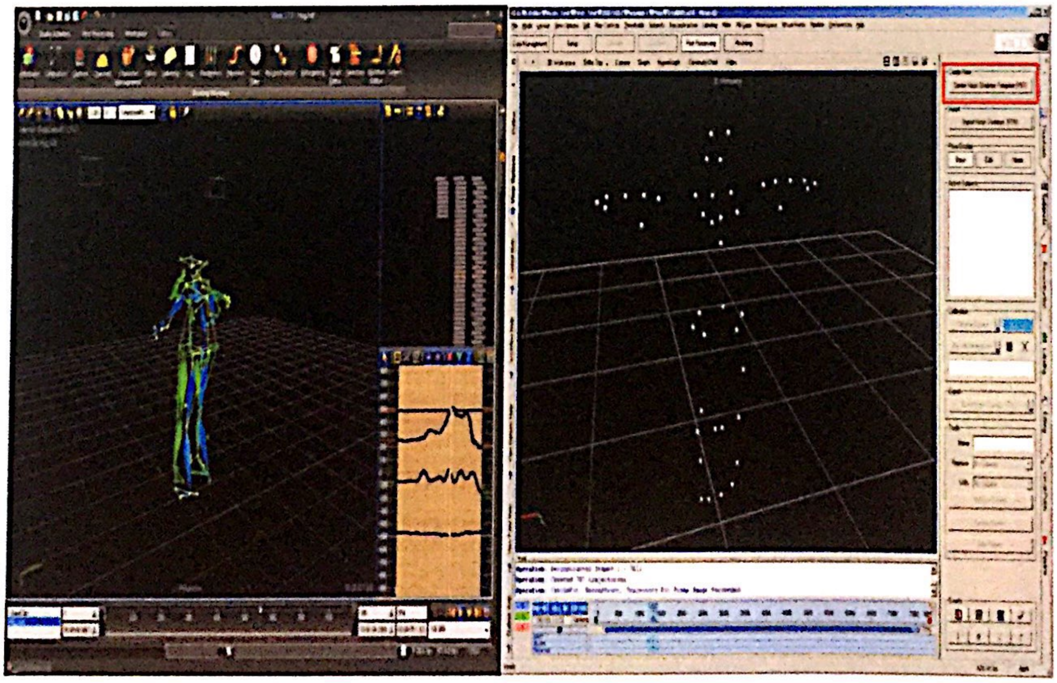


Figure 3.5: Human Motion 3D Vicon

Figure 3.6: Infrared camera

Figure 3.6 shows infrared camera that been used at Human Motion Lab, UITM Shah Alam, Selangor. This infrared camera will detects the reflective markers that attached at the subjects skin. If not possible, a less minimum of clothing need to be concerned.[29] The use of lycra or tights stretchable clothes is highly recommended.

3.5 Marker Placement

The spheres coated in the retro-reflective tape are known as markers. It is use 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. Where necessary, they will be 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. By using Optical-Passive, this technique used to retroreflective markers that are tracked by infrared cameras.

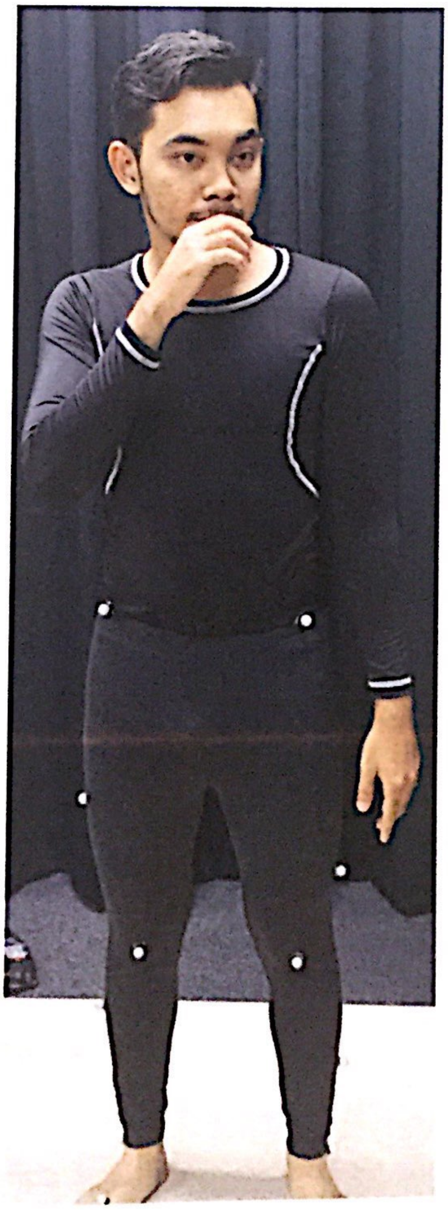


Figure 3.7: Example of Marker Placement

Figure 3.7 shows the marker placement on the subject. The marker that have been used were as stated before, the reflective marker that been detected by the infrared camera. Also, in this research, the lycra material of clothing were used as previous research shows it is highly recommended. The clothing must be as close as human skin and loose cloth will affect the detection of the marker by the camera if the camera been swing away by the cloth.

3.6 Canonical Correlation

Canonical Correlation analysis is the analysis of multiple-X multiple-Y correlation. The Canonical Correlation Coefficient measures the strength of association between two Canonical Variates. The property of canonical correlations is that they are invariant with respect to affine transformations of the variables. The dimensionality of these new bases is equal to or less than the smallest dimensionality of the two variables. A Canonical Variate is the weighted sum of the variables in the analysis. The canonical variate is denoted CV. Similarly to the discussions on why to use factor analysis instead of creating unweighted indices as independent variables in regression analysis, canonical correlation analysis is preferable in analyzing the strength of association between two constructs. This is such because it creates an internal structure, for example, a different importance of single item scores that make up the overall score (as found in satisfaction measurements and aptitude testing). Canonical correlation analysis seeks a pair of linear transformations, one for each of the sets of variables, such that when the set of variables is transformed, the corresponding coordinates are maximally correlated.

3.7 Cumulative Distribution

Cumulative distribution function is defined for discrete random variables as: ("**c.d.f.**") of a continuous random variable X is defined

$$P(x) = \int_{-\infty}^{x} p(t)\, dt$$

Meaning is, the proportion of population with value less than x and the probability of having a value less than x. Every cumulative distribution function F is non-decreasing and right-continuous, which makes it a càdlàg function.

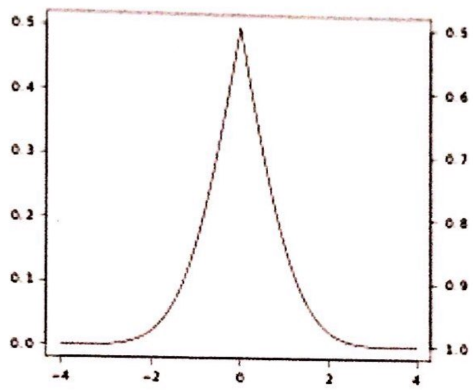


Figure 3.8: Cumulative distribution function with an expected value of 0 and a standard deviation of 1.

3.8 Cross – Correlation

Cross-correlation is a central digital signal processing (DSP) algorithm with applications in many areas. Cross-correlation 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.

Therefore, all stride timing were collerated in all cases indicated that the correlation is consistent. Adjustment of any hardware and software allowing a consistent result. For image-processing applications in which the brightness of the image and template can vary due to lighting and exposure conditions, the images can be first normalized. This is typically done at every step by subtracting the mean and dividing by the standard deviation. That is, the cross-correlation of a template.

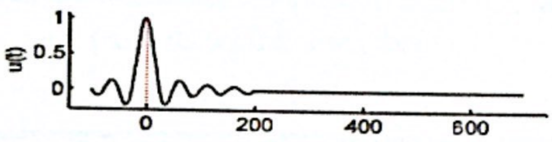


Figure 3.9: u(t) is the test waveform

3.9 T – Test

T-test is an analysis of two populations means using statistical examination; a t-test with two samples is used with small sample sizes, testing the difference between the samples when the variances of two normal distributions are not known. It was used in two groups with paired observations (e.g., before and after measurements), T-values are an example of what statisticians call test statistics. Each observation of the dependent variable is independent of the other observations of the dependent variable (its probability distribution isn't affected by their values). Measurement error can occur from many sources, such as the localisation of bony landmarks, placement of markers, movement of markers with movement of the skin, and accuracy of the motion analysis system itself. Lastly the t-test also tells you how significant the differences are; In other words it will know if those differences could have happened by chance.

3.10 Pilot – Test

Pilot test or pilot experiment is a small scale preliminary study conducted in order to evaluate feasibility, time, cost, adverse events, and effect size (statistical variability) in an attempt to predict an appropriate sample size and improve upon the study. After pilot testing the instrument on a number of people the data to revise the instrument. Then field test the revised version before starting actual data collection. Remember, this process is critical as it can minimize measurement error. Pilot test can be based on quantitative and/or qualitative methods and patient groups did differ from normal on some measures. These screening tests may be useful for assessing performance over time among patients with known diagnoses. However, it will be not useful for screening members of the general population quickly or for initial assessment of someone who presents to a person with balance problem. Patient subgroups to normal should be considered as pilot data. The lack of differences among subgroups may be related to small samples, especially where the patient group, as a whole, differs from normal. Lastly, the data suggest that some commonly used screening tests, which are often used by clinicians, are not useful for epidemiologic screening. Investigators and clinicians should use these tests with caution.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Table 4.1: Shows the 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	89.43	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

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 is 0.25 ± 0.11.[5] That is average stride length 0.70m for normal is higher than 0.25m for cerebral palsy[5], and related to my finding it show that 1.133695167m o the average mean of the three respondents of pilot test for stride length, which close to the previous research done by Longwei Chen that prove that the reading is correct without concerning about any major error.

After gaining the result from both questionnaire and Pilot Test, it could be analyze 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.

DATA ANALYSIS

4.2 Overview

In this part, it is implemented analysis and collection of data. Through this data, it can know the need and knowledge about this study where it can give big impact throughout study. After studying a numerous amount of literature review, a questionnaire was being constructed which the main objective of it was to identify the public knowledge on Gait and Balance training exercise. A pilot test was been carried out before an actual research is being performed. This pilot test will function as a small-scale test of the methods and procedures to be used on a larger scale.[30] This pilot test will examine the feasibility of an approach that is intended to be used in the next actual research. For this research, a certain parameters was chosen to validate the data before making a conclusion and actual experiment.

Three children aged 8, 10, 12 respectively was been choose. Then, a pilot test was run on them, and the expected outcome is to find the valid result, and to identified if weather the procedure and all the equipment was robust. The parameters that being tabulated is cadance, walking speed, stride time, step time, stride length, and step length. After all the result was tabulated, it could be say that the objective of executing the pilot test was achievable.

4.3 Questionnaire

Through this part, the questionnaire is conducted among 50 public respondent. The 50 respondent was selected randomly without any bias towards their age, gender, and profession. Thus, the respondent will contain of students and lecturers. This questionnaire is consisting of two section which is section A and Section B. Section A consist of three questions that is about the basic details of the respondents. All respondent need to state their range of age, profession and gender. This detail is only needed, which to know about the personal data of the respondents.

Section B of this questionnaire is consist of 10 open questions which is the main and important data from respondents will be taken. All the data taken then will be analysis and will be taken to make sure the survey showed positive feedback towards to achieving the objective.

4.3.1 Questionnaire - section A

In this section, basic personal data was taken for 50 respondents, below is table of the answer for 3 questions from 50 respondents:

Table 4.2: result of respondent age

No	Question	15-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55
1	Age	15	17	6	3	4	0	4	1

From the above, all age range from 15 years old until age 55 years old taking part in the questionnaire. As many as 15 respondents are from age 12-20, while 17 respondents from age 21-25 taking part in the questionnaire. Besides, from age 25-30 years old only 6 respondent and from age31-35 years old are 3 people. Furthermore, 4 respondents from age 36-40 years old and no respondent recorded for age 41-45 years old. Lastly only 4 people are recorded for respondent age from 46-50 years old and 1 people from age 51-55 years old. Below is the pie chart showing the percentage of the age of respondents recorded

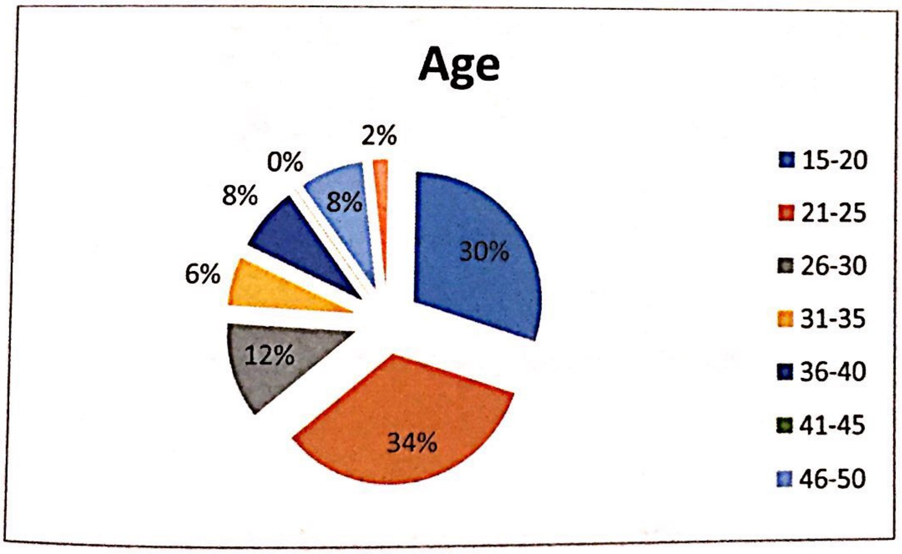


Figure 4.1: Percentage of respondent's age

Table 4.3: result of respondent profession

No	Questions	Working	Students	Other
2	Profession	18	32	

In above table shows that from 50 respondents we can conclude that 32 people are students and 18 people already working. Moreover, we can relate from respondents that age from 15-25 are total 32 people and from 26-55 are 18 people who already working. Below is the pie chart showing the percentage of the profession of respondents recorded:

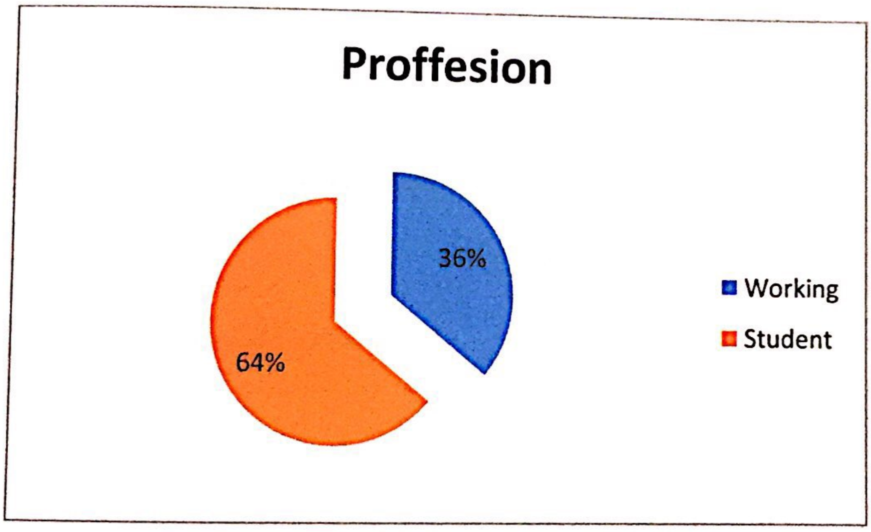


Figure 4.2: percentage of respondents profession

Table 4.4: result of respondent gender

No	Questions	Female	Male
3	Gender	25	25

From above, the questionnaire is answered by 25 people of female respondent and 25 people male respondent. Below is the pie chart showing the percentage of the gender of respondents recorded:

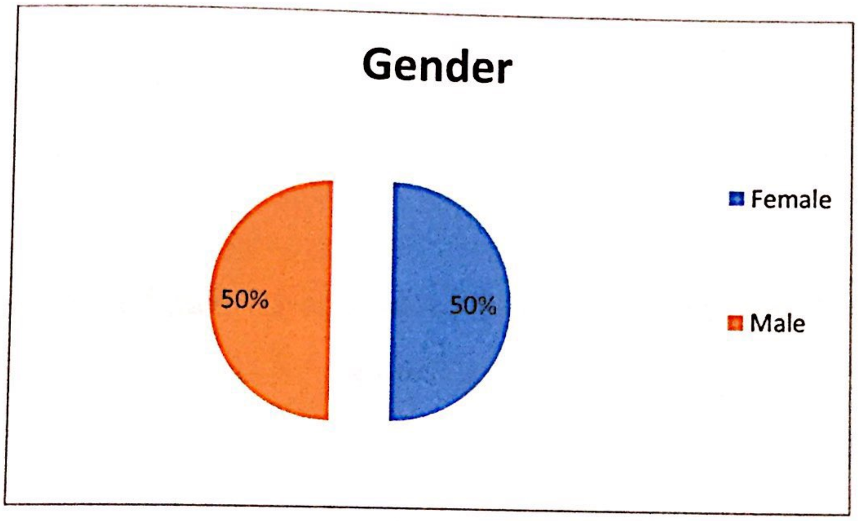


Figure 4.3: percentage of respondents Gender

4.3.2 Questionnaire – Section B

The data of the questionnaire of section B was taking. 10 total questions are consisted in this section. From the question 1 until question 5, the purpose of this question was to determine whether the public knows about the Gait and Balance Training. Below is the table of answered recorded from 10 respondent for question 1 to 5:

Table 4.5: result of question 1 to question 5

No	Questions	YES	NO
1	Do You Know About Gait	25	25

2	Do You Know There is Method to measure if you are walking is or not in correct way?	23	27
3	Do you have difficulties in walking?	10	40
4	Do you know, by exercise can help you to correct the way of your walking?	15	35
5	Do you experienced any improvement in waling by any other method before?	5	45

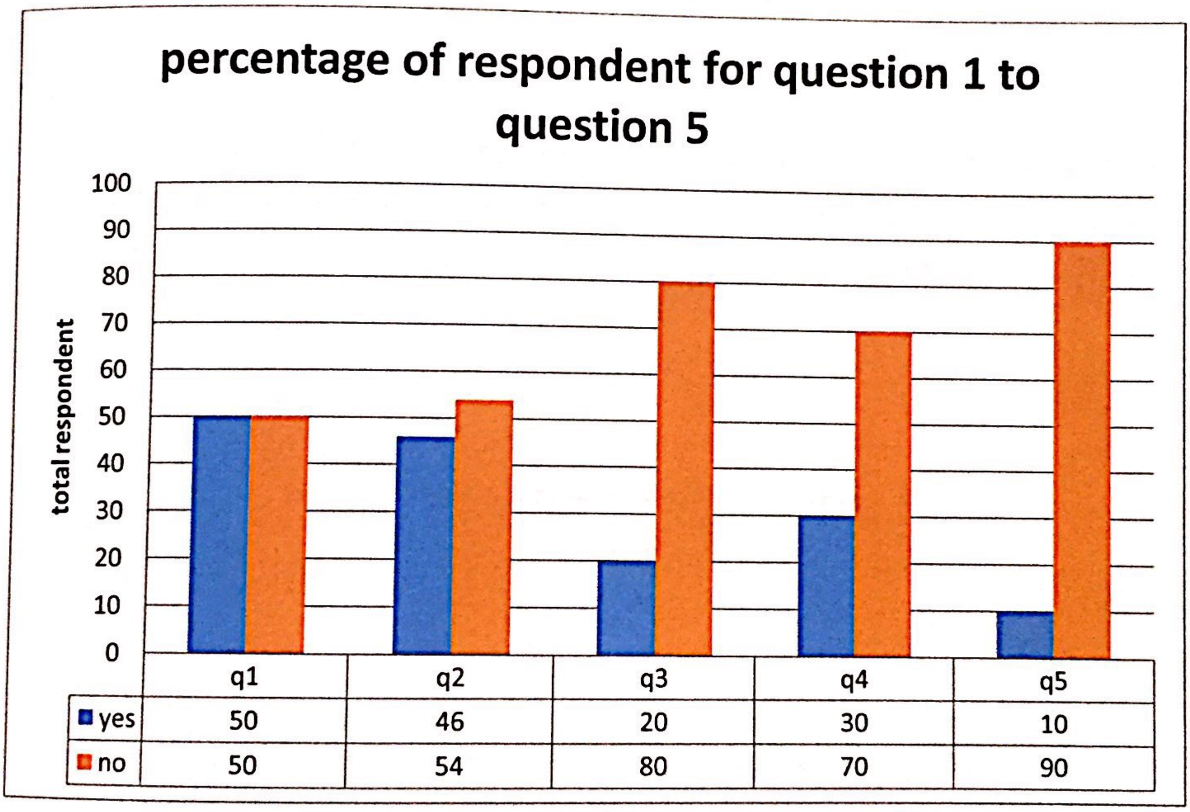


Figure 4.4: Percentage for question 1 to question 5

From the graph of percentage, it show that for question 1only half of respondent that is 50% know about gait and 50% do not know about gait. In addition for question 2 also, not many respondents know there is a method to measure a correct way of walking. The result show only 46% respondent know about it and balance 54% don't know about the method. For question 3, only 20% or respondent having difficulties in walking and 80% respondent not having difficulties, this is reasonable reason as total 38 people of respondent are in young age range from 15-30 years old.

Furthermore, in question 4 also total of 70% respondents do not that exercise can help the way of someone walking and only 30% of respondent about it. Lastly, for question 5 only 10% of the respondents having an experience of using a method to improve their walking while 90% don't. Lastly this could be concluded that public are not well known about Gait and Balance Training. There is a minimum value of percentage for question 1 to 5 of respondents know about gait and balance training.

Then, for Question 6,7 and 10, the data was taking. The question was all about asking the public about their opinion about Gait and Balance training after the definition of both have been brief. Below is the table and graph for question 6,7 and 10

Table 4.6: result of question 6,7 and 10

No	Questions	YES	NO
6	If, you having problem in walking, do you want to correct it by doing exercise?	92	8
7	"Gait analysis is the is the methodical investigation of the human motion and all the particularly of investigation of the human movement. Its utilizing the measuring body developments, body mechanics, and the action of the muscles." In terms for your health which is correcting the way you walk, will Gait would be helpful?	100	0

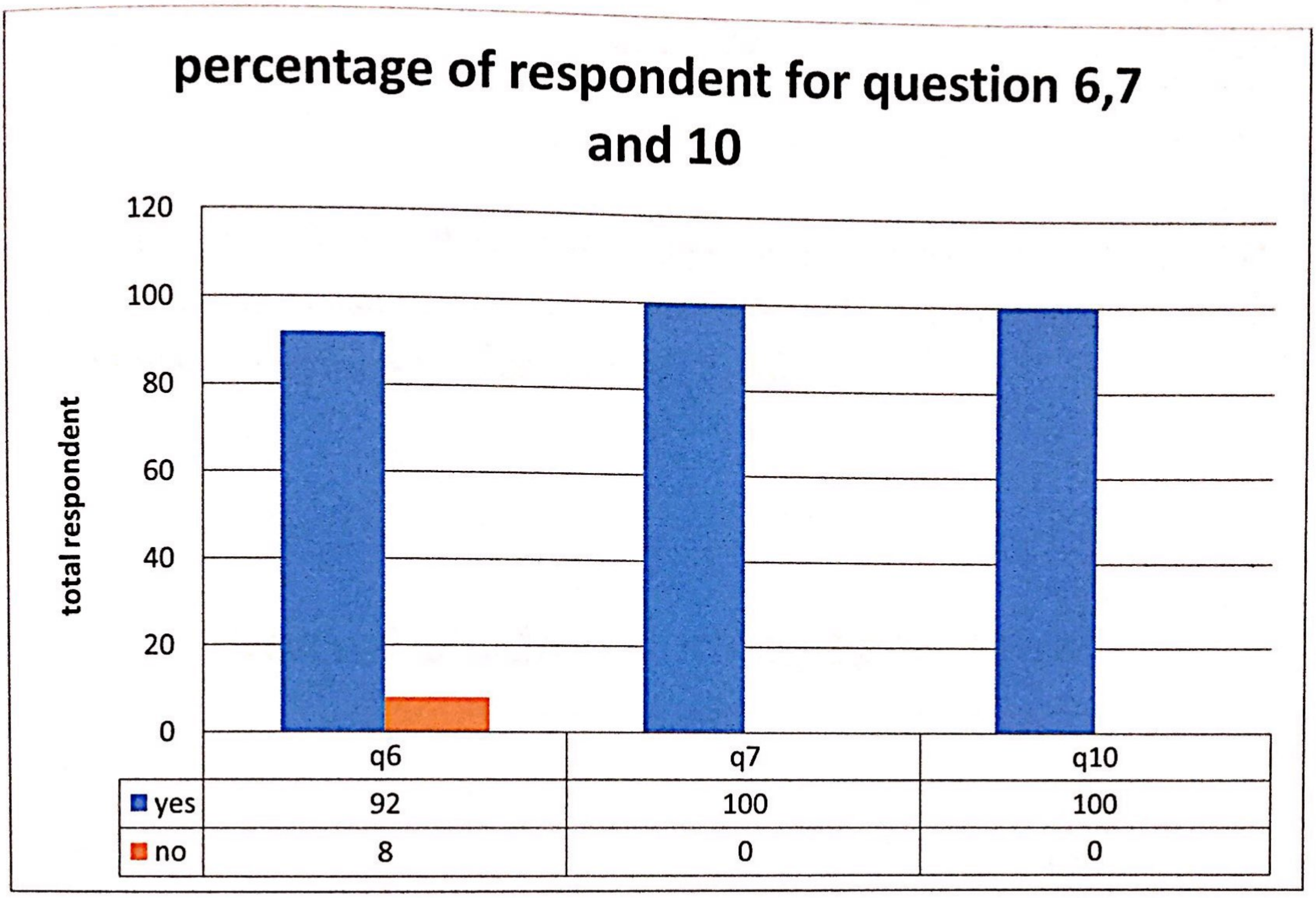


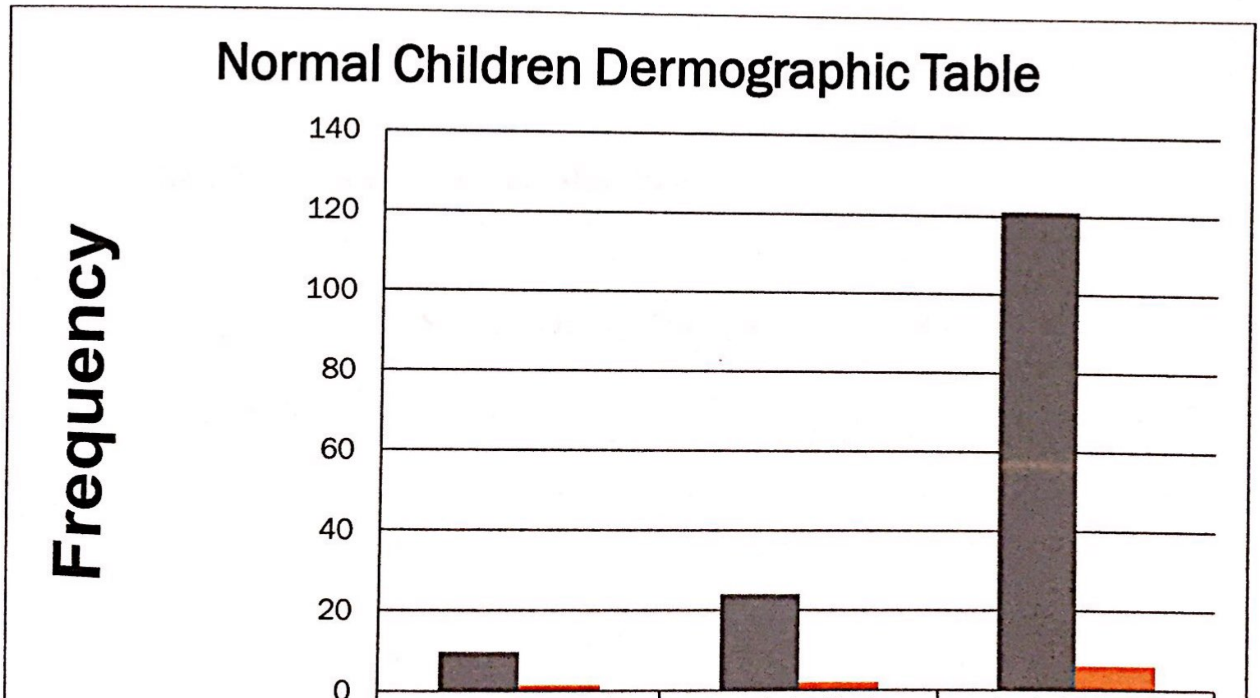
Figure 4.5: Percentage for question 6,7 and 10

From the graph of percentage it can be shown almost all respondent that is 92% want to improve their walking problem by exercise, and only 8% did not want used exercise to improve the walking problem. Moreover, in question 7 all respondent agree that using gait can help them in correcting the way their walk. Also for question 10, all respondent agree that as age increase the pattern of someone walking will be change. Lastly, In this section conclude that a maximum value of frequency have been recorded that after they know a bit about Gait and Balance training, 100% of them agree that the Gait Analysis would help in the movement improvement.

4.4 Pilot Analysis

This pilot test will function as a small-scale test of the methods and procedures to be used on a larger scale.[30] This pilot test will examine the feasibility of an approach that is intended to be used in the next actual research. For this research, a certain parameters was chosen to validate the data before making a conclusion and actual experiment.

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 of demographic below



	mean(years)	weight(kg)	height(cm)
mean	9.6667	24.1	121.13
standard deviation	1.52753	2.0502	6.17981

Figure 4.6: Demographic of Subject

4.4.1 Subjects Data

4.4.1.1 Anis DataTable

4.7: Anis Pilot Test Parameter Data

	Cadance (steps/min)	Walking Speed (m/s)	Stride Time (s)	Step Time (s)	Stride Length (m)	Step Length (m)
Left	133.333191	1.396663	0.9	0.46	1.256997	0.632134
Right	134.831406	1.366078	0.89	0.43	1.215809	0.57813
Mean	134.0823	1.38133	0.895	0.445	1.2364	0.60513

4.4.1.2 Ikhmal Danish DataTable

4.8: Ikhmal Danish Pilot Test Parameter Data

	Cadance (steps/min)	Walking Speed (m/s)	Stride Time (s)	Step Time (s)	Stride Length (m)	Step Length (m)
Left	115.384796	1.096262	1.04	0.51	1.140112	0.548098
Right	113.207405	1.120469	1.06	0.53	1.187698	0.589999
Mean	114.2961005	1.1083655	1.05	0.52	1.163905	0.5690485

4.4.1.3 Syakimie Data

Table 4.9: Syakimie Pilot Test Parameter Data

	Cadance (steps/min)	Walking Speed (m/s)	Stride Time (s)	Step Time (s)	Stride Length (m)	Step Length (m)
Left	98.360405	0.794433	1.22	0.69	0.969208	0.550322
Right	95.237999	0.819327	1.26	0.57	1.032353	0.48549
Mean	96.799202	0.80688	1.24	0.63	1.0007805	0.517906

4.4.1.4 Full Data Pilot Test

Table 4.10: Full Data Pilot Test of all subjects

	Cadance (steps/min)	Walking Speed (m/s)	Stride Time (s)	Step Time (s)	Stride Length (m)	Step Length (m)
Anis	134.0823	1.38133	0.895	0.445	1.2364	0.60513
IkhmalDanish	114.2961005	1.1083655	1.05	0.52	1.163905	0.5690485
Syakimie	96.799202	0.80688	1.24	0.63	1.0007805	0.517906
Mean	115.0592008	1.0988585	1.061666667	0.531667	1.133695167	0.564028167
S.D	18.65326	0.28734	0.1728	0.09305	0.12068	0.04383

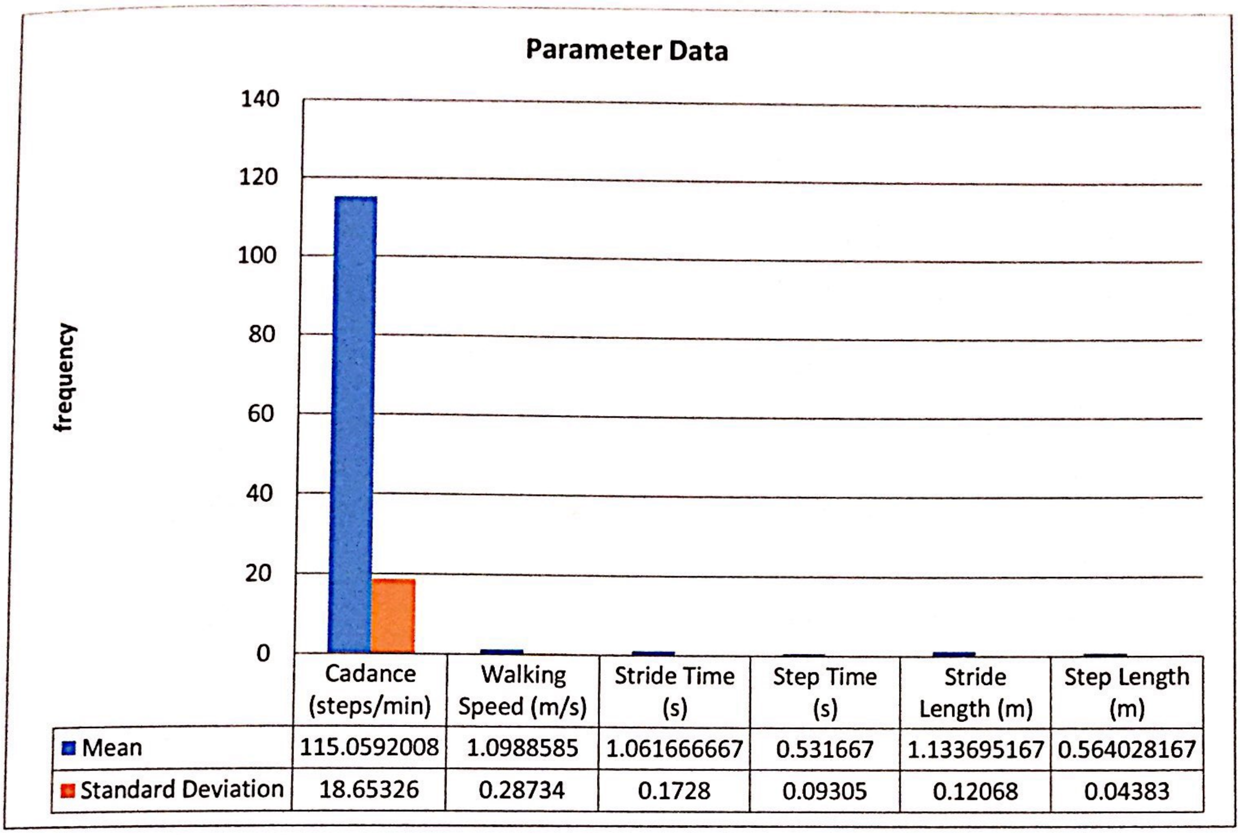


Figure 4.7: Full Data of Pilot Test

Table 4.11: Full Data Pilot Test

Parameter	Mean	Standard Deviation
Cadance (steps/min)	115.0592008	18.65326
Walking Speed (m/s)	1.0988585	0.28734
Stride Time (s)	1.061666667	0.1728
Step Time (s)	0.531667	0.09305
Stride Length (m)	1.133695167	0.12068
Step Length (m)	0.564028167	0.04383

From the pilot test, it could be said that the data of the measurement of gait parameter is different depending on their gender, weight and height. This finding been used in the actual research that involving the actual 10 subject that to test the effect on balance training exercise.

4.5 Full Data Analysis

Then, the actual research was done. This chapter will explain briefly about the analysis of the result of balance training exercise of the 10 young adult. After the result was gain from the data collection, it need to be analyses and be process by a several test to prove the result was be able to make a conclusion of this research.

Table 4.12: Raw data on 6 parameter before and after balance training exercise

	Cadence		Walking Speed		Stride Time		Step Time		Stride Length		Step Length	
	Average											
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	100	114	1.01	0.98	1.2	1.06	0.6	0.57	1.22	1.03	0.6	0.59
2	108	124	1.13	1.28	1.11	0.97	0.56	0.49	1.25	1.24	0.61	0.64
3	97.2	124	0.95	0.7	1.24	1	0.63	0.61	1.17	0.76	0.58	1.07
4	114	112	1.21	1.25	1.05	1.07	0.52	0.53	1.27	1.33	0.64	0.65
5	125	125	1.2	1.2	0.97	0.97	0.47	0.47	1.17	1.17	0.53	0.53
6	113	131	1.15	1.06	1.06	0.92	0.53	0.49	1.22	0.99	0.6	0.59
7	122	140	1.19	1.23	0.98	0.86	0.49	0.49	1.16	1.06	0.57	0.62
8	11	137	1.17	1.06	1.08	0.88	0.54	0.52	1.27	0.92	0.64	0.62
9	110	133	1.06	0.84	1.1	0.91	0.58	0.55	1.16	0.77	0.62	0.59
10	158	167	0.48	0.37	0.76	0.72	0.5	0.52	0.37	0.27	0.58	0.61
Sd	17.2	15.5	0.22	0.29	0.13	0.1	0.05	0.04	0.27	0.3	0.03	0.15
Average	116	131	1.06	1	1.05	0.93	0.54	0.52	1.13	0.95	0.6	0.65

Table 4.12 was the table on 6 parameter before and after balance training exercise of the 10 young adult. From the table, there is an obvious reading of the parameter because there is existence of standard deviation and average. This is crucial to data that next to analysed.

4.5.1 Plotting Raw Data of Each 6 Parameter of Before and After Balance Training Exercise

Then, the six parameter was put into test which is Cumulative Distribution, Cross-Correlation, and T-Test analysis. First, the plotting of the 6 parameter analysis was as such below:

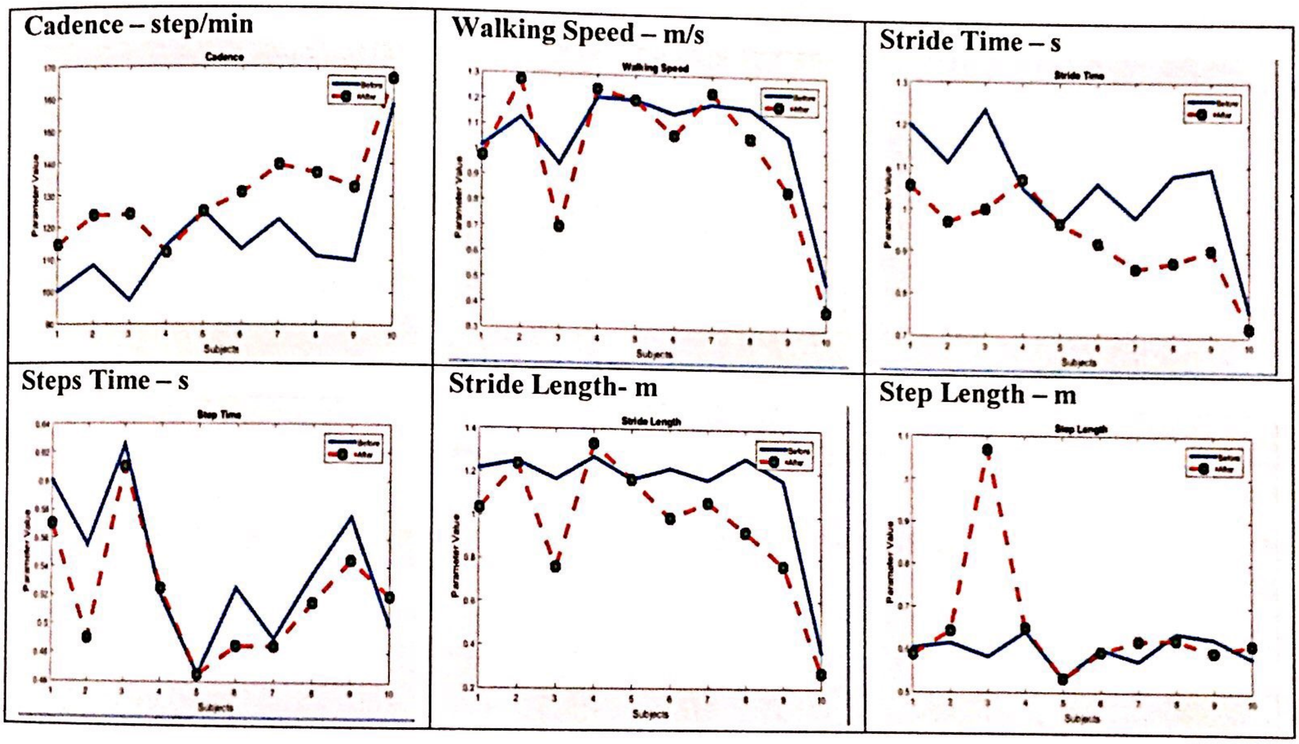
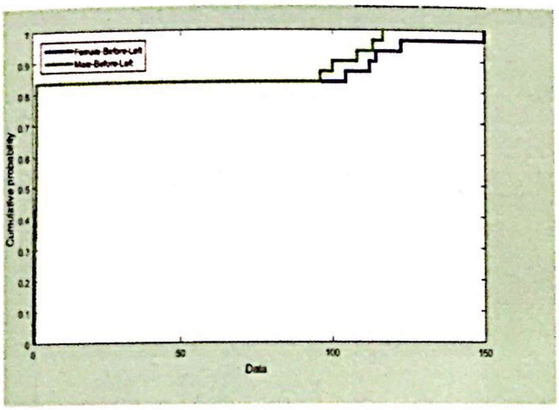


Figure 4.8: Plotting Raw Data of Each 6 Parameter of Before and After Balance Training Exercise

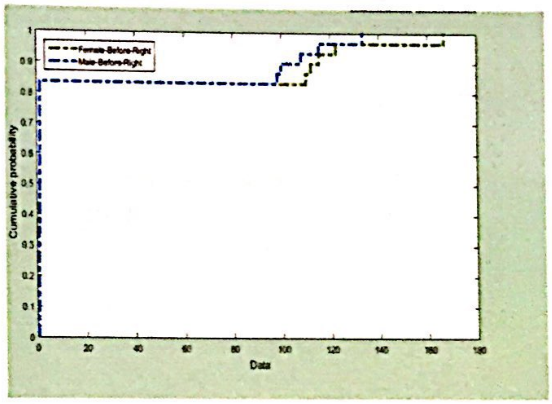
Figure 4.8 shows that there is a difference in each six parameter which is cadence, waling speed, stride time, step time, stride length, and step length of before and after balance training exercise. It is easy to see from this data plotting that the differences is different for each subject. As an example, in the parameter of cadence (step/min) for subject no 9, the parameter of before balance training exercise is lower than after balance training exercise. While for gait parameter step time (s), subject 9 parameter of before balance training exercise is higher than after. This result was also happened in other parameter and other nine subject. Then, after this table was been analyses, the next step was taken, which is the cumulative distribution, cross-correlation, and T-Test. These test was to prove the reability and validity of this research data.

4.6 Reability Test Result: Cumulative Distribution Analysis

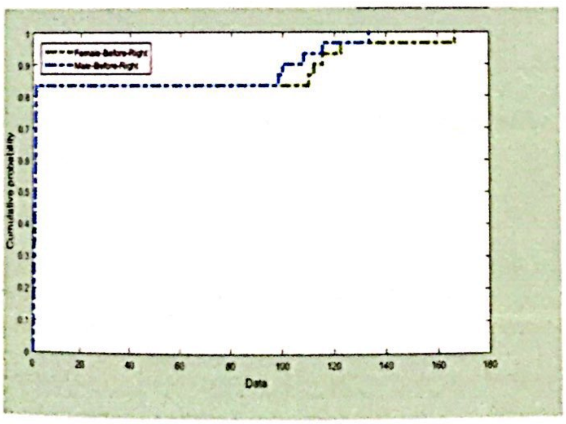
Cumulative Distributions – Female/Male Before Left



Cumulative Distributions – Female/Male Before Right



Cumulative Distributions – Female Before Left/Right



Cumulative Distributions – Male Before Left /Right

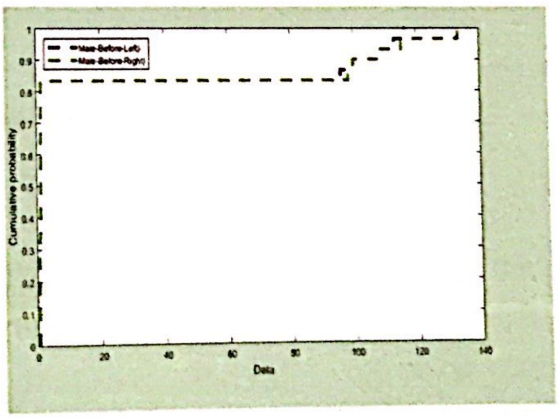
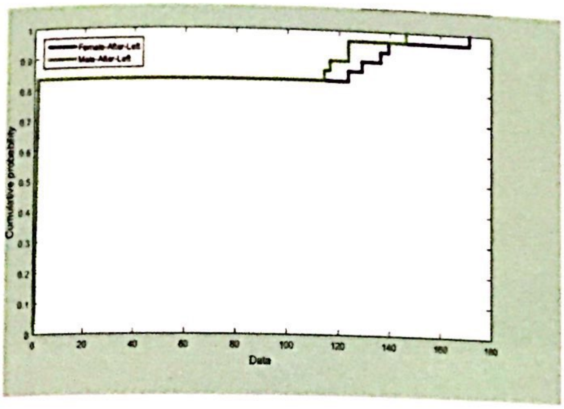
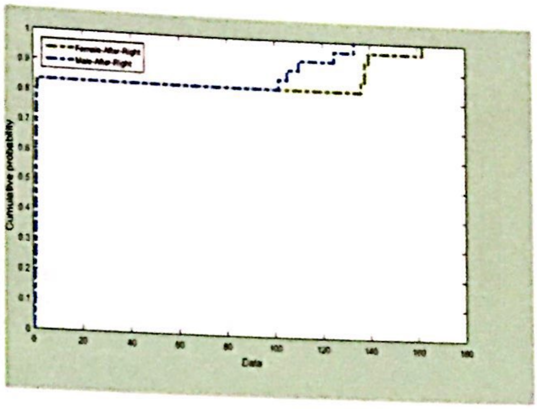


Figure 4.9: Reability Test Result: Cumulative Distributions – Female/Male Before Left/Right

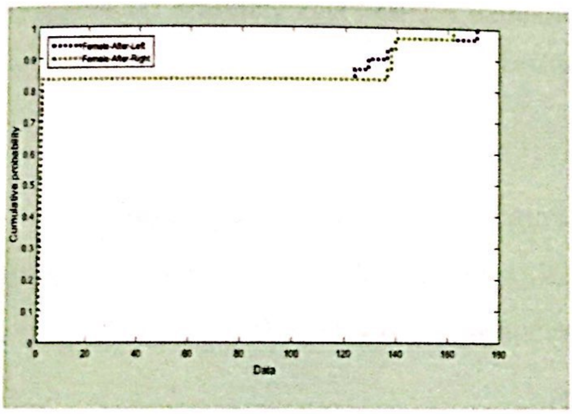
Cumulative Distributions – Female/Male After Left



Cumulative Distributions – Female/Male After Right



Cumulative Distributions – Female After Left/Right



Cumulative Distributions – Male Before Left /Right

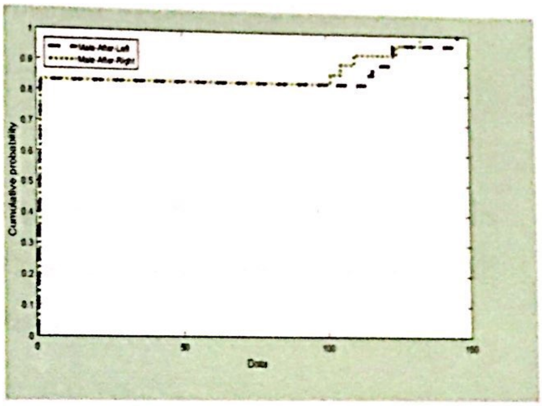
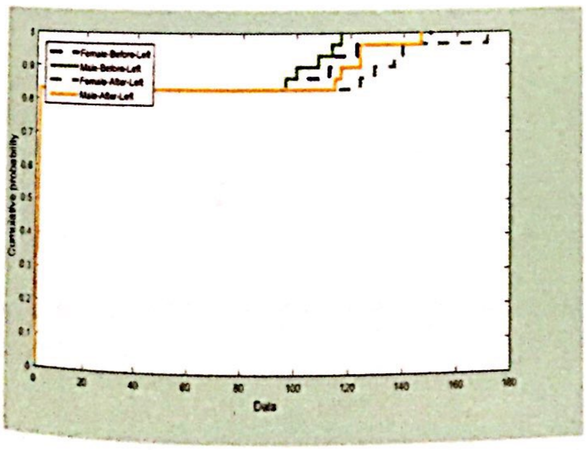
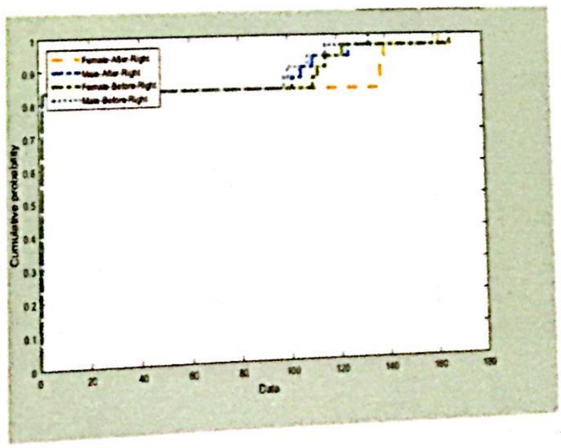


Figure 4.10: Reability Test Result: Cumulative Distributions – Female/Male After Left/Right

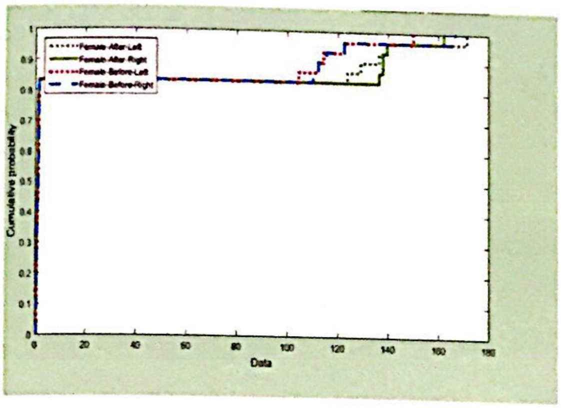
Cumulative Distributions – Female/Male Before/After Left



Cumulative Distributions – Female/Male Before/After Right



Cumulative Distributions – Female Before/After Right



Cumulative Distributions- Male Before/After Right

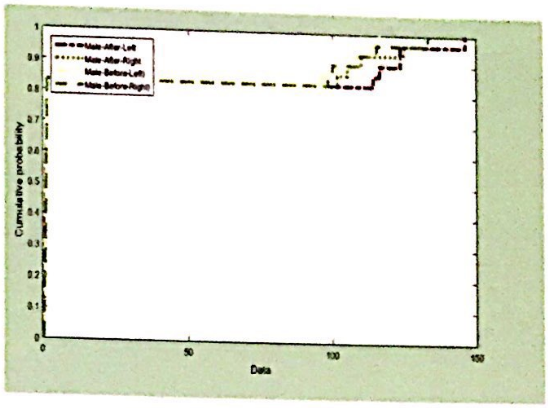
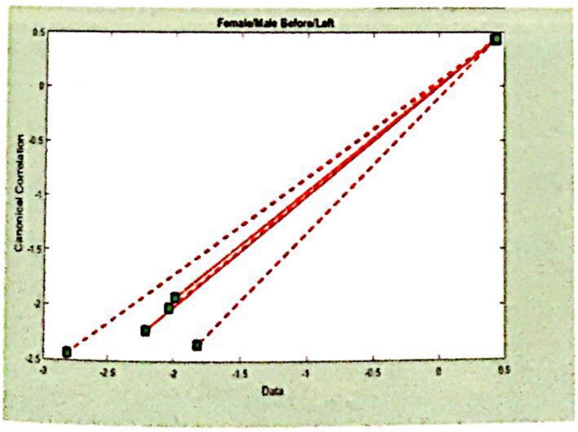


Figure 4.11: Reability Test Result: Cumulative Distributions – Female/Male Before/After Left/Right

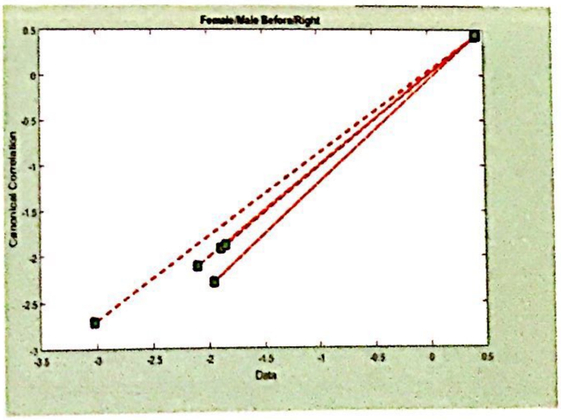
By looking at the analysis of Figure 4.9, Figure 4.10 and Figure 4.11, it could be seen that distribution of the data was similar. Those 12 result of each analysis have the same pattern. By this, this test was succeeded to prove the data of reability

4.7 Validity test result: Cross-Correlation Analysis

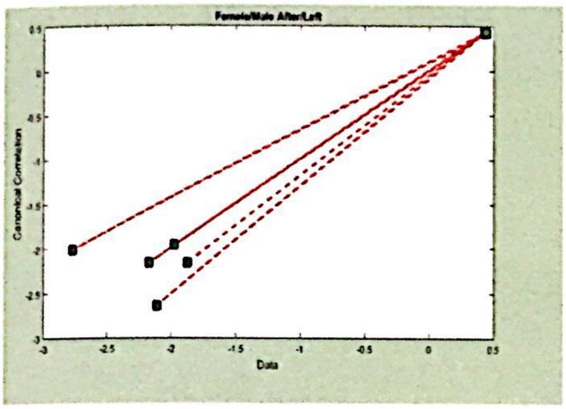
Correlation Analysis – Female/Male Before Left



Correlation Analysis – Female/Male Before Right



Correlation Analysis – Female/Male After Left



Correlation Analysis – Female/Male After Right

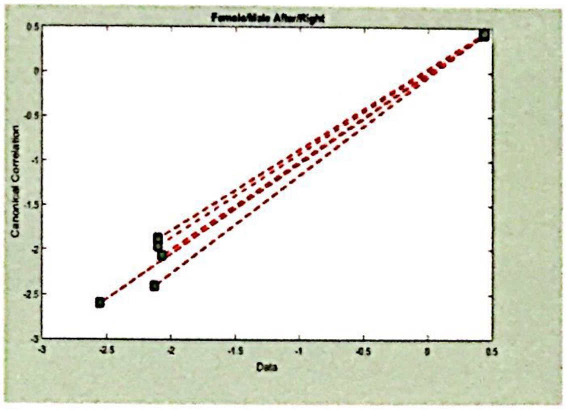
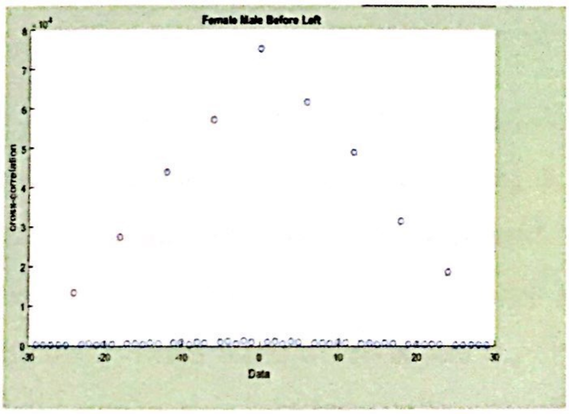
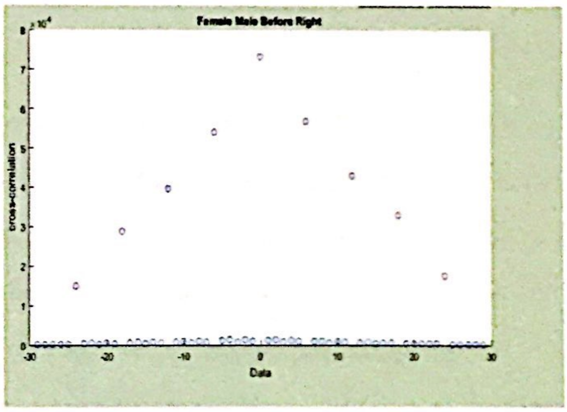


Figure 4.12: Validity test result: Cross Correlation Analysis – Female/Male Before/After Left/Right

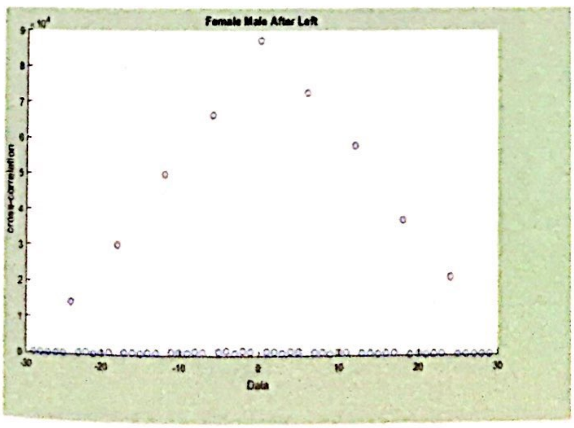
Correlation Analysis – Female/Male Before Left



Correlation Analysis – Female/Male Before Right



Correlation Analysis – Female/Male After Left



Correlation Analysis – Female/Male After Right

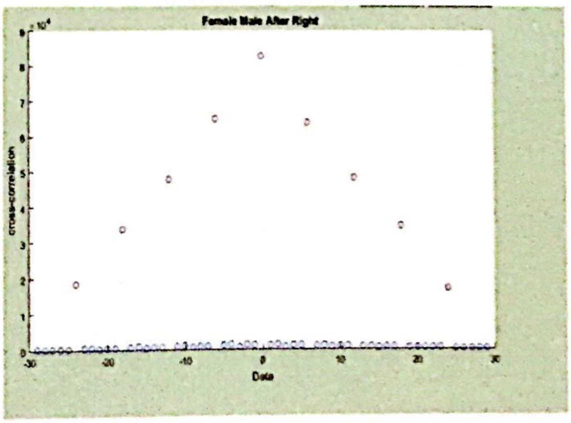


Figure 4.13: Validity Test Result: Correlation Analysis – Female/Male Before/After Left/Right

From the analysis by Figure 4.12 and Figure 4.13, it could be seen that the tabulation of the distribution of data have the same pattern. Each of the eight data have the similar pattern of distribution which by doing this Cross-Correlation test, it prove the validity of the result.

4.8 T-Test Anaysis

Table 4.13: The T-est Result.

Gait parameter	Mean and standard deviation T test result			
	Before	After	P value	H value
Cadence	115.95 (±17.18)	130.63(±15.49)	0.0012*	1
Walking Speed	1.06 (±0.22)	1(±0.29)	0.1644*	0
Stride Time	1.05 (±0.13)	0.93 (±0.1)	0.0018*	1
Step Time	0.54 (±0.05)	0.52 (±0.04)	0.0462*	1
Stride Length	1.13 (±0.27)	1 (±0.3)	0.0108*	1
Step Length	0.6 (±0.03)	0.65(±0.15)	0.3011*	0

From the result of T-test which is done by Matlab Software, the parameters that have a significant value after the young adult completing balance training exercise is cadence, stride time, step time, and stride length. While the parameter that does not have a significant value is walking speed and step length. This is because it could be seen that P value = 5% which is less than 0.05 and it have the significant value for the four parameter that have been influence by balance training exercise.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion and Recommendation

From the result of T-test which is done by Matlab Software, the parameters that have a significant value after the young adult completing balance training exercise is cadence, stride time, step time, and stride length. While the parameter that does not have a significant value is walking speed and step length. This is because it could be seen that P value = 5% which is less that 0.05 and it have the significant value for the four parameter

The machine learning that be used, analysed the by using the Matlab Software of gaining these data analysis:

- Cumulative Distribution
- Cross-Correlation
- T-Test

This data analysis was also to prove the realibilty of the data. Then, this analysis was then made to be displayed in GUI for easy viewing and user friendly. The GUI first need to be write in complex coding in Matlab Software. A Matlab Software were as Figure 5.1 Below

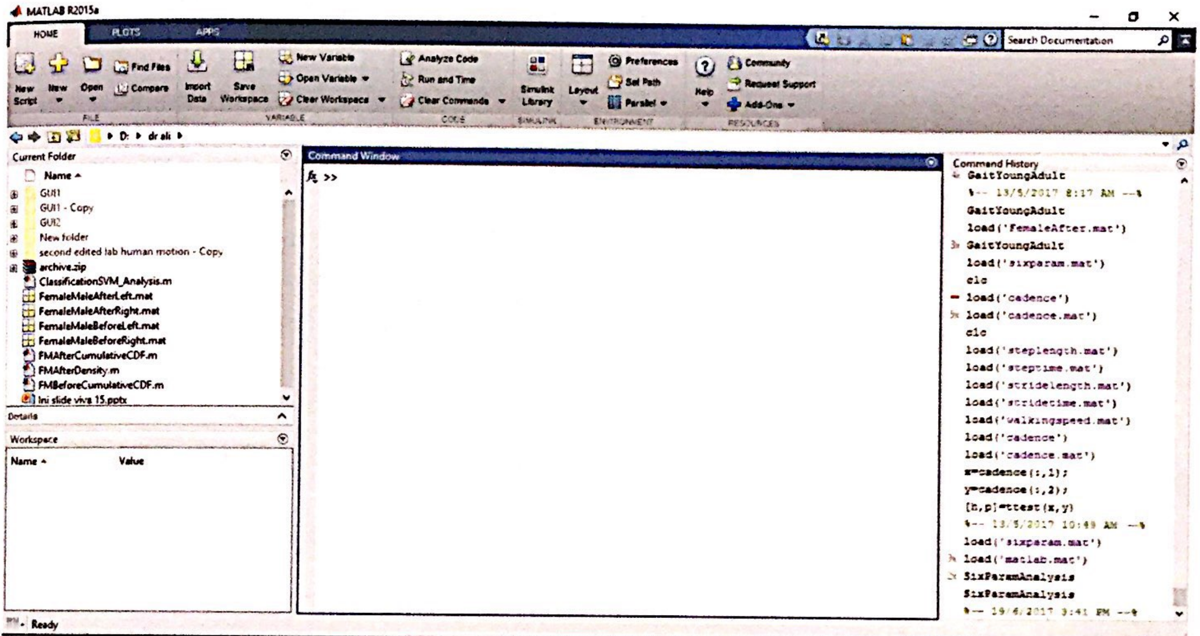


Figure 5.1: Blank page of Matlab

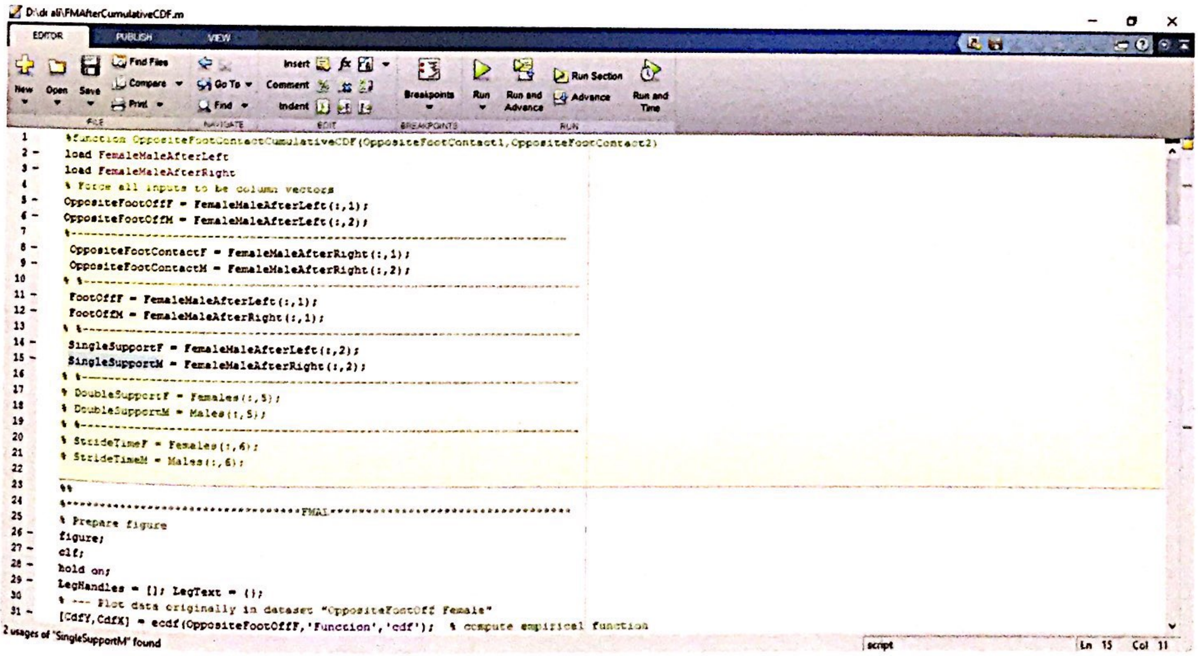


Figure 5.2: complex coding inserted in Matlab

After that, a GUI can be done. As in Figure 5 below, that is the final interface of a GUI for this research.

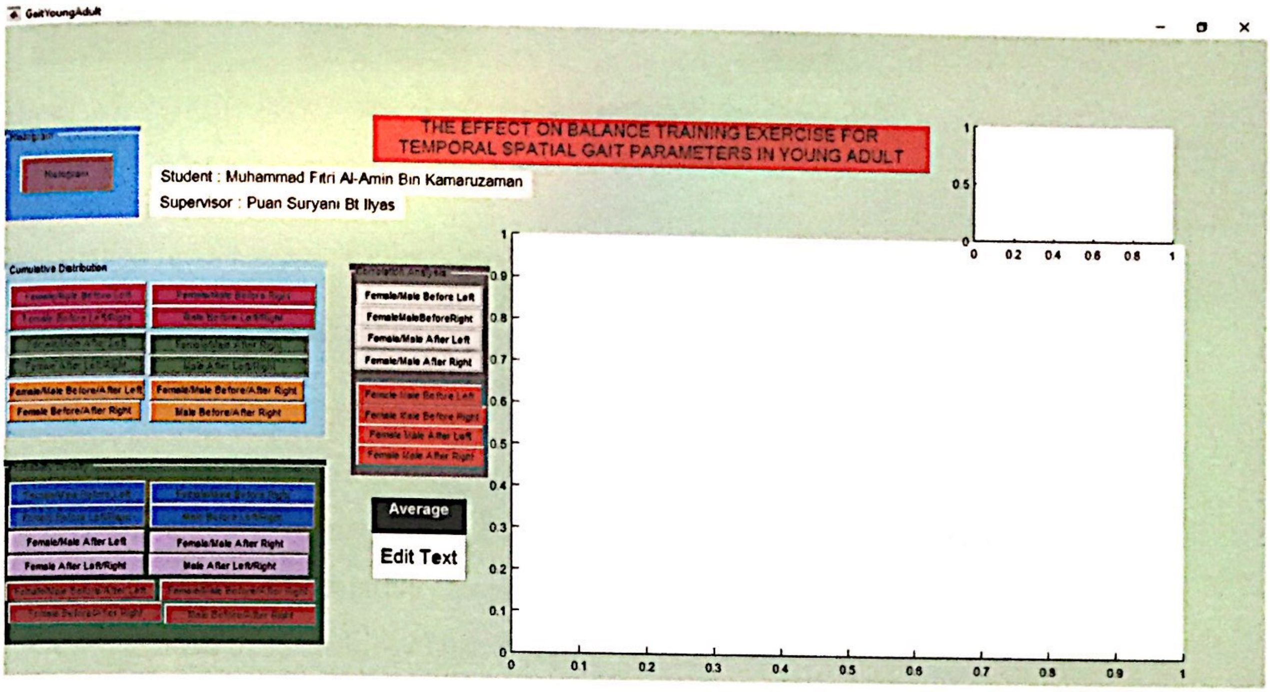


Figure 5.3: GUI for The Effect On Balance Training Exercise For Temporal Apatial Gait Parameters In Young Adult

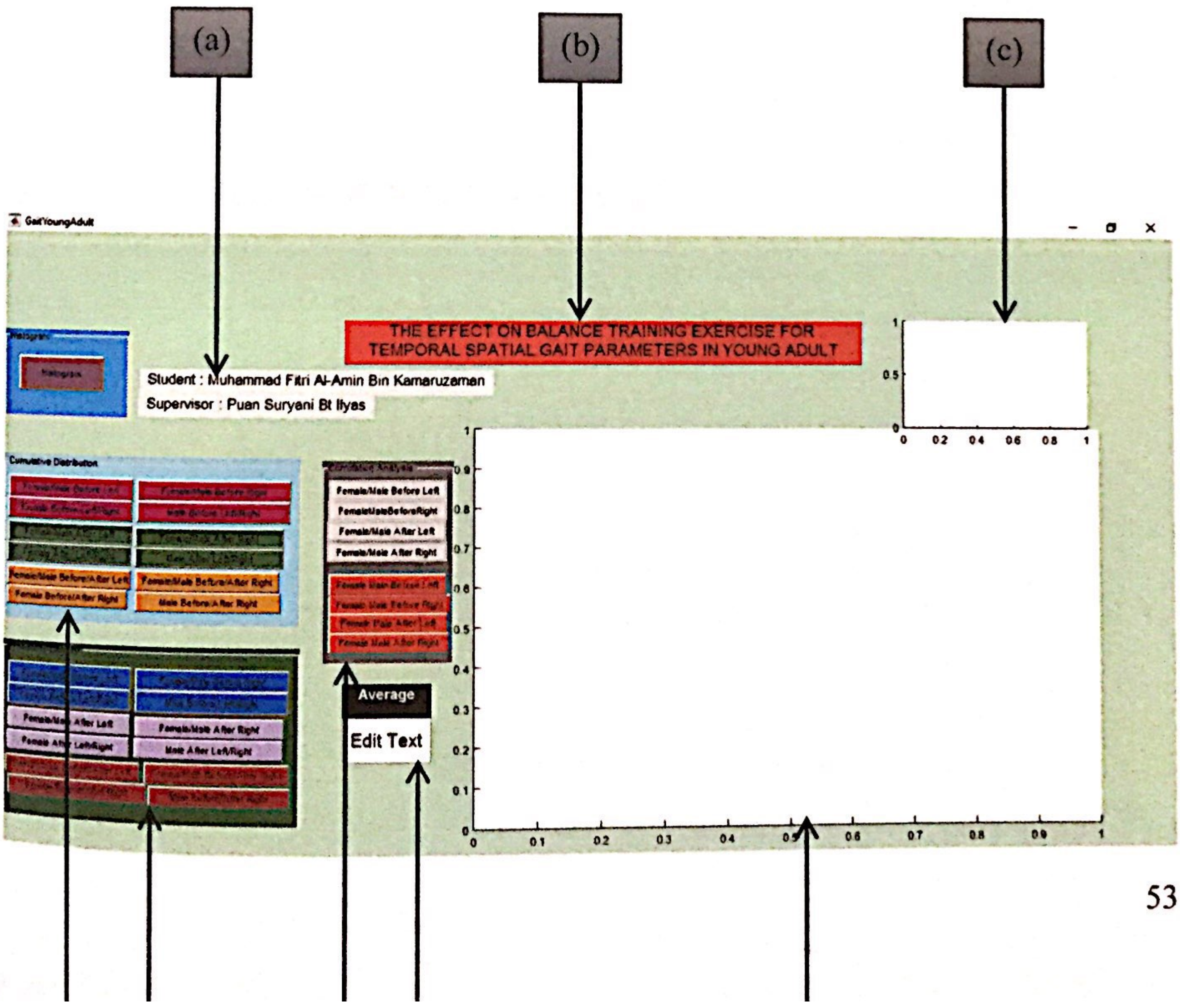


Figure 5.4:

The components were as follows:

a) The name of researcher
b) The title of the research
c) The logo of the institute, Politeknik Sultan Salahuddin Abdul Aziz Shah
d) 12 result of Cumulative Distribution
e) 12 result of Probability Distribution
f) 8 result of Corrolation Analysis
g) The average of each result
h) The graph of each of the result

Below was the example of GUI of this research:

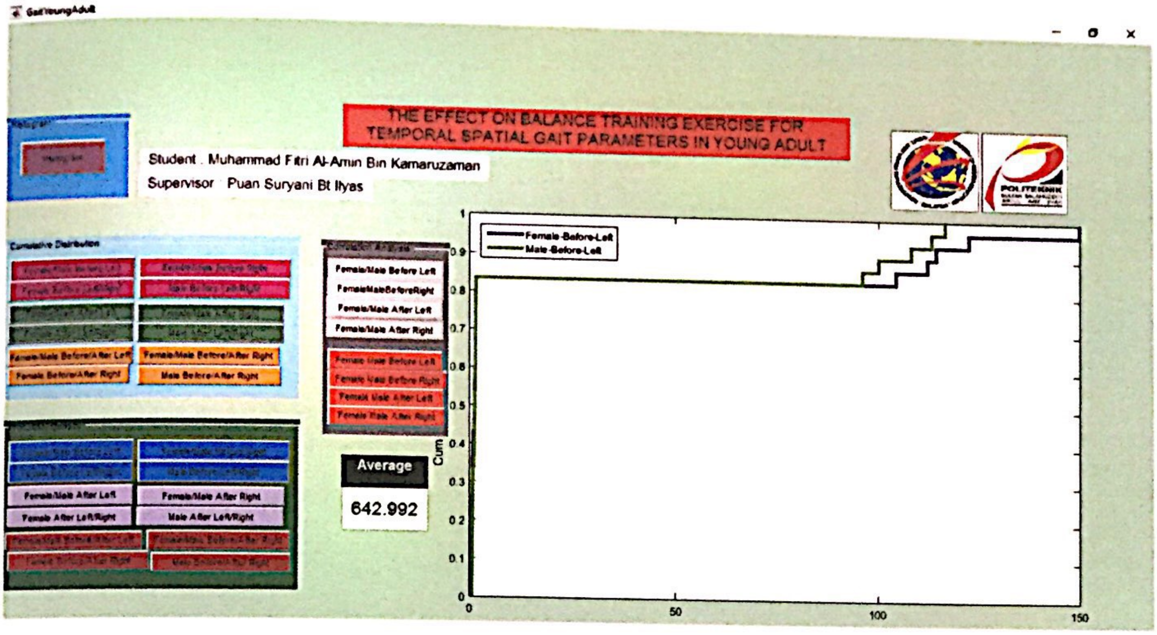


Figure 5.5: Cumulative Distribution Female/Male Before Left

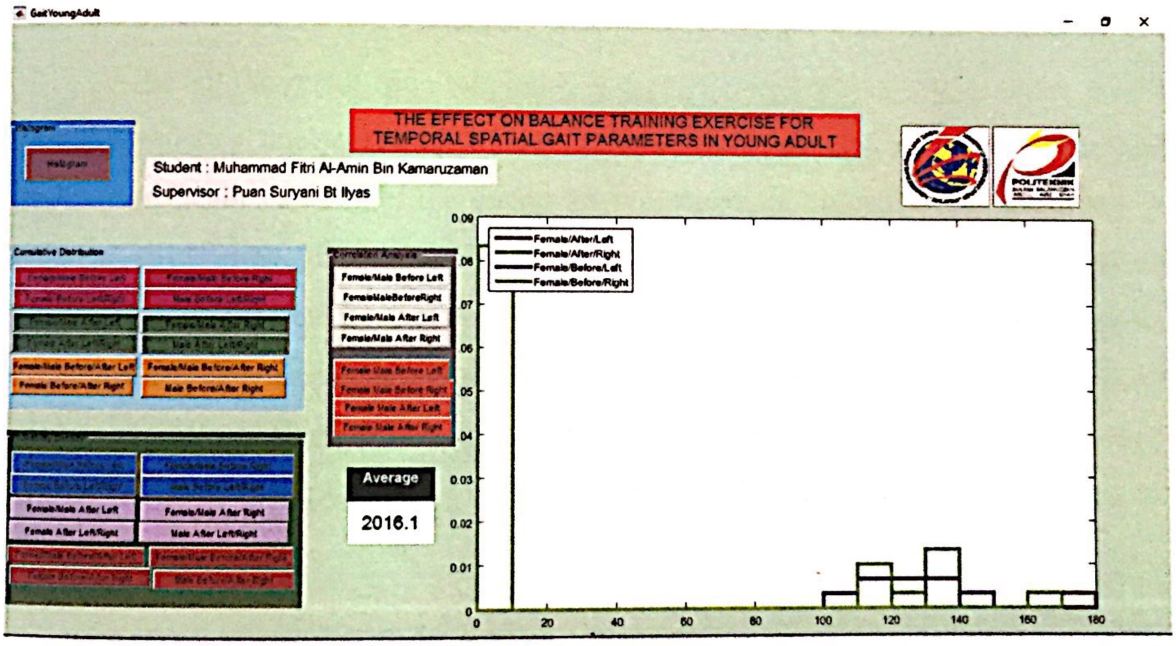


Figure 5.6: Probability Density Female Before/After Right

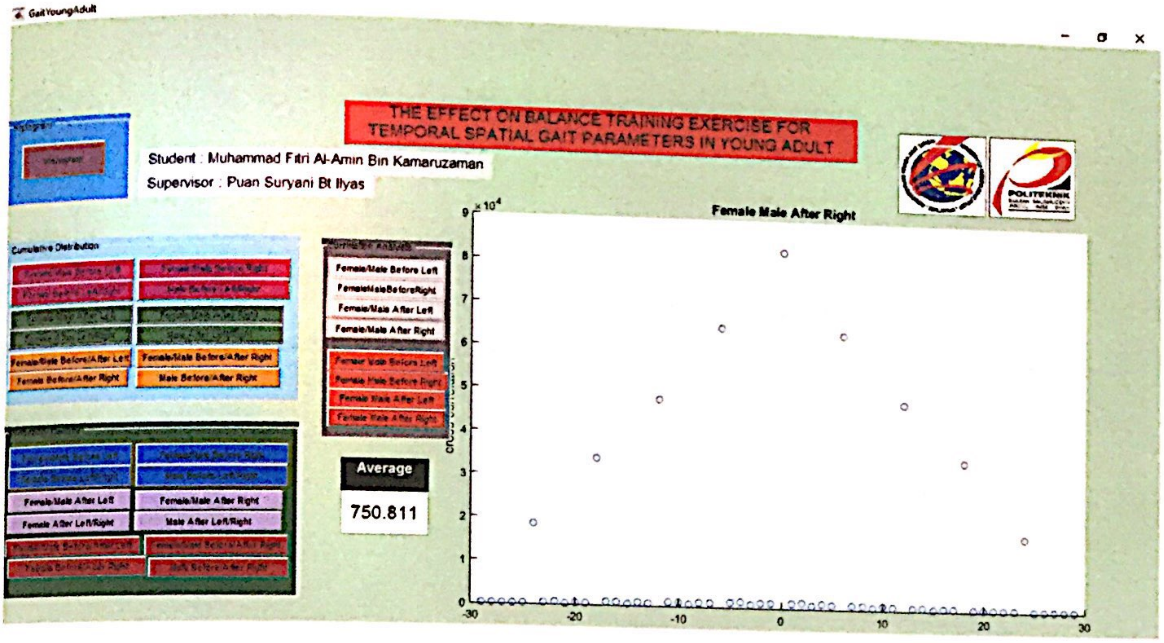


Figure 5.7: Corrolation Analysis Female Male Before Left

After all the result been tabulated, it is proven that the finding is valid, which from the statistical analysis using Matlab Application, T-Test result, the parameters that have a significant value after the young adult completing balance training exercise is cadence, stride time, step time, and stride length. This is because the step length on involve a single foot and it is not noticeable while for stride length, it is the full complete cycle of a step involving the left and right foot. Understanding this research ethology of abnormalities or changes allows the future formulation of a treatment plan that may involve physical therapy, bracing or surgery that can be used for doctors, athletes, or even normal people.

In this study, it will only study the normal young adult with no disabilities as the subject. Thus, the final result only stated the normal state of subject also. Thus for future recommendation, it will a useful approach if a different scope of subject be taken. These can be a subject with a chronic disease such as diabetes or even a subject with internal complication such as heart condition or a subject that have experiencing an organ procedure. This kind was study was to find if there any differences in their walking parameter before and after they have the sickness. Also, a different kind of Gait Parameter could be use such as kinetics and kinematics method.

COSTING

Table 5.1: Costing

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

REFERENCE

[1] D. R. Hocking, J. C. Menant, H. E. Kirk, S. Lord, and M. A. Porter, "Research in Developmental Disabilities Gait profiles as indicators of domain-specific impairments in executive control across neurodevelopmental disorders," Res. Dev. Disabil., vol. 35, no. 1, pp. 203–214, 2014[1] D. R. Hocking, J. C. Menant, H. E. Kirk, S. Lord, and M. A. Porter, "Research in Developmental Disabilities Gait profiles as indicators of domain-specific impairments in executive control across neurodevelopmental disorders," *Res. Dev. Disabil.*, vol. 35, no. 1, pp. 203–214, 2014.

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Questionnaire-Part B

1. Do you know about Gait?

YES ☐ NO ☐

2. Do you know that there is a method to measure if you are walking is or not in correct way?

YES ☐ NO ☐

3. (A) Do you have difficulties in walking?

YES ☐ NO ☐

(B) If yes, do you know why? Please explain,

____

4. Do you know, by doing exercise can help you to correct the way of your walking?

YES ☐ NO ☐

5. (A) Do you experienced any improvement in walking by any other methods before?

YES ☐ NO ☐

(B) If YES, What method? Please explain,

____

6. If, you having problem in walking, do you want to correct it by doing exercise?

YES ☐ NO ☐

7. "Gait analysis is the is the methodical investigation of the human motion and all the particularly of investigation of the human movement. Its utilizing the measuring body developments, body mechanics, and the action of the muscles."

In terms for your health which is correcting the way you walk, will Gait would be helpful?

YES ☐ NO ☐

8. "Balance exercises, along with certain strength exercises, can help prevent falls by improving the ability to control and maintain body's position, whether when are moving or still."

From your opinion, how far balance training exercise would affect those who do it and those who do not?

____

9. From question 8, at what age people realised the importance of exercise?

15-20 ☐	21-25 ☐	26-30 ☐	31-35 ☐
36-40 ☐	41-45 ☐	46-50 ☐	51-55 ☐

10. As the age increase, from your opinion, will the pattern of a person walking change?

YES ☐ NO ☐

From your answer, why?

```
%Classification SVM
%%
%*************************************************************
**********
%----------------------------------------------------------------------
%+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++
clear all
%%
%Create data
load FemaleMaleBeforeLeft.mat
load FemaleMaleAfterLeft.mat
load ClassGroup.mat
data = [FemaleMaleAfterLeft(:,2),...
  FemaleMaleBeforeLeft(:,1)]
%%
%create a new column vector, groups, to classify data
%into two groups: Male and Female
groups = ismember(FemaleMaleBeforeS2,'Male')
%%
%Randomly select training and test sets
[train, test] = crossvalind('holdOut',groups)
% train=sort(train);
% test=sort(test);
cp = classperf(groups)
%%
%Train an SVM classifier using a linear kernel function and plot the grouped
data
%Linear SVM
figure
svmStruct = svmtrain(data(train,:),groups(train),'showplot',true);
title(sprintf('Kernel Function: %s',...
 func2str(svmStruct.KernelFunction)),...
 'interpreter','none');
%Use the svmclassify function to classify the test set.
classes = svmclassify(svmStruct,data(test,:),'showplot',true);
%Evaluate the performance of the classifier.
classperf(cp,classes,test)
cp.CorrectRate
%%
%nonLinear SVM
```

```
figure
svmStruct = svmtrain(data(train,:),groups(train),'showplot',true,
'kernel_function','rbf');
title(sprintf('Kernel Function: %s',...
 func2str(svmStruct.KernelFunction)),...
 'interpreter','none');
%Use the svmclassify function to classify the test set.
classes = svmclassify(svmStruct,data(test,:),'showplot',true);
%Evaluate the performance of the classifier.
classperf(cp,classes,test)
cp.CorrectRate
%%
% quadratic SVM
figure
svmStruct =
svmtrain(data(train,:),groups(train),'showplot',true,'kernel_function','quadratic');
%Use the svmclassify function to classify the test set.
classes = svmclassify(svmStruct,data(test,:),'showplot',true);
%Evaluate the performance of the classifier.
classperf(cp,classes,test);
cp.CorrectRate

%%
% polynomial SVM
figure
svmStruct =
svmtrain(data(train,:),groups(train),'showplot',true,'kernel_function','polynomial'
);
%Use the svmclassify function to classify the test set.
classes = svmclassify(svmStruct,data(test,:),'showplot',true);
%Evaluate the performance of the classifier.
classperf(cp,classes,test);
cp.CorrectRate

%%
% Multilayer Perceptron SVM
figure
svmStruct =
svmtrain(data(train,:),groups(train),'showplot',true,'kernel_function','mlp');
%Use the svmclassify function to classify the test set.
classes = svmclassify(svmStruct,data(test,:),'showplot',true);
%Evaluate the performance of the classifier.
classperf(cp,classes,test);
cp.CorrectRate
```

```
%function
OppositeFootContactCumulativeCDF(OppositeFootContact1,OppositeFootCont
act2)
load FemaleMaleBeforeLeft
load FemaleMaleBeforeRight
% Force all inputs to be column vectors
OppositeFootOffF = FemaleMaleBeforeLeft(:,1);
OppositeFootOffM = FemaleMaleBeforeLeft(:,2);
%-----------------------------------------------------------------
 OppositeFootContactF = FemaleMaleBeforeRight(:,1);
 OppositeFootContactM = FemaleMaleBeforeRight(:,2);
% %-----------------------------------------------------------------
 FootOffF = FemaleMaleBeforeLeft(:,1);
 FootOffM = FemaleMaleBeforeRight(:,1);
% %-----------------------------------------------------------------
 SingleSupportF = FemaleMaleBeforeLeft(:,2);
 SingleSupportM = FemaleMaleBeforeRight(:,2);
% %-----------------------------------------------------------------
% DoubleSupportF = Females(:,5);
% DoubleSupportM = Males(:,5);
% %-----------------------------------------------------------------
% StrideTimeF = Females(:,6);
% StrideTimeM = Males(:,6);

%%
%*******************************FMBL*********************
***********
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "OppositeFootOff Female"
[CdfY,CdfX] = ecdf(OppositeFootOffF,'Function','cdf');  % compute empirical
function
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} = 'Female-Before-Left';
% --- Plot data originally in dataset "OppositeFootCOff Male"
[CdfY,CdfX] = ecdf(OppositeFootOffM,'Function','cdf');  % compute empirical
```

```
function
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} = 'Male-Before-Left';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%*************************************((((FemaleMaleBeforeRight))
))**********************
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "FemaleMaleBeforeRight"
[CdfY,CdfX] = ecdf(OppositeFootContactF,'Function','cdf'); % compute
empirical function
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} = 'Female-Before-Right';
% --- Plot data originally in dataset "OppositeFootContact Male"
[CdfY,CdfX]  =  ecdf(OppositeFootContactM,'Function','cdf');   %  compute
empirical
```

```
function
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} = 'Male-Before-Right';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%*************************((((FemaleBeforeLeft/Right))))************
*
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "FemaleBefore/AfterRight"
[CdfY,CdfX] = ecdf(FootOffF,'Function','cdf'); % compute empirical function
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} = 'Female-Before-Left';
% --- Plot data originally in dataset "FootCOff Male"
[CdfY,CdfX] = ecdf(FootOffM,'Function','cdf'); % compute empirical function
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} = 'Female-Before-Right';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
%box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%*************************((((MaleBeforeLeftRight))))**************
*****
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "MaleBeforeLeftRight)"
[CdfY,CdfX] = ecdf(SingleSupportF,'Function','cdf'); % compute empirical
function
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} = 'Male-Before-Left)';
% --- Plot data originally in dataset "SingleSupport Male"
[CdfY,CdfX] = ecdf(SingleSupportM,'Function','cdf'); % compute empirical
function
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} = 'Male-Before-Right)';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
```

```
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');

%{
%%
%************************(((((5))))*****************************
**********
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "Double Support Female"
[CdfY,CdfX] = ecdf(DoubleSupportF,'Function','cdf');  % compute empirical
function
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} = 'Double Support Female';
% --- Plot data originally in dataset "DoubleSupport Male"
[CdfY,CdfX] = ecdf(DoubleSupportM,'Function','cdf');  % compute empirical
function
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} = 'DoubleSupportM Male';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
```

```
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%*************************((((6))))*****************************
**********
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "Stride Time Female"
[CdfY,CdfX] = ecdf(StrideTimeF,'Function','cdf'); % compute empirical
function
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';
% --- Plot data originally in dataset "StrideTime Male"
[CdfY,CdfX] = ecdf(DoubleSupportM,'Function','cdf'); % compute empirical
function
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';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%}
```

```
%function
OppositeFootContactCumulativeCDF(OppositeFootContact1,OppositeFootCont
act2)
load FemaleMaleAfterLeft
load FemaleMaleAfterRight
% Force all inputs to be column vectors
OppositeFootOffF = FemaleMaleAfterLeft(:,1);
OppositeFootOffM = FemaleMaleAfterLeft(:,2);
%-----------------------------------------------------------------
 OppositeFootContactF = FemaleMaleAfterRight(:,1);
 OppositeFootContactM = FemaleMaleAfterRight(:,2);
% %-----------------------------------------------------------------
 FootOffF = FemaleMaleAfterLeft(:,1);
 FootOffM = FemaleMaleAfterRight(:,1);
% %-----------------------------------------------------------------
 SingleSupportF = FemaleMaleAfterLeft(:,2);
 SingleSupportM = FemaleMaleAfterRight(:,2);
% %-----------------------------------------------------------------
% DoubleSupportF = Females(:,5);
% DoubleSupportM = Males(:,5);
% %-----------------------------------------------------------------
% StrideTimeF = Females(:,6);
% StrideTimeM = Males(:,6);

%%
%*********************************FMAL**********************
***********
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "OppositeFootOff Female"
[CdfY,CdfX] = ecdf(OppositeFootOffF,'Function','cdf');  % compute empirical
function
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} = 'Female-After-Left';
% --- Plot data originally in dataset "OppositeFootCOff Male"
[CdfY,CdfX] = ecdf(OppositeFootOffM,'Function','cdf');  % compute empirical
```

```
function
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} = 'Male-After-Left';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%**************************************((((FemaleMaleAfterRight))))
***********************
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "FemaleMaleAfterRight"
[CdfY,CdfX] = ecdf(OppositeFootContactF,'Function','cdf'); % compute
empirical function
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} = 'Female-After-Right';
% --- Plot data originally in dataset "OppositeFootContact Male"
[CdfY,CdfX]  =  ecdf(OppositeFootContactM,'Function','cdf');    %  compute

empirical
```

```
function
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} = 'Male-After-Right';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%*************************((((FemaleAfterLeft/Right))))*************
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "FemaleAfter/AfterRight"
[CdfY,CdfX] = ecdf(FootOffF,'Function','cdf');  % compute empirical function
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} = 'Female-After-Left';
% --- Plot data originally in dataset "FootCOff Male"
[CdfY,CdfX] = ecdf(FootOffM,'Function','cdf');  % compute empirical function
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} = 'Female-After-Right';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
```

```
% Adjust figure
%box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
%*************************((((MaleAfterLeftRight))))***************
****
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "MaleAfterLeftRight)"
[CdfY,CdfX] = ecdf(SingleSupportF,'Function','cdf');  % compute empirical
function
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} = 'Male-After-Left)';
% --- Plot data originally in dataset "SingleSupport Male"
[CdfY,CdfX] = ecdf(SingleSupportM,'Function','cdf');  % compute empirical
function
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} = 'Male-After-Right)';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
```

```
%{
%%
%*************************((((5))))*****************************
*********
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "Double Support Female"
[CdfY,CdfX] = ecdf(DoubleSupportF,'Function','cdf');  % compute empirical
function
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} = 'Double Support Female';
% --- Plot data originally in dataset "DoubleSupport Male"
[CdfY,CdfX] = ecdf(DoubleSupportM,'Function','cdf');  % compute empirical
function
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} = 'DoubleSupportM Male';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%%
```

```
%*************************((((6))))*******************************
**********
% Prepare figure
figure;
clf;
hold on;
LegHandles = []; LegText = {};
% --- Plot data originally in dataset "Stride Time Female"
[CdfY,CdfX] = ecdf(StrideTimeF,'Function','cdf');  % compute empirical
function
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';
% --- Plot data originally in dataset "StrideTime Male"
[CdfY,CdfX] = ecdf(DoubleSupportM,'Function','cdf');  % compute empirical
function
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';
% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);
% Adjust figure
box on;
hold off;
% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical', 'Location',
'NorthWest');
set(hLegend,'Interpreter','none');
%}
```

```
load FemaleMaleAfterLeft
load FemaleMaleAfterRight
% Force all inputs to be column vectors
OppositeFootOffF = FemaleMaleAfterLeft(:,1);
OppositeFootOffM = FemaleMaleAfterLeft(:,2);
%-------------------------------------------------------------
 OppositeFootContactF = FemaleMaleAfterRight(:,1);
 OppositeFootContactM = FemaleMaleAfterRight(:,2);
% %-------------------------------------------------------------
 FootOffF = FemaleMaleAfterLeft(:,1);
 FootOffM = FemaleMaleAfterRight(:,1);
% %-------------------------------------------------------------
 SingleSupportF = FemaleMaleAfterLeft(:,2);
 SingleSupportM = FemaleMaleAfterRight(:,2);
% %--------------------(((1)))---------------------------------------
% Prepare figure
clf;
hold on;
LegHandles = []; LegText = {};

% --- Plot data originally in dataset "OppositeFootContact1 data"
[CdfF,CdfX] = ecdf(OppositeFootOffF,'Function','cdf');  % compute empirical
cdf
BinInfo.rule = 1;
[~,BinEdge] =
internal.stats.histbins(OppositeFootOffF,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0 0.666667],...
   'LineStyle','-', 'LineWidth',3);
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Female/After/Left';

% --- Plot data originally in dataset "OppositeFootContact2 data"
[CdfF,CdfX] = ecdf(OppositeFootOffM,'Function','cdf');  % compute empirical
cdf
BinInfo.rule = 1;
[~,BinEdge] =
internal.stats.histbins(OppositeFootOffM,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0.666667 0],...
   'LineStyle','-', 'LineWidth',3);
```

```
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Male/After/Left';

% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);

% Adjust figure
box on;
hold off;

% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical');
set(hLegend,'Units','normalized');
Position = get(hLegend,'Position');
Position(1:2) = [0.157461,0.693063];
set(hLegend,'Interpreter','none','Position',Position);
% %------------------------(((2)))----------------------------------------
% Prepare figure
figure,
clf;
hold on;
LegHandles = []; LegText = {};


% --- Plot data originally in dataset "OppositeFootContact1 data"
[CdfF,CdfX] = ecdf(OppositeFootContactF,'Function','cdf'); % compute
empirical cdf
BinInfo.rule = 1;
[~,BinEdge] =
internal.stats.histbins(OppositeFootContactF,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0 0.666667],...
   'LineStyle','-', 'LineWidth',3);
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Female/After/Right';
```

```
% --- Plot data originally in dataset "OppositeFootContact2 data"
[CdfF,CdfX] = ecdf(OppositeFootContactM,'Function','cdf'); % compute
empirical cdf
BinInfo.rule = 1;
[~,BinEdge] =
internal.stats.histbins(OppositeFootContactM,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0.666667 0],...
    'LineStyle','-', 'LineWidth',3);
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Male/After/Right';

% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);

% Adjust figure
box on;
hold off;

% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical');
set(hLegend,'Units','normalized');
Position = get(hLegend,'Position');
Position(1:2) = [0.157461,0.693063];
set(hLegend,'Interpreter','none','Position',Position);
% %------------------------(((3)))----------------------------------------
% Prepare figure
figure,
clf;
hold on;
LegHandles = []; LegText = {};


% --- Plot data originally in dataset "OppositeFootContact1 data"
[CdfF,CdfX] = ecdf(FootOffF,'Function','cdf'); % compute empirical cdf
BinInfo.rule = 1;
[~,BinEdge] = internal.stats.histbins(FootOffF,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0 0.666667],...
    'LineStyle','-', 'LineWidth',3);
```

```
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Female/After/Left';
% --- Plot data originally in dataset "OppositeFootContact2 data"
[CdfF,CdfX] = ecdf(FootOffM,'Function','cdf'); % compute empirical cdf
BinInfo.rule = 1;
[~,BinEdge] = internal.stats.histbins(FootOffM,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0.666667 0],...
   'LineStyle','-', 'LineWidth',3);
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Male/After/Right';

% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);

% Adjust figure
box on;
hold off;

% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical');
set(hLegend,'Units','normalized');
Position = get(hLegend,'Position');
Position(1:2) = [0.157461,0.693063];
set(hLegend,'Interpreter','none','Position',Position);
% %------------------------(((4)))------------------------------------------
% Prepare figure
figure,
clf;
hold on;
LegHandles = []; LegText = {};
```

```
% --- Plot data originally in dataset "OppositeFootContact1 data"
[CdfF,CdfX] = ecdf(SingleSupportF,'Function','cdf');  % compute empirical cdf
BinInfo.rule = 1;
[~,BinEdge] = internal.stats.histbins(SingleSupportF,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0 0.666667],...
   'LineStyle','-', 'LineWidth',3);
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Female/After/Left';

% --- Plot data originally in dataset "OppositeFootContact2 data"
[CdfF,CdfX] = ecdf(SingleSupportM,'Function','cdf');  % compute empirical cdf
BinInfo.rule = 1;
[~,BinEdge] = internal.stats.histbins(SingleSupportM,[],[],BinInfo,CdfF,CdfX);
[BinHeight,BinCenter] = ecdfhist(CdfF,CdfX,'edges',BinEdge);
hLine = bar(BinCenter,BinHeight,'hist');
set(hLine,'FaceColor','none','EdgeColor',[0.333333 0.666667 0],...
   'LineStyle','-', 'LineWidth',3);
xlabel('Data');
ylabel('Density')
LegHandles(end+1) = hLine;
LegText{end+1} = 'Male/After/Right';

% Create grid where function will be computed
XLim = get(gca,'XLim');
XLim = XLim + [-1 1] * 0.01 * diff(XLim);
XGrid = linspace(XLim(1),XLim(2),100);

% Adjust figure
box on;
hold off;

% Create legend from accumulated handles and labels
hLegend = legend(LegHandles,LegText,'Orientation', 'vertical');
set(hLegend,'Units','normalized');
Position = get(hLegend,'Position');
Position(1:2) = [0.157461,0.693063];
set(hLegend,'Interpreter','none','Position',Position);
```