BIOELECTRICAL IMPEDANCE ANALYSIS OF FAT IN THE BODY COMPOSITION INFLUENCED BY OGAWA MASTERDRIVE 4D

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ABSTRACT

Ogawa MasterDrive 4D is a state-of the art massage chair that was designed to bring relaxation to your home. The chair was equipped with heat function that allow the user to experience warm hand-like massages that claimed to increase the metabolic rate of the user and subsequently reduce body fat. Bioelectrical Impedance Analysis (BIA) is a technique that is used to estimate the body composition of the human body. It is well known for its non-invasive approach, simplicity, convenience, affordable price and it is able to obtain instant results of your body immediately without technical supervision. The objective of this study is to test the claim from Ogawa by using two BIA devices to measure the body fat percentage. The study conducted the test using 11 subjects, 5 males and 6 females between 15 – 75 years old with the BMI between 16.3 – 33.1 kg/m^2. The study used two BIA devices to obtain the body fat percentage results. The subjects experience all four massages and completed the sessions in an hour using the Ogawa MasterDrive 4D. The paired t- test showed that the t-value is 0.127, and p-value is 0.902. The study is unable to reject the null hypothesis of no difference. Based on the study, the differences of body fat percentage measured by the BIA method is insignificant after using the Ogawa MasterDrive 4D.

ABSTRAK

Ogawa MasterDrive 4D merupakan kerusi urut yang melengkapi dengan teknologi yang terkini. Kerusi urut ini mempunyai fungsi haba yang membenarkan pengguna untuk menikmati urutan yang menyerupai dengan pengurut tangan manusia yang sebenar. Ogawa telah membuat tuntutan bahawa kerusi urut ini boleh meningkatkan kadar metabolik dan mengurangkan peratusan lemak dalam badan pengguna. Analisis impedans bioelektrik merupakan teknik untuk menganggarkan komposisi dalam badan. Analisis ini dikenali sebagai teknik bukan invasif, senang, murah, dan mampu mendapatkan keputusan komposis badan dengan segera tanpa pembantuan penyelia medikal. Objektif penyelidikan ini ialah untuk menguji tuntutan Ogawa dengan mengunakan teknik analisis impedans bioelektrik. Kajian ini mempunyai sebelas ahli peserta, lima ahli lelaki dan enam ahli perempuan dalam lingkungan umur 15 – 75 tahun. Indeks jisim badan adalah dalam lingkungan 16.3 – 33.1 kg/m^2. Penyelidikan ini mengunakan dua peranti analisis impedans bioelektrik untuk mendapatkan keputusan peratusan lemak dalam badan ahli peserta. Ahli – ahli peserta akan berada atas kerusi urut selama sejam untuk menghabiskan semua empat jenis urutan. Ujian-t menunjukkan bahawa nilai-t adalah 0.127, manakala nilai-p adalah 0.902. Untuk menunjukkan bahawa kajian ini boleh menolak hipotesis nol, nilai p haruslah ($p < 0.05$). Oleh itu, keputusan peratusan lemak dalam badan tidak menunjukkan perubahan yang bermakna selepas penggunaan kerusi Ogawa.

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LIST OF ABBREVIATIONS AND SYMBOLS

BIA	Bioelectrical Impedance Analysis
kg/m^2	Kilogram per meter square
TBW	Total Water Body
BMI	Body Mass Index
DEXA	Dual Energy X-Ray Absorptiometry
MRI	Magnetic Resonance Imaging
Re	Extracellular Resistance
Ri	Intracellular Resistance
Cm	Membrane Capacitance
I	Currrent
V	Voltage
R	Resistance
Z	Impedance
Xc	Reactance

C	Circumference
kHz	Kilo Hertz
FFM	Fat Free Mass
°	Degrees
BCM	Body Cell Mass
ARM	Advanced RISC (Reduced Instruction Set Computer) Machine

CHAPTER 1: INTRODUCTION

1.1. Overview

Massage therapy is often promoted to reduce weight loss. The sensation of kneading skin, muscles and other bodily tissues can provide relaxation, relieved injured tissues, increasing flexibility and even hormone stimulation like endorphins that provides euphoric happy feeling. Ogawa Master Drive is a massage chair equipped with recent technology and uplift massage machines to a whole new level. This new product by Ogawa is the only massage chair whereby the heat function is dispersed from the massage rollers itself which will provide the feeling of real pairs of warm hand massaging the human body. The rollers provide moderate pressure that is good for blood circulation and improves overall well-being. Precision sensors built into the massage chair can adjust the intensity levels in real-time, which greatly improve massages to hit the right spots with the right power. All these features are powered by the high performance Advance (RISC) Reduced Instruction Set Computer Machine microprocessor (A.R.M).

Ogawa inventor claim their massage chair can reduce user weight by consistently using their product when it paired with healthy diet and good amount of physical activity. Instead of evaluating body weight, this project will evaluate the body fat changes of the subjects. Body fat is the fatty (adipose) tissue portion of the body. Body weight includes body fat and all other components of body including bone, organs, fluid, muscle, etc. Body fat is typically shown as a percentage of total weight.

Body fat of human can be evaluated by using bio-impedance analysis (BIA). BIA is a method of assessing body composition, the measurement of body fat in relation to lean body mass. Body composition as prove by researcher is directly related to health. BIA allows for early detection of an improper balance in body composition, which fosters earlier intervention and prevention. BIA also provides a measurement of fluid and body mass that can be a critical assessment tool for current state of health.

1.2. Problem statement

The paper of this investigation is to study the claim of the Ogawa Masterdrive 4D Thermo Care Massage Chair's ability to increase the metabolic rate and reduce the user's percentage body fat by using the massage chair for one hour. There are no other research studies that provide concrete evidence that conventional massage therapy and machined-type massage therapy can increase metabolic rate and reduce fat percentage in the body. Therefore, this study is to determine whether the claim is true by using BIA measuring equipment to measure the electrical impedance of the human body.

1.3. Aim and Objective

The aim of the study is to determine the ability of the OGAWA MasterDrive 4D massage chair to reduce the percentage of body fat of the user by undergoing all four default massage types, i.e. Master's Choice, Sensei, Spine Care and Joint Care, using two (2) bio-impedance analyzer, the bio-impedance weighing scale and the Body Key InBody Watch to monitor the subjects' body mass (kg), muscle mass (kg) and percentage by fat (%), before and after each massage sessions.

1.4. Scope of Study

The research is to investigate the act of massage and its influence towards the body fat percentage. The body fat percentage can be analyzed using Bioelectrical Impedance Analyzer. However, the study will only focus on the body fat percentage of the subject after the application of the Ogawa Massage Chair 4D. The research is conducted by obtaining primary data from two Bioelectrical Impedance Analyzers, i.e. the InBody Watch and the BIA weighing scale. The BIA devices will provide data such as body mass (kg), muscle mass (kg), fat mass (kg), total water body mass (kg), body mass index (BMI) and bdy fat percentage (%).

1.5. Report Organisation

This report contains five chapters, namely: introduction, literature review, methodology, result and discussion, and conclusion. Introduction explains therapeutic massages briefly and its known benefits of providing relaxation to the human body and reduces stress. The problem statement and objective of the project are also discussed in the same section. Literature review consists of detailed background bioelectrical impedance analysis as a method to obtain body composition and therapeutic massages as a means of increasing metabolic rate and reduce body fat. Methodology comprises of the process of obtaining the corporeal composition using BIA devices. Observation was taken place to assess the subjects reaction towards every massage modes from the Ogawa MasterDrive 4D. Result and discussion provides a comprehensive analysis of the data collected and discusses the significance of the analyzed data. Conclusion summarizes the overall work that has been done in this research study.

CHAPTER 2: LITERATURE REVIEW

2.1. Bioelectrical Impedance Analysis

Bioelectrical Impedance Analysis (BIA) is well known to be a noninvasive method to estimate body composition. It provides the overall measurement of cellular health. This technique, if performs over a substantial amount of time will allow the subjects to observe their health status and its trends. It is an excellent way to monitor health for anyone who is experiencing certain fitness regime, diet plan, life style and with additional nutraceuticals added into the person's lifestyle; the BIA will be able to provide an accurate health trend to allow the subject to stay on the path of healthy lifestyle. Many private healthcare centers have been practicing this method for over 3 decades. The method is currently applied in various settings and locations including healthcare centers, private clinicians' offices, and hospitals. Even commercialized and portable BIA devices are available and can be purchased for home use.

BIA is so fast, simple, painless and provides accurate corporeal measurements results of a person (Foster & H.C., 1996). The technique is used to monitor patient's' organs like heart and kidneys. The general public can easily be well informed of the corporeal measurements that BIA is able to provide. The general public's popular perception towards BIA is to measure body fat. Percentage body fat is a well-known factor to determine a person's health status.

BIA can provide more information through phase angle (Biospace, 2014). Phase angle able to measure the aging stress at a cellular level known as oxidative stress. Oxidative stress level is given a scale from 1 to 10 (Biospace, 2014). Ideally, a healthy human being should keep their oxidative stress level at 5 and above (Biospace, 2014). BIA can also determine muscle mass, which is an important biomarker that ascertain our health condition (Biospace, 2014) (Dehghan & Merchant, 2008). Muscle mass drives metabolism, energy and regulates the hormones in the body. BIA is also able to measure basal metabolic rate. The idea is to measure the human body rate of burning calories for 24 hours at rest. The basal metabolic rate is largely affected by the muscle mass, thyroid and adrenals. If any of the bio-factors are affected the basal metabolic rate will decrease. Lastly, BIA is known to measure the percentage of body fat in the body. An ideal human being should have 15% to 22% of body fat percentage in their body (Biospace, 2014). Body fat is important for the production of hormones in the body, maintaining the health of the skin and support brain function. However, if the body fat percentage is too high it becomes inflammatory. Total water body is an essential biomarker that ideally should be 50% and above. When a person is dehydrated, the joints, skin, organs, muscle and brain function will deteriorate drastically. It is one of the most common nutrition deficiencies. Once a person is classified as dehydrated below 50% of total body water percentage, it requires 2 to 3 months for the person to rehydrate the body at a cellular level (Biospace, 2014). BIA can also determine the percentage of extra-cellular and intra-cellular water which is often used to observe health trends (Deurenberg, van der Kooy, Leenen, & Schouten, 1989) (Biospace, 2014).

The study of epidemiology, body fat percentage is strongly associated with the risk of several chronic diseases like hypertension, dyslipidemia, diabetes mellitus and coronary heart disease (Dehghan & Merchant, 2008). In the beginning, measurements such as body mass index (BMI), waist circumference, waist-hip ratio and skin fold thickness are often used as substitute parameters to body fat percentage which primarily determine the health of a person. The surrogate measurements were inaccurate and unable to precisely depict the body composition of a human being without acknowledging other human factors like age, gender, sex and ethnic groups.

There are other methods that have been used to assess percentage of body fat, but in a controlled setting such as underwater weighing (densitometry), dual energy x-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA) and magnetic resonance imaging (MRI).

However, out of the four (4) methods available in the medical setting, the most favorable and practical technique is BIA. This is due to the other three methods utilize expensive, large, and specialized equipment that are inconvenient, time consuming and not feasible to conduct without proper supervision in order to obtain body composition results (Lukasik H. , 2013). Thus, the applications are limited and unpopular. BIA on the other hand is quick, simple, and non-invasive. The equipment is handy and portable which provides accurate corporeal measurements with minimum supervision. The results obtain within minutes and are repeatable with errors <1%.

In 1980s, BIA was made available to the public for the first time and the requirements of the analysis were simple, inexpensive, handy and extremely user friendly to assess corporeal measurements in epidemiological studies. In order to obtain accurate results, subjects are not allow to consume food for at least an hour before the test; vigorous exercises are refrained twelve hours before the analysis (Dehghan & Merchant, 2008); caffeine and alcohol are both prohibited a day before the test and the subjects must remain hydrated at all times.

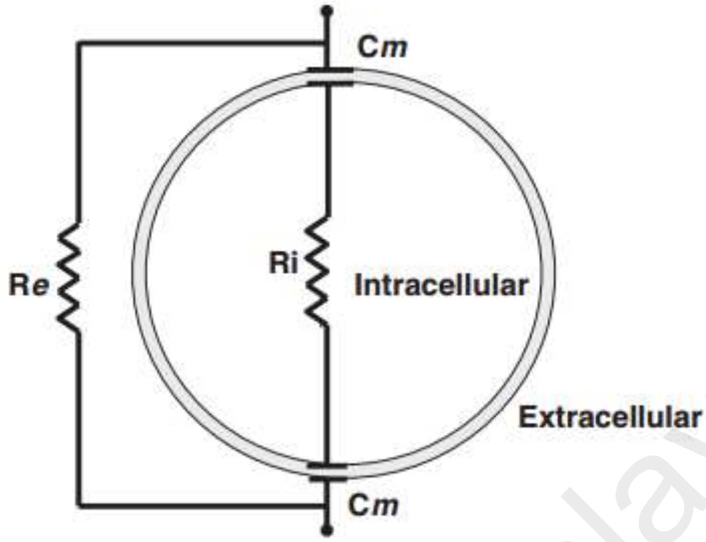

Figure 2.1: Electrical circuit equivalence to describe Bioelectrical Components of the living cell. Alternative current flows through the body it impedes the resistor which is the ion concentration at the extracellular part of the cells (Re); the current is then condensed and stored at the lipid of the cell membrane (Cm) and shortly released behaved as a capacitor and a reservoir of electric current that reduces the flow into the intracellular ions (Ri). (Dehghan & Merchant, 2008) (Lukasik H. , 2013).

2.2. Principles of Bioelectrical Impedance Technique

Bioelectrical impedance analysis allows estimation of the physiological function to assess body composition also known as biomarkers that determines the status of our health. The contemporary principle of BIA technique is to apply minute amount of electrical current into to the body and allow electricity to explore the tissues and cells to reveal information about the corporeal information. The diversity of BIA assessments provide numerous in vivo information that allows human beings to assess their health daily. However, as convenient as it may seem, the BIA prediction equations also have its limitations. Most equations are imprecise which are subject to the person's age, gender, sex, ethnicity and many other factors that might require to be incorporated into the BIA mathematical models to improve accuracy of the corporeal results.

The principle of using bioelectrical impedance to study the body structure and its function is similar to the electrical circuit of $I = \frac{V}{R}$ suggested by (Fricke, 1925) and elaborated by (KS., 1972). The understanding of Ohm's Law (Grimnes & Orjan .G, 2000) explained that the electric current (*I)* flowing through two points of conductors is equivalent to the voltage drop (*V)* divided by the resistant (*R)* between them (Lukasik H. , 2013). Alternating current yield the concept of electrical impedance (Foster & H.C., 1996) (Lukasik H. , 2013) with different electrical flow rates through the body depending on the composition of the individual (Dehghan & Merchant, 2008). Body impedance (Z) consists of reactance (Xc) which is the extracellular nonfat part of the body and resistance (R) which is lipid component of the cell membrance (Dehghan & Merchant, 2008). Electric current is hydrophilic, thus it can easily flow through water with ions which the body is mostly composed (Dehghan & Merchant, 2008) . Generally, water can be found in two locations within the body, i.e. intracellular and extracellular (Dehghan & Merchant, 2008). The non-conducting parts of the body are muscle, bones and adipose tissues that provide resistance to the electric current flow, and adipose tissue is significantly less than the two (Scharfetter, et al., 2001) (Dehghan & Merchant, 2008). Therefore, the conductivity value plays a significant role in determining biomarkers such as muscle mass or lean mass and fat mass (Pietrobelli & Heymsfield, 2002) (Dehghan & Merchant, 2008).

2.3. BIA History, Measurements, Validity and Considerations

The structure of the human body varies individually among different ethnic groups, sex, age and gender (Ward, et al., 2000) . Each person has different cross sectional area, length or ionic composition which affects the accuracy of BIA measurements (Pietrobelli & Heymsfield, 2002). The validity of different BIA varies based on the positioning of the electrodes on the body to obtain results (Dehghan & Merchant, 2008) . The initial assumption of BIA is to consider the human body to be a large cylindrical-shaped ionic conductor with homogenous composition which includes the limbs and the trunks (Houtkooper, Lohman, Going, & Howell, 1996).

In the 1980s, the first BIA innovation managed to achieve the total body content by allowing a single low radiofrequency of 50 kHz flowing through the body with the electrodes at the right hand and the right foot to measure bio-impedance (Biospace, 2014). However, as many researchers have applied and tested this method towards different groups of people, the results only yield the right half of the body water impedance (Biospace, 2014). Later, empirical equations were created to include factors such as age and gender, but the limitations of this estimation were confine to their specific test group and ethnicity which did not fully represent the global population (Biospace, 2014). In order to overcome the inaccuracy of BIA assessments, BIA technology requires improvements to provide segmental impedance measurement of the body. The human body exhibits five (5) cylindrical shaped estimated compartments, each with different length and width, i.e. the two upper limbs, lower limbs and the trunk (Biospace, 2014).

Prior to the latest BIA inventions, the human body was considered as a cylindrical shape ionic conductor and with the assumption of the body composition to be homogenous, the device offered a single whole body impedance value (Houtkooper, Lohman, Going, & Howell, 1996) (Kyle, et al., 2004) (Biospace, 2014). Predictive equations have been developed to estimate total water body (TBW), lean mass or fat free mass (FFM) and body cell mass (BCM) (Dehghan & Merchant, 2008). The mixture theory (Hanai, 1968) described the electrical conductivity within the body composition is heterogeneous based on the distribution of conductivity (water and ionic fluids) and non-conductivity (anhydrous components such as adipose tissues, bones, muscles and cell membrane) (Hanai, 1968) (Lukasik H. , 2013). Thus, empirical equations and modelling are essential because it is the only technique to obtain body composition results individually and analyzing the individual components of a respective heterogeneous system (Lorenzo, Andreoli, J.Matthie, & P.Withers, 1997). The prediction of extracellular water (ECW) and intracellular water (ICW) are separate and the sums of both values are the subject's total body water (TBW). The calculation of extracellular and intracellular fluids incorporate resistance parameters like membrane capacitance (C_m), extracellular fluid resistance, (R_e), intracellular fluid resistance (R_i), resistance associate with both intracellular and extracellular fluid ($R_{\infty)}$ and biomarkers such as body mass (kg), height (m), empirically derived gender and age specific resistivity constants , and body geometry factors to calculate the percentage or mass of total water body (Lukasik H. , 2013). However, these predictions derived from empirical formula and mathematical modelling will provide inaccurate results because they are population specific (Deurenberg, Deurenberg-Yap, & Schouten, 2002). Many factors have to be accounted for to overcome the inaccuracy of the results, like gender, age and body water distribution (Deurenberg & Deurenberg-Yap, The Assessment of Body Composition: Uses and Misuses, 1992). The latter is a confounding factor that is related to the subject's specific extracellular and intracellular resistivity (Deurenberg, van der Kooy, Leenen, & Schouten, 1989) (Deurenberg, Deurenberg-Yap, & Schouten, 2002).

The latest innovations on BIA technologies take into account the limitations of the BIA devices apply multi-frequency method to several segments of the body across ethnic groups. The trunk is short in length and wide area account 5% of the whole body impedance, but comprises approximately half of the whole body mass (Biospace, 2014). Hence, a slight impedance change in the trunk's impedance value will have significant implications on the whole body lean mass. The challenge of measuring the body composition depends on the technique chosen to acquire more sophisticated results (Deurenberg & Deurenberg-Yap, Validation of skinfold thickness and hand-held impedance measurements for estimation of body fat percentage among Singaporean Chinese, Malay and Indian subjects, 2002). According to (Fuller & Elia, 1989), contribution of the impedance value from the limbs is disproportional to the amount of body water in these body compartments (Deurenberg, Deurenberg-Yap, & Schouten, 2002). The body build of each ethnic group differs from one another; for instance Chinese and Malays have relatively short limbs and are overall petite (Eveleth & J.M., 1976), The Indians and Australian aborigines have lengthier limbs compared to their overall body height (Norgan, 1995). Therefore , predictive equations and mathematical modelling for the estimation of TBW, FFM and body cell mass (BCM) should include bio-factors such as age, weight, height and race (Dehghan & Merchant, 2008) (Deurenberg, Deurenberg-Yap, & Schouten, 2002).

The variety of BIA devices will also predict different percentages of body fat (Deurenberg & Deurenberg-Yap, Validation of skinfold thickness and hand-held impedance measurements for estimation of body fat percentage among Singaporean Chinese, Malay and Indian subjects, 2002) for different ethnic groups. The validity of the BIA analyzers highly dependent on the placements of the electrode on the body ; may it be hand to hand like the Omron BF306 BIA, foot to foot (Tanita, TBF – 102), or hand to foot (Selko, SIF – 891). According to (Demura, et al., 2002), the hand to foot BIA has a higher correlation than a foot to foot among all BIA devices.

2.4. Consumption of Solid Foods or Fluids

Food and fluid intake are known to affect the value of total body water percentage (TBW) and extracellular water (ECW) (Dehghan & Merchant, 2008). Since the trunk of the body has a huge girth, fluid intake will not be able to be detected by the BIA until approximately an hour later which will affect the impedance value of the body causing it to be inaccurate (Dehghan &

Merchant, 2008) (Kushner, R., & D.A., 1996) (L.A. & M.H., 1993). Some studies however, indicated that dehydration of the human body will increased resistance of the electric current flow, which resulted to increase the impedance value (Lukaski, W.W., Hall, & W.A., 1986) (Dehghan & Merchant, 2008). Hence, the value of fat free mass (FFM) will be underestimated because the body is lacked of water. A similar issue with food consumption; some researchers claimed that there are no effects in BIA measurement after food consumption (W.C., A.F., S.M, & B, 1987) (Dehghan & Merchant, 2008); whereas some researchers showed that there are approximately 10% differences in body fat percentage after food intake during 24 hours (F, Rossander, & L., 2001) (Dehghan & Merchant, 2008) . Therefore, from the reviews there are lacked of concrete answers and guideline to dictate subjects to fast or abstain from food and fluid consumption before and during the BIA test.

2.5. Body Activity

Light exercise might not achieve any repercussions towards a BIA based body composition value, but moderate to intense body activity before measurement may alter the impedance value and hence causes over or under estimation of the body composition value (Dehghan & Merchant, 2008). This is because exercise increases cardiac output which promotes the blood to flow through the muscles in the body and like water, the intense flow of the blood enters the cells which will decrease the impedance value within the cells and underestimate the body fat percentage (Kushner, R., & D.A., 1996) (Dehghan & Merchant, 2008). In order to reduce measurement error, refrain from strenuous exercises before BIA.

2.6. Massage Therapy

Massage therapy has proven to serve benefits on various conditions such as prenatal depression for women, preterm infants to promote weight gain, full term infants, autism, skin condition, pain syndrome, hypertension, cancer, fibromyalgia, headaches, HIV/AIDS and many more (Field, 2016). However, there is lack of studies that stated massage can definitely reduce body fat percentage. Many commercialized massage centers and spa treatment centers often promote massage, if it is done properly it can help to lose weight. It was said that a full body massage can help to increase blood circulation, tone muscles and relieves from stress (Naomi, 2017). Many people wonder that losing weight through massages might be a misconception, because there isn't any scientific research to support the claim. Contrary to popular believe, a study proved that massage improves growth quality and decrease body fat deposition in male preterm infants (Moyer-Mileur, Shannon, Hillarie, Beachy, & Smith, 2013). The study specifically mentioned that the preterm infant will experience weight gain, but decrease the circulation of adiponectin that associate in increasing infants' body fat (Moyer-Mileur, Shannon, Hillarie, Beachy, & Smith, 2013). Therefore, it is insignificant whether conventional massage therapy would decrease fat percentage in the body.

Table 2.1: Related Studies to the Research

	Research title	Aim of the study	Methodology	Pros	Cons	Contributors
1	Review: Is bioelectrical impedance accurate for use in large epidemiological studies? (Dehghan &	The review discussed issues linked with the usage of bioelectrical impedance analysis (BIA) to measure body	The review focused on rationale, theory and technique of the current development and recent technologies	The study review embraces BIA as a popular method in estimation of body fat percentage because it is	The study also highlight that there are no predictive equation or mathematical models that allows BIA	Mashid Dehghan and Anwar T Merchant

	Merchant, 2008)	composition in large epidemiologic studies.	that assess BIA, as well as other elements that provide impact to the international epidemiologic studies.	inexpensive and convenient.	to estimate the body composition of the global population because it is highly affected on the age, gender, level of physical activity, ethinicity, and other major factors of the individual.	
2	Review: Evolution of bio impedance: a circuitous journey from estimation of physiological function to assessment of body composition and a return to clinical research (Lukasik H. , 2013)	The research aims to translate bioelectrical measurements into physiological variables that supersede the creation of predictive equations that often yields inconsistent results.	The paper evaluates the BIA concept models following the implementation of these models in clinical research that includes assorted physiological functions and body composition.	The review paper revealed the application of bio impedance is very well known for its simplicity and convenience of procuring corporeal composition results.	Despite the popularity of this method, it is limited to certain population and ethnic groups that has the available predictive equations to accurately assess and provide results.	Henry C Lukaski
3	Validation of skinfold thickness and hand-held impedance measurements for estimation of body fat percentage among Singaporean	This research is to validate the body fat composition of the Singaporeans Chinese, Malays and Indians by using hand-held	Skinfold methods were measuring the biceps, triceps, subscapular and suprailiac to assess body fat percentage; and the use of hand held BIA device by	There are 298 subjects participated in this study. The study is able to proof that the body composition is correlated with level of body fat, age and	The biasness of the research has been overcome.	Paul Deurenberg and Mabel Deurenberg-Yap

	Chinese, Malay and Indian subjects (Deurenberg & Deurenberg-Yap, Validation of skinfold thickness and hand-held impedance measurements for estimation of body fat percentage among Singaporean Chinese, Malay and Indian subjects, 2002)	impedance measurement versus skinfold thickness method.	keying in personal particulars to calculate the body fat percentage.	arm span and body height to obtain accurate impedance value. After the correction. The differences among ethnic groups disappear.		
4	Application of Bioelectrical Impedance Analysis and Anthropometry as Interchangeable Methods to Assess Body Composition of Sportpersons (Khan, Aggarwala, & Dhingra, 2017)	The study was to find the procedure of BIA and anthropometry as interchangeabl e method to procure body composition of a sportspersons.	Bioelectrical Impedance Analysis and anthropometry method that strictly comply criteria to measure sportspersons.	The research requires further validation and in depth study.	The results indicated that the findings have large discrepancies and the methods are not interchangea ble to one another.	Alisha Khan, Jyotsna Aggarwala and Meenu Dhingra
5	The validity of predicted body fat percentage from body mass index and from impedance in samples of five European populations (Deurenberg, et	To test the validity of body mass index and BIA based prediction equation for body fat percentage among various European	The BIA results were assessed against dual-energy X-ray absorptiometry (DXA) or densitometry (under water weighing).	The prediction equations developed were sufficient to estimate body fat percentage for five populations of people in Europe ,	The individual misclassificat ion is more noticeable for BMI based prediction. More comparative study should	P Deurenberg, A Andreoli, P Borg, K Kukkonen-Harjula, A de Lorenzo, WD van Marken Lichtenbelt, G Testolin, R

	al., 2001)	populations groups.		except in Tampere..	be done to obtain a more generalized equation.	Vigano and N Vollaard
6	Body fat measurement among Singaporean Chinese, Malays and Indians: a comparative study using a four-compartment and different two compartment models (Deurenberg-Yap, Schmidt, Staveren, & Hautvast, 2001)	The cross sectional study comparing the body fat percentage using four compartment model against body fat percentage from hydrometry, dual-energy X Ray absorptiometry and densitometry using Chinese, Malays and Indians to determine the suitability of two-compartment model as a surrogate method to obtain body fat percentage.	A total of 291 subjects between aged 18 – 75 with BMI range (16-40 kg/m^2) measured total body water, body height and body weight using densinometry and H2O dilution, body fat percentage measurement with 4C model.		Two compartment model found to be unsuitable for accurate measurement for Body Fat percentage at the individual level with high errors and violation of body hydration assumption.	Mabel Deurenberg-Yap, Gordon Schmidt, Wija A. van Staveren, Joseph G. A. J. Hautvast and Paul Deurenberg[2]
7	Validity of total and segmental impedance measurements for prediction of body composition across ethnic population groups	The study is to assess the implications of body build factors on the validity of impedance-based body composition prediction	100kHz radiofrequency were introduced to the body segment by segment based on the anthropometry parameters	The study declared that impedance based formula can be improved by including body build factors into the equation. The		P Deurenberg, M Deurenberg-Yap and FJM Schouten

	(Deurenberg, Deurenberg-Yap, & Schouten, Validity of total and segmental impedance measurements for prediction of body composition across ethnic population groups, 2002)	across ethnics and the validity of segmental impedance measurements.	calculated as height, arm length and leg length respective impedance value.	study revealed that the body composition prediction based on BIA is bias among ethnicity and the general prediction equation has to be re-evaluated to eliminate underestimated values and over-estimated values.		
8	Predicting body cell mass with bioimpedance by using theoretical methods: a technological review (Lorenzo, Andreoli, J.Matthie, & P.Withers, 1997)	The study is to estimate the total water body content using BIA theoretical models	Extracellular water and intracellular water were measured by bromide dilution and deuterium oxide dilution. The impedance data were fit into a Cole Model and the extracellular water and intracellular water volumes were predicted by using electrical resistance mathematical model.	The extracellular and intracellular water in the body can possibly predict the body composition based on fundamental principles.	The study does not account for ethnicity, age, gender which therefore the claim of the theoretical model cannot accurately estimate the corporeal composition values for the global population	A. De Lorenzo, A. Andreoli, J. Matthie and P. Withers

9	A Multi-Frequency Current Source For Bio impedance Application (Cheng, Chen, Huang, & Chen, 2018)	The aim is to design a BIA device with a wide range of radio frequency.	The design includes a micro-controller, a programmable waveform generator and a voltage controlled current source.	The proposed multi-frequency BIA design can be developed in an inexpensive methodology.	The study did not emphasize on the accuracy of the device for medical uses.	Kuo-Sheng Cheng, Senior Member, IEEE, Cheng-Yu Chen, Min-Wei Huang, and Chien-Hung Chen
10	Estimation of Body Fluids Volumes Using Tetrapolar Bioelectrical Impedance Measurements (Lukasik H. C., 1989)	To create a mathematical equation using tetrapolar bioelectrical resistive and reactive impedance measures to predict total water body.	The study used corrected bromide space to cross validated the TBW predicted results based on BIA technique	The study revealed that the validity of the tetrapolar BIA method was able to assess body fluids within the human body.	However, the number of subjects that were involved in this study were only based on gender and age. Ethnicity, body build were not mentioned.	Henry C Lukaski
11	A comparison of three bioelectrical impedance analyses for predicting lean body mass in a population with a large difference in muscularity (Tanaka, Kanehisa, Masae, Masuo, & Fukunaga, 2005).	The study aimed to compare whole body BIA values and segmental BIA values on lean mass and which would be more accurate.	Subjects were divided into two cohorts, i.e.: atheletic males and non-athletic. The values were validated and cross-validated		The study showed the prediction equation of the whole body BIA produced systematic error and fail to represent the changes of lean mass composition at the limbs.	Noriko Ishiguro; Hiroaki Kanehisa; Masae Miyatani; Yoshihisa Masuo; Tetsuo Fukunaga
12	Phase Angle Measurement in Healthy Human	The objective of the study is to compare	Anthropometr y Measurements,	The phase angle values were similar	The study is based on aged and	Satish Kumar, Aswini Dutt,

	Subjects through Bio-Impedance Analysis (Kumar, Dutt, Hemraj, Bhat, & Manipadybhima , 2011)	phase angle values of normal and healthy individuals and their anthropometry measurements.	Bioelectrical Impedance Analysis and Phase angle measurements of 42 subjects between aged groups 18 to 50 years old for 8 months.	with the anthropometry measurement of Body Mass Index.	gender, but it did not account for other bio-factors that might influence the results.	Sandhya Hemraj, Shankar Bhat, Bhat Manipadybhima
13	Why bioelectrical impedance analysis should be used for estimating? (Houtkooper, Lohman, Going, & Howell, 1996)	The review paper is to assess the estimated values of fat free mass and total water body appropriate for estimating adiposity of individuals.	Using BIA procedures for the same population and criterion method with similar prediction equation.	The prediction equation that was applied in the BIA method have been validated and cross referenced with anthropometry parameters and other groups of population such as children, youths, adults and the elderly.		Linda B Houtkooper, Timothy G Lohman, Scott B Going, and Wanda H Howell
14	Validity of Arm-to-Arm BIA Devices Compared to DXA Estimating % Fat in College Men and Women	The aim of the research is to validate 4 commonly used BIA devices against the values from dual energy X-ray absorptiometry .	BIA devices are convenient and simple.	However, the compared results between BIA and DXA the result variations were huge/ Thus the accuracy of the 4 BIA devices were questionable.	Rebecca A. Rockmann; Emily K. Dalton; Jana L. Arabas; Liz Jorn; Jerry L. Mayhew	

15	Validity and Reliability of Bioelectrical Impedance Analysis and Skinfold Thickness in Predicting Body Fat in Military Personnel (Aandstad, Holtberget, Hageberg, Holme, & Anderssen, 2014)	The aim is to obtain a BIA predictive equation designed for military personnel, because the normal predictive equations are invalid.	Two methods were use in this study, a skinfold test using single frequency BIA against the result of a multi-frequency BIA. Validation methods were also used to validate the predicted equations.	The validity of ±1% cannot be achieved and thus required re-evaluation of the mathematical model and the technology used. The validity of the predicted equation seems to favour military men.		Anders Aandstad; Kristian Holtberget; Rune Hageberg, Ingar Holme, Sigmund A. Anderssen.
16	Reliability and Validity of Bioelectrical Impedance in Dertermining Body Composition (Jackson, Pollock, Graves, & Mahar, 1988)	The study objective is to examine the validity of BIA by comparing the body composition results based on BIA against the body composition values according to the standards of anthropometric methods.	Body composition values were acquire using BIA, Skinfold method and hydrostatic method to measure the percentage of adiposity of the human body.	BIA results are acceptable against anthropometric methods. The body mass index parameters like weight and height of the subject are accounted for in the equation and thus the BIA results are comparable.	This study did not emphasis on the ethnicity which therefore cannot state for sure that the equation is valid and reliable for all human population.	A.S. Jackson; Michael L. Pollock; James E Graves; M.T. Mahar

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter narrates the fundamentals of bio-impedance, the tools and materials required to measure the body fat percentage of the subjects' body. The basic principle is bio-impedance analysis. The technique uses small alternating current to flow through between two (2) electrodes that are placed on the fingers and the sole of the feet to determine the value of impedance of the cellular tissue. By determining the opposition to the electric current through body tissues, we can estimate the total body composition and the body fat mass. The Bio-Impedance electrodes are available on the bio-impedance weighing scale and the Body Key InBody Watch. The watch performs InBody Tests which measures the body composition which are percentage of body fat (%), fats mass (kg), muscle mass (kg), and body mass index via BIA (Bioelectric Impedance Analysis) method that can be performed independently on the InBody Watch and the results will be updated and presented through the Body Key Mobile Application. The data has been collected from eleven (11) different subjects. There were five (5) male and four (6) female subjects between the age 16 to 73 years of age.

3.2. Bioelectrical Impedance Measuring Apparatus

3.2.1 Bio-impedance Analyzer Weighing Scale

Bio-impedance analysis is a common method for determining the body composition in estimation. The technology determines the electrical impedance of the human body tissue which allows the estimation of total body water (TBW), adiposity or body fat mass, and muscle mass. The Bio-Impedance Analyser Weighing Scale uses similar technique described in U.S. Pat. Nos. 6473643 (Chai & Cha, 2002), where live subjects will be measured by standing on the weighing scale –like device attached with four electrodes mounted on its upper surface. The electrodes are covered using two aluminum plates with the shape and size of the feet. The bio-impedance analyzer weighing scale is powered by three (3) AAA batteries each rated as 1.5 volts which each produced approximately 0.1 mA. The bio-impedance analyzer weighing scale is powered once the subject has his/her feet on the aluminum plates. The current is produced and first pass through the two electrodes in contact with the subject's toes and the resultant electrical impedance is developed across the subject's heels allowing the screen to project the body composition information. The device uses a microprocessor-controlled switch array which consists of a voltage measuring circuit located at the heels of two (2) feet via the electrodes which provides an accurate measurement of heel-to-heel impedance (Chai & Cha, 2002). Additional parameters such as gender, age, and height are manually entered into the microprocessor. Using its algorithm with relations to body impedance density is obtained and subsequently the microprocessor performs a secondary calculation using a second algorithm to convert body density into body mass, fat mass, total body water percentage, muscle mass, bone mass, body mass index (BMI) and calories.

3.2.2 Body Key InBody Watch

The InBody Watch is a bio-impedance analyzer that attaches on the subject's wrist pairs with the mobile phone using the Body Key application. The device claims it is able to obtain accurate test results. It has four electrodes to conduct BIA, two electrodes at the bottom of the watch that must touch the wrist completely, and another two electrodes on top of the watch the requires the subjects' thumbs and index fingers to touch the electrodes completely in order to generate corporeal readings. It has a mass of 35g, which is light weight for easy portable use on the wrist. Firstly, the watch has to pair up with a mobile phone in order to obtain readings of the subject. The InBody Test is the feature that was used on all eleven (11) subjects to measure the body composition. The watch uses Bioelectrical Impedance Analysis (BIA) to analyze the body and provide results such as muscle mass, fat mass and percentage body fat. Additional parameters such as age, gender, body mass, and height must be included before the start of the InBody Test. The subject must wear the watch directly on the wrist, instead of the upper arm or on the hand, and stand still for few seconds to a minute to allow BIA analysis to occur. The subjects are restricted from moving and talking during the analysis. The watch must not be placed on the sleeves or bracelet. During the InBody Test, ensure that the arms and fingers are not touching each other. The subject must wear shirt with sleeves to avoid body contact of the upper arm and armpits. Body hairs on the hand are also a hindrance to the electrode from direct contact with the skin on the wrists. The subject's skin must be moist to ensure successful BIA analysis.

3.3. Demographic data

3.3.1. Subjective Assessment

<u>Subject 1</u>

20 years old, female and a quantity surveyor student from Tunku Abdul Rahman University College. She looks lean, thin and has a height of 162 cm and weighs 50.1 kg. She is healthy and has a body mass index (BMI) of 19.1kg/m^3. She experienced all four massage sessions and completed them in on hour and thirty minutes, inclusive of the InBody Test and BIA weighing scale test after every 15 minutes massage intervals. After the first massage session, the MasterDrive 4D, she described the rollers at the back are intense and can be quite aggressive towards the skin and the back. She enjoys Sensei the most as it was the least aggressive massage of all four massage modes and she enjoys the thermocare function which was relaxing.

Subject 2

26 years old, female a working professional in the construction industry. She is very petite with the height of 155 cm and weighs 39.3 kg. She is underweight and has a body mass index (BMI) of 16.4kg/m^3. She completed all four massages in an hour and a half inclusive of InBody Test and BIA weighing scale test after every 15 minutes massage intervals. She described both MasterDrive 4D and Spine Care to be aggressive, especially when the rollers were concentrating on her back. She had to lift her entire body to avoid the total pressure of the rollers on her back. She enjoys Sensei the most as it was the mildest massage session of the four.

Subject 3

28 years old, male. He is a working professional in a multinational telecommunications company in the Research and Development department. He enjoys playing a friendly game of badminton, basketball and plays them every week. He is average in height of 168 cm and weighs 59.7 kg. His BMI is normal which reads 21.1kg/m^3 on the BIA weighing scale. He completed all four massages in an hour and fifteen minutes. He described MasterDrive to be intense, and raise his body slightly when the back rollers are activated. He found the leg rollers to be extremely ticklish and lift the legs entirely when the rollers come into play. He enjoyed Joint Care sessions the most as he described.

Subject 4

15 years old, female. She is a student from Seremban and is very active in athletic sports. She is a school champion and state qualifying candidate for discus throw, shot put and javelin throw. Her height measures 170 cm and weighs 95.9 kg. Her BMI indicates that she is overweight. She completed all four massages in one hour and fifteen minutes. She described the massage rollers to be quite uneasy on her back. However, she did not lift her body to avoid the massages. Her

favorite massage was spine care as she was relaxed and immediately fell asleep during that fifteen minutes massage. Her least favorite massage was the MasterDrive because of the back rollers.

Subject 5

58 years old, female. She is a senior citizen housewife who lives in Mantin, Negeri Sembilan. She enjoys gardening and does it every morning once she is awakes. Her height measures 158 cm and weighs 43.7 kg. Her BMI indicates that she is underweight. She completed all four massage sessions in one hour and thirty minutes. Her least favorite massage was the MasterDrive 4D. She found that the back rollers are extremely aggressive to her. She lifted her body whenever the back rollers reached at her lower back heading towards the buttocks. She enjoyed the Sensei Massage. She described this mode to be most suitable for healthy petite senior citizens. She does not recommend this massage chair to senior citizens with a weak and fragile back.

Subject 6

22 years old, female. She currently studies in Seoul, Korea in Korean Literature. She works out for half an hour every day to keep herself fit and healthy. She does not perform any outdoor activities. She completed all four massage sessions one hour and forty minutes. She described the feet rollers to be extremely ticklish and avoided them completely whenever the feet rollers came into play. She found the back rollers in MasterDrive to be uncomfortable and fidgeted slightly when the rollers were against her back towards her buttocks. Her favorite massage was Sensei as she felt relaxed and into almost immediate sleep when Sensei started.

Subject 7

20 years old, male. He is a degree student studying Mechatronic Engineering in Malacca. He is very active in sports and trains competitively in badminton. He enjoys running and often participates in half marathons. He trains in badminton for three times a week and runs every day in the evening. His height measures 164 cm and weighs 54 kg. His BMI indicate that he was normal. He completed all four massage sessions in one hour and thirty minutes. He found the feet rollers to be ticklish instead of relaxing and was not too fond with the back rollers rolling down his buttocks. During Master Drive and Spine Care, he avoided the back rollers slightly as it was moving towards the lower half of his body. He enjoyed Joint Care massage session and described the mode to be relaxing. His least favorite was Spine Care and described Spine Care to be extremely vigorous on his back.

Subject 8

24 years old, male. He is a working professional in Kuala Lumpur with an Electrical Engineering background. He enjoys a friendly game of badminton and running. He is 180 cm tall and weighs 64.4 kg. His BMI indicated that he was normal. He completed all four massages in one hour and a half. He enjoyed the Sensei massage as he described the massage to be just right, not too vigorous for his back, unlike both Master Drive and Spine Care. He has a weak back as he was diagnosed with scoliosis and occasionally uses the harness to support his back to ensure his back is straight.

Subject 9

73 years old, male. He is a retired senior citizen, currently resides in Mantin, Negeri Sembilan. He enjoys doing light exercises in the morning. He is 164 cm in height and weighs 57.4 kg. He completed all four massage sessions in one hour and a half. Overall, he felt the massage chair was too overwhelming for senior citizens his aged and older. He is extremely lean. Therefore, he felt the back rollers were extremely uncomfortable. He lifted his body to avoid the back rollers completely as it rolled down towards the lower back of the body in both Master Drive and Spine Care. He described Spine Care to be the most inappropriate mode for senior citizens. He enjoyed Joint Care the most as it focused more on the limbs. He personally enjoys the feet rollers and found it very relaxing.

Subject 10

58 years old, male. He is a retired senior citizen and enjoys gardening every morning. He enjoys a good game of badminton and plays twice a week. His height measures 164 cm and weighs 65.1 kg. His BMI measures 24.1 kg/m^3 which mean he is healthy and normal. He completed all four massage sessions in one hour and a half and described all massages to be tolerable. Sensei massage was the most relaxed among the rest of the massages. He enjoyed the massage rollers for his back and described that the back rollers are suitable for people who has a straight muscular back. He described MasterDrive and Spine Care to be aggressive and the back rollers that massaged down towards the lower back were barely tolerable. He did not lift his body up entirely, but jolted and yelled a little as he was taken by surprised by the rollers pressure towards the back.

Subject 11

28 years old, female. She is a working professional and enjoys aerobic exercises every twice a week. She is 158 cm tall and weighs 51 kg. Her BMI is 20.6 kg/m^3 indicates that she is healthy and normal. She completed all four massage sessions in two hours. She enjoyed the Sensei massage session and found it really relaxing. She described that there was a reasonable amount of trust to be seated and laid back and allow the massage to take its course throughout the session. She found that Master Drive and Spine Care was quite aggressive and could be quite hurtful as the arm rollers made its way to roll right beside the spine towards the lower back of the body. She slightly lifted her body when the back rollers made its way to the buttocks. She needed to be alert throughout the entire massage for Master Drive and Spine Care.

3.3.2. Objective Assessment

There were 11 subjects in this experiment. All subjects are aged between 15 to 75 years old with a BMI ranged between 16.3 – 33.1 kg/m^2. Each subject does not often use a massage chair nor own one. The 11 subjects comprised of five (5) males and four (6) females. All subjects required to measured using the BIA weighing scale to obtain the weight, fat mass, total body water, muscle mass, bone mass, BMI and calories. Subsequently, all subjects will be measured prior to the massage sessions using the Body Key InBody Watch to perform the InBody Test before the massage. This was to obtain muscle mass, fat mass, percentage of body fat and BMI. Each subjects took the following parameters into account throughout the whole experiment, i.e. weight, muscle mass, fat mass and percentage body fat as depicted in Table 3.1.

Table 3.1: Subject 1 Initial Body Composition Results

	SUBJECT 1			
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %
INITIAL RESULTS	50.1	23.7	8.6	17.1

3.4. Flowchart of the Process

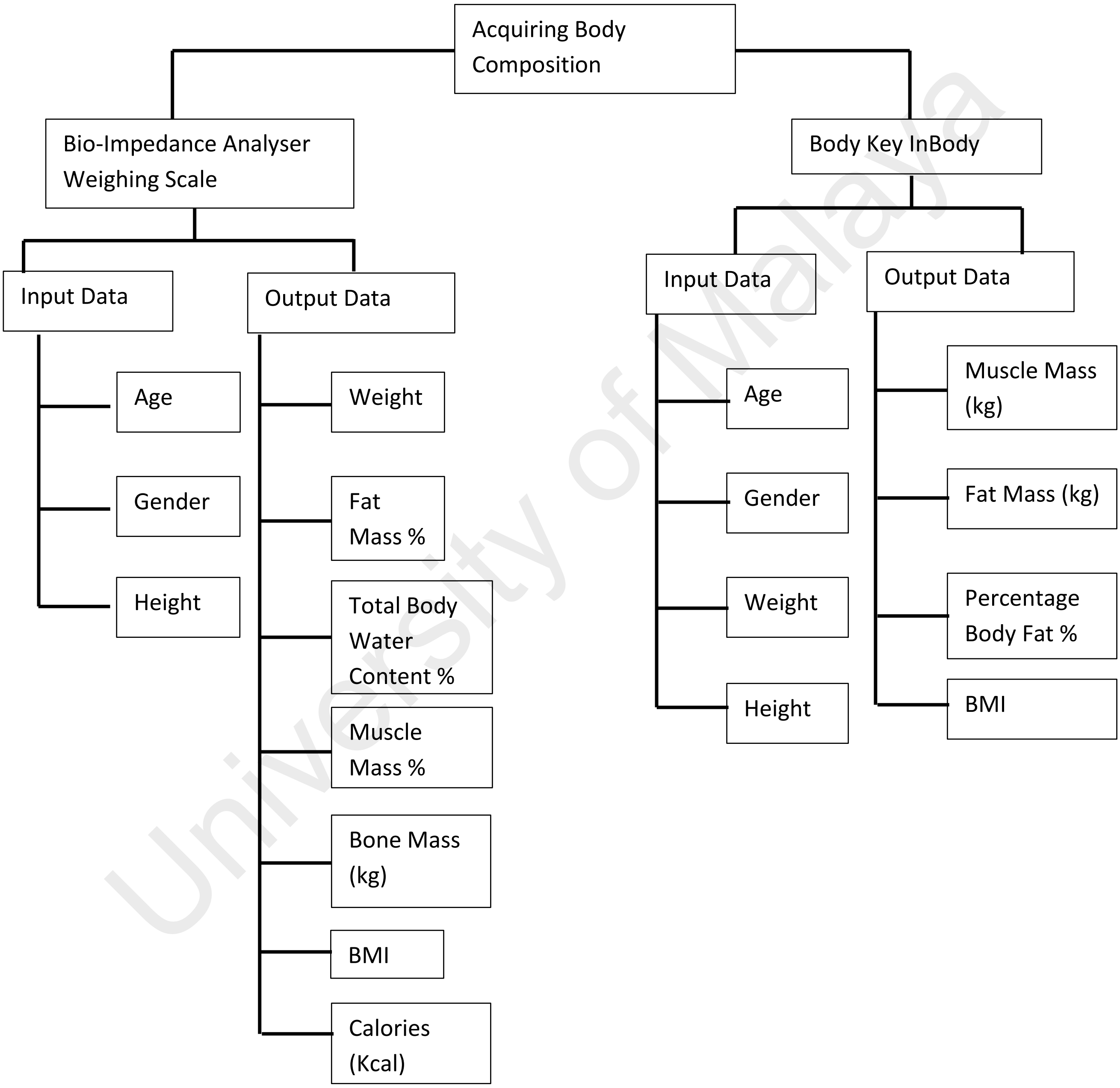

Figure 3.1: Flowchart of the process

3.5. Acquiring Corporeal Data

3.5.1. Initial Measurements before Massage Sessions

a. Before starting the measurements, the subjects were advised not to drink or eat for at least 3 hours before the massage session. Although there are no references indicating the ideal amount of time between food and fluids intake before BIA measurements, food or fluid intake before BIA measurements will affect Total Water Body (TBW) results (Dehghan & Merchant, 2008).

b. The subjects were bare footed on the BIA weighing scale to obtain their corporeal measurements.

c. Input Data such as age, gender and height were provided in the scale output data such as weigh, muscle mass, fat mass, total water body, body mass index, bone mass and calories were provided.

d. The subjects took their corporeal measurements twice on the BIA weighing scale during the initial measurement to ensure that the data displayed on the weighing scale was consistent.

e. The subject will then stepped away from the scale and put on the Body Key InBody Watch to perform the InBody Test.

f. The subject's wrists and fingers must not be too dry to prevent the watch from providing error data.

g. During the initial measurement from the InBody Test, input data such age, gender, height and weight obtained from BIA weighing scale were provided before the test. The initial output data such as muscle mass, fat mass, percentage body fat and body mass index were provided using the Body Key mobile application.

3.5.2. During Massages

a. The subject will be seated on the Ogawa MasterDrive massage chair. The chair uses Zero Gravity Technology that lifts the subjects at a 126º lying on the massage chair to allow the subject to be at the resting state which there were least amount of pressure and build up tension on nerves, tendons, muscles and bones. The chromo therapy lighting is an added feature on the massage chair to set the mood. The high performance A.R.M Processor allowed the subject to experience the massages at the right pressure points of the body. The Master Drive first underwent body scan using M sensing L track which were the back rollers that rolls beneath from the neck, the entire back and under the glutes. It has smart acupunctural point detection technology that locates the acupuncture points from the neck to the hips, and thermocare that emits warm heat which helps to increase metabolic rate and reduce body fat.

b. There are four (4) default massage programs available in the MasterDrive. The first massage mode offered by the Ogawa Master Drive 4D was the Master's Choice which took fifteen (15) minutes to complete. The subject experienced all the features of the massage, i.e. kneading, sweedish, tapping, shiatsu, clapping, rolling, hand and foot massage at its highest level of intensity.

c. The second massage mode is Sensei, also took 15 minutes to complete has all the features of the massage as well, but with lower intensity level, except the thermocare where it's temperature is than Master's Choice.

d. The third massage program is Spine Care. The Spine Care program uses the M Sensing L-Track to accentuate the subject's spine. The 4D massage rollers incorporated with thermocare massages the subjects' neck to the hips and performed kneading, clapping, rolling and shiatsu to mimic the massage movements of the professional masseuse.

e. After each massage programs, the subject took corporeal measurements using the BIA weighing scale and the InBody Watch.
f. The subjects were refrained from consuming fluids and food throughout the process to avoid results inaccuracy.

CHAPTER 4: RESULT AND DISCUSSION

This chapter provides the relevant data that has been acquired from the Bioelectrical Impedance Analyser weighing scale and InBody Watch. There were eleven (11) subjects participated in this experiment; five (5) of the participants are males and the remaining six (6) were females. There were aged 15 to 73 years old.

4.1 Subject 1

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	50.1	23.7	8.6	17.1	19.1
MASTER'S CHOICE	50.1	22.5	10.8	21.5	19.1
SENSEI	50.1	24.7	6.9	13.7	19.1
SPINE CARE	50.1	25	6.4	12.7	19.1
JOINT CARE	50.4	22.9	10.1	20.1	19.1

Table 4.1: Subject 1's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	50.1	18.5	60.3	37.9	2.2	19.1	1182
MASTER'S CHOICE	50.1	18.5	60.3	37.9	2.2	19.1	1182
SENSEI	50.1	18.5	60.3	37.9	2.2	19.1	1182
SPINE CARE	50.1	18.5	60.3	37.9	2.2	19.1	1182
JOINT CARE	50.4	21.5	58	34.3	2.1	20.7	1192

Table 4.2: Subject 1's Bio-impedance Analyzer Weighing Scale Measurements

			SUBJECT 1		
MASSAGE MODE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	50.1	23.7	8.6	60.3	17.1
MASTERDRIVE 4D	50.1	22.5	10.8	60.3	21.5
SENSEI	50.1	24.7	6.9	60.3	13.7
SPINE CARE	50.1	25	6.4	60.3	12.7
JOINT CARE	50.4	22.9	10.1	58	20.1
DIFFERENCES	0.3	-0.8	1.5	-2.3	3.0

Table 4.3: Subject 1's Initial Results and results after each massage modes derived from Table 4.1 and Table 4.2

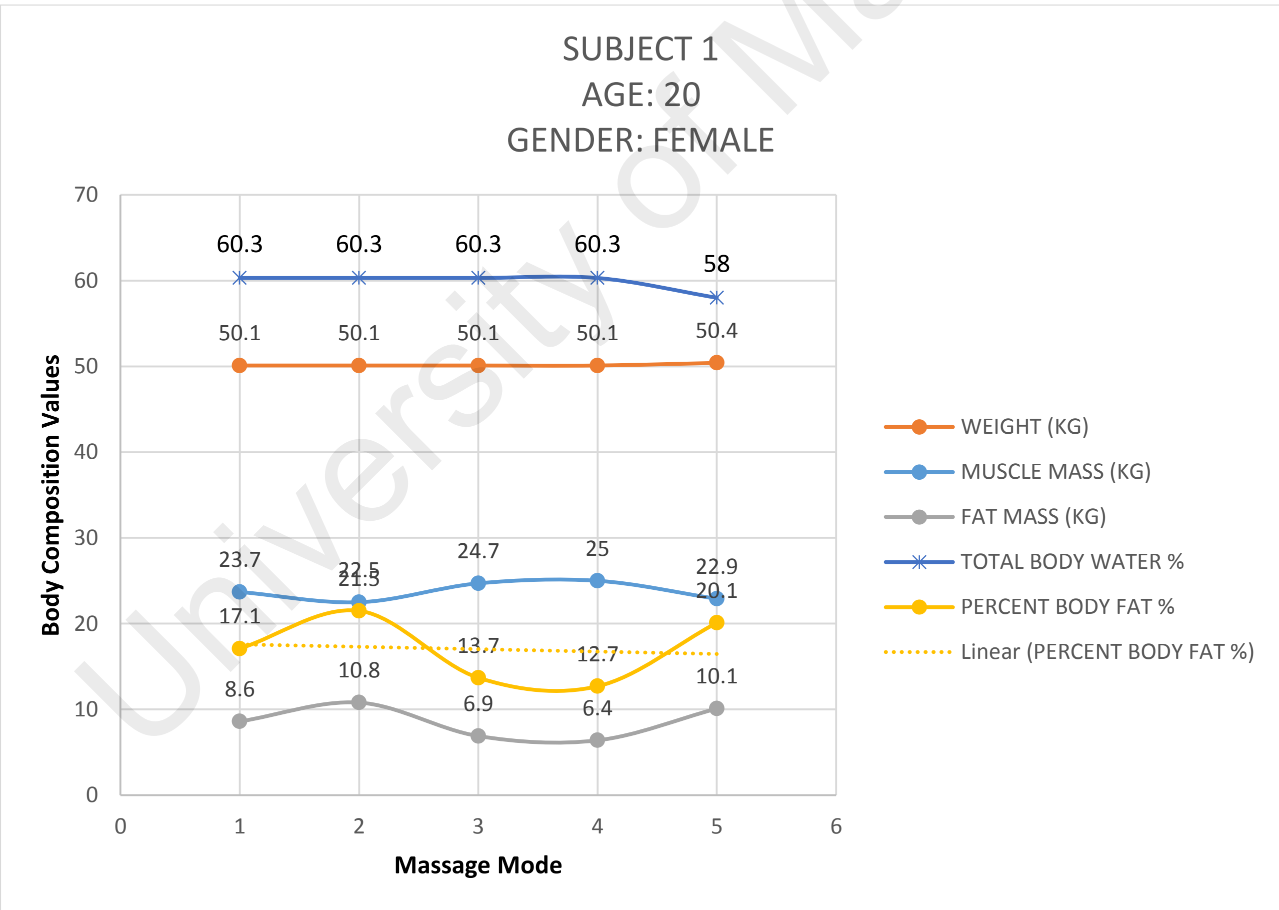

Figure 4.1 Subject 1's Initial Results and results after each massage modes based on Table 4.3

Based on the results from Figure 4.1, the graph portrayed that subject one (1) had increased 3% of her percentage body fat after her final massage. Her total body mass and fat mass increased in 0.3 kg and 1.5 kg respectively and she had lost 0.8 kg and 2.3 % of her muscle mass and total water body (TBW) percentage.

4.2 Subject 2

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	39.3	17.6	8.5	21.7	16.4
MASTER'S CHOICE	39.3	17.8	8.1	20.5	16.4
SENSEI	39.3	17.9	8.1	20.5	16.4
SPINE CARE	39.3	17.4	8.8	22.3	16.4
JOINT CARE	39.3	17.8	8.1	20.7	16.4

Table 4.4: Subject 2's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	39.3	13.5	64	44.2	1.7	16.3	927
MASTER'S CHOICE	39.3	13.5	64	44.5	1.7	16.3	927
SENSEI	39.3	13.5	64	44.5	1.7	16.3	927
SPINE CARE	39.3	13.5	64	44.5	1.7	16.3	927
JOINT CARE	39.4	13.5	64	44.1	1.7	16.4	930

Table 4.5: Subject 2's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 2					
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	39.3	17.6	8.5	64	21.7
MASTER'S CHOICE	39.3	17.8	8.1	64	20.5
SENSEI	39.3	17.9	8.1	64	20.5
SPINE CARE	39.3	17.4	8.8	64	22.3
JOINT CARE	39.3	17.8	8.1	64	20.7
DIFFERENCES	0.0	0.2	-0.4	0.0	-1.0

Table 4.6: Subject 2's Initial Results and results after each massage modes derived from Table 4.4 and Table 4.5

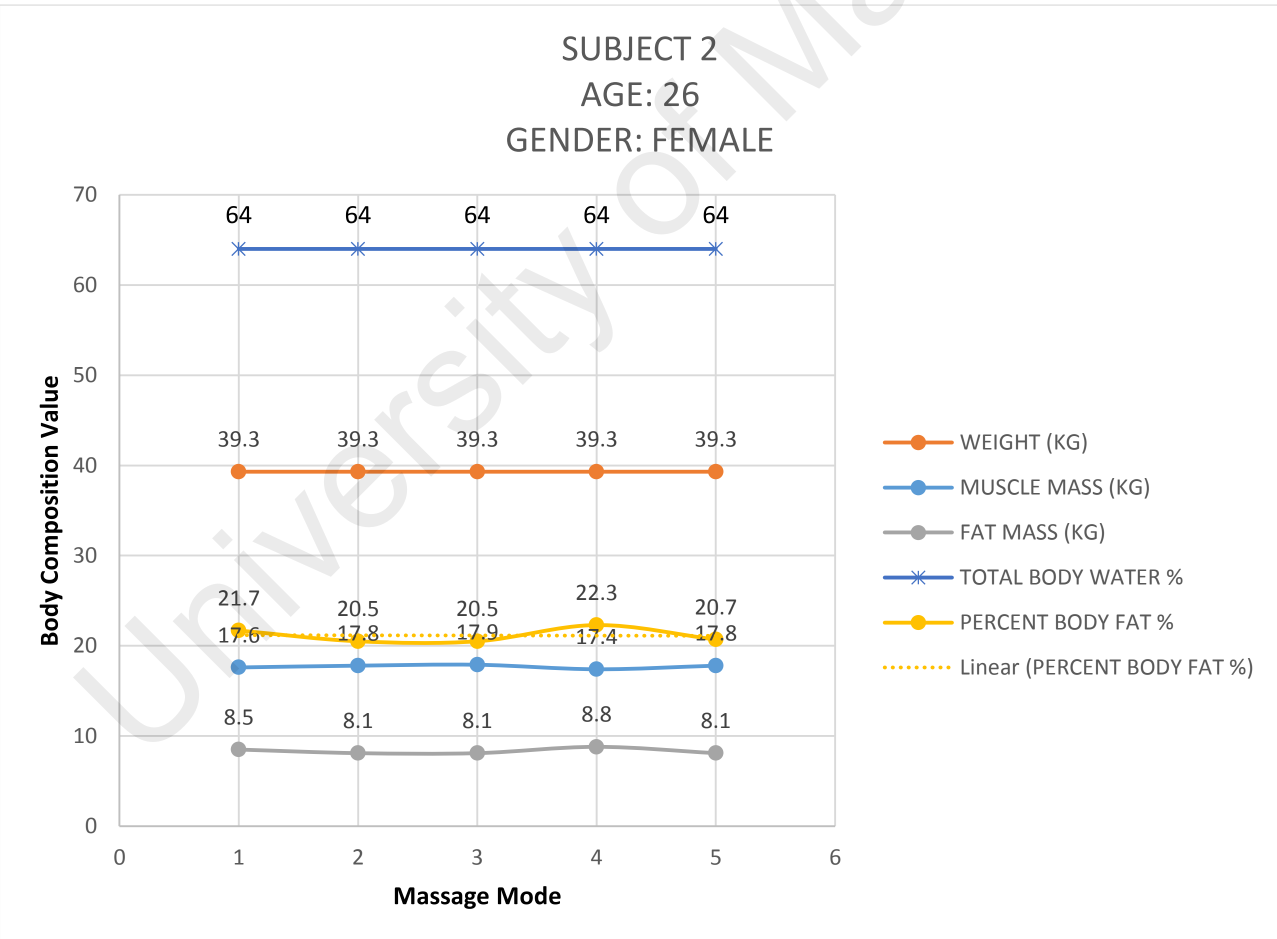

Figure 4.2 Subject 2's Initial Results and results after each massage modes based on Table 4.6

Referring to Figure 4.2, the body fat percentage of subject two (2) had decreased 1% whilst her total body mass maintained throughout the massage session at 39.3 kg. Her muscle mass increased by 0.2 kg, fat mass decreased by 0.4 kg and her total water body percentage remained constant.

4.3 Subject 3

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	59.7	26.2	13.9	23.3	23.3
MASTER'S CHOICE	59.7	27.8	11.0	18.4	21.2
SENSEI	59.7	28	10.7	18	21.2
SPINE CARE	59.7	28.4	10	16.7	21.2
JOINT CARE	59.7	27.8	11.0	18.4	21.2

Table 4.7: Subject 3's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	59.7	16.2	61.1	38.6	3	21.1	1433
MASTER'S CHOICE	59.7	16.2	61.1	38.6	3	21.1	1433
SENSEI	59.7	16.2	61.1	38.6	3	21.1	1433
SPINE CARE	59.7	16.2	61.1	38.6	3	21.1	1433
JOINT CARE	59.7	16.2	61.1	38.6	3	21.1	1433

Table 4.8: Subject 3's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 3					
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	59.7	26.2	13.9	61.1	23.3
MASTER'S CHOICE	59.7	27.8	11.0	61.1	18.4
SENSEI	59.7	28	10.7	61.1	18
SPINE CARE	59.7	28.4	10	61.1	16.7
JOINT CARE	59.7	27.8	11.0	61.1	18.4
DIFFERENCES	0.0	1.6	-2.9	0.0	-4.9

Table 4.9: Subject 3's Initial Results and results after each massage modes derived from Table 4.7 and Table 4.8

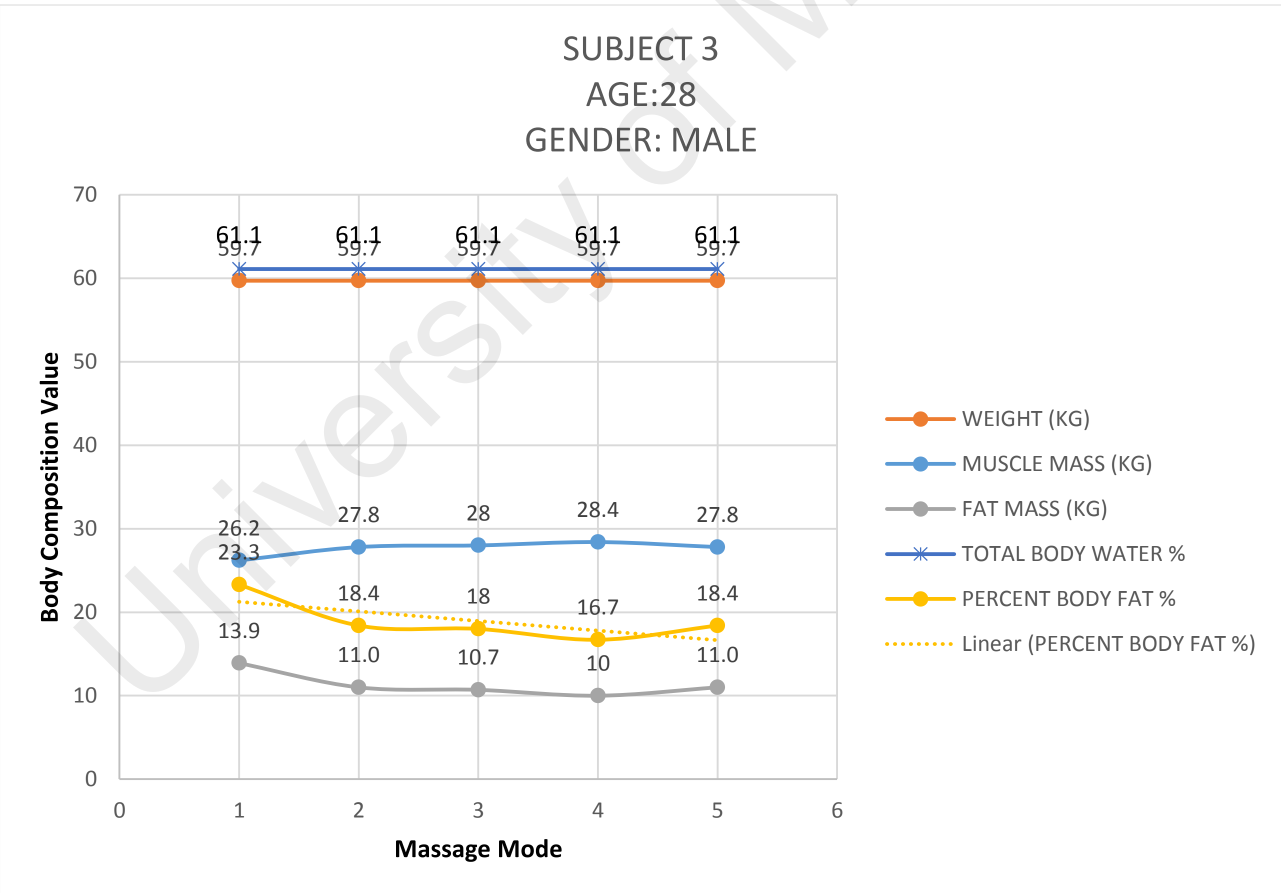

Figure 4.3 Subject 3's Initial Results and results after each massage modes based on Table 4.9

Based on Figure 4.3, subject three (3) managed to maintain his body mass and total body water percentage at 59.7 kg and 61.1% respectively. After completed all four (4) massage sessions, 4.9% of his percentage body fat decreased. His body fat mass also decreased in 2.9 kg and subsequently his muscle mass increased in 1.6 kg.

4.4 Subject 4

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	95.9	33.3	37.7	39.3	33.2
MASTER'S CHOICE	95.9	33.8	36.7	38.3	33.2
SENSEI	95.9	33.1	38	39.6	33.2
SPINE CARE	95.9	32.7	38.6	40.2	33.2
JOINT CARE	95.9	32.9	38.4	40	33.2

Table 4.10: Subject 4's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	95.9	53.5	36.7	34.5	2.4	33.1	2426
MASTER'S CHOICE	95.9	53.5	36.7	34.6	2.4	33.1	2426
SENSEI	95.9	53.5	36.7	34.6	2.4	33.1	2426
SPINE CARE	95.9	53.5	36.7	34.6	2.4	33.1	2426
JOINT CARE	95.9	53.5	36.7	34.6	2.4	33.1	2426

Table 4.11: Subject 4's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 4					
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	95.9	33.3	37.7	36.7	39.3
MASTER'S CHOICE	95.9	33.8	36.7	36.7	38.3
SENSEI	95.9	33.1	38	36.7	39.6
SPINE CARE	95.9	32.7	38.6	36.7	40.2
JOINT CARE	95.9	32.9	38.4	36.7	40
DIFFERENCES	0.0	-0.4	0.7	0.0	0.7

Table 4.12: Subject 4‘s Initial Results and results after each massage modes derived from Table 4.10 and Table 4.11

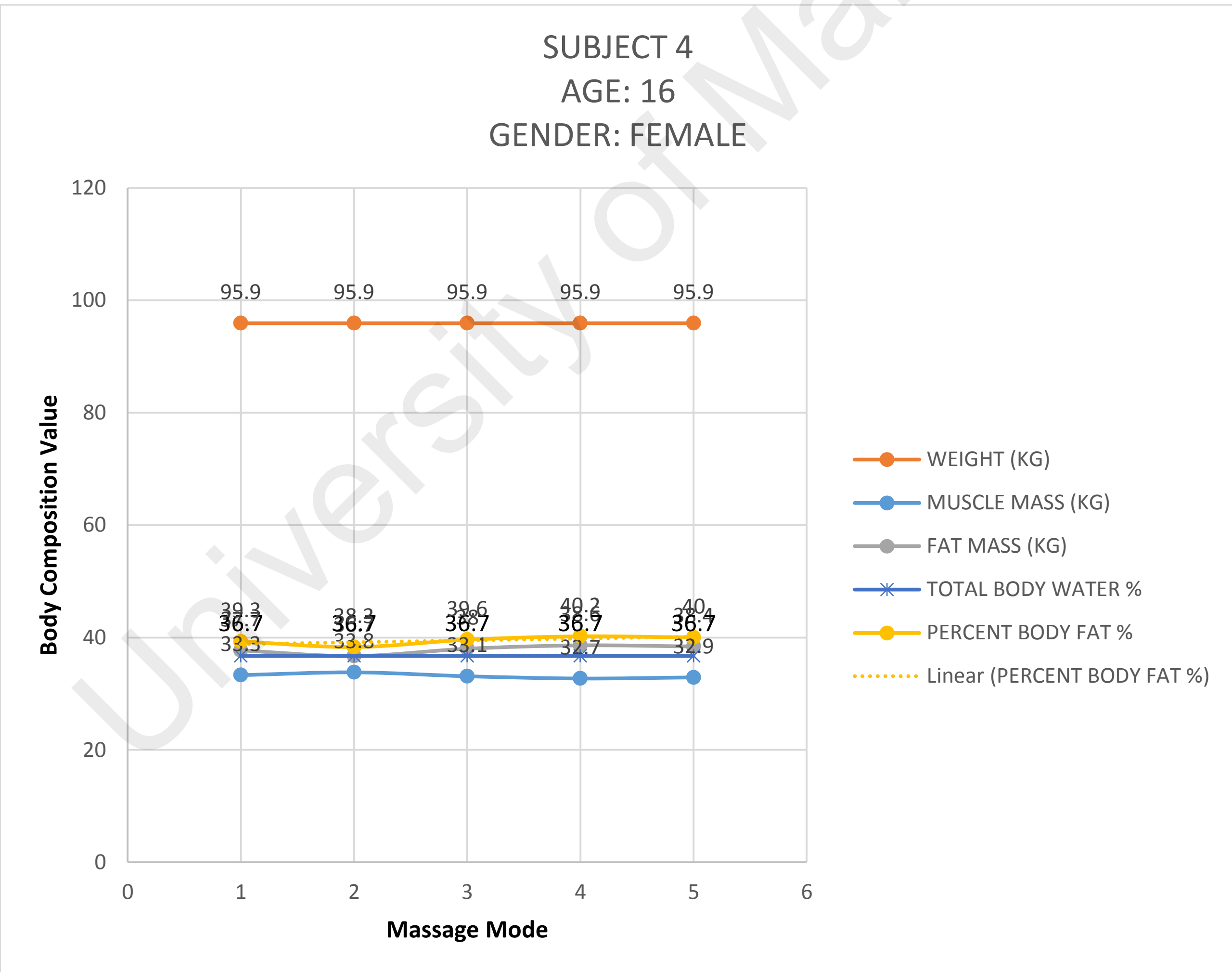

Figure 4.4 Subject 4's Initial Results and results after each massage modes based on Table 4.12

Based on Figure 4.4, subject four managed to maintain her total body mass at 95.9 kg and her TBW percentage at 36.7% throughout the entire massage session. However, both her percentage body mass and fat mass increased after the massages by 0.7 % and 0.7 kg respectively. Subsequently, her muscle mass decreased by 0.4 kg.

4.5 Subject 5

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	43.7	18.4	11.5	26.3	17.5
MASTER'S CHOICE	43.7	18.2	11.8	27	17.5
SENSEI	43.7	18.1	12	27.5	17.5
SPINE CARE	43.7	19.4	9.7	22.1	17.5
JOINT CARE	43.7	18.3	11.7	26.7	17.5

Table 4.13: Subject 5's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	43.7	15.5	54.9	36.1	1.9	17.5	905
MASTER'S CHOICE	43.7	15.5	54.9	36.1	1.9	17.5	905
SENSEI	43.7	15.5	54.9	36.1	1.9	17.5	905
SPINE CARE	43.7	15.5	54.9	36.1	1.9	17.5	905
JOINT CARE	43.7	15.5	54.9	36.1	1.9	17.5	905

Table 4.14: Subject 5's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 5	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	43.7	18.4	11.5	54.9	26.3
MASTER'S CHOICE	43.7	18.2	11.8	54.9	27
SENSEI	43.7	18.1	12	54.9	27.5
SPINE CARE	43.7	19.4	9.7	54.9	22.1
JOINT CARE	43.7	18.3	11.7	54.9	26.7
DIFFERENCES	0.0	-0.1	0.2	0.0	0.4

Table 4.15: Subject 5's Initial Results and results after each massage modes derived from Table 4.13 and Table 4.14

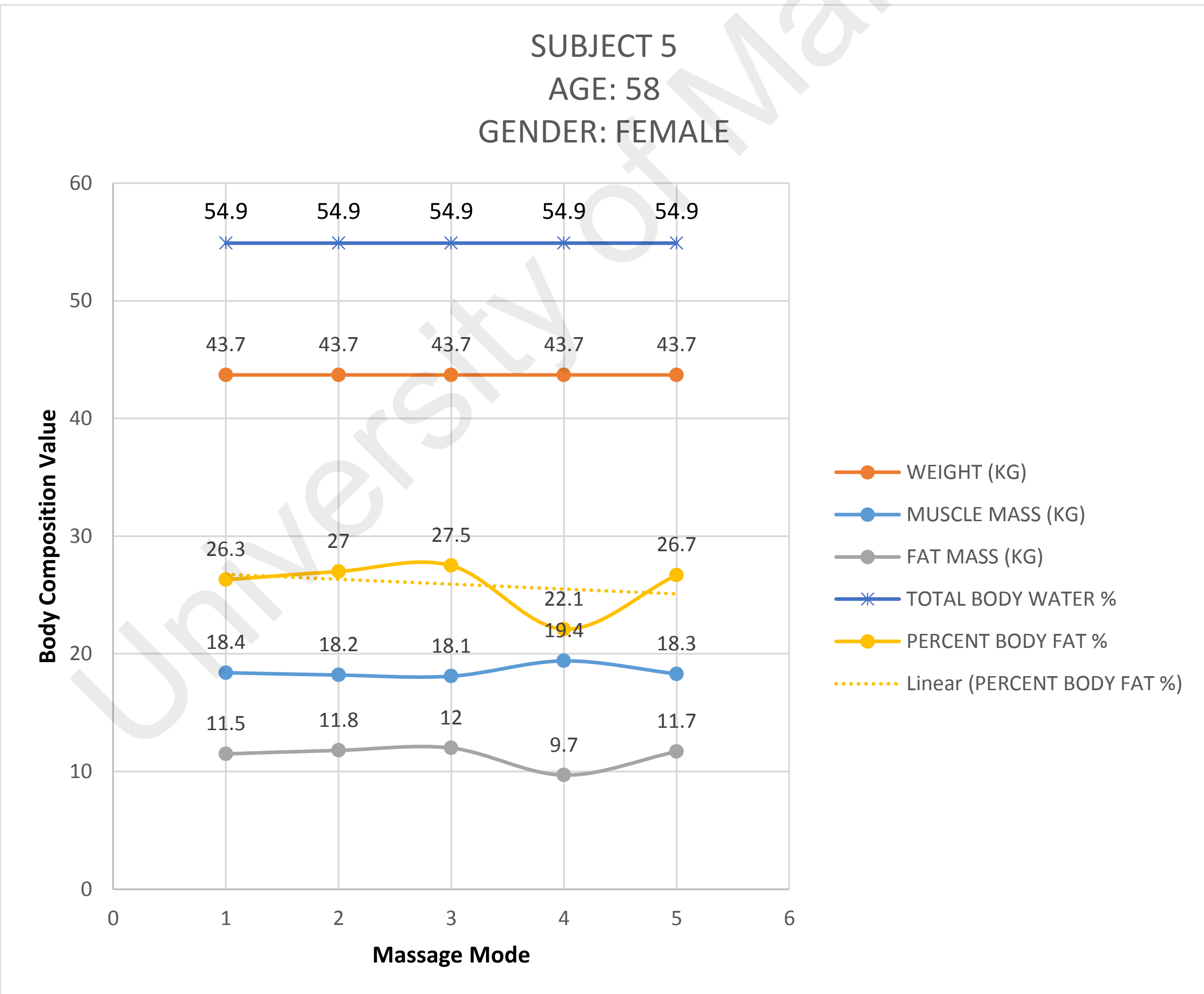

Figure 4.5 Subject 5's Initial Results and results after each massage modes based on Table 4.15

Figure 4.5 described subject five where she managed to maintain her total body mass at 43.79 kg and TBW at 54.9% throughout the entire massage session. However, both her percentage body mass and fat mass increased after the massages by 0.4 % and 0.2 kg respectively. Subsequently, her muscle mass decreased by 0.1 kg.

4.6 Subject 6

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	56.1	23.7	14.5	25.9	20.9
MASTER'S CHOICE	56.1	25.3	11.8	21	20.9
SENSEI	56.1	23.2	15.4	27.5	20.9
SPINE CARE	56.1	23.8	14.5	25.8	20.9
JOINT CARE	55.7	23	15.5	27.8	20.7

Table 4.16: Subject 6's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	56.1	13.8	62.9	41.3	2.9	19.8	1346
MASTER'S CHOICE	56.1	13.8	62.9	41.3	2.9	19.8	1346
SENSEI	56.1	13.8	62.9	41.3	2.9	19.8	1346
SPINE CARE	56.1	13.8	62.9	41.3	2.9	19.8	1346
JOINT CARE	55.7	13.6	63	41.7	2.9	19.7	1337

Table 4.17: Subject 6's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 6					
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	56.1	23.7	14.5	62.9	25.9
MASTER'S CHOICE	56.1	25.3	11.8	62.9	21
SENSEI	56.1	23.2	15.4	62.9	27.5
SPINE CARE	56.1	23.8	14.5	62.9	25.8
JOINT CARE	55.7	23	15.5	63	27.8
DIFFERENCES	-0.4	-0.7	1.0	0.1	1.9

Table 4.18: Subject 6's Initial Results and results after each massage modes derived from Table 4.16 and Table 4.17

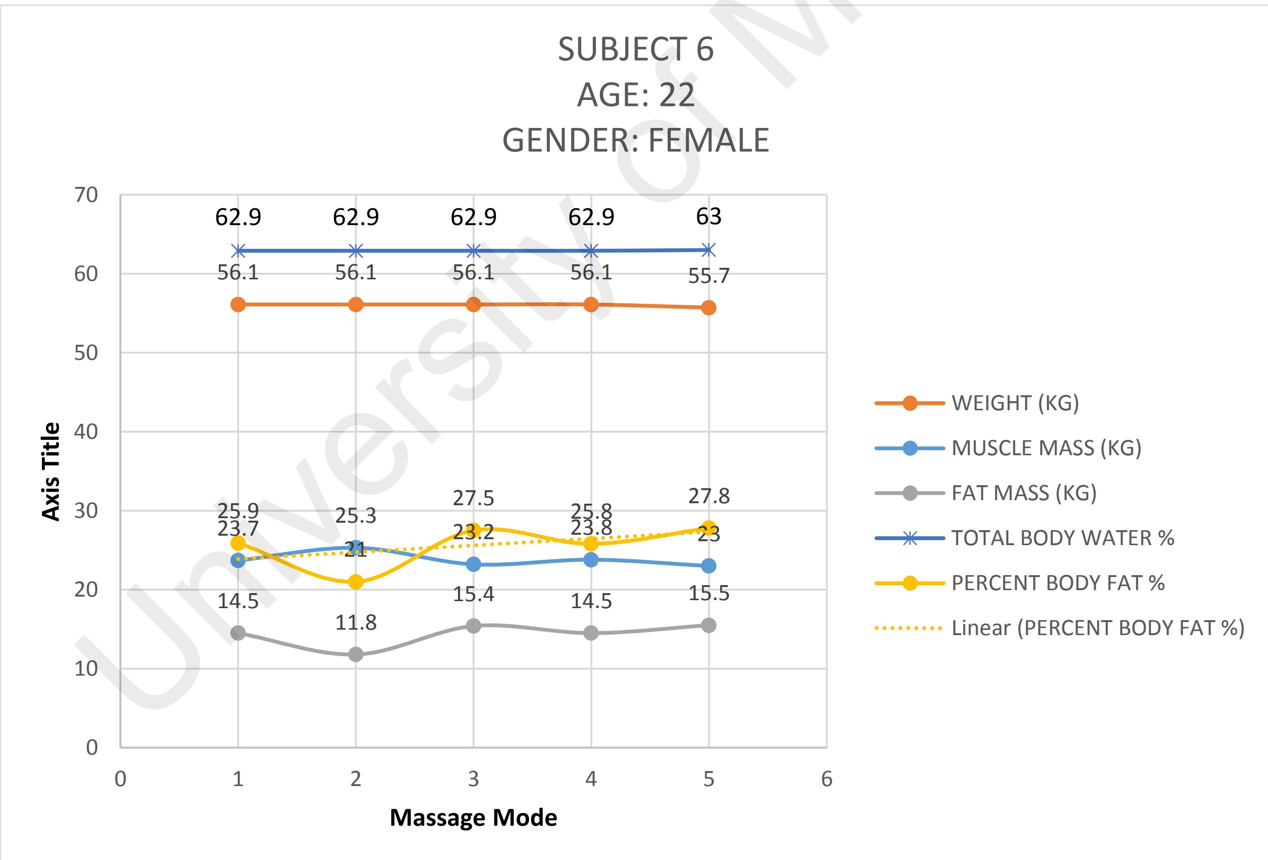

Figure 4.6 Subject 6's Initial Results and results after each massage modes based on Table 4.18

Based on Figure 4.6, subject six's total body mass decreased to 55.7 kg after completed the massage session. However, her TBW, percentage body mass and fat mass increased after the massages by 0.1%, 1.9 % and 1.0 kg respectively. Subsequently, her muscle mass decreased by 0.7 kg.

4.7 Subject 7

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	54.0	26.8	7.1	13.1	20.1
MASTER'S CHOICE	54	27	6.8	12.5	20.1
SENSEI	54	26.6	7.4	13.7	20.1
SPINE CARE	53.9	26.8	7.0	13.0	20
JOINT CARE	53.9	26.1	8.2	15.2	20

Table 4.19: Subject 7's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	54	14.2	62.6	42.2	2.8	20	1296
MASTER'S CHOICE	54	14.2	62.6	42.5	2.8	20	1296
SENSEI	53.9	14.1	62.7	42.6	2.8	20	1294
SPINE CARE	53.9	14.1	62.7	42.6	2.8	20	1294
JOINT CARE	53.9	14.1	62.7	42.6	2.8	20	1294

Table 4.20: Subject 7's Bio-impedance Analyzer Weighing Scale Measurements

	SUBJECT 7				
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	54.0	26.8	7.1	62.6	13.1
MASTER'S CHOICE	54	27	6.8	62.6	12.5
SENSEI	54	26.6	7.4	62.7	13.7
SPINE CARE	53.9	26.8	7.0	62.7	13.0
JOINT CARE	53.9	26.1	8.2	62.7	15.2
DIFFERENCES	-0.1	-0.7	1.1	0.1	2.1

Table 4.21: Subject 7's Initial Results and results after each massage modes derived from Table 4.19 and Table 4.20

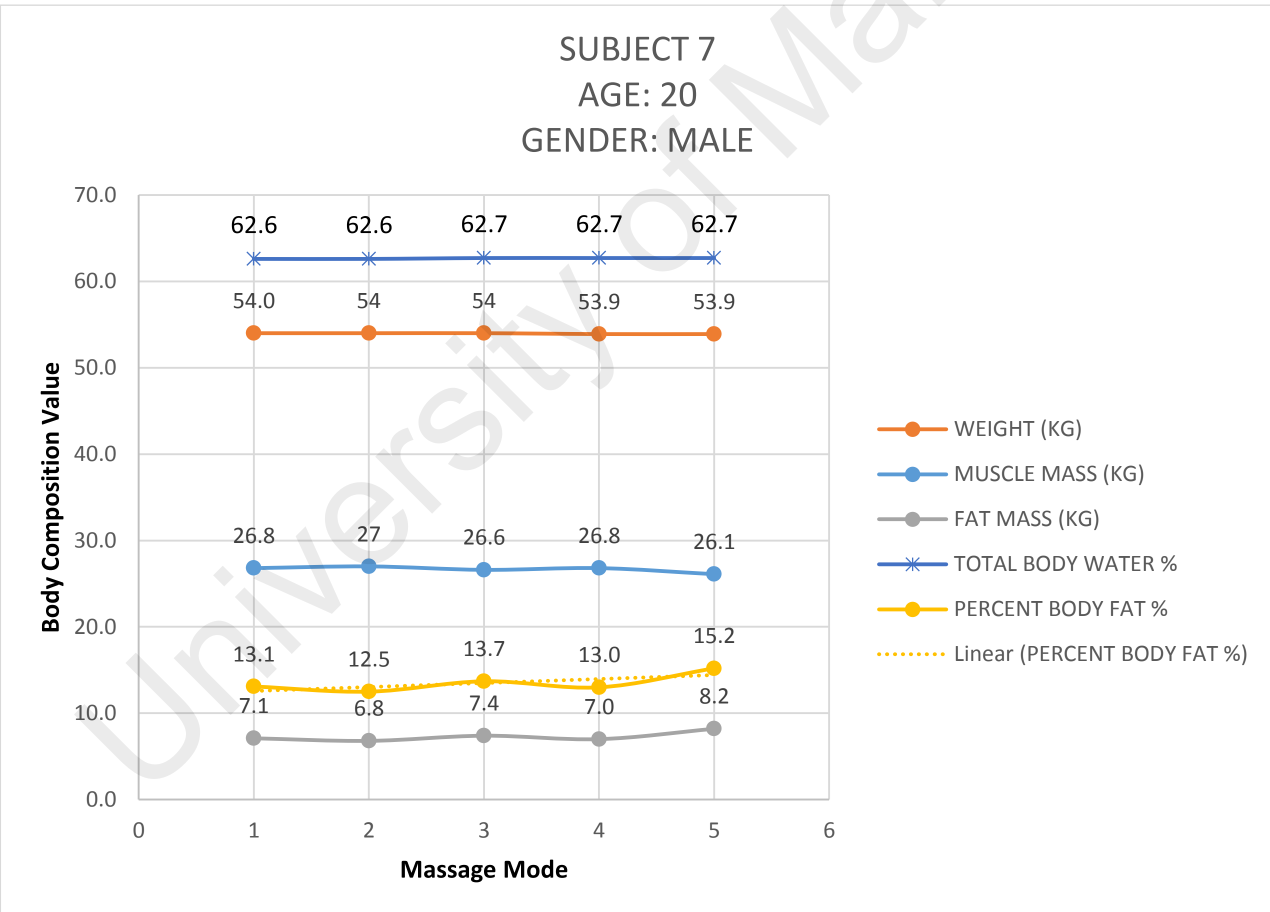

Figure 4.7 Subject 7's Initial Results and results after each massage modes based on Table 4.21.

Figure 4.7 described subject seven's total body mass decreased by 0.1 kg after completed the massage session. However, his TBW, percentage body mass and fat mass increased after the massages by 0.1 %, 2.1 % and 1.1 kg respectively. Subsequently, his muscle mass decreased by 0.7 kg.

4.8 Subject 8

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	64.4	32.6	7.3	11.4	19.9
MASTER'S CHOICE	64.2	32.7	6.9	10.8	19.8
SENSEI	64.2	32.6	7.2	11.2	19.8
SPINE CARE	64.2	31.4	9.3	14.5	19.8
JOINT CARE	64.2	31.5	9.1	14.1	19.8

Table 4.22: Subject 8's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	64.4	13.8	62.9	40.8	3.3	19.8	1546
MASTER'S CHOICE	64.2	13.7	62.9	40.9	3.3	19.8	1541
SENSEI	64.2	13.7	62.9	40.9	3.3	19.8	1541
SPINE CARE	64.2	13.7	62.9	40.9	3.3	19.8	1541
JOINT CARE	64.2	13.7	62.9	40.9	3.3	19.8	1541

Table 4.23: Subject 8's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 8					
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	64.4	32.6	7.3	62.9	11.4
MASTER'S CHOICE	64.2	32.7	6.9	62.9	10.8
SENSEI	64.2	32.6	7.2	62.9	11.2
SPINE CARE	64.2	31.4	9.3	62.9	14.5
JOINT CARE	64.2	31.5	9.1	62.9	14.1
DIFFERENCES	-0.2	-1.1	1.8	0.0	2.7

Table 4.24: Subject 8's Initial Results and results after each massage modes derived from Table 4.22 and Table 4.23

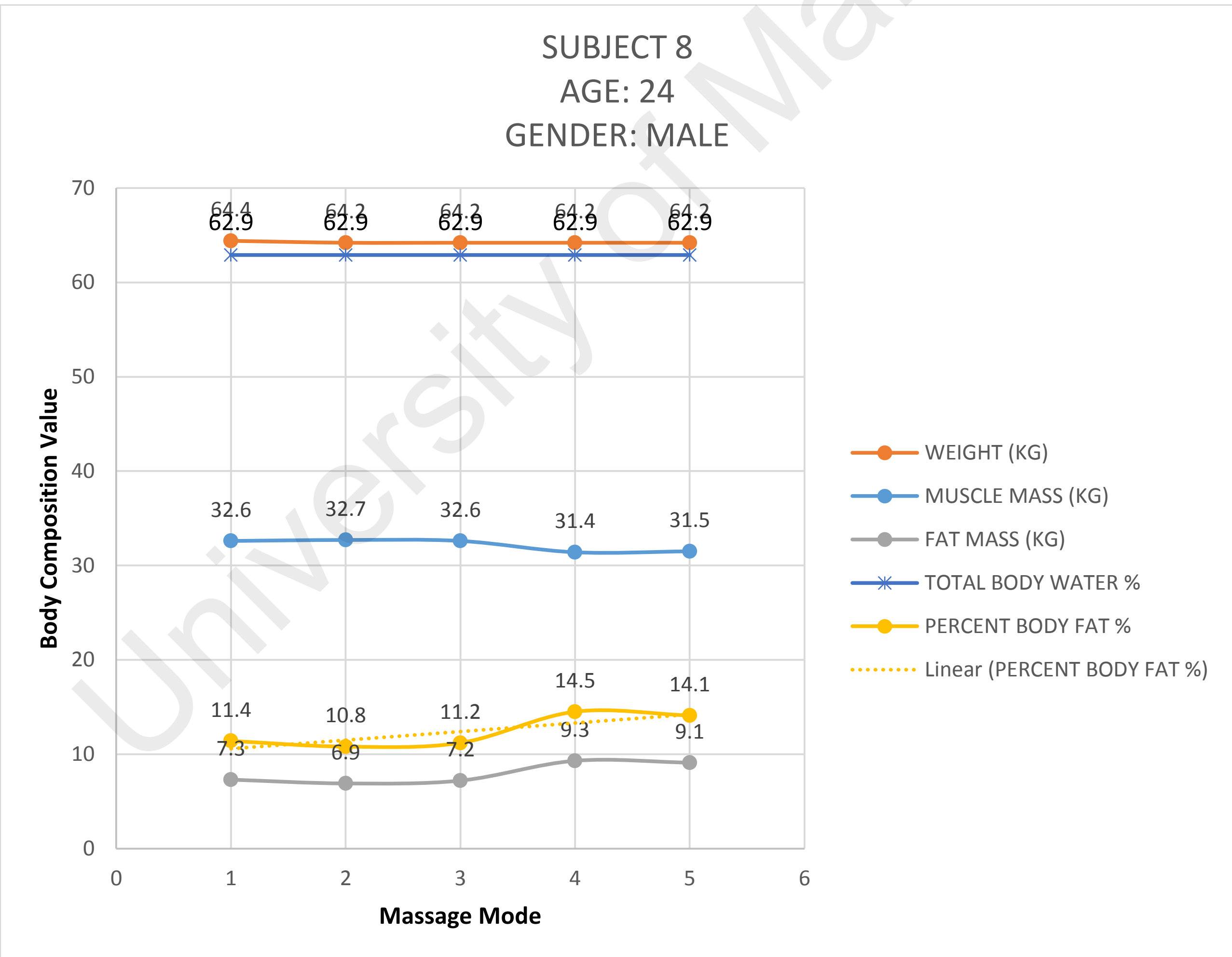

Figure 4.8 Subject 8's Initial Results and results after each massage modes based on Table 4.24.

Based on Figure 4.8 described subject eight's total body mass decreased by 0.2 kg after completed the massage session. However, both his percentage body mass and fat mass increased after the massages by 2.7 % and 1.8 kg respectively. Subsequently, his muscle mass decreased by 1.1 kg. His total water body percentage remained constant.

4.9 Subject 9

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	57.4	25.5	12.8	22.3	20.3
MASTER'S CHOICE	57.4	25.2	13.3	23.1	20.3
SENSEI	57.4	25.7	12.4	21.6	20.3
SPINE CARE	57.4	25.2	13.2	23	20.3
JOINT CARE	57.4	28.7	7.2	12.5	20.3

Table 4.25: Subject 9's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	57.4	14.7	54.5	33.5	2.9	20.3	1234
MASTER'S CHOICE	57.4	14.7	54.5	33.5	2.9	20.3	1234
SENSEI	57.4	14.7	54.5	33.5	2.9	20.3	1234
SPINE CARE	57.4	14.7	54.5	33.5	2.9	20.3	1234
JOINT CARE	57.4	14.7	54.5	33.5	2.9	20.3	1234

Table 4.26: Subject 9's Bio-impedance Analyzer Weighing Scale Measurements

	SUBJECT 9				
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	57.4	25.5	12.8	54.5	22.3
MASTER'S CHOICE	57.4	25.2	13.3	54.5	23.1
SENSEI	57.4	25.7	12.4	54.5	21.6
SPINE CARE	57.4	25.2	13.2	54.5	23
JOINT CARE	57.4	28.7	7.2	54.5	12.5
DIFFERENCES	0.0	3.2	-5.6	0.0	-9.8

Table 4.27: Subject 9's Initial Results and results after each massage modes derived from Table 4.25 and Table 4.26.

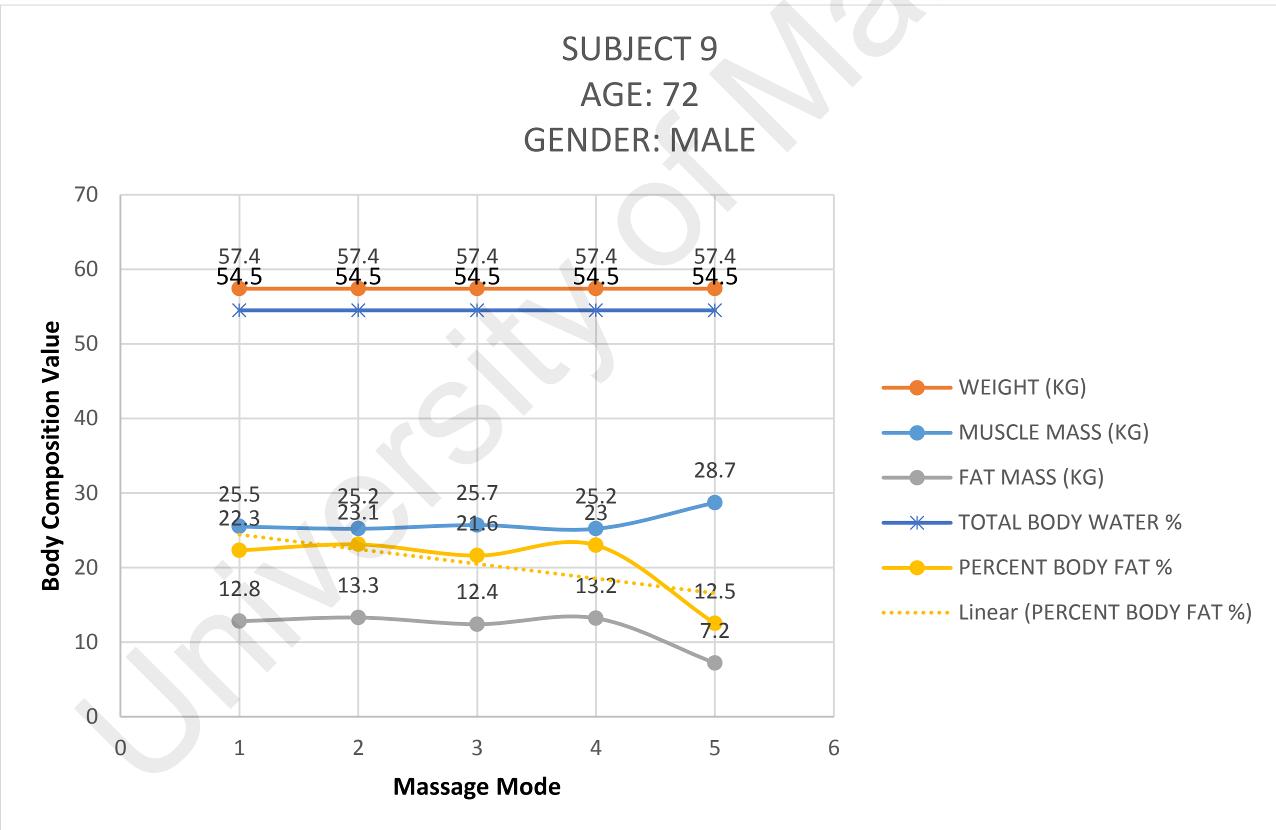

Figure 4.9: Subject 9's Initial Results and results after each massage modes based on Table 4.27.

Based on Figure 4.9 described subject nine's total body mass and TBW maintained after completed the massage sessions. Both his percentage body mass and fat mass decreased after the massages by 5.6 % and 1.1 kg respectively. Subsequently, his muscle mass increased by 3.2 kg.

4.10 Subject 10

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	65.4	27.7	17	26	24.3
MASTER'S CHOICE	65.1	27.7	16.5	25.4	24.2
SENSEI	65.1	27.6	16.9	25.9	24.2
SPINE CARE	65.1	27.5	17	26.1	24.2
JOINT CARE	64.8	27.7	16.3	25.1	24.1

Table 4.28: Subject 10's Body Key InBody Watch Measurements

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	65.1	21.8	53.1	29.1	3	24.2	1400
MASTER'S CHOICE	65.1	21.8	53.1	29.1	3	24.2	1400
SENSEI	65.1	21.8	53.1	29.1	3	24.2	1400
SPINE CARE	65.1	21.8	53.1	29.1	3	24.2	1400
JOINT CARE	64.8	21.6	53.3	29.2	3	24.1	1393

Table 4.29: Subject 10's Bio-impedance Analyzer Weighing Scale Measurements

SUBJECT 10					
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	65.4	27.7	17	53.1	26
MASTER'S CHOICE	65.1	27.7	16.5	53.1	25.4
SENSEI	65.1	27.6	16.9	53.1	25.9
SPINE CARE	65.1	27.5	17	53.1	26.1
JOINT CARE	64.8	27.7	16.3	53.3	25.1
DIFFERENCES	-0.6	0.0	-0.7	0.2	-0.9

Table 4.30: Subject 10's Initial Results and results after each massage modes derived from Table 4.28 and Table 4.29.

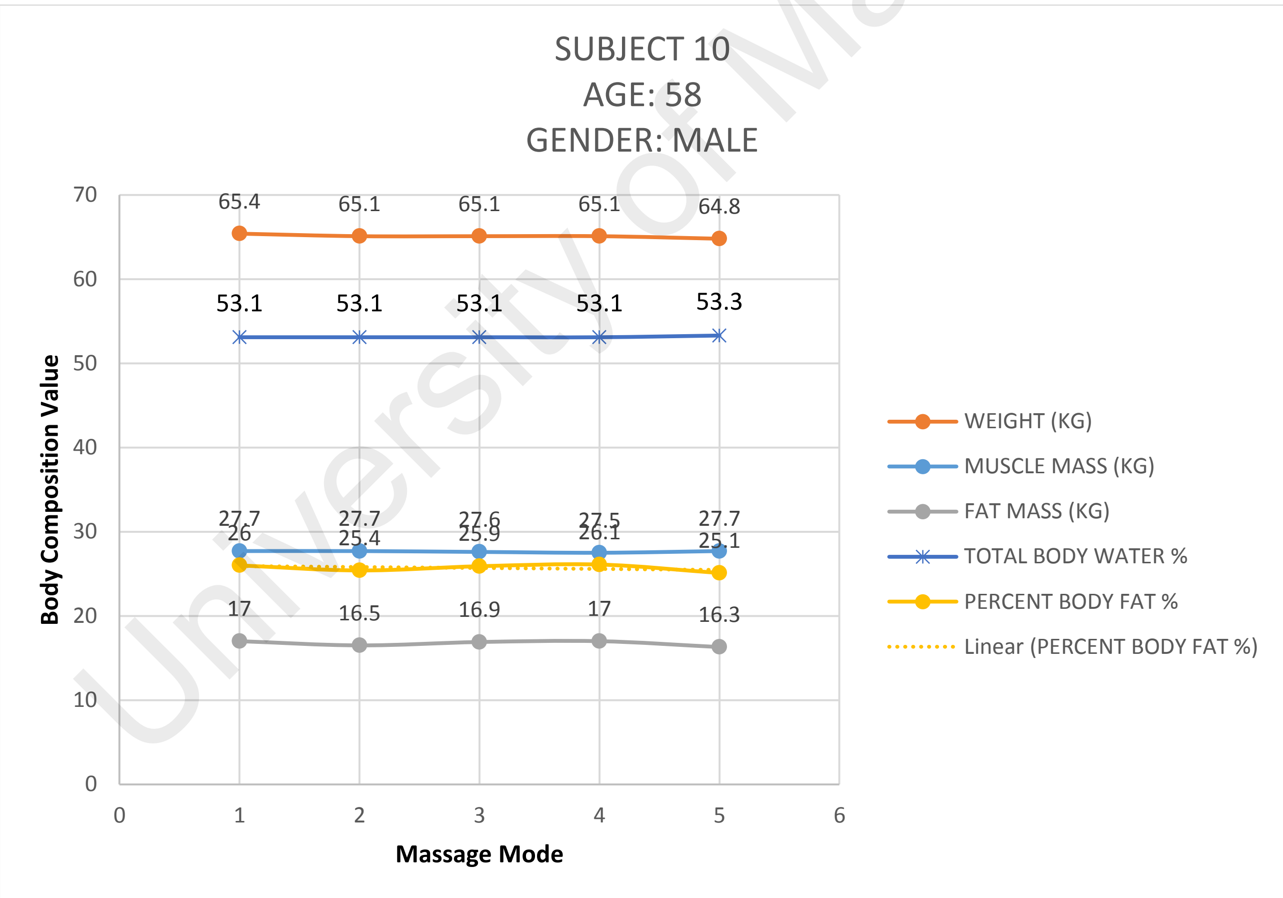

Figure 4.10: Subject 10's Initial Results and results after each massage modes based on Table 4.30.

Based on Figure 4.10 described subject ten's total body mass decreased by 0.6 kg after completed the massage session. Both his percentage body mass and fat mass decreased after the massages by 0.9 % and 0.7 kg respectively. Subsequently, his muscle mass maintains.

4.11 Subject 11

	BODY KEY INBODY WATCH MEASUREMENT				
MASSAGE TYPE	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	PERCENT BODY FAT %	BMI (KG/M2)
INITIAL AT REST	51.4	22.4	12.2	23.7	20.6
MASTER'S CHOICE	51.4	22.7	11.7	22.8	20.6
SENSEI	51.4	20.9	14.8	28.7	20.6
SPINE CARE	51	20.8	14.5	28.5	20.4
JOINT CARE	51	21	14.2	27.8	20.4

Table 4.31: Subject 11's Body Key InBody Watch Measurements.

	BIOIMPEDANCE WEIGHING SCALE MEASUREMENTS						
MASSAGE TYPE	WEIGHT (KG)	FAT MASS %	TOTAL BODY WATER %	MUSCLE MASS %	BONE MASS (KG)	BMI (KG/M2)	CALORIES (KCAL)
INITIAL AT REST	51.4	21.7	57.9	33.4	2.1	20.8	1213
MASTER'S CHOICE	51.4	21.7	57.9	33.4	2.1	20.8	1213
SENSEI	51.4	21.7	57.9	33.4	2.1	20.8	1213
SPINE CARE	51	21.4	58.1	33.7	2.1	20.7	1204
JOINT CARE	51	21.4	58.1	33.7	2.1	20.7	1204

Table 4.32: Subject 11's Bio-impedance Analyzer Weighing Scale Measurements.

	SUBJECT 11				
	WEIGHT (KG)	MUSCLE MASS (KG)	FAT MASS (KG)	TOTAL BODY WATER %	PERCENT BODY FAT %
INITIAL RESULTS	51.4	22.4	12.2	57.9	23.7
MASTER'S CHOICE	51.4	22.7	11.7	57.9	22.8
SENSEI	51.4	20.9	14.8	57.9	28.7
SPINE CARE	51	20.8	14.5	58.1	28.5
JOINT CARE	51	21	14.2	58.1	27.8
DIFFERENCES	-0.4	-1.4	2.0	0.2	4.1

Table 4.33: Subject 11's Initial Results and results after each massage modes derived from Table 4.31 and Table 4.32.

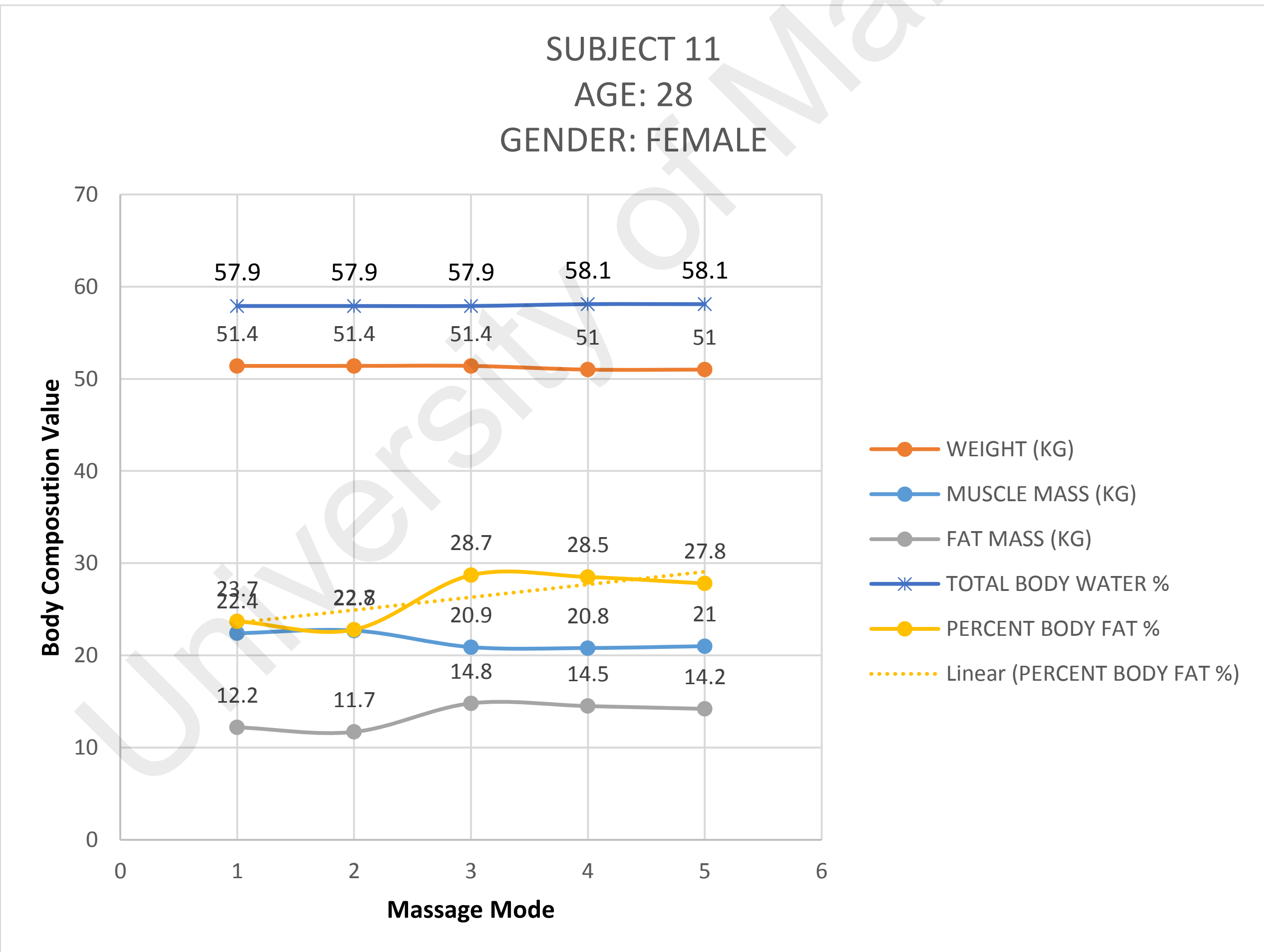

Figure 4.11: Subject 11's Initial Results and results after each massage modes based on Table 4.33.

Figure 4.11 described subject eleven's total body mass decreased by 0.4 kg after completed the massage session. Her percentage TBW, body mass and fat mass increased after the massages by 0.2%, 4.1 % and 2.0 kg respectively. Subsequently, her muscle mass decreased by 1.4 kg.

4.12 Body Mass Difference

Subject	Gender	Δ Body Mass	Δ Muscle Mass (KG)	Δ Fat Mass (KG)	Δ TBW (%)	ΔFat%	BMI%
1	F	0.3	-0.8	1.5	-2.3	3.0	19.1
2	F	0	0.2	-0.4	0	-1.0	16.4
3	M	0	1.6	-2.9	0	-4.9	23.3
4	F	0	-0.4	0.7	0	0.7	39.3
5	F	0	-0.1	0.2	0	0.4	26.3
6	F	-0.4	-0.7	1	0.1	1.9	25.9
7	M	-0.1	-0.7	1.1	0.1	2.1	-13.1
8	M	-0.2	-1.1	1.8	0	2.7	12.5
9	M	0	3.2	-5.6	0	-9.8	22.3
10	M	-0.6	0	-0.7	0.2	-0.9	26.0
11	F	-0.4	-1.4	2	0.2	4.1	23.7

Table 4.34: Differences of body mass (kg), muscle mass (kg), fat mass (kg) and percentage body fat (%)

Based on Table 4.34, the difference of body mass of the eleven (11) participants, five (5) participants experienced body mass lost after the massage sessions. Out of the five participants that experienced weight lost, four (4) of them are male and one (1) female. One (1) female participant gained body weight after the massage. The remaining five (5) participants who consist of four (4) females and one (1) male did not experience any significant change.

The difference of muscle mass indicated that out of the eleven (11) participants, three (3) participants increased in muscle mass. From these three (3) participants, two (2) of them were male and one (1) female. Subject 10 did not experience any changes in muscle mass. The remaining seven (7) participants, subject 1, 4, 5, 6, 7, 8, and 11 experienced a decreased in muscle mass. There four (4) participants who experienced muscle mass reduction, also experienced body mass reduction were subject 6, 7, 8, and 11.

The difference of fat mass and percentage of body fat are inter-related. It described four (4) subjects managed to reduce body fat percentage. Out of the four (4) subjects, three (3) of them are males and one (1) female. These subjects that managed to reduced their percentage body fat, three of them did not reduce their body mass.

Therefore, throughout this study, subject 2, 3 and 9 managed to reduce body fat percentage after the massage session. Only subject 10, aged 58 years old, male managed to reduce his body fat percentage and body mass after the one hour massage session.

4.12 Hypothesis Using T-Test

The data collected were analysed statistically to test the hypothesis and significance of the collected data. Based on the objective constructed, a null hypothesis (H_0) and an alternative hypothesis (H_1) was created. This study is trying to proof that the Ogawa MasterDrive 4D will be able to reduce body fat percentage after using all massage modes of the Ogawa Massage Chair.

H_0: Percentage difference of body fat percentage before and after massage is zero, ΔFat%, $\mu = 0$.

H_1: Percentage difference of body fat percentage before and after massage is not zero, ΔFat%, $\mu \neq 0$

In this study, the significant level is determine that $p < 0.05$ (5%) and it is predicted using paired T-test.

Paired Samples Test

		Paired Differences					t	df	p-value
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Initial - Last	0.15455	4.04187	1.21867	-2.56082	2.86991	0.127	10	**0.902**

Table 4.35: Paired Sample t-Test: All four massage modes included.

The t-value is 0.127, and p-value is 0.902. This means the probably of this result occurring by chance, under the null hypothesis of no difference. The study showed failed to reject the null hypothesis, since the $p > 0.05$ (in fact $p = 0.902$).

CHAPTER 5: CONCLUSION

The study is lacked of strong evidence to prove that the Ogawa MasterDrive 4D is able to reduce the percentage of body fat of the individual after experiencing the massage chair as each massage modes or all four modes combined. Based on BIA results, the Ogawa MasterDrive managed to reduce 4 subjects' body fat percentage and subsequently only subject 10 managed to reduce both weight and body fat percentage after experiencing all four massage sessions. The study has huge limitations and there are possibilities of missing some studies. Subject categorisation for the study was improper and the method of execution can be more comprehensive. The study can be improved by increasing the number of subjects and select a specific age group and the research must be conducted for more than a year by treating the activity as a lifestyle rather than an experiment in order to observe a result trend. There is also a lack of research to prove that conventional massage therapy can reduce body fat percentage specifically; instead massage therapy stimulates optimal growth and the development in infants as a supplemental aid for preterm infants and full term infants (Field, 2016). Another issue would be, BIA technique may be insufficient to assess body fat percentage.

In future, the study requires validation and comparative results between BIA based body composition value against DEXA, anthropometry, or perhaps MRI based body composition value. The investigation will be conducted in a more comprehensive manner. The number of subjects will be increased and the subjects will be required to incorporate the use of the massage chair into their way of life. The subjects are also allowed to consume water throughout the BIA session and during the massage sessions, in order to keep the subject body hydrated.

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