PSYCHOPHYSIOLOGY ALTERATION AND VASOMOTOR RESPONSES OF OVERWEIGHT SUBJECT TO STIMULI USED IN CONVENTIONAL VASCULAR RESPONSE TESTING

CHANSUBHA THONGCHAN

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....
Miss. Chansubha Thongchan
Candidate

....
Assoc. Prof. Thyon Chentanez, Ph.D.
(Neuroscience)
Major-Advisor

....
Assoc. Prof. Panya Kaimuk, M.D.
(Orthopedic Surgery)
Co-Advisor

....
Lect. Tossaporn Yimlamai, Ph.D.
(Physiology of Exercise)
Co-Advisor

....
Prof. Banchong Mahaisavariya, M.D.
Dean
Faculty of Graduate Studies

....
Prof. Arth Nana, M.D.
Chair Master of Science Programme in Sports Science
College of Sports Science and Technology

Thesis

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On
May 14th, 2008

....
Miss. Chansubha Thongchan
Candidate

....
Assist. Prof. Opas Sinphurmsukskul, M.D.
(Facharzt fur Orthopaedic)
Chairman

....
Assist. Prof. Daroonwan Suksom, Ph.D.
(Physiology)
Member

....
Assoc. Prof. Thyon Chentanez, Ph.D.
(Neuroscience)
Member

....
Assoc. Prof. Panya Kaimuk, M.D.
(Orthopedic Surgery)
Member

....
Lect. Tossaporn Yimlamai, Ph.D.
(Physiology of Exercise)
Member

....
Prof. Banchong Mahaisavariya, M.D.
Dean
Faculty of Graduate Studies
Mahidol University

....
Prof. Arth Nana, M.D.
Director
College of Sports Science and Technology
Mahidol University

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Chansubha Thongchan

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CHANSUBHA THONGCHAN 4637557 SPSS/M

M.Sc. (SPORTS SCIENCE)

THESIS ADVISORS: THYON CHENTANEZ Ph.D. (NEUROROSCIENCE), PANYA KAIMUK M.D. (BOARD OF ORTHOPEDIC SURGERY), TOSSAPORN YIMLAMAI Ph.D. (EXERCISE PHYSIOLOGY).

ABSTRACT

This study was to investigate the effect of overweight on psycho-physiological alteration and vasomotor responses of the left arm and leg. Ten overweight males (age 20-40yr, BMI = 25.0 to 29.9 kg per m²) and 10 control males (age 20-40yr,BMI = 18.5 to 24.9 kg per m²) volunteered for this study. The left arm and leg of both subject groups were acutely stimulated with hot water (42˚C), cold water (12˚C), exercise and cuff occlusion of blood flow. The volume changes in the vasomotor responses were determined using a volumeter. Results in the psychophysiological parameter assessment before and after exercise showed that the overweight had warned tactile reaction time at the 7th cervical level with the left big toe response (TRTlbtC_7), the right big toe response and the tapping speed test of the left index finger which were all significantly greater than the control. The physical performance of the controls in relation to oxygen consumption was significantly higher than the overweight. Vasomotor responses of blood vessels of the left lower and upper extremities in the controls were significantly higher than the overweight subjects after stimulation by hot water (42˚C), cold water (12˚C) and exercise. A significant reduction of Ankle Brachial Pressure Index (ABPI) in the overweight subjects was found which was similar to the vasomotor responses. These findings suggest that being overweight is associated with reductions in physical performance and vasomotor responses. This may indicate the risk of atherosclerotic vascular disease. Even though there are many factors inducing the risk of atherosclerotic vascular disease such as smoking and hypertension, being overweight is the one of the most important factors leading to the disease. However, being overweight can be avoided by regularly doing aerobic physical activity and carefully controlling body weight to appropriate levels.

KEY WORDS: VASOMOTOR RESPONSE / EXERCISE / OVERWEIGHT / PSYCHOMOTOR TASK

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LIST OF ABBRIVIATIONS

bpm	beat per minute
BMI	body mass index
BP	blood pressure
BW	body weight
cm	centimeter
CG	control group
Db	body density
HR	heart rate
Kg	kilogram
kg/m^2	kilogram per square meter
L	liter
LBM	lean body mass
Lt.	left
mmHg	millimeters mercury
msec.	millisecond
OG	overweight group
Rt.	right
SD	standard deviation
sec.	seconds
SEM	standard error of mean
W/H	waist and hip ratio
yr	year

CHAPTER I
INTRODUCTION

The overweight population is a tremendous healthcare problem nowadays. This is because the people have less activity than before and having imbalance of energy intake and energy expenditure and many reports showed the association between the excess body weight and disease. (42, 7, 3, 60)

Overweight refers to increased body weight in relation to height, when compared to some standard of acceptable or desirable weight. Overweight may or may not be due to only increases in body fat. It may also be due to an increase in lean muscle. For example, professionals athletes may be very lean and muscular, with very little body fat so they may weight more than others of the same height .While they may qualify as “overweight” due to their large muscle mass even though they are not necessarily “over fat” regardless of BMI (BMI= 25.0 to 29.9 kg. m square. which is defined as overweight) (31)

The state of being overweight or obese is well known to associate with significantly increased morbidity and mortality from atherosclerotic cardiovascular disease (10, 23) and overweight individuals commonly demonstrate impairment of vascular endothelial function. Olson and co-worker (2006) showed that the impairment of endothelial function has been implicated as an initial step in the pathogenesis of atherosclerosis and accelerated risk of cardiovascular disease (CVD) .The increasing of intima media thickness (IMT) of the carotid artery is closely related to the severity of atherosclerotic changes associated with CVD. There is a significant relationship between elevated IMT and the presence of traditional risk factors for CVD, including age, body mass index (BMI), hypertension, low-density lipoprotein (LDL) cholesterol, blood pressure, diabetes, and cigarette smoking. Furthermore, carotid artery IMT is a better predictor of risk for CVD than carotid artery dispensability, which is associated with the severity of obesity and distribution of body fat, particularly in middle-aged overweight women(59).

The vascular endothelium plays an important role in the regulation of arterial tone, thrombosis, and inflammation. Endothelial dysfunction may predispose arteries to the development of atherosclerotic lesions and is pathophysiologically linked to cardiovascular syndromes(52).

Endothelial dysfunction was characterized by a shift of the actions of the endothelium toward reduced vasodilatation, a proinflammatory state, and prothrombic properties. It is associated with most forms of cardiovascular disease, such as hypertension, coronary artery disease, chronic heart failure, peripheral artery disease, diabetes, and chronic renal failure(5).

Several studies investigated effects of overweight to vasomotor control. Kannel and co-worker (1996) reported that the degree of overweight was related to the rate of development of cardiovascular disease. After 26 years of follow-up in the Framingham study, each the increment in relative weight was associated with 15% and 22% increases in cardiovascular events in men and women, respectively (62). Siervogel et al (2000) reported that the reduced physical activity observed in the overweight adults may be related to their accumulation of adipose tissue at a rate about double their never-overweight counterparts, and this may be driving the higher rate of increase of CVD risk factors in the overweight groups (50). Gordon et al (1989) studied that the vasomotion of epicardial coronary arteries during exercise and tested the hypotheses that whether abnormal vasoconstriction was related to the presence of atherosclerosis or may be related to endothelial dilator dysfunction. It appears likely that atherosclerosis plays an important role in the abnormal vasomotion of diseased coronary arteries during exercise and the pattern of abnormality suggests the impairment of vasodilator function (31). Therefore, it could be hypothesized that there should be differences in vasomotor response in overweight subjects when compared to the sedentary subjects. It was also interesting to study the long term effect of exercise on vasomotor response to stimuli.

The purpose of this study was to demonstrate the effects of some manipulation such as the exercise and temperature on vasomotor responses in overweight by using simple equipment (e.g.volumeter) to measure the vascular volume changes in the normal sedentary and the overweight subjects.

Although the existing literatures, most studies were done to measure blood circulation of the heart in overweight by using electromagnetic flow meter. However, there were a few studies of peripheral vascular resistance measurement. In addition, the volumeter has rarely been used to measure indication change in the blood flow of extremities. Therefore, this study was aiming to investigate the changes in blood flow of upper and lower extremities before and after exercise in overweight and normal subjects by using the conventional vascular response testing. The hypothesis of this thesis should have the differences in vasomotor response of overweight subjects by the patho-physiology of the vascular endothelial function compared to the normal subjects having various stimuli such as exercise, hot water and cold water. Furthermore, the expectation of this thesis was to introduce the volumetric technique which may reflect roughly change of vascular and may be able to detect abnormal vasomotor in response to variety of stimuli in overweight subjects. This observation proof whether it is possible for the early detection and treatment of individuals risk by using simple inexpensive methods.

Objective

1. Evaluated the effect of long-term overweight on physical fitness parameters in overweight and normal subjects.
2. Assessed psycho-physiological responses to various stimuli in overweight and normal groups.
3. Assessed long term effects of overweight on the indicators of blood flow in response to various stimuli in both upper and lower extremities.
4. Compared blood pressure of each side of the upper and lower extremities between overweight group and normal group.

CHAPTER II
LITERATURE REVIEW

Blood Circulation System

The circulatory system (or cardiovascular system) is an organ system that moves nutrients, gases, and wastes to and from cell, helps fight diseases and helps stabilize body temperature and pH to maintain homeostasis.

The systemic circulation is the portion of the cardiovascular system which carries oxygenated blood away from the heart, to the body and returns deoxygenated blood back to the heart Arteries always take blood away from the heart, regardless of their oxygenation and veins always bring blood back. In general arteries bring oxygenated blood to the tissues; vein bring deoxygenated blood back to the heart. In the case of the pulmonary vessels, however, the oxygenation is reserved: the pulmonary artery takes deoxygenated blood from the heart to the lungs, and oxygenated blood is pumped back through the pulmonary vein to the heart. As blood circulates through the body, oxygen and nutrients diffuse from the blood into cells surrounding the capillaries, and carbon dioxide diffuse into the blood from the capillary cells. The release of oxygen from red blood cells or erythrocytes is regulated in mammals. It increases with an increase of carbon dioxide in tissues, an increase in temperature, or a decrease in pH. Such characteristics are exhibited by tissues undergoing high metabolism, as they require increased levels of oxygen.

Physiology of Systemic Circulation

The anatomy of the circulatory system, the physics of blood flow, and the regulatory mechanisms that control the heart and blood vessels determine the physiologic characteristics of the circulatory system. The entire circulatory system functions to maintain adequate blood flow to all tissues. Approximately 84% of the total blood volume is contained in the systemic circulation system. Most of the blood volume is in the veins, which are the vessels with the greatest compliance; smaller volumes of blood are in the arteries and capillaries.

Vasomotor

The main function of the vasculature is to deliver metabolic requirements to the tissue of the body. Some tissues have a greater need than other depending on their functions of a given time (such as muscles in exercise). Some tissue can survive without the substrates longer than other such as muscle cell can survive hypoxia for hours, where the brain that will die with minute in similar hypoxia.

The vasomotor centre in the medulla is the main control centre. It has control centres for affecting the peripheral blood vessels, and also the heart. It is affected by a variety of influences including respiratory centres, chemoreceptors (central and peripheral), pain and cold receptors, baroreceptors, receptors from the walls of the heart and pulmonary vessels and from higher centres such as the hypothalamus and cortex.

Control of blood vessel

Blood vessels show vascular or 'basal' tone, which is defined as ' state of contraction of the vascular smooth muscle within the walls of blood vessels'. The amount of tone at any one time is a balance between central and local control mechanisms. The exact mechanism for this tone is uncertain. There are two main hypotheses, the Myogenic and the Metabolic. The myogenic hypothesis suggests that constant changes of stretch of the smooth muscle acts via negative feedback to maintain a constant tone. Whilst the metabolic hypothesis, suggests that the tone is dependant on the vasodilator substances released from metabolism such as adenosine, lactic acid, low pH, high PCO_2 and low PO_2. Both could however be acting together. In 1976, Jason and co-worker presented interactions between local and reflex influences on human forearm skin blood flow. They concluded that local and reflex influences to skin interact so as to modify the degree but not the pattern of skin vasomotor response (27). Cleroux and co- worker present baroreflex regulation of forearm vascular resistance after exercise in hypertensive and normotensive human in 1992. They suggested that the after exercise effect could not be attributed to change in cutaneous blood flow (30).

Transmural pressure: this is the pressure across the wall of the vessel and can be affected by external and internal pressure: External pressure, blood flow is impaired by high external pressure outside the vessels such as when muscle is contracting or when sitting or kneeling. Internal pressure, initially, raised blood pressure causes the vessel to distend briefly. This causes smooth muscle to be stretched, producing flow within the vessel. This is termed the myogenic response and is a mechanism of auto regulation. In 1992, Stick and co- worker investigates whether walking or running prevents the formation of edema in the lower leg. The experimental results probe that walking prevents dependent edema formation, however, cannot be fully explained by the lowered venous pressure (31). Local metabolites cause vasodilatation and increase perfusion of the tissue. These include: hypoxia(decrease pO_2), acidosis (causes by CO_2 and lactate) , adenosine triphosphate(ATP) break down products, K^+ from contracting muscle and brain neurons, increase in osmolarity. Different tissues are influenced to varying degrees by these factors: for example, coronary vessels react mainly to hypoxia and adenosine whereas cerebral vessels are influenced by K^+ and H^+.

Cytokines are chemical substances.that can produced and secreted locally and act locally as local hormones, producing local response such as inflammation. They include:

- Histamine; this is an inflammatory mediator that causes arteriolar vasodilatation (H1-receptor mediated) . In veins, it causes vasoconstriction and increases permeability (H2- receptor mediated)
- Bradykinin: This inflammatory mediator causes vasodilatation nitic oxide(NO)mediated and increase vascular permeability(mediator by Ca^{2+})
- 5-Hydrocxytryptamine (5-HT, serotonin): This is found in platelets, the intestinal wall, and the central nervous system. It causes vasoconstriction.
- Prostaglandins(PGs): These are inflammatory mediator synthesized from aracidonic acid by cyclooxygenase. They are produced by macrophages, leukocytes, fibroblasts, and endothelium, Their production is inhibited by nonsteroidal anti-

inflammatory drug (NSAIDS) and steroid. PGF causes vasoconstriction, PGEcauses vasodilatation, and PGI2 (prostacyclin) causes vasodilatation.

- Thomboxane: This is a platelet activator that causes vasoconstriction; it is involved in homeostasis

- Leukotrienes: These are inflammatory mediators synthesizes from arachidonic acid by lipoxygenase. They are produced by leucocytes, and cause vasoconstriction and increased vascular pressure.

- Platelet activating factor (PAF): This is an inflammatory mediator that causes vasodilatation, increased vascular permeability, and vasospasm in hypoxic coronary vessels.

Endothelium dependent relaxation and contraction: when stimulated, the endothelium of arteries and veins produce endothelium derived relaxing factor (EDRF). EDRF was discovered to be nitric oxide (NO) and is produced in endothelial cells by cleavage from L- arginine by NO synthetics. In 1999, Radegran and Saltin study the role of nitric oxide as a regulator of vasomotor tone has been investigated in resting and exercising human skeletal muscle. These finding indicate that nitric oxide is not essential for initiation or maintenance of active hyperemia in human skeletal muscle but support a role for nitric oxide during rest, including recovery from exercise. Moreover, changes in blood flow during rest and recovery caused by nitric oxide synthase inhibition are accompanied by reciprocal changes in oxygen extraction, and thus VO2 is maintained (28). Stimuli include thrombin, bradykinin, substance-P, adenosine diphosphate(ADP), acetylcholine, and histamine. NO diffuses into smooth muscle cells and activates on intracellular cyclic guanosine monophosphate (cGMP) messenger system and causes vasodilatation. Blood flowing through an artery causes shear stress on the endothelial cell. When arterioles dilate to in crease tissue perfusion, flow increases in feeder arteries by a process called flow induced vasodilatation. This process is caused by increase shear stress, increasing NO production. Vasoconstriction substances are also produced by the endothelium prostanoid is produced in large arteries to cause constriction in response to hypoxia; endothelium is a powerful vasoconstrictive peptide.

Autoregulation is the process whereby tissue perfusion remain relatively constant even though blood pressure changes. It also keeps capillary filtration pressure at a stable value. Flow is proportional to pressure/ resistance. Therefore, to keep flow constant, any pressure causes arteriolar vasoconstriction, Thereby increasing resistance. A decrease in pressure causes arteriolar vasodilatation and decreases resistance. It take 30-60 s for the effect to take place so, for example, there is an initial increase inflow with a pressure increase before a steady state is reached. Autoregulation only occurs over a limited pressure range. It is an intrinsic feature of the vessels and is independent of nervous control. However, it does not mean that perfusion is constant all the time in vivo. In 1982, Johnson and Park presented effect of heat stress on cutaneous vascular responses to the initiation of exercise. These finding a cutaneous participation in the vasoconstrictor responses to exercise but also indicate that sufficient hyperthermia can attenuate or even abolish this response (29). In 1994, Ducharne and Tikuisis investigate the relative contribution of the convective heat transfer in the forearm and hand to the total heat loss during partial immersion in cold water and the heat gained during partial immersion in warm water. These results suggest that during local cold stress the convective heat transfer by the blood has a greater role than that suggested by previous studies for the form but lesser role for the hand (32).

Neuronal control of vasomotor response

The nervous system is divided into the central nervous system (CNS) which includes the brain and spinal cord, and the peripheral nervous system (PNS) comprising cranial nerves and spinal nerves. The PNS includes nerves emerging from the brain (cranial nerves) and nerves emerging from the spinal cord (spinal nerves). These nerves are divided into sensory nerves which conduct messages from various parts of the body to the CNS, whilst motor nerves conduct impulses from the CNS to muscles and glands. The PNS is further divided into the somatic system (SNS) and autonomic system (ANS), depending on the area of the body these messages are transmitted to and from .The SNS consists of sensory neurons from the head, body wall, and extremities, and motor neurons to skeletal muscle. The motor responses are under conscious control and therefore the SNS is voluntary. Certain peripheral nerves perform specialised functions and form the autonomic nervous system; they control various activities which occur automatically or involuntarily such as the contraction of smooth muscle in the walls of the digestive system. The autonomic system is further divided into the sympathetic and parasympathetic systems. These two systems provide nerve stimuli to the same organs throughout the body, but bring about different effects.

The sympathetic nervous system helps prepare the body for "fight or flight" and create conditions in the tissues for physical activity. It is stimulated by strong emotions such as anger and excitement and will therefore speed up heart rate, increase the activity of sweat glands, adrenal glands, and decrease those of the digestive system. It also produces rapid redistribution of blood between the skin and skeletal muscles.

Conversely the parasympathetic nervous system slows down the body and helps prepare for a more relaxed state, ready for digestion and sleep. It will therefore increase peristalsis of the alimentary canal, slow down the heart rate, and constrict the bronchioles in the lungs. The balance between these two systems is controlled to create a state of homeostasis which is where the internal stability of the bodily systems is maintained in response to the external environment.

Many external factors (several discussed above) are superimposed on local regulatory mechanisms and can substantially modulate coronary blood flow. Although coronary blood flow is primarily regulated by local metabolic mechanisms, the autonomic nervous system exerts an important influence on coronary flow regulation, as do hormonal and vascular endothelial systems. Each of these systems act through specific vascular smooth muscle receptors to modulate coronary vasomotor tone. Coronary vessels are innervated by both parasympathetic and sympathetic fibres. Parasympathetic stimulation causes release of acetylcholine which results in a coronary dilation, but the physiological importance of this effect is felt to be minimal. Sympathetic stimulation, such as occurs during exercise, causes release of norepinephrine, which can act on several myocardial and vascular receptors. Stimulation of myocardial α and ß1 adrenergic receptors cause the increase in myocardial contractility (inotropic state) and heart rate, which in turn cause an increase in myocardial metabolic rate, and thus a metabolic mediated coronary dilation. Stimulation of coronary vascular ß2-adrenergic receptors causes a direct vasodilatation, but this effect during exercise may not be quantitatively important. The dominant direct sympathetic effect on the coronary vasculature is an α-adrenergic receptor mediated vasoconstriction, which opposes or counters the metabolic vasodilatory mechanisms. The full importance and physiological significance of sympathetic effects on the coronary circulation is at present unclear. Under conditions of physiological or pathological stress, when a substantial coronary vasodilatation is required to meet metabolic demands, a functional sympathetic coronary α adrenergic constrictor tone appears to restrict myocardial perfusion and oxygenation. A coronary sympathetic vasoconstriction is negligible under resting conditions, but this competition between neural vasoconstriction and metabolic vasodilation is evident when sympathetic drive to the heart is increased by various physiological, surgical or pathological perturbations. Evidence for a tonic coronary constriction mediated by sympathetic nerves has been shown during intense cardiac sympathetic stimulation, during coronary autoregulation, during sympathetic nervous reflex activation, such as baroreceptor and chemoreceptor reflexes, myocardial ischemia and exercise

During exercise, the work output of the heart can increase many fold. Involved in this increased pumping capacity of the heart is sympathetic stimulation to increase heart rate and inotropic state of the myocardium. Due to local metabolic influences on the coronary circulation, coronary resistance vessels dilate and coronary flow increases. It is also realized that during exercise, adrenergic constrictor influences increase concomitantly with the local metabolic dilatory influences. Many laboratories have indicated that an α adrenergic receptor mediated coronary constriction limits the increase in coronary blood flow during moderate to intense (maximal) exercise. Using either systemic injections or direct intracoronary injections to avoid confounding systemic effects of α adrenergic receptor antagonists has revealed that coronary blood flow increases anywhere from 16-42% after α blockade during exercise. These studies strongly imply that and adrenergic coronary constriction competes with local metabolic vasodilatation and limits the increase in coronary blood flow and oxygen delivery during exercise.

Hormonal control

Although the vasculature is influenced by circulating hormones, short term control is mainly achieved by the nervous system.

Adrenalin: The catecholamines (adrenalie and noradrenaline) are secreted from the adrenal medulla. More than the three times as much as adrenaline is secreted as noradrenaline. Plasma levels at rest of adrenaline are 0.1-0.5 nmol/L, and noradrenaline 0.5-3.0 nmol/L. There is more noradrenaline in plasma because of spill over from sympathetic nerve terminals. Secretion is increased in exercise, hypotension, hypoglycemia, and flight or flight situation. Both hormones are β-adrenoceptor agonists, so they increase heart rate and contractility of the myocardium. Both hormones cause vasoconstriction in most tissue via α- receptors: adrenaline causes vasodilatation in skeletal muscle, myocardium and liver. This is because there are more β-receptor in tissues and adrenaline has a higher affinity to these receptor.

Noradrenaline usually cause vasoconstriction because it has a higher affinity to α-receptors. Adrenal gland stimulation result predominantly in adrenaline release, which causes vasodilatation in the large vascular beds of skeletal muscle and liver and increase stroke volume and heart rate. This lead to increase cardiac output, but which little change to blood pressure due to decrease total peripheral resistance. In 1985, Christman and Gisolfi study the anterior hypothalamic sensitivity to norepineprine which is altered by chronic exercise in the heat that can increase norepinephrine induced peripheral heat dissipating capacity in the preoptic area (33). In 1990, Connelly and co-worker examine the influence of an increase in central blood volume with head-out water immersion on the sympathoadrenal response to graded dynamic exercise; nine healthy men underwent upright leg cycle exercise on land and water immersion. There was the central shift in blood volume with water immersion which reduces the sympathoadrenal response to high intensity dynamic exercise (36).

Vasopressin (antidiuretic hormone,ADH):ADH is a peptide produced in the hypothalamus and released from the posterior pituitary into the bloodstream. A rise in plasma osmolarity is the main stimulus for its secretion. A fall in blood pressure and volume are also stimuli, but a lesser degree. ADH promotes water retention by the kidney. High levels of ADH cause vasoconstriction in most tissues. In the brain and heart, EDRF- mediated vasodilatation occurs. This ensures preferential supply to the brain and heart in the condition of hypovolaemia.

Renin- angiotensin aldosterone system: Renin is an enzyme produced by the juxtaglomeruli cells of the kidney. Its production is increased by: a fall in afferent arterial pressure to the glomeruli, increase sympathetic activity, decrease Na+in the mucula densa of the adjacent tubule. The formation of angiotensin II are as fallows. It stimulates aldosterone secretion from the adrenal cortex. Cause vasoconstriction at high concentration by acting directly on vascular smooth muscle, initiating release of noradrenaline from sympathetic nerve terminals, and increasing central sympathetic drive in the brainstem, increase cardiac contractility. Aldosterone increase salt and water retention by renal tubules.

Atrial natriuretic peptide (ANP): In response to high cardiac filling pressure, specialized myocytes in the atria increase ANP production .The ANP increase the excretion of salt and water by renal tubules. It also has a small vasodilating effect. Ventricles similarly secret brain natriuretic peptide (BNP), which increase in heart failure. Levels of ANP may be used as a blood test for heart failure. In 1992, Flore and co-worker study the influence of moderate cold exposure on the hormonal responses of atrial nariuretic factor, arginine vasopressin, catecholamine, and plasma rennin activity after exhaustive exercise. They found that the alterations in hormonal concentrations are likely to have been induced by changes in central blood volume and/or blood pressure; these hormonal responses may serve as a feedback mechanism modulating the blood pressure and volume responses to both exercise and cold pressure (37).

Measurement of blood flow

Blood flow can be monitored with Power lab data acquisition system using direct (invasive) or indirect (non-invasive) techniques.

1. Non –invasive Techniques

Laser Doppler

Laser Doppler systems use a fibre optic probe to apply light to a small area of tissue. The light is scattered by the tissue and a small amount of this light re-enters the optic fiber for recording. The direction and rate of blood flow in the capillaries cause a doppler shift in the returned light, and it is these shifts that constitute the signal. The absolute strength of the signal is related to several factors including the degree of vascularisation of the tissue. Therefore, the signal strength can vary markedly with position of the laser tip and the tissue type. The signal is often referred to as "tissue perfusion" rather than blood flow, as it cannot be directly calibrated in units such as local vasodilatation/constriction and so the method is of use for some pharmacological studies where more invasive methods are suitable.

Venous Occlusion Plethysmography

Venous Occlusion Plethysmography is a common technique used to study human vascular physiology by occluding venous blood flow within the forearm or calf. A strain gauge device (usually a stretchable tube containing a liquid metal, mercury or an indium-gallium alloy) is placed around the limb. An occlusion cuff is then placed proximal to this site and inflated above venous pressure (an inflation pressure of around 40 mmHg is typically used for intervals of 10s, followed by 5s of deflation).

As venous pressure is substantially lower than arterial pressure, arterial inflow is unalter while venous return is blocker. Consequently, the circumference of the forearm or calf increases with blood pooling and the strain gauge shows linear an increase in output with accumulating blood volume .The deflation time (5s) allows for venous emptying and blood flow measurements are then obtained using the changes in blood volume during the known inflation period. Human hands contain many arterio-venous shunts therefore the peripheral blood flow is highly susceptible to temperature changes.A smaller cuff is placed around the wrist and inflated to an above-systolic pressure (typically 220 mmHg), thereby localizing the measurement area in forearm plethysmography techniques. However, care must be taken to minimize the duration of this ischemic period (typically less than 13 minutes).Nevertheless, measurement of limb blood after 5-10 min of arterial occlusion is probably a reliable index of vascular activity.

1.3 Near-infrared spectroscopy (NIRS)

Near-infrared spectroscopy (NIRS) has been shown to be capable of measuring muscle blood flow and oxygen consumption in muscles continuously. It is based on the relative transparency of muscle tissue to infrared light and on the existence of five chromophores in the biological tissues whose light-absorbing properties vary with oxygenation.(38)

1.4 Volumeter

Volumeter is the instrument for measuring fluid displacement. It developed by Brand and the Research Laboratory in the early 1970's. The measurement by a fluid displacement was equal to the volume of the body and in fact has been well known since the Archimedes. The volumeter has particular application to arthritic patients and oedema disease. Another study used volumeter to measure volume of foot and ankle. Moholkar and Fenelon (2001) studied any difference in volumes of the right and left foot and ankle in 20 normal subjects. The result shows no statistically significant difference between right and left foot and ankle volumes and the testing by the volumeter shows that measurement is a relatively high degree of reliable in the reading. However, the measurement technique is also helpful n situations where there is swelling in the post operative period of hand surgery to evaluate of treatment about blood flow. So that the instrument has particular application to measure peripheral blood flow.

2. Invasive Technique

2.1 Thermodilution technique, which requires insertion of catheter into the vein, has been extensively used to measure limb blood flow at rest and during exercise. This method uses a small temperature probe to monitor the drop in blood temperature when a bolus of cool fluid is injected into the circulatory system. Thermoconductivity within the catheter leads to underestimating skeletal muscle blood flow at extremely high flows.

2.2 Transit-time Ultrasound flow meter is contrast to traditional ultrasound techniques. It incorporate two transmitters/sensors and a reflector plate the allows them to provide calibrated measurements of blood flow rate in millilitres per minute.

Transit-time ultrasounds technologies are not subject to problems with electrical interference or baseline drift and do not require direct contact with the vessel.

Measurements of blood volume in skeletal muscle can be monitored non-invasively using venous occlusion plethysmography techniques. It is a common techniques used to study human vascular physiology by occluding venous blood flow within the forearm or calf. However, several methods are used to assess blood flow in different organs such as doppler ultrasound or magnetic resonance spectroscopy. Moreover, its clinical use is limited due to high costs and poor availability (18)

It is generally accepted that exercise improve cardio-pulmonary performance and decrease risk of cardiovascular disease. Major risk factors for cardiovascular disease such as hypertension, diabetes mellitus, hyperlipidemia, obesity and smoking. (16,19,20,22) These factors increase arteriosclerosis. Amery and co-worker (1969) studied influence of ischemic exercise on muscle blood flow and resistance in normal and hypertensive subject this result showed that muscle blood flow after ischemic exercise is not significantly higher in the hypertensive than in the normal subjects, but the vascular resistance in the muscle is significantly higher in the hypertensive than in the normal subjects. (16)

Ankle-Brachial Pressure Index Test

This test is done by measuring blood pressure at the ankle and in the arm while a person is at rest and place in a supine position, the brachial and ankle systolic pressure measurements are obtained. (35)

1. Measure the brachial systolic blood pressure:
   - Place an appropriately sized cuff around the upper arm.
   - locate the brachial pulse and apply ultrasound contact gel.
   - Angle the Doppler probe at 45 degrees and move the probe to obtain the best signal.
   - Inflate the cuff until the signal is abolished then deflate the cuff slowly and record the pressure at which the signal returns being careful not to move the probe from the line of the artery.
   - Repeat the procedure for the other arm
   - Use the highest of the two values to calculate the ABPI

2. Measure the ankle systolic pressure:

- Place an appropriately sized cuff around the ankle immediately above the malleoli having first protected any ulcer that may be present.

-Examine the foot, locating the dorsalis pedis or anterior tibial pulse and apply contact gel.

-Continue as for the brachial pressure, recording this pressure in the same way.

-Repeat this for the posterior tibial and if required the peroneal arteries.

-Use the highest reading obtained to calculate the ABPI for the leg.

-Repeat for the other leg.

-Calculate the ABPI for the each leg using the formula below.

ABPI = P1/Pa

ABPI = ABPI for a leg

P1= Highest pressure obtained from the ankle vessels for that leg

Pa = Highest brachial pressure of the two arms

- ABPI normally >1.0
- ABPI <0.9 indicates some arterial disease.
- ABPI > 0.5 and < 0.9 can be associated with claudication and if symptoms warrant a patient should be referred for further assessment.
- ABPI < 0.5 indicates severe arterial disease and may be associated with gangrene, ischemic ulceration or reset pain and warrants urgent referral for a vascular opinion.

Overweight

Overweight refers to increased body weight in relation to height, when compared to some standard of acceptable or desirable weight. Overweight may or may not be due to increases in body fat. It may also be due to an increase in lean muscle. For example, Professionals athletes may be very lean and plenty of muscle , with very little body fat so they may weight more than others of the same height. While they may qualify as “ overweight” due to their large muscle mass they are not necessarily “over fat” regardless of BMI (15)

There are many ways can measure the percentage of body fat composition; however, reliability and accuracy vary, as does the expense and time requirements. This article looks at the various methods of measuring body composition.

The bioelectric impedence

The bioelectric impedance method works by measuring the speed of a low electrical current as it passes through the body, since fat is resistant to the flow of electrical current, higher amounts of body fat composition will resist the flow of the current. This method is easy, fast, and inexpensive; scales that use the bioelectric impedance method can be purchased at a local store. it is also available at many gyms and health clubs. This method can be inaccurate if water balances are low such as during dehydration or following heavy exercise; also, the stomach and bladder need to be empty.

Skinfold Thickeness

Calipers are used to pinch the subcutaneous (fat that lies under the skin and over the muscles) fat at several locations such as the back of the arm, abdominals, and thighs. This method is presuming that the amount of subcutaneous fat is in direct proportions to the total body fat. This method is fast and inexpensive, and it is fairly easy, provided the user is trained in the use of calipers; it can be inaccurate if the person performing the skinfold thickness test is not properly trained. This method can usually be obtained through doctors, personal trainers, and some gyms.

Dual-energy X-ray (DEXA)

The Dual-energy X-ray Absorptiometry or DEXA uses X-rays to measure body composition. One X-ray can accurately measure bone mineral mass, total body mass, and total percentage of body fat. DEXA is accurate, but very expensive. It requires the individual to lie still for the length of the X-ray and it does not differentiate between visceral fat and subcutaneous fat\

ComputerizedTomography(CT)

Computerized tomography uses X-rays to literally visualize the amount of fat and lean tissues. This method is useful for measuring the total amount of visceral fat and subcutaneous fat but it is expensive.

Magnetic Resonance Imaging (MRI)

The Magnetic Resonance Imaging method or MRI uses magnetic fields to create an image of the internal body. It is highly accurate; it measures visceral fat; and it is expensive, but easier to access than some of the other more accurate methods.

Body Mass Index (BMI)

General consensus exists for an indirect measurement of body fatness. Called weight for height index or body mass index (BMI). The body mass index is an easily obtained and reliable measurement for overweight and obesity and it defined as a person's weight (in kg) divided by the square of the person's height (in m.)

In 1997, The International Obesity Task Force, convened by the World Health Organization (WHO), recommended standard classification of adult overweight and obesity based on the following BMI calculation

- A BMI of 25.0 to 29.9 kg per m. square is defined as overweight
- A BMI of 30.0 kg per m. square or more is defined as obesity

BMI is a direct calculation based on height and weight, regardless of gender. The limitations of BMI as a measure of total body fat, nonetheless, must be recognized. For example, BMI overestimates body fat in persons who are very muscular and can underestimate body fat in persons who have lost muscle mass such as the elderly.

The effect of weight on the people who have the overweight condition commonly leads to increased blood pressure as well as to many other health problems. The health problems that affect overweight teens include:

- **Blount's disease.** Excess weight on growing bones can lead to this bone deformity of the lower legs.

- **Arthritis.** Wear and tear on the joints from carrying extra weight can cause this painful joint problem at a young age.

- **Slipped capital femoral epiphyses (SCFE).** Obese children and teens are at greater risk for this painful hip problem. SCFE requires immediate attention and surgery to prevent further damage to the joint.

- **Asthma.** Obesity is associated with breathing problems that can make it harder to keep up with friends, play sports, or just walk from class to class.

- **Sleep apnea.** This condition (where a person temporarily stops breathing during sleep) is a serious problem for many overweight kids and adults. Not only does it interrupt sleep, sleep apnea can leave people feeling tired and affect their ability to concentrate and learn. It also may lead to heart problems.

- **High blood pressure.** When blood pressure is high, the heart must pump harder and the arteries must carry blood that's moving under greater pressure. If the problem continues for a long time, the heart and arteries may no longer work as well as they should. Although rare in most teens, high blood pressure, or hypertension, is more common in overweight or obese teens.

- **High cholesterol.** Long before getting sick, obese teens may have abnormal blood lipid levels, including high cholesterol, low HDL ("good") cholesterol, and high triglyceride levels. These increase the risk of heart attack and stroke when a person gets older.

- **Gallstones.** An accumulation of bile that hardens in the gallbladder forms gallstones. These may be painful and require surgery.

- **Fatty liver.** When fat accumulates in the liver, it can cause inflammation, scarring, and permanent liver damage.

- **Pseudotumor cerebri.** This is a rare cause of severe headaches in obese teens and adults. There is no tumor, but pressure builds in the brain. In addition to headaches, symptoms may include vomiting, an unsteady way of walking, and vision problems that may become permanent if not treated.

- **Polycystic ovary syndrome (PCOS).** Girls who are overweight may miss periods — or not get their periods at all — and may have elevated testosterone (the male hormone) levels in the blood. Although it is normal for girls to have some testosterone in their blood, too much can interfere with normal ovulation and may cause excess hair growth, worsening acne, and male-type baldness. PCOS is associated with insulin resistance, a precursor to developing type 2 diabetes. Women who are overweight also might have fertility problems.

- **Insulin resistance and diabetes.** When there is excess body fat, insulin is less effective at getting glucose, the body's main source of energy, into cells. More insulin becomes needed to maintain a normal blood sugar. For some overweight teens, insulin resistance may progress to diabetes (high blood sugar).

- **Depression.** People who are obese are more likely to be depressed and have lower self-esteem

One of the health problems that affect overweight is high blood pressure. The means that if you have high blood pressure you are at greater risk of developing these condition than someone who does not have high blood pressure . The health risks from being overweight are much greater if you also have high pressure.

If your blood pressure is high it causes strain on the vessels carrying blood around your body. This strain can cause vessels to become clogged to or to weaken, and this in turn can lead to narrow blood vessel and clot which can cause damage to heart or brain. More rarely, it can lead to the blood vessel bursting. Having high blood pressure can also cause heart failure, kidney disease and strokes. But in another way if your blood pressure is high, it can be lowered by making your diet, exercising and losing weight. Changes to your lifestyle, for example changing your diet, exercising and losing weight, and when needed, with tablets. This will reduce your risk of developing heart and brain problems that might otherwise occur if your blood pressure is not treated. In many people, blood pressure is not checked or measured, and in some people who have high blood pressure it may not be treated adequately.

Vascular disease is mainly caused by atherosclerosis (hardening of the arteries) due to a thickening of the lining of the arteries .The arteries are blood vessels that supply blood, oxygen and nutrients, to the body from the heart. Atherosclerosis is a condition leading to narrow, hardened arteries so that there is insufficient blood flow to satisfy the needs of the tissue in question. Those parts of the body most affected by this disease suffer the consequences of an inadequate blood supply, namely poor function, tissue damage or death. Atherosclerosis strikes many people. It can start at the age of 20 and increases with advancing age. The exact cause is unknown but several risk factors are understood to accelerate the formation of atherosclerosis such as being overweight**,** being male**,** hypertension (high blood pressure), and high cholesterol levels in the blood.

CHAPTER III
MATERIAL AND METHOD

1. Subjects

Twenty health males (average age 29.50; range 20-40 yr) volunteers to serve as subjects for this study .All subjects were living in the community with a normal active life style. They were recruited from the worker of Police General Hospital, Bangkok and none were taking medications except vitamins or ergogenic aids for health. .The subjected are divided 2 groups; 10 overweight male average age 20-40yr. (BMI = 25.0 to 29.9 kg per m^2) volunteers and 10 control male average age 20-40yr.(BMI = 18.5 to 24.9 kg per m^2) .The two subject groups were matched for their average age and physical activity and BMI. No subjects were reported skin and cardiac disease or were known to be suffering from any chronic disease. None was on any regular medication

All subjects signs informed consent form before participating in the study after they read all description of the experimental protocol. The experimental protocol was approved by the Human Right Committee of Mahidol University NO. MU 2005-067.

2. Experimental protocols

On the first test day, each subject was familiarized once with each test. Data collection includes anthropometric measurement such as body weight, height, skinfold thickness, vital sign and physical fitness tests. The tests were conducts at Sports Science Laboratory, College of Sports Science and Technology, Salaya Campus,Mahidol University, Bangkok, Thailand.

At least 1 day apart following the first test, all subjects was measured the left upper and lower extremity volume by water displacement method in difference thermal stimulation. Subjects were tested for volume changing of extremities by four stimulus that 1) Immersion he left forearm and leg in warm water at temperature 42 ºC continuously, left forearm and leg were immersed at volumeter for measure volume 2) Immersion the left forearm in cold water at temperature 12 ºC continuously, left forearm and leg were immersed at volumeter for measure volume 3) the VO2 max test (Astrand-Rhyming protocol test), the subject was seated on the saddle which height was adjusted appropriately, started pedalling the ergometer at 0 watt for 1 minute as a warm up period. Thereafter, the resistance was increase by 100-150 watts (600-900 kgm/min) until heart rate (HR) more than 120beat/min. Start recording HR every minute until 6 minutes. The left upper extremities and lower extremities were measured at volumeter for volume measurement. 4) Wingate test, starts pedaling the ergometer at freeload for 1 minute as a warm up period. The resistance was set to 75 g/kg for Monark ergometer. Subject continued pedalling at highest speed as possible for 30 seconds. The left upper extremities and lower extremities were measured at volumeter for the volume measurement. Volume changed of both extremities and heart rate were recorded at four times that before each test conditions(Pre), at minute 0-1/2(M1)and after stimulation at minute 5-51/2(M2),at minute 10-10 ½ (M3).All data were collected for a subject on the same day while allowing for adequate rest, at least, about 30 minute between each condition, except in VO2 max test and Wingate test conditions were rest at least 1 day between them.

Experimental scheme of the study

Subject recruitment

Questionnaires (General health & Physical activities & Sport training)

Physical examination (vital sigh at rest)

↓

Informed consent signing

↓

Familiarization

↓

Anthropometric measurement

(Body weight & height & skinfold thickness & Physical Fitness)

At least 2 days

Study the effect of difference thermal stimulation on volume of extremities

Normal weight ↓ Overweight ↓

Testing of upper and lower extremity water displacement

Immersion of left extremity in warm water at temperature 42ºC continuously

Immersion of left extremity in normal water at temperature 30ºC

Pre and post Astand exercise

One Day Rest

Immersion of left extremity in cold water at temperature 12ºC continuously

Immersion of left extremity in normal water at temperature 30ºC

Pre and post Wingate exercise

↓

Data Analysis

3. Experimental procedure

3.1 Vital sign

Blood pressure of each subject were measured by using blood pressure monitor (Hico,Japan),resting heart rate by using Polar (Polar Electro OY SF-90440 Kampele,Finland), body temperature was measured by using Thermometer (Matsuda,Japan),after arriving the laboratory and rest on a chair for about 10 minutes.

3.2 Anthropometric studies

3.2.1 Body size measurement

Body weight of each subject was measured by using Digital weight balance (AD-6201, Japan). Body Mass Index was calculated from ratio of weight (kg) and height 2(m2). All measurements were carried out by using the same equipments, were handled by the same investigator.

3.2.2 Body fat measurement

The skin fold thickness technique was used for determining of body fat by skinfold calliper (John Bull, British indications, UK). Body density was calculated based on Jackson and Pollock's equations (35) and Brozek et all's equation for calculation of percent body fat.

$$Db = 1.10938-0.0008267(X1) + 0.0000016(X1-0.0002574(X5)$$

Equation for male age 18-61 years

Db = body density

X1 = sum of triceps brachii,suprailiac and thigh (mm)

X5 = ages of subjects

$$\text{Percent body fat} = [\ (4.57/Db)-4.142]\ x100$$

The detail of standardized sites by Lohnman (35)

- Triceps brachii : over the mid point of the muscle belly between the olecanon and the tip of acromion, with upper arm hanging vertically and loosely.
- Suprailiac: just above the iliac crest in the mid axillary line.
- Thigh: over mid point between inguinal crease and patella

3.3 Muscle strength measurements

Isometric handgrip strength as measured by using digital handgrip dynamometer (Takei and Company, Japan). The subject was asked to perform to grip with relaxed Standing and hold the dynamometer both right and left hand, which the dynamometer was adjusted to comfort grip .The subject was asked to squeeze the handles together with as much force as possible. The best o three attempts was recorded (coefficient of variation < 10%) (Elkin, 2000).

Isometric muscle strength of back extensor and knee extensor (Quadriceps femoris muscle) were measured by back and leg dynamometer (Takei and Company, Japan).First, the subject was asked to measure the leg strength by subject stand with squat position and straight back on the dynamometer . The hand bar was adjusted to comfortable pull, then the subject was asked to pull the hand bar with fully extend elbows and back, with maximum effort. Three trials were performed and the highest value was recorded (coefficient of variation < 10%).

Next, the subject was asked to perform to measure the back strength. The subject stand on the dynamometer and bending forward with fully extend knee. The hand bar was adjusted for comfortable to pull, then subject was asked to pull the hand bar with fully extend elbows and knees with maximum effort, three trials were performed and the highest back strength was recorded(coefficient of variation < 10%).

3.4 Flexibility and Agility test

Flexibility was measured by Sit and Reach Box (College of Sports Science and Technology,Mahidol Uiversity). The subject was asked to perform to relaxed long sitting and hold he position. The subject was asked to stretch the body toward together with as much force as possible. The best reach in centimetre of three attempts was recorded.

Agility was measured by nine square tests. The subject was asked to perform to left step move to each corner of square (150×150 cm) as much fast and as possible for 10 steps to the second and to the right step as fast as possible the same as the left step. The summation of right and left values was calculated as agility index.

3.5 Neuropsychophysiology determination

3.5.1 Reaction Time Testing

Before warned simple reaction time (WRT) testing, each subject was asked to sit comfortably on the chair and forearm was rested. The subjects were instructed to rest the index fingers lightly on the micro switch key of the reaction time and be ready to push the key as fast as possible after sensing the stimulus.

Various site of stimulation (SOS) were varied by using red light (Visual reaction time;VRT) , 1000 Hertz sound to ear (Auditory reaction time; ART) , tactile on posterior midline at C7 (Cervical 7^{th} tactile reaction time; C7RT) and lateral malleolus stimulation (TRTH)

The site of response assessed for 10 times through right index finger (RI), left index finger (LI), right big toe (RBT), and left toe (LBT).

3.5.2 Tapping Speed Testing

The tapping speed testing was using a dominator (The Denominator Company Inc. Woody bury, (CT).The subjects are instructed to tap the denominator as fast as possible for 10 seconds. Three repetitions are determined for the right index finger (RI), left index finger (LI), right big toe (RBT), and left big toe (LBT). The tapping speed test recorded maximum tapping speed and the average of three sessions of tapping for 10 seconds.

3.5.3 Critical Flicker Fusion Frequency (CFFF)

Grass stimulator (Grass Instrument, Quincy,USA) is used to generate the flicker light. The frequency of alternating light and dark of frequency monitor bulb of the stimulator could be increased or decreased by knob controlled. The stimulator will be adjusted 10 millisecond of duration time, 10 millisecond delay time. Subjects are asked to sit still and look at the flickering light which was adjusted by the researcher at the frequency knob. Each subject was instructed to observe the light and looking at the monitor carefully to see the bulb of flicker changed from flickering to the smooth light. The critical flicker frequency (CFF) can be read at any time from frequency control knob. This CFFF was tested from low to high frequency (CFFFL) and high to low frequency (CFFFH) and recorded for each subject of each groups.

3.5.4 Mental status questionnaire

Instructed by Mental Health Department,Ministry of Public Health,Stress test. Bangkok (1998) was tested but the data will not yet analyzed.

Stress test questionnaire

Stress test questionnaire format (1998) of the Department of Mental Health, Ministry of Public Health. Self rating of symptom and behavior or perception was rated and analyzed in the period of the past two months, with reliability coefficients of 0.87 (see Appendix C) (Raghabut et al, 2006).

Stress assessment scores (score level)

0-5	point	indicates the	uncertainty
9-17	point	indicates the	normal/no stress
18-25	point	indicates the	little stress
26-29	point	indicates the	intermediate stress
More than 30	point	indicates the	high stress

3.6 Anaerobic power and capacity test

Anaerobic power and capacity was determined by 30 second Wingate test. Anaerobic power and capacity of each subject was measured by using bicycle ergometer (Bodyguard 990). Before testing the procedure was explained to each subject until full familiarity was achieved. The subject was asked to perform to relaxed sitting on bicycle. The subject was asked to spin a wheel that increase load together with as much force as possible into 30 seconds. Anaerobic power and capacity value was calculated. (37)

3.7 Maximum Oxygen Consumption (VO2 max)

The VO2 max was determined by using a bicycle ergometer (Bodyguard 990).Before testing the procedure each subject was explained to each subject until full familiarity was achieved. The subjects were asked to relax sitting on bicycle. The maximal oxygen consumption test was calculated from submaximal exercise with Astrand- Rhyming protocol test. (37)

3.8 Extremities volume measurement

Extremities volumes were measured by using volumeter (Biomedical Equipment Technology, Mahidol University). Volumeter's size was 27 cm of diameter and 83 cm of height.The procedures for water displacement volume of the upper and lower extremity were demonstrated and practiced by each subject after water added to the volumeter. The volumeter was filled with water to the level of the overflow spout, and the water was allowed to stabilize prior to reading the water temperature and beginning the immersion. Water temperature for both the upper and lower extremity measurements was maintained at room temperature 30ºC. For the upper extremity measurements, subjects were instructed to lower the arm slowly into the volumeter and to stop when the top of the volumeter came in contact with the marked elbow (lateral epicondyle). At this point, a label line that determined the depth of immersion for Repeat measurement was marked by a magic marker. In the left hand immersion in water continuously. For the lower extremity measurements, subjects were instructed to lower the leg slowly into the volumeter and to stop when the top of the volumeter came in contact with the knee. At this point, a label line that determined the dept of immersion for accurate repetition of immersions was marked with a magic marker. The subject immersed the extremity into the volumeter, stopping at the preset label line. The displace water was weighed on digital weight machine which calibrated previously for computation which gave measurement of the water volume (litre) displaced and record.

The process began at T0 until T3 for each part, then, next part was completed at the same cycle to finish 4 parts: left arm and left leg. First, each part was submerged into the water at 30 ºC (T0) as control. Next, this part was dipped into the water at 12 ºC and 42 ºC. At the first minute of submerging into specific temperature was T1, then, it was moved and submerged into another tub for 5 minutes to maintain the same require temperature. The second tub contained water at the same temperature (12 ºC or 42 ºC .Volume was measured in the first tub at 6^{th} minute (T2).After that, the target part was submerged into the second tub again for 5 minutes at the same temperature. volume at 12th minute was measured in the water at the same temperature of the first tub (T3). Volume of each part at 30 ºC after Astand Exercise and Wingate Exercise was measured by dipping both arm and leg at the same side into the water in each period of time. The volume of water was calculated from the weight of out flow water of each period that was measured by digital scale. The result was subtracted by plastic bag's weight, then, calculated from gram to litre by using predetermined calibrated value:

Water preparation

Tap water at room temperature was 26 ºC .Water at 42 ºC was prepared by mixing 600 ml of water at 32 ºC and 200 ml of water at 84 ºC due to container's size availability. Water at 12 ºC was prepared by mixing 300 ml of water at 32 ºC and 100 ml gram of ice. Water was mixed until one volumeter was reached and the temperature was measured at least two times to get target temperature. One volumeter contains 37,400 ml.

In this thesis, at temperature 32 ºC, water 1,000 ml equal 1.003 kg.For 1,000ml of water, the calculation using in this experiment was done and based on water temperature: at temperature 12 ºC, 30 ºC and 42 º C, water weighed 990,975 and 970 gram respectively.

3.9 Ankle-Brachial Pressure Index (ABPI) and Mean Arterial Pressure Ratio (MAPR)

Before and after the exercise test, all subjects were measured of supine blood pressure in both arms and ankles. Arterial blood pressure was measured by using an automatic BP monitor (Dinamap plus Vital signs Monitor, 73F3, Japan). The appropriated size cuff was placed over the brachial artery and around each ankle, proximal to the malleolus. For each subject, systolic blood pressure was measured in the left brachial artery first, then in the right brachial artery, then in the left ankle and right artery, respectively. The ABPI was calculated by the formula below:

$$\text{ABPI} = \frac{\text{Highest pressure from the ankle vessel}}{\text{Highest pressure from the brachial vessels}}$$

The Mean Arterial Blood Pressure (MABP) is the pressure averaged in the arterials over time. It can be determined mathematically by the diastolic blood pressure plus one third of pulse pressure (systolic blood pressure minus diastolic blood pressure). The Mean Arterial Pressure Ratio (MAPR) was calculated as the ratio of MABP at various locations.

4. Statistics

All data were presented as mean ± SEM. Independent samples t-test was used to evaluate significant differences in anthropometrics and physical characteristics between overweight and control, which were accepted at P-value less than 0.05. Analysis of variance with repeated measure was used to determine the mean differences within group. Data between group at the same period of time and same variable was analyzed using ANOVA was applied to individual variables in order to investigate differences of overweight and control, which were accepted at P-value less than 0.05. All the statistical tests were performed using the SPSS for Window Versions 11.1 program. Stress test data were analyzed by percent different of member of overweight and control in various degrees of stress.

CHAPTER IV
RESULT

The physical characteristics of the subjects in the control group , overweight group are shown in Table1.The average values of age , body weight, and height of the control group were 32.40±2.06yr, 57.55±2.55kg,165.60±2.30 cm , respectively; the overweight group were 33.20± 1.54 yr , 71.30± 1.66 kg , 166.10± 1.36 cm , respectively. Their average heart rate , systolic blood pressure and diastolic blood pressure were 71.20±2.55 bpm , 113.50±3.19 mmHg ., 69.70± 2.75 mmHg, respectively for the control group; 71.20 2.69 bpm , 133.90± 4.27 mmHg, 83.40± 1.99 mmHg, for the overweight group respectively. Their average body mass index (BMI) ,body density (Db), percent fat, lean body mass (LBM), waist circumference (cm) , hip circumference (cm) and waist/ hip ratio (w/h ratio) were 20.87±0.54 kg/m-^{2},1.07±0.002, 8.49±0.80, 52.52±2.03, 75.70± 1.23 cm , 87.80±1.71 cm,0.86± 1.70 cm, respectively for the control and were 25.92±0.71 ,kg/m-^{2},1.06±0.005, 15.55±2.12, 60.05±1.50, 88.50±1.91 cm, 99.50± 1.47 cm , 0.88± 1.17 cm , respectively for the overweight.

The other physical fitness of subjects; the right and the left handgrip strength, leg strength, flexibility and agility , the data shown as mean±SEM ; the control group were 37.39±2.45 kg/ BW, 36.18±2.58 kg/ BW,121.16±9.94 kg/ BW,2.29±1.87 cms and 12.30±0.54 respectively, and were 39.30±1.60 kg/ BW, 36.82±1.28 kg/ BW, 117.87±12.09 kg/ BW, 9.16±4.06 cms and 13.15±0.87 , respectively for the overweight group, Their average anaerobic power and maximal oxygen consumption of the control group were 5.53±0.33ml/kg/min, 25.34±2.07watt/kg, respectively, and were 5.78±0.52ml/kg/min, 16.45±0.85 watt/kg, respectively for the overweight group.

The control group had significantly higher in maximal oxygen consumption and the overweight group had significantly higher in weight ,BMI, waist , hip, systolic blood pressure and diastolic blood pressure, body density, percent fat and lean body mass when compared to control group ($p<0.05$). No significant differences in age , height, waist-hip ratio, the right and the left hand grip strength, leg strength and flexibility are seen between the two group of subjects($p<0.05$)

Table 1 General characteristic of control group and overweight group used in this study

Parameter	Control group N=10	Overweight group N=10
AGE (Yr)	32.40±2.06	33.20±1.54
Height (cm)	165.60±2.30	166.10±1.36
Weight (kg)	57.55±2.55	71.30±1.66*
BMI (kg/m²)	20.87±0.54	25.92±0.71*
Waist (cm)	75.70±1.23	88.50±1.91*
Hip (cm)	87.80±1.71	99.50±1.47*
W/H	0.86 ±1.70	0.88±1.17
Body Density	1.07±0.002	1.06±0.005*
Percent Fat(%)	8.49±0.80	15.55±2.12*
LBM	52.52± 2.03	60.05±1.50*
HR (bpm)	71.20±2.55	71.20±2.69
Sys BP(mmHg)	113.50±3.19	133.90±4.27*
Dias BP(mmHg)	69.70±2.75	83.40±1.99*
VO2max(ml/kg/min)	25.34±2.07	16.45± 0.85*
Wingate(watt/kg)	5.53±0.33	5.78±0.52
Rt. Handgrip	37.38±2.45	39.30±1.60
Lt.Handgrip	36.18±2.58	36.82±1.28
Leg strength	121.10±9.94	117.87±12.09
Flexibility	2.29±187	9.16±4.05
Agility	12.30±0.54	13.15±0.87

Values are mean±SEM LBM; Lean Body Mass, W/H; Waist/Hip ratio, HR; Heart Rate , Sys BP; Systolic Blood Pressure, Dias BP; Diastolic Blood Pressure, BMI; Body Mass Index,Db; Body Density, Percent Fat, LBM;Lean Body Mass, VO2 max.;Maximal Oxygen Consumption, Significantly from control ;p<0.05(*)

Neuropsychophysiological Performance

Several neuropsychophysiological parameters were investigated including the reaction time (warned reaction time; WRT) determination, tapping speed test (TST) and critical flicker fusion frequency (CFFF). The mean values of the pre- post exercise were demonstrated.

1. Warned Visual Reaction Time (WVRT)

The mean values of warned visual reaction time of the right index finger (WVRTr) at pre-and post-exercise are shown in Table 2 and Figure 1 of WVRTr showed no significant difference between the two groups of subjects ($p<0.05$) and within each group of the subject.

The mean values of warned visual reaction of the left index finger (WVRTl) at pre-and post-exercise are shown in Table 3 and Figure 2 of WVRTl showed no significant difference between the two groups of subjects ($p<0.05$) and within each group of subject.

The mean values of warned visual reaction time of the right big toe (WVRTrbt) at pre-and post-exercise are shown in Table 4 and Figure 3 of WVRTrbt showed no significant difference between the two groups of subjects ($p<0.05$) and within each group of subject .

Lastly, the mean values of warned visual reaction time of the left big toe (WVRTlbt) at pre-and post-exercise are shown in Table 5 and Figure 4. of WVRTlbt had no significant difference between the two groups of subjects ($p<0.005$) and within each group of subject .

Table 2 The warned visual reaction time (msec.) of the right index finger (WVRTr) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	185.36±7.08	186.34±7.25
overweight	169.8±8.54	179.06±4.02

Values were milliseconds and shown as mean± SEM. No significant difference between the two group ($p<0.05$)

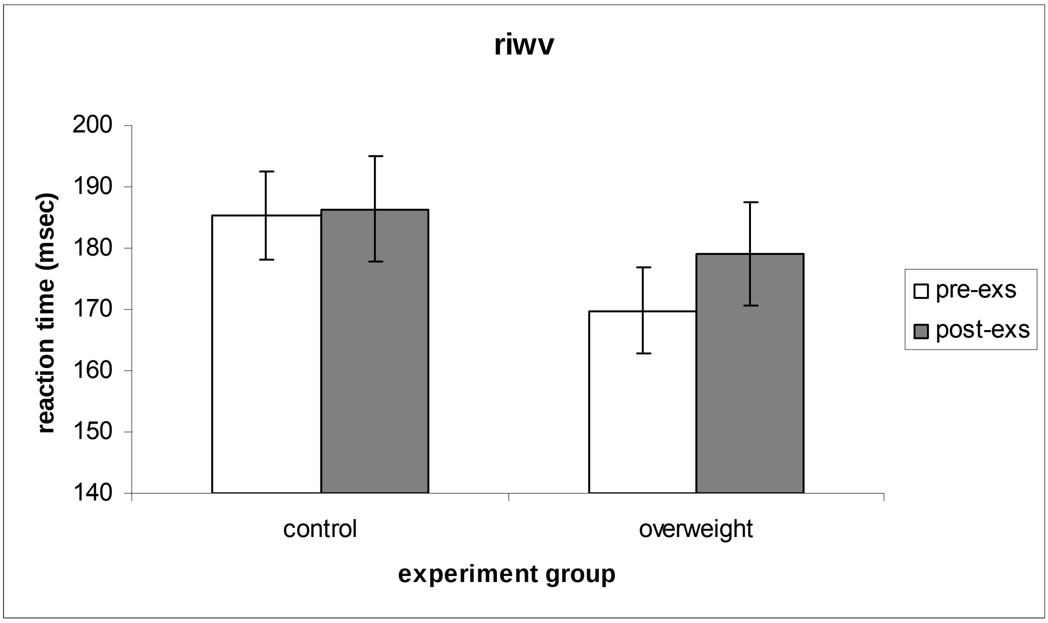


Figure 1 Comparison warned visual reaction time of the right index finger of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 3 The warned visual reaction time (msec.) of the left index finger (WVRTl) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	185.94±11.77	184.34±4.47
overweight	172.40±8.44	176.97±9.64

Values were milliseconds and shown as mean± SEM. No significant difference between the two group (p<0.05)

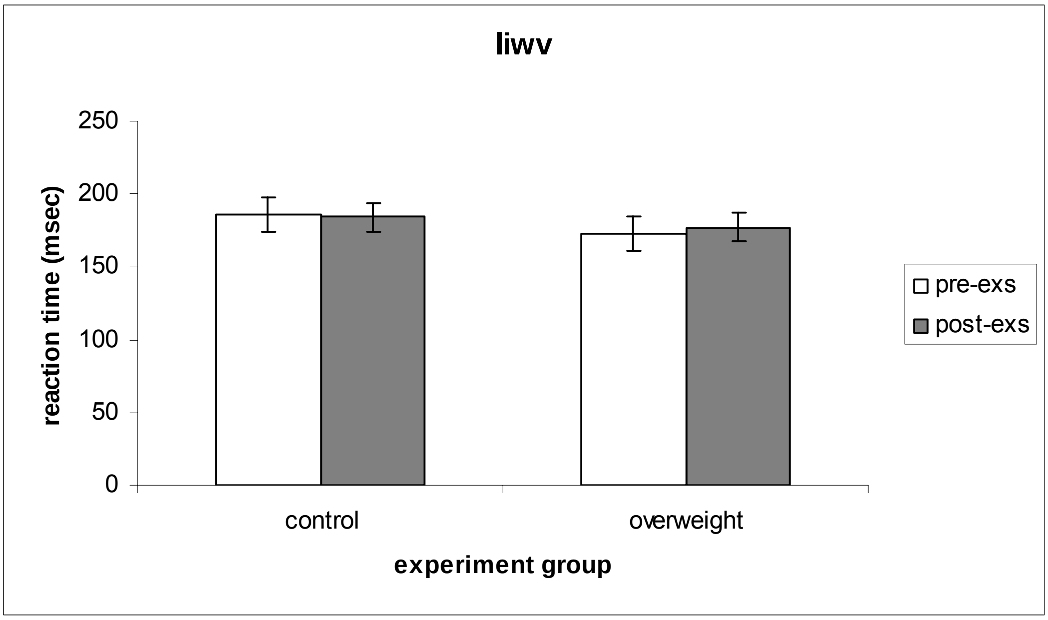


Figure 2 Comparison of warned visual reaction time of the left index finger of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 4 The warned visual reaction time (msec.) of the right big toe (WVRTrbt) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	221.30±7.93	221.00±10.30
overweight	215.70±15.76	213.10±8.59

Values were milliseconds and shown as mean± SEM. No significant difference between the two group (p<0.05)

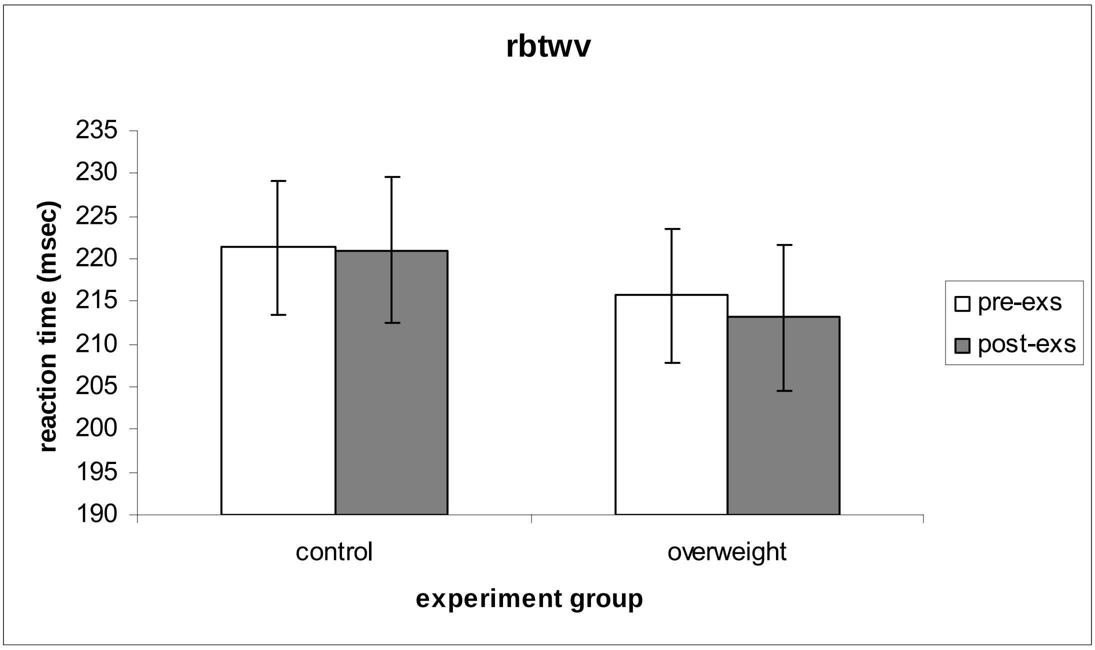


Figure 3 Comparison of warned visual reaction time of the right big toe of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 5 The warned visual reaction time (msec.) of the left big toe (WVRTlbt) of control and overweight groups during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	233.02±13.31	222.76±11.11
overweight	216.99± 12.69	214.06±7.04

Values were milliseconds and shown as mean± SEM, no significant between the two group (p<0.05)

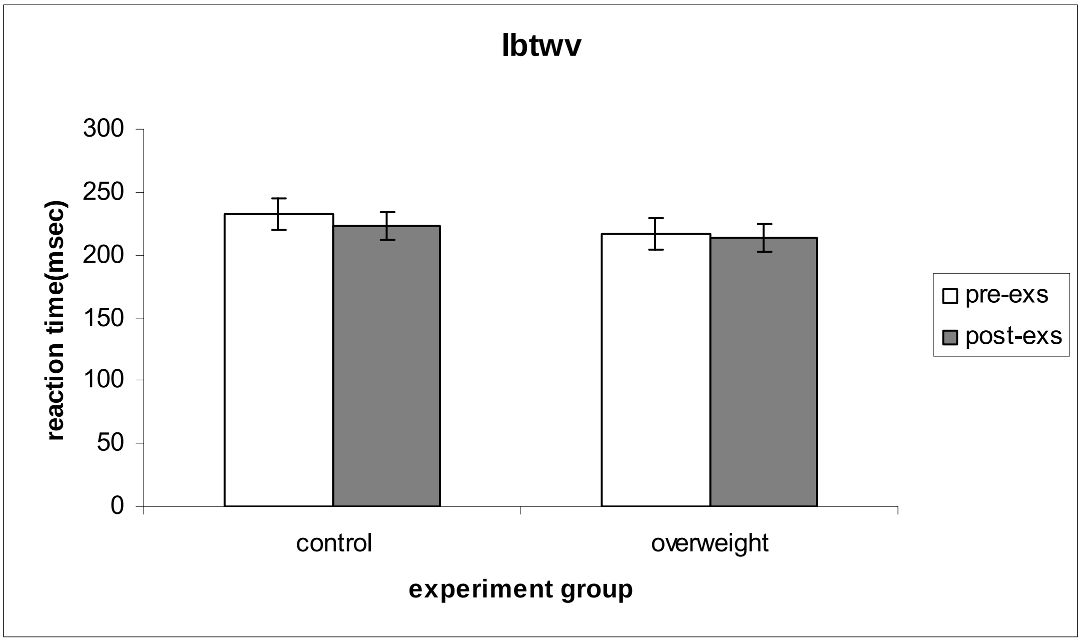


Figure 4 Comparison of the warned visual reaction time of the left big toe of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

2. Warned Auditory Reaction Time (WART)

The mean values of warned auditory reaction time of the right index finger (WARTr) during pre-and post-exercise are shown in Table 6 and Figure5. of WARTr showed no significant difference between the two groups of subjects ($p<0.05$) in warned auditory reaction time and within each group of the subject.

The mean values of warned auditory reaction time of the left index finger (WARTl) during pre-and post-exercise are shown in Table 7 and Figure 6 of WRTl showed no significant difference between the two groups of subjects ($p<0.05$) and within each group of subject.

The mean values of warned auditory reaction time of the right big toe (WARTrbt) during pre-and post-exercise are shown in Table 8 and Figure 7 of WRTrbt showed no significant difference between the two groups of subjects ($p<0.05$) and within each group of subject had shown in Figure7. The control group had significantly greater in post exercise than pre exercise (p<0.05)

Lastly, the mean values of warned auditory reaction time of the left big toe (WARTlbt) during pre-and post-exercise are shown in Table 9 and Figure 8. The WARTlbt showed no significant difference between the two groups of subjects (p<0.005) and within each group of subject.

Table 6 The warned auditory reaction time (msec.) of the right index finger (WARTr) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	204.26±11.24	206.22±10.92
overweight	194.00 ±8.80	189.88 ±9.92

Values were milliseconds and shown as mean± SEM. No significant difference between the two group (p<0.05)

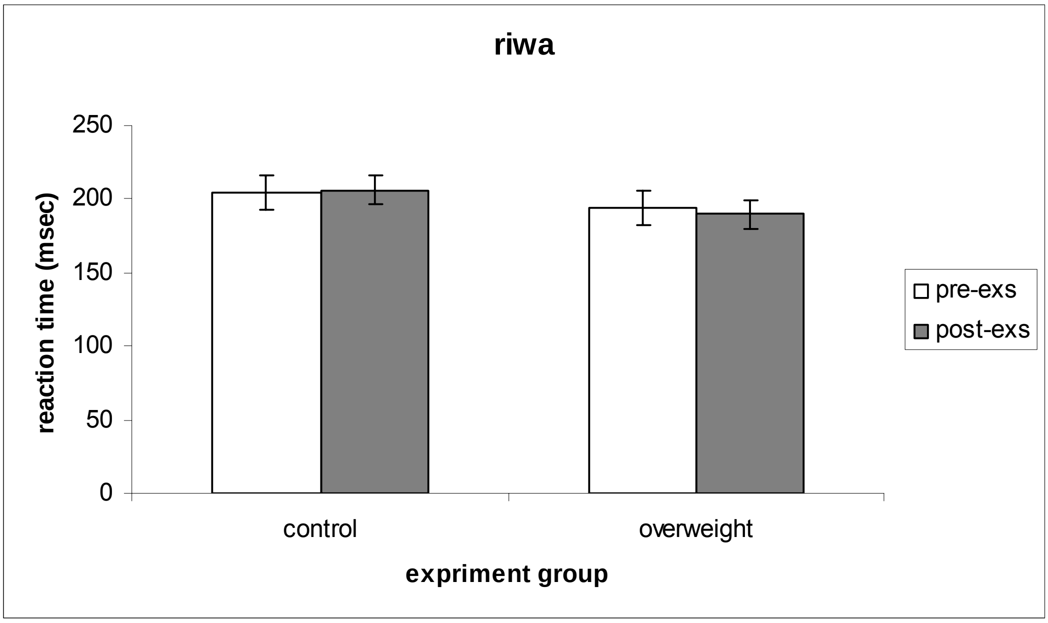


Figure 5 Comparison of warned auditory reaction time of the right index finger of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 7 The warned auditory reaction time (msec.) of the left index finger (WARTl) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	198.96±10.57	200.04±9.53
overweight	187.68±11.42	173.56 ±14.14

Values were milliseconds and shown as mean± SEM .No significant difference between the two group ($p<0.05$)

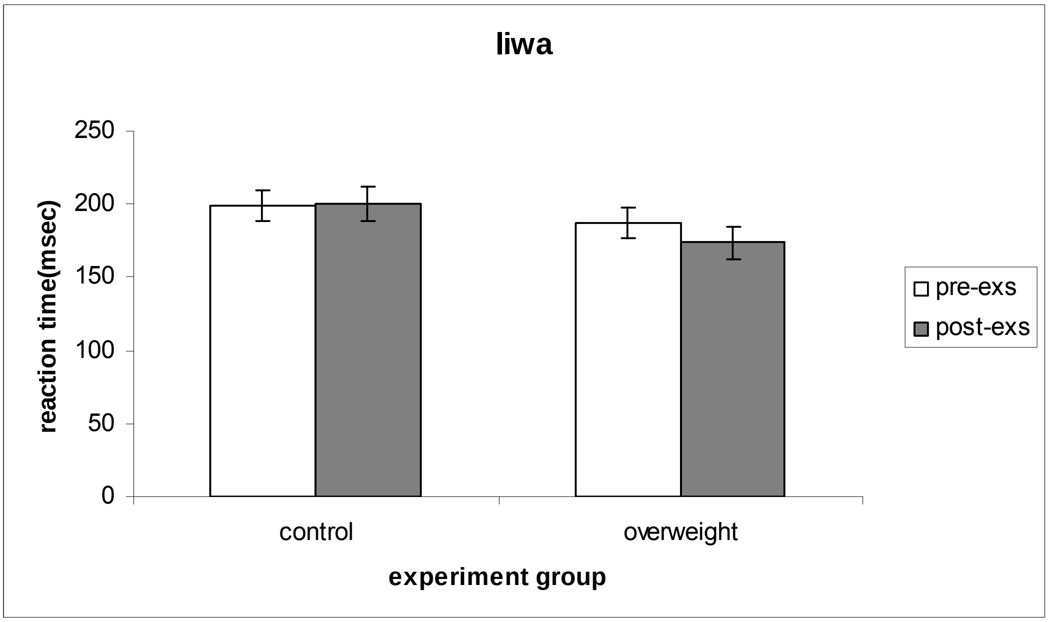


Figure 6 Comparison of warned auditory reaction time of the left index finger of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value $p< 0.05$, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 8 The warned auditory reaction time (msec.) of the right big toe (WARTrbt) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	249.14 ±9.52	229.88±8.33 [a]
overweight	220.78±13.73	213.88±10.29

Values were milliseconds and shown as mean± SEM, significant value $p<0.05$; a: different from pre -exercise control

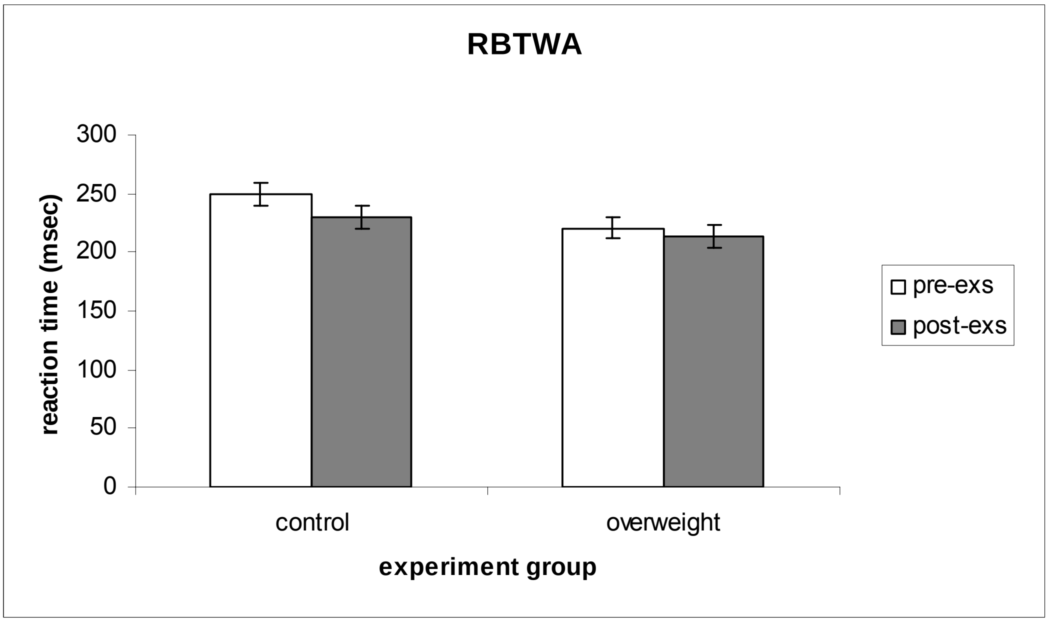


Figure 7 Comparison of warned auditory reaction time of the right big toe of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre -exercise control, b: different from pre- exercise overweight, c: different from post- exercise control, d: different from post -exercise overweight

Table 9 The warned auditory reaction time (msec.) of the left big toe (WARTlbt) of control and overweight groups during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	250.08±13.19	247.52±11.26
overweight	232.44 ±14.09	218.98± 9.97

Values were milliseconds and shown as mean± SEM. No significant difference between the two group (p<0.05)

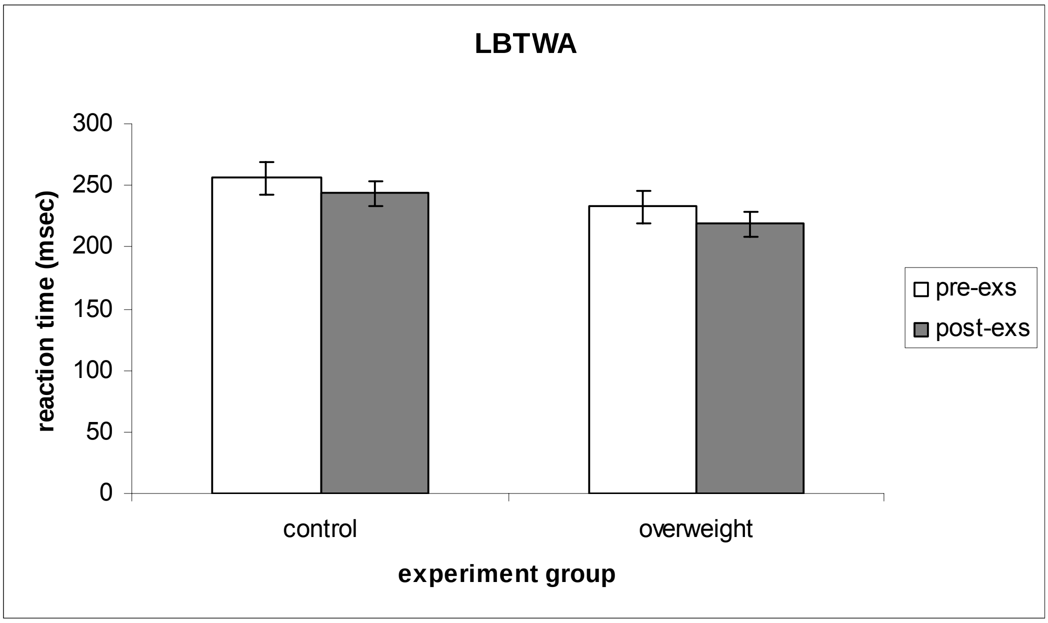


Figure 8 Comparison of warned auditory reaction time of the left big toe of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

2. Warned Tactile Reaction Time (WTRT)

The determination of warned tactile reaction time (WTRT) was divided into tactile reaction times at the 7th cervical level (TRTC7) and at the lateral malleolus level of the right ankle.

-Tactile reaction time at the 7th cervical level (TRTC7) stimulation

The warned tactile reaction time at the 7th cervical level in the right index finger response (TRTrC7) during pre- and post-exercise were shown in Table 10 ,figure 9 showed no significant difference between two group of subjects ($p<0.05$) and the mean values of TRTrC7 within each group of the subjects was also not significant difference.

The warned tactile reaction time at the 7th cervical level in the left index finger response (TRTlC7) during pre- and post-exercise were shown in Table 11, figure 10 showed no significant difference between two groups of subjects ($p<0.05$), However, the mean values of TRTlC7 within each group of subject had shown in figure 10 of overweight group had significantly greater during post- exercise than pre- exercise.

The warned tactile reaction times at the 7th cervical level in the right big toe response (TRTrbt C7) during pre- and post-exercise were shown in Table 12, figure 11; The overweight group had significantly greater in TRTrbt C7 during post-exercise compare to the control group ($p<0.05$). The mean value of TRTrbtC7 within each group of subject was not significant difference.

Lastly, warned tactile reaction times at the 7th cervical level in the left big toe response (TRTlbtC7) during pre- and post-exercise were shown in Table 13, figure 12; The overweight group had significantly greater in TRTlbtC7 during post exercise compare to the control group. The mean value of TRTlbtC7 within each group of subject was not significant difference.

Table 10 The warned tactile reaction time (msec.) of the right index finger (RIWTCr) of control and overweight groups during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	160.56±7.38	149.92±8.64
overweight	147.74±9.73	134.52 ±7.34

Values were milliseconds and shown as mean± SEM. No significant difference between the two group ($p<0.05$)

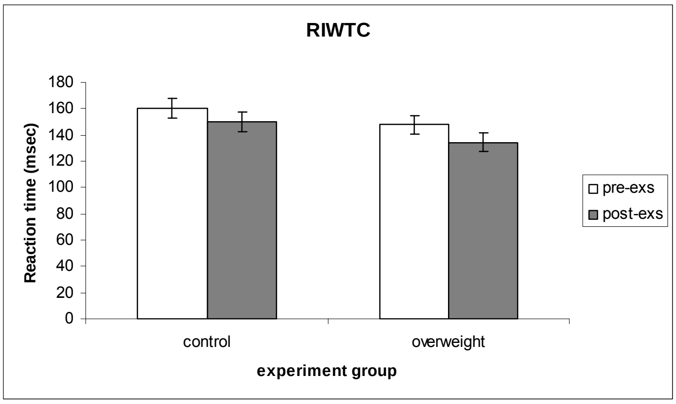


Figure 9 Comparison of the warned tactile reaction time at the 7^{th} cervical level of the right index finger of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM , Significant value $p< 0.05$, a : different from pre-exercise control, b: different from pre- exercise overweight, c: different from post-exercise control, d: different from post- exercise overweight

Table11 The two sessions of warned tactile reaction time (msec.) of the left index finger (LIWTCr) of control and overweight groups

Variable	Pre- exercise	Post - exercise
control	171.88±10.47	159.40±12.86
overweight	172.36±15.40	141.78± 6.09 b

Values were milliseconds and shown as mean± SEM; significant difference value $p<0.05$; b: different from pre -exercise overweight

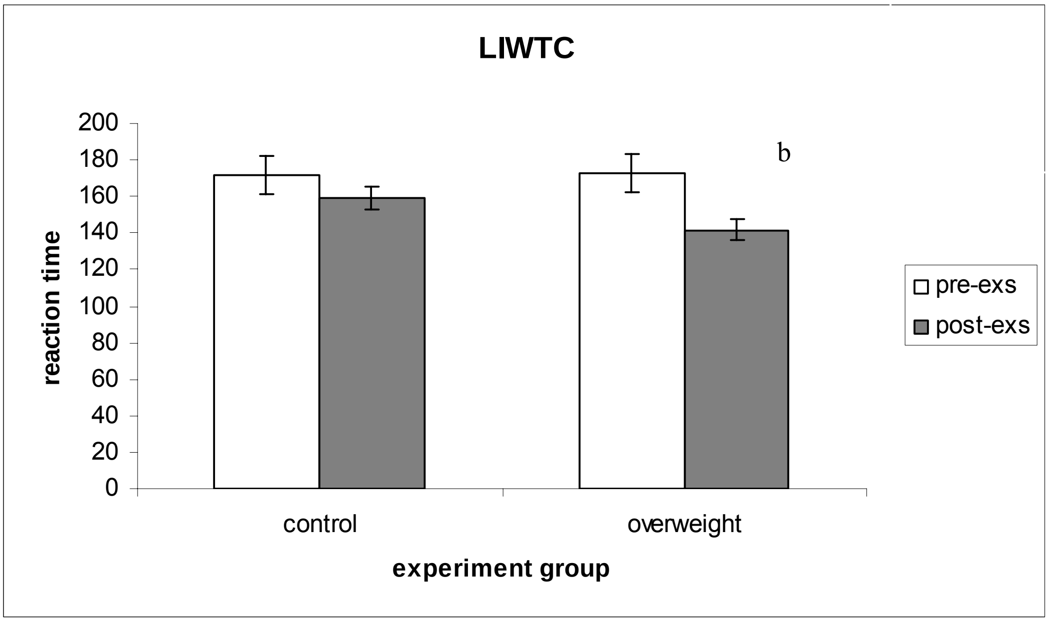


Figure 10 Comparison of warned tactile reaction time at the 7th cervical level of the left index finger of control and overweight groups during pre-and post-exercise. Data were presented as mean± SEM , Significant value $p< 0.05$, a : different from pre -exercise control, b: different from pre -exercise overweight, c: different from post -exercise control, d: different from post- exercise overweight

Table12 The two sessions of warned tactile reaction time (msec.) of the right big toe (rbtWTCr) of control and overweight groups during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	203.72±11.01	211.26±7.62
overweight	183.62±10.22	168.46± 9.36 c

Values were milliseconds and shown as mean± SEM; significant difference value p<0.05; c: different from post- exercise control

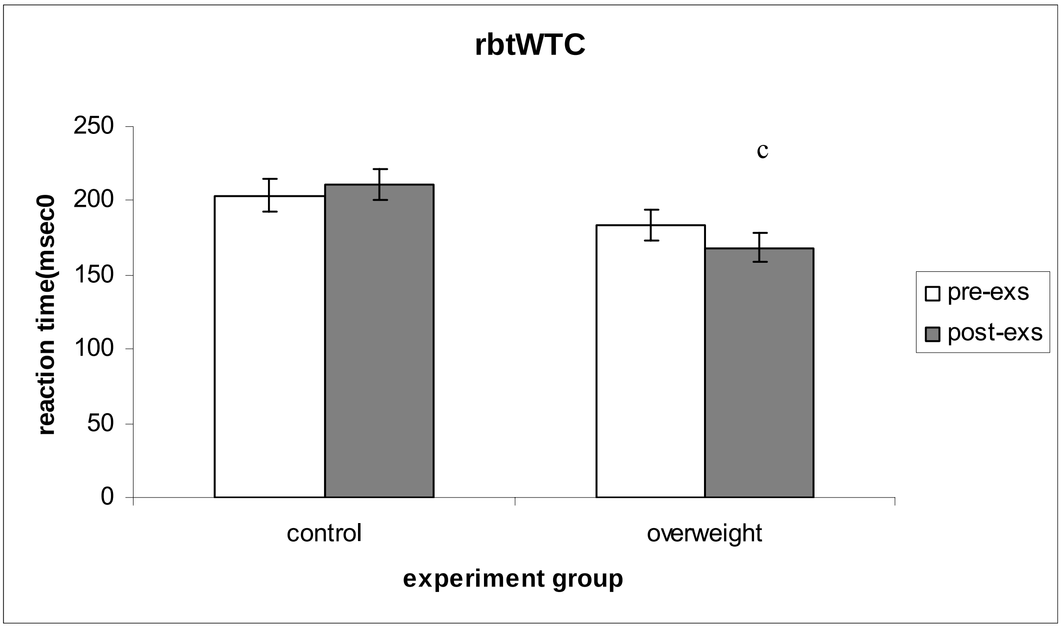


Figure 11 Comparison of warned tactile reaction time at the 7th cervical level of the right big toe of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM , Significant value p< 0.05, a : different from pre- exercise control, b: different from pre- exercise overweight, c: different from post- exercise control, d: different from post- exercise overweight

Table13 The two sessions of warned tactile reaction time (msec.) of the left big toe (lbtWTCr) of control and overweight groups

Variable	Pre- exercise	Post - exercise
control	207.30±13.19	210.84±11.44
overweight	199.60±21.59	176.20± 9.06 c

Values were milliseconds and shown as mean± SEM;significant value ($p<0.05$); c: different from post- exercise control

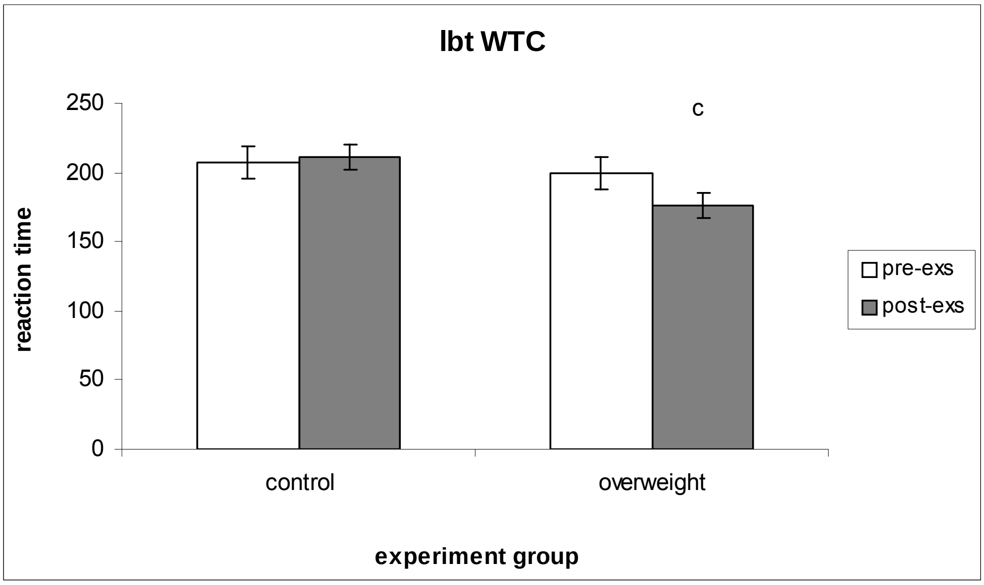


Figure 12 Comparison of the two sessions of warned tactile reaction time at the 7th cervical level of the left big toe of control and overweight group. Data were presented as mean± SEM , Significant value $p< 0.05$, a : different from pre- exercise control, b: different from pre- exercise overweight, c: different from post- exercise control, d: different from post- exercise overweight

4. Tactile reaction time at the right lateral malleolus level (TRTM))

Firstly, the mean values of warned tactile reaction time of the right lateral malleolus level in the right index finger (TRTMr) during pre- and post- exercise were shown in Table 14 and Figure13. The descriptive statistics of TRTMr showed no significant difference between the two groups of subjects ($p<0.05$) and the TRTMr within each group of the subject was also not significantly difference.

Secondly, the descriptive statistics of warned tactile reaction of the right lateral malleolus level in the left index finger (TRTMl) during pre- and post- exercise were shown in Table 15 and Figure 14. The descriptive statistics of TRTMl shown no significant difference between the two groups of subjects ($p<0.05$) and the TRTMl within each group of subject was also not significant difference.

Thirdly, the mean values of warned tactile reaction time of the right lateral malleolus level in the right big toe (TRTMrbt) during pre- and post- exercise were shown in Table 16 and Figure 15; The descriptive statistics of TRTMrbt showed no significant difference between the two groups of subjects ($p<0.05$) and the TRTMrbt within each group of subject was also not significant difference .

Lastly, the mean values of warned tactile reaction time of the right lateral malleolus level in the left big toe (TRTMlbt) during pre- and post- exercise were shown in Table17 and Figure 16. The descriptive statistics of TRTMlbt showed no significant of the two groups of subjects ($p<0.005$) and the TRTMlbt within each group of subject was also not significant difference.

Table14 The warned tactile reaction time (msec.) of the right lateral malleolus stimulation of the right index finger (TRTMr) of control and overweight groups during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	190.00±11.29	180.02± 12.32
overweight	172.60± 10.02	169.68± 7.21

Values were milliseconds and shown as mean± SEM. No significant difference between the two group ($p<0.05$)

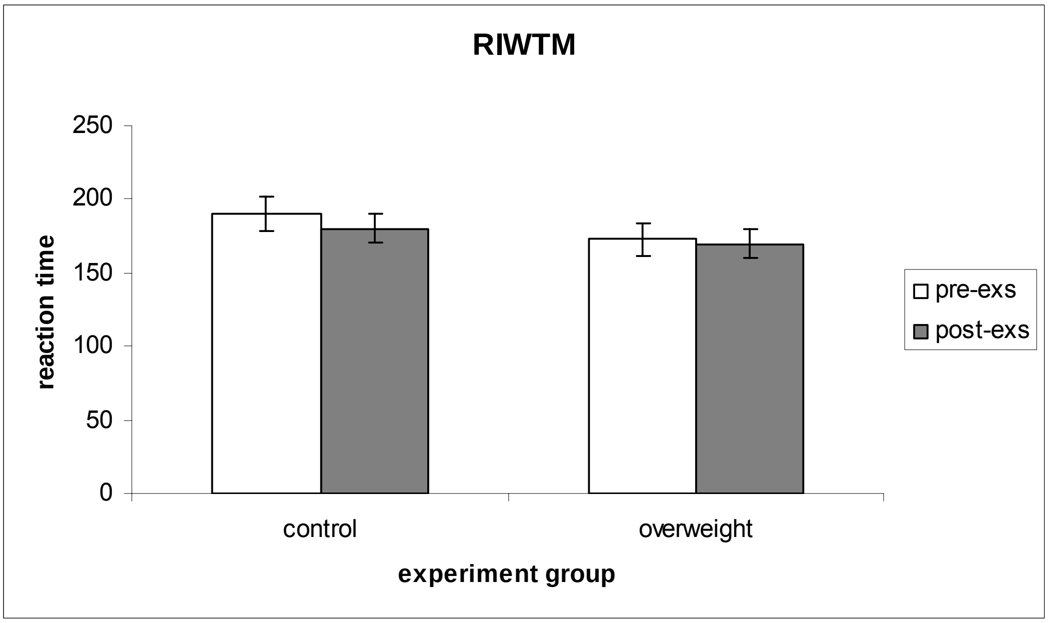


Figure 13 Comparison of warned tactile reaction time of the right lateral malleolus stimulation of the right index finger of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table15 The warned tactile reaction time (msec.) of the right lateral malleolus stimulation of the left index finger (TRTMl) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	187.68±13.98	184.14± 9.55
overweight	171.18±12.06	168.40± 10.32

Values were milliseconds and shown as mean± SEM . No significant difference between the two group (p<0.05)

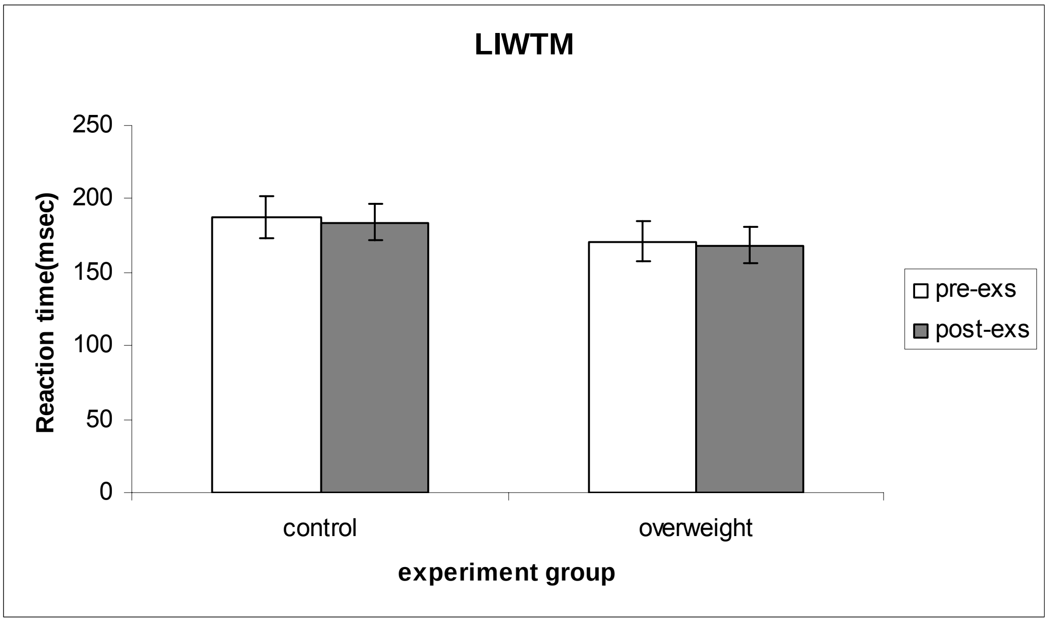


Figure 14 Comparison of warned tactile reaction time of the right lateral malleolus stimulation of the left index finger of control and overweight groups during pre-and post-exercise .Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre- exercise control, b: different from pre-exercise overweight, c: different from post- exercise control, d: different from post-exercise overweight

Table 16 The warned tactile reaction time (msec.) of the right lateral malleolus stimulation of the right big toe (TRTMrbt) of control group and overweight group during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	203.72±11.01	211.26± 7.62
overweight	183.62± 10.22	168.46±9.36

Values were milliseconds and shown as mean± SEM. No significant difference between the two group (p<0.05)

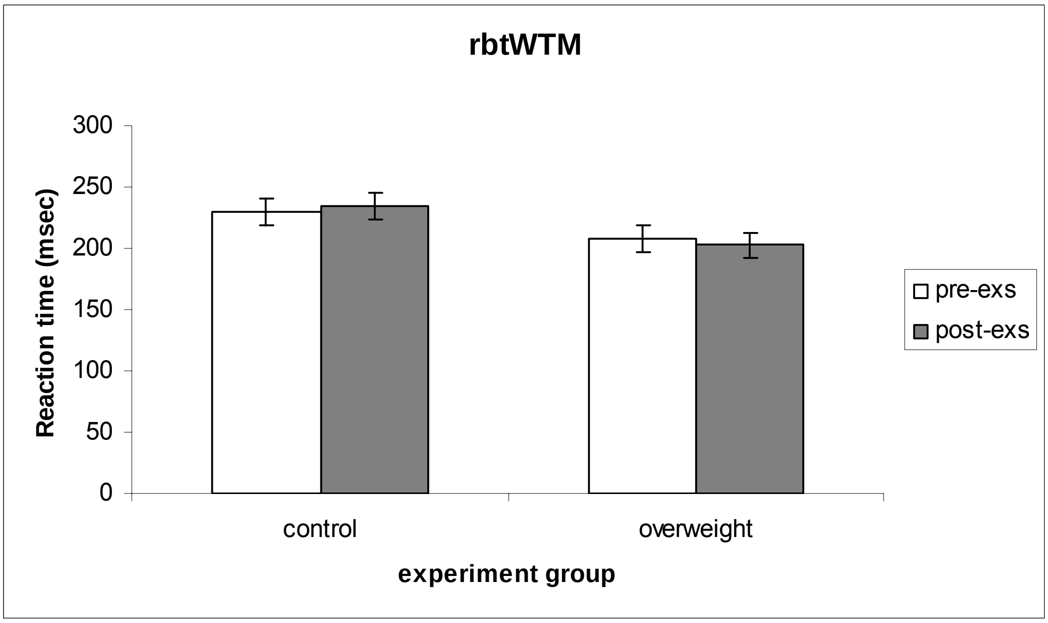


Figure 15 Comparison of warned tactile reaction time of the right lateral malleolus stimulation of the right big toe of control and overweight groups during pre-and post-exercise.Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre- exercise control, b: different from pre-exercise overweight, c: different from post- exercise control, d: different from post-exercise overweight

Table17 The warned tactile reaction time (msec.) of the right lateral malleolus stimulation of the left big toe (TRTMlbt) of control and overweight groups during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	223.42±12.31	232.68 ±17.82
overweight	224.92± 10.88	215.82± 12.48

Values were milliseconds and shown as mean± SEM. No significant difference between the two group (p<0.05)

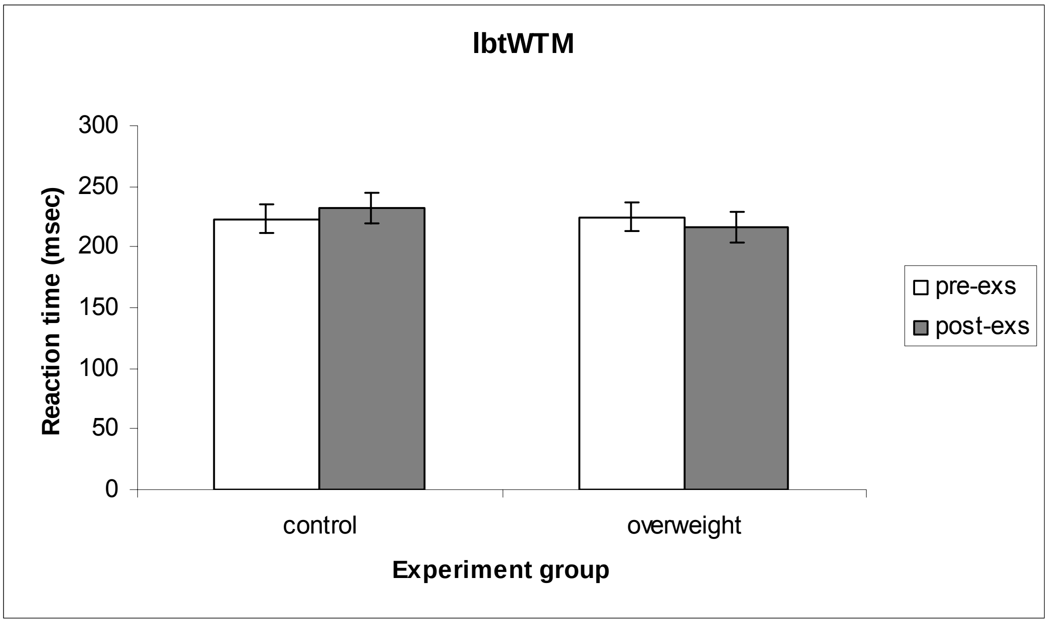


Figure 16 Comparison of warned tactile reaction time of the right lateral malleolus stimulation of the left big toe of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre- exercise control, b: different from pre- exercise overweight, c: different from post- exercise control, d: different from post-exercise overweight

5. Tapping Speed Testing (TST)

The mean values of tapping speed (cycle/10 sec) of the right index finger TSTr during pre-and post-exercise were shown in Table 18 and Figure 17. The TSTr showed no significant difference between the two groups of subjects ($p<0.05$) and within each group of subject was also not significant difference.

The tapping speed of the left index finger (TSTl) during pre-and post-exercise were shown in Table 19 and Figure 18. The TSTl of the overweight group had significantly greater than the control group at post-exercise, however, the repeated measures TSTl within each group of subject was not significant difference .

The mean values of tapping speed of the right big toe (TSTrbt) during pre-and post-exercise were shown in Table 20 and Figure 19; The TSTrbt showed no significant difference between the two groups of subjects ($p<0.05$), however, the TSTrbt within each group of subject in the control group had significantly greater at pre exercise compare to post exercise..

Lastly, the mean values of tapping speed of the left big toe (TSTlbt) during pre- and post-exercise were shown in Table21 and Figure 20. The TSTlbt showed no significant difference between the two groups of subjects (p<0.005). The TSTlbt within each group of subject was also not significant difference.

Table18 The two sessions of tapping speed testing of the right index figer (TSTr) during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	67.49 ±2.62	68.53± 2.06
overweight	67.85± 3.16	71.56± 1.92

Values were cycle/10 sec and shown as mean± SEM. No significant difference between the two groups (p<0.05)

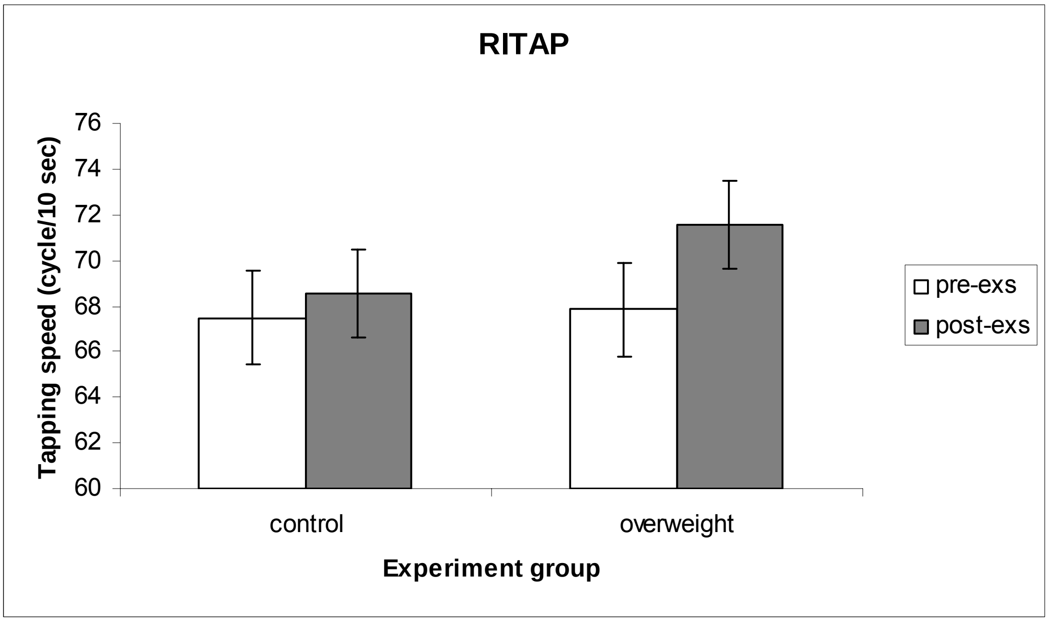


Figure 17 Comparison of tapping speed testing of the right index finger of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM, ,Significant value p< 0.05, a: different from pre exercise control, b: different from pre exercise overweight, c: different from post exercise control, d: different from post exercise overweight

Table 19 The two sessions of tapping speed testing of the left index finger (TSTl) during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	60.50 ±2.79	59.89± 2.26
overweight	64.26± 2.54	66.75±2.19 c

Values were cycle/10 sec and shown as mean± SEM; significant difference value $p<0.05$; c: different from post- exercise control

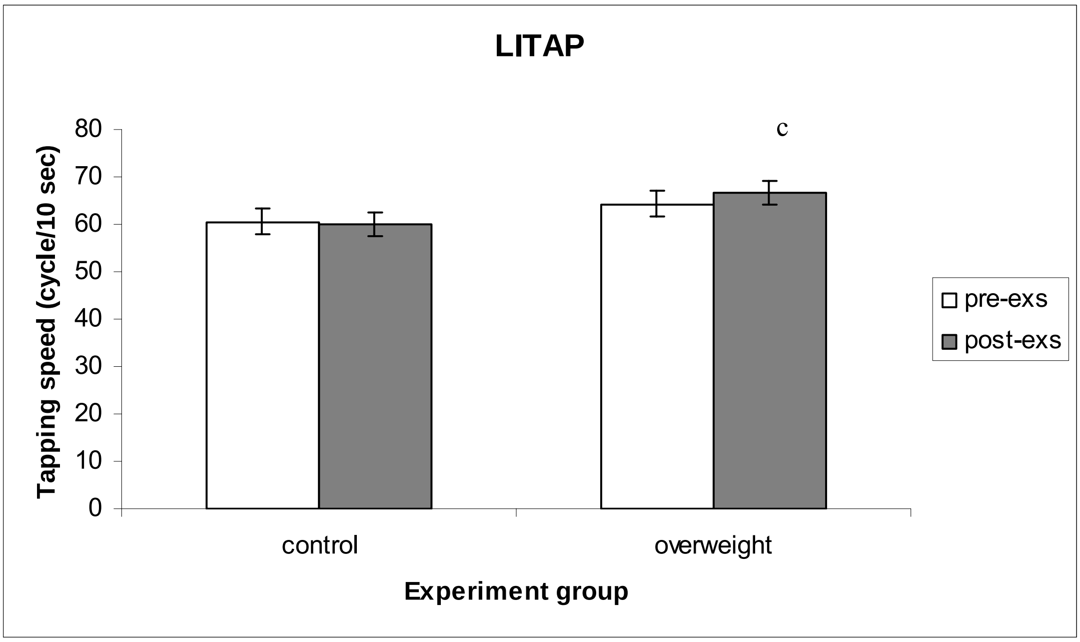


Figure 18 Comparison of tapping speed testing of the left index finger of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM, Significant value $p< 0.05$, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 20 The tapping speed testing of the right big toe (TSTrbt) during pre-and post-exercise

Variable	Pre- exercise	Post - exercise
control	43.53 ±2.73	39.30±2.12 [a]
overweight	45.52± 2.43	43.49± 3.70

Values were cycle/10 sec and shown as mean± SEM; significant difference value p<0.05; a: different from pre-exercise control

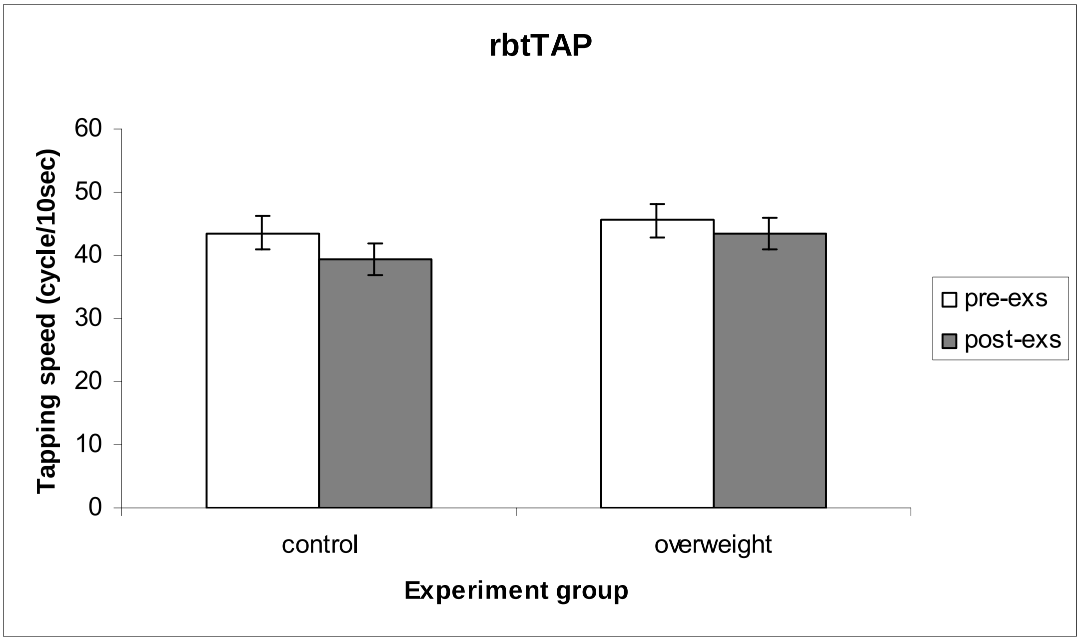


Figure 19 Comparison of tapping speed testing of the right big toe of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM, Significant value p< 0.05, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

Table 21 The tapping speed testing of the left big toe (TSTlbt) during pre-and post-exercise during pre-and post-exercise.

Variable	Pre- exercise	Post - exercise
control	39.33 ±2.49	38.86± 1.73
overweight	43.49± 2.29	43.62± 3.89

Values were cycle/10 sec and shown as mean± SEM. No significant difference between the two group ($p<0.05$)

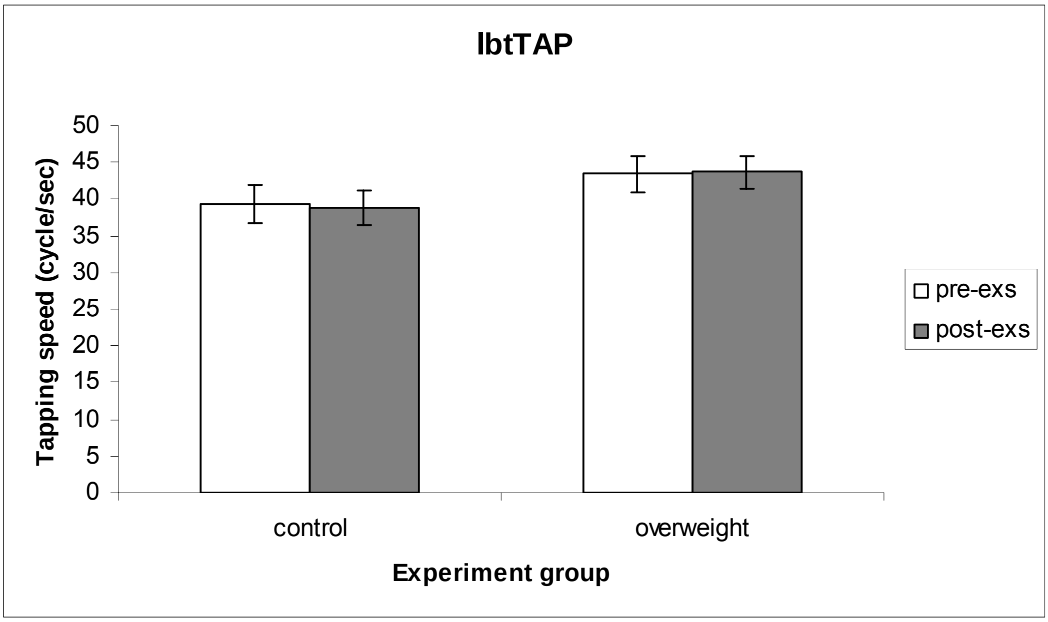


Figure 20 Comparison of tapping speed testing of the left big toe of control and overweight group during pre-and post-exercise. Data were presented as mean± SEM, Significant value $p< 0.05$, a: different from pre-exercise control, b: different from pre-exercise overweight, c: different from post-exercise control, d: different from post-exercise overweight

6. Critical Flicker Frequency (CFFF)

The frequency of flicker fusion changed was investigated from flickering to the smooth of light. The CFFF was tested from low- to high-frequency (CFFF L-H) and from high- to low- frequency (CFFF H-L).

The critical flicker fusion frequency (CFFF) at pre- and post-exercise were shown in Table 22.Firstly , the CFFF L-H in the first evaluation showed that overweight group had significantly lower of CFFF L-H during pre-exercise when compare to the control group. However, no significant were observed within groups

Secondly, the descriptive values at CFFF H-L in the first evaluation showed no significant different of the two groups of subjects ($p<0.05$). However, no significant were seen within groups.

Table 22 The critical flicker fusion frequency (cycle/sec) low to high frequency (CFFFL-H) and high to low frequency (CFFFH-L) of control and overweight groups during pre-and post-exercise

Variable	Pre exercise		Post exercise	
	CFFFL-H	CFFFH-L	CFFFL-H	CFFFH-L
Control	10.17±0.7	9.02±0.75	9.52±0.70	9.15±0.62
Overweight	7.27±0.5 [a]	8.40±0.89	8.05±0.47	8.05±0.76

Values are Hertz and shown as mean ± SEM. Significant value $p< 0.05$, a: different from pre-exercise control.

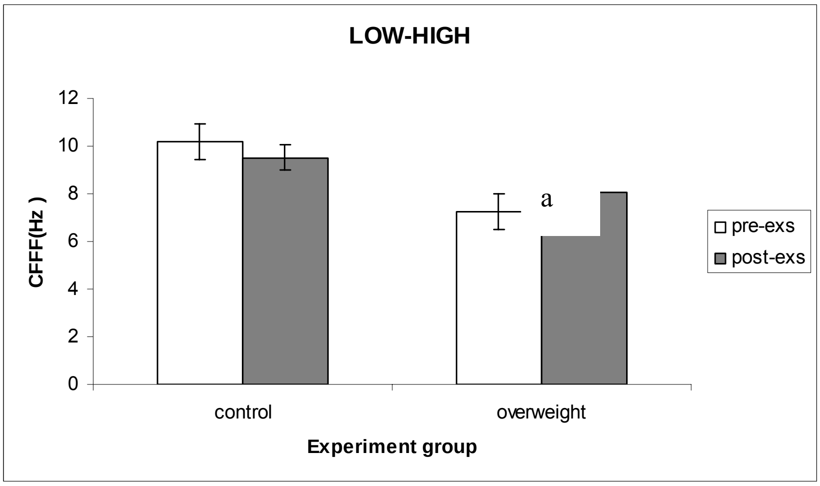


Figure 21 Comparison of the low-high CFFF (CFFFL-H) during pre-and post-exercise. Data were presented as mean± SEM , Significant value $p<0.05$, a : different from pre-exercise control, b: different from pre -exercise overweight, c: different from post-exercise control, d: different from post- exercise overweight

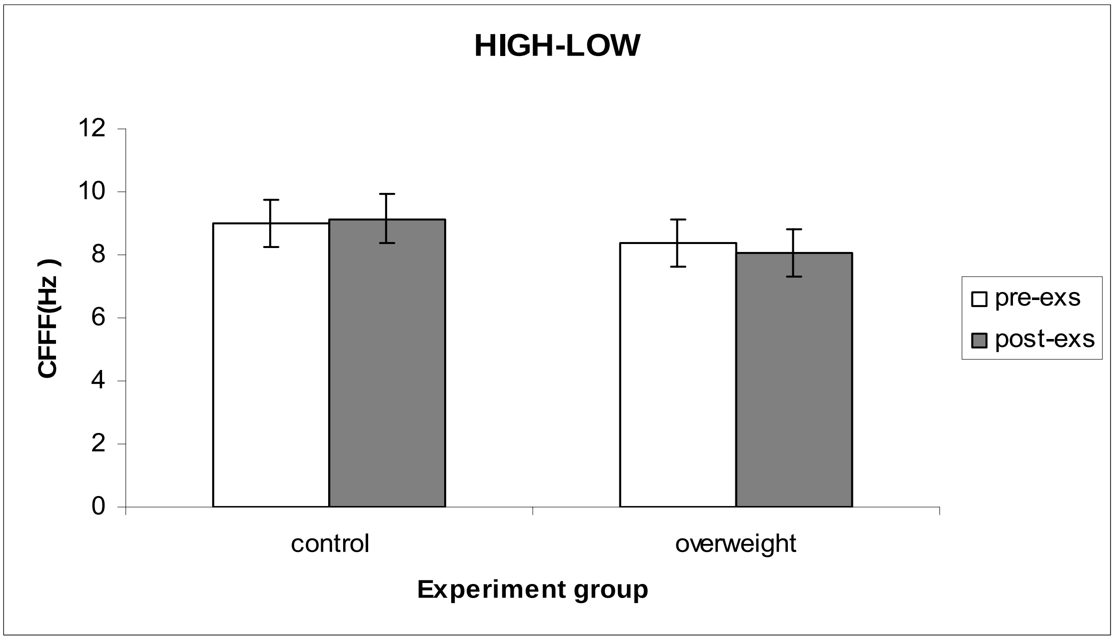


Figure 22 Comparison of the high-low CFFF(CFFF H-L) during pre-and post-exercise. Data were presented as mean±SEM, Significant value $p<0.05$, a : different from pre exercise control, b: different from pre exercise overweight, c: different from post exercise control, d: different from post exercise overweight

Blood circulation in both upper and lower extremities

Before various vasomotor response tests, all subjects were asked to immerse the left arm in normal water (30°C) to determine the baseline volume of the left arm that practiced in time course of the protocol. The mean values of volume of the left arm were reported in different conditions; First, immersion the left arm in hot water (42º C) conditions; values of the left arm volume (Figure 23) showed that the overweight group had a significant higher left arm volume compared to the control group at all time points. Second, immersion the left arm in cold water (12ºC) condition ; values of the left arm volume (Figure 24) showed that the overweight group had a significant higher left arm volume compared to the control group at all time points. Third, immersion the left arm in normal water (30ºC) during post- the Wingate exercise condition; values of the left arm volume (Figure 26) showed that the overweight group had significantly higher left arm volume compared to the control group at all time points as well.

Before the vasomotor response test, all subjects were asked to immerse the left leg in normal water (30°C) for baseline volume of left leg in time course of the protocol. The mean values of the left leg were reported in different conditions : First, immersion the left leg in hot water (42º C) condition; values of the left leg volume (Figure 27) showed that the overweight group had significantly higher left leg volume than the control group at all time points. Second, immersion the left leg in cold water (12ºC) condition ; values of the left leg volume (Figure 28) showed that the overweight group had significantly higher left leg volume when compared to the control group at all time points. Third, immersion the left leg in normal water (30ºC) during post- the Astrand exercise condition; values of the left leg volume (Figure 29) showed that the overweight group had significantly higher left leg volume when compared to the control group at all time points as well.

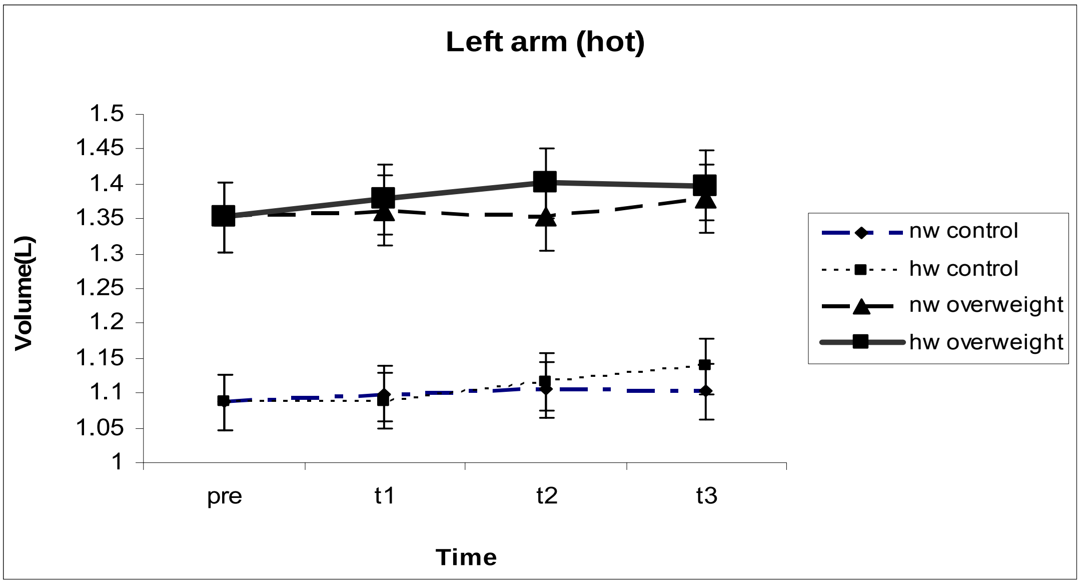


Figure 23 Comparison of the left arm volume of normal and overweight groups during immersion in hot water (42º C) condition. Data were presented as mean ± SEM , statistical comparison shown was paired t- test , Pre = pre test , t 1= immediately post – test , t2 = post-test at minute 6th , t3 = post-test at minutes 12th , significant value < 0.05

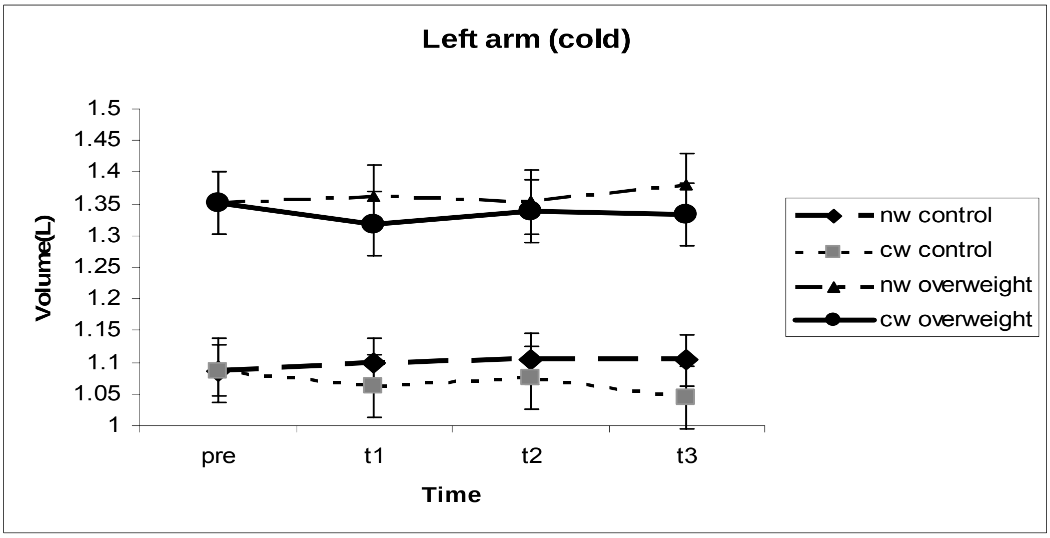


Figure 24 Comparison of the left arm volume of normal and overweight groups in during immersion in cold water (12º C) condition. Data were presented as mean ± SEM, statistical comparison shown was paired t- test, Pre = pre test, t 1= immediately post – test, t2 = post-test at minute 6th , t3 = post-test at minutes 12th , significant value < 0.05

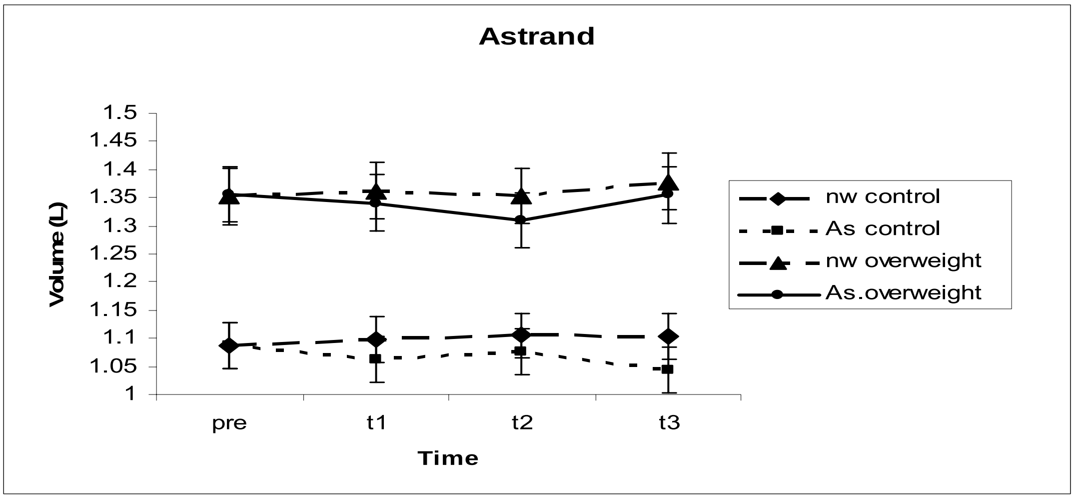


Figure 25 Comparison of the left arm volume of normal and overweight groups during immersion in normal water (30º C) condition post Astrand . Data were exercise presented as mean ± SEM , statistical comparison shown was paired t- test , Pre = pre test , t 1= immediately post – test , t2 = post-test at minute 6th , t3 = post-test at minutes 12th , significant value < 0.05

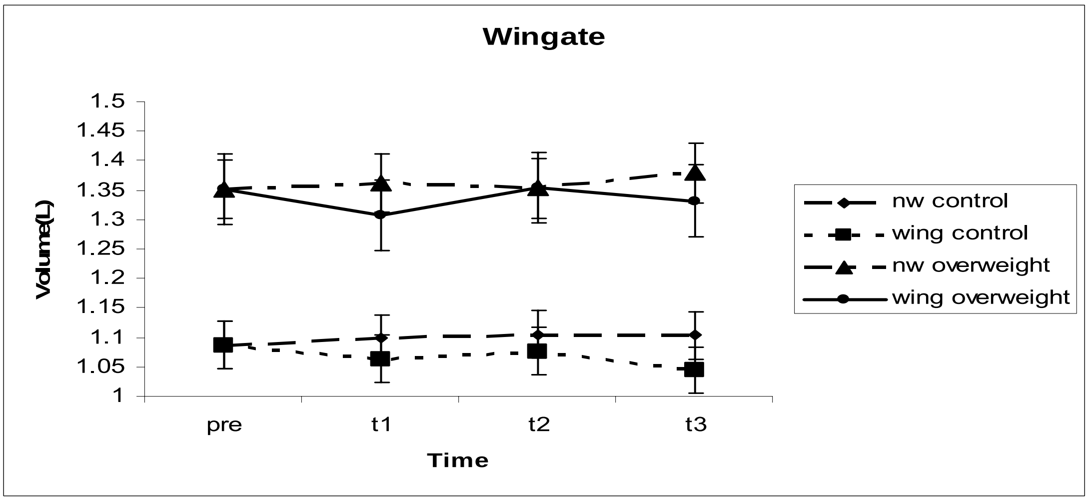


Figure 26 Comparison of the left arm volume of normal and overweight groups during immersion in normal water (30º C) condition post Wingate exercise. Data were presented as mean ± SEM, statistical comparison shown was paired t- test, Pre = pre test, t 1= immediately post – test, t2 = post-test at minute 6th, t3 = post-test at minutes 12th, significant value < 0.05

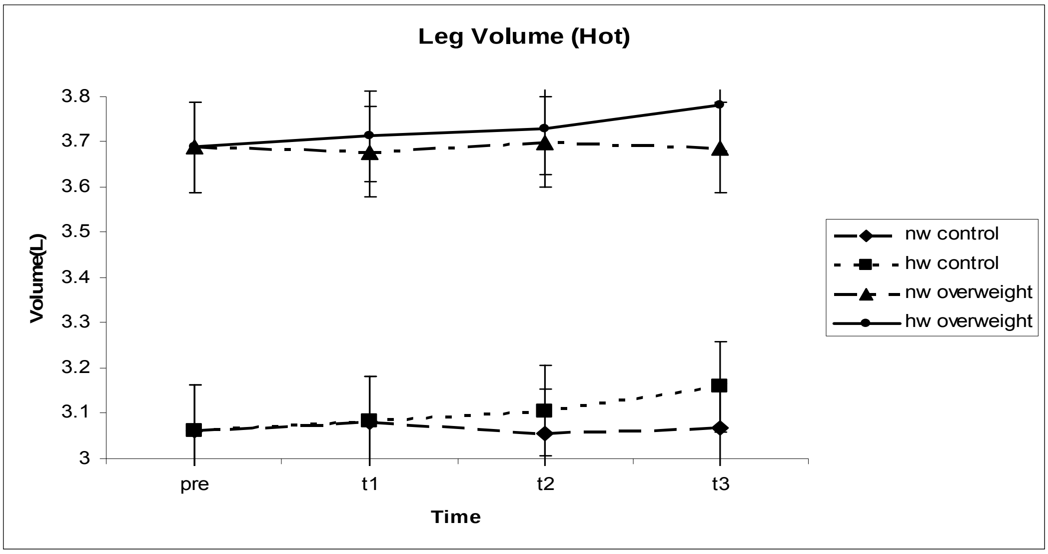


Figure 27 Comparison of the left leg volume of normal and overweight groups during immersion in hot water (42º C) condition. Data were presented as mean ± SEM, statistical comparison shown was paired t- test, Pre = pre test, t 1= immediately post – test, t2 = post-test at minute 6^{th} , t3 = post-test at minutes 12^{th} , significant value < 0.05

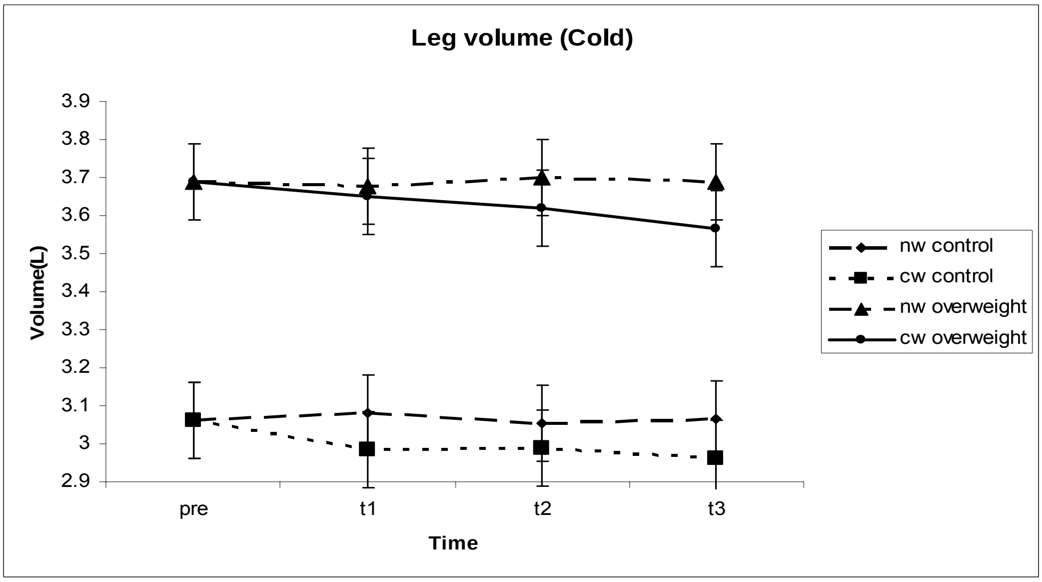


Figure 28 Comparison of the left leg volume of normal and overweight groups during immersion in cold water (12º C) condition. Data were presented as mean ± SEM, statistical comparison shown was paired t- test, Pre = pre test, t 1= immediately post – test, t2 = post-test at minute 6^{th} , t3 = post-test at minutes 12^{th} , significant value < 0.05

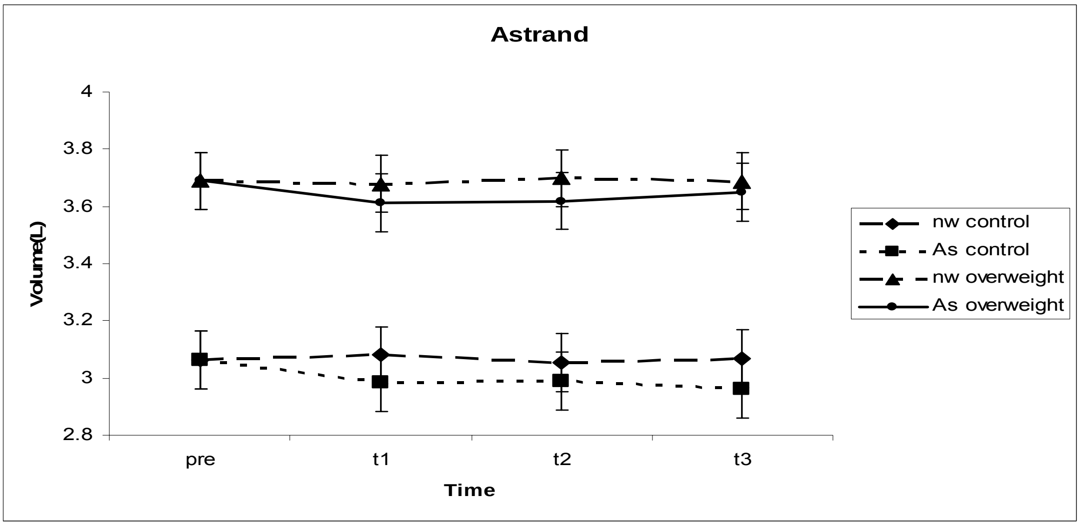


Figure 29 Comparison of the left leg volume of normal and overweight groups during immersion in normal water (30° C) condition post Astrand exercise. Data were presented as mean ± SEM, statistical comparison shown was paired t- test, Pre = pre test, t 1= immediately post – test, t2 = post-test at minute 6th , t3 = post-test at minutes 12th , significant value < 0.05

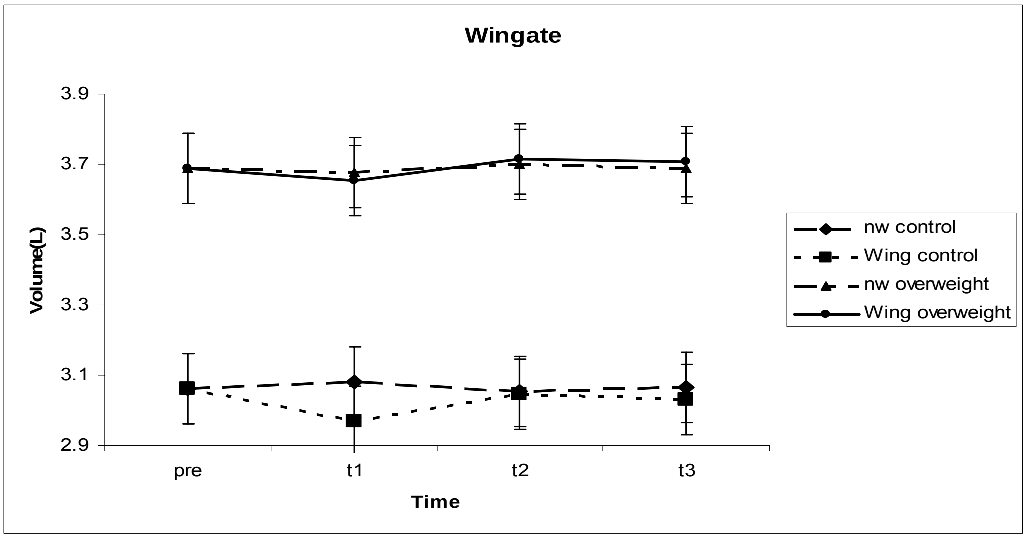


Figure 30 Comparison of the left leg volume of normal and overweight groups during immersion in normal water (30° C) condition post Wingate exercise. Data were presented as mean ± SEM, statistical comparison shown was paired t- test, Pre = pre test, t 1= immediately post – test, t2 = post-test at minute 6th , t3 = post-test at minutes 12th , significant value < 0.05

Figure31 showed the mean values of the percent volume change of the left arm in different condition; First, immersion in hot water (42ºC) condition caused no significant differences between the two groups of subjects across times. Second, immersion in cold water (12ºC) condition (Figure 32) showed no significant differences between the two groups of subjects across times. Third, immersion in normal water (30ºC) condition post Astrand exercise (Figure 33) showed no significant difference between the two groups of subjects across times. Finally, immersion in normal water (30 ºC) condition post Wingate exercise (Figure34) showed no significant differences between the two groups of subjects across times.

The comparison of the left arm volume during pre- and post- test in the same condition , showed no significant differences between the two groups of subjects all conditions .(Figure 36,37,38) excepted the immersion in hot water(42ºC) condition where, the overweight had significantly higher at the immediately post test and post test at the 6th minute compared to the control group (Figure 35) and the control group had significantly lower at the immediately post test and post test at the12th minute compared to the overweight group (Figure 35)

The mean value of the percent volume change of the left leg in different condition were shown in Figure39: First, the mean values of percent volume change during immersion in hot water (42ºC) showed no significant differences between the two groups of subjects at all time. Second, immersion in cold water (12ºC) condition (Figure40) showed no significant differences between the two groups of subjects at all time. Third, immersion in normal water (30ºC) condition post Astrand exercise (Figure 41) showed no significant differences between the two groups of subjects at all time. Finally, immersion in the normal water (30ºC) condition post Wingate exercise (Figure 42) showed no significant differences between the two groups of subjects at all time.

The comparison of the left leg volume during immersion in hot water (42º) pre and post- test in the same condition showed no significant differences between the groups of subjects at all time but the control group had a significant greater volume at the12th minute post test compared to pre test (Figure 43) . In contrast, immersion in the cold water (12ºC) showed no significant differences between the two group of subjects at all time but the control group had a lower volume at the12th minute post test .The overweight showed significantly lower volume at the12th minute post test compare to pre test , and immediately post test (Figure44) . Immersion in normal water (30ºC) post Astrand exercise showed no significant differences volume between the two group of subjects at all time ,however, the overweight group had significantly lower volume at immediately post test compare to pre test and at the 6th minute post test compared to pre test (Figure45).Last, immersion in normal water (30ºC) post Wingate exercise showed no significant differences volume between the two group of subjects at all time (Figure 46).

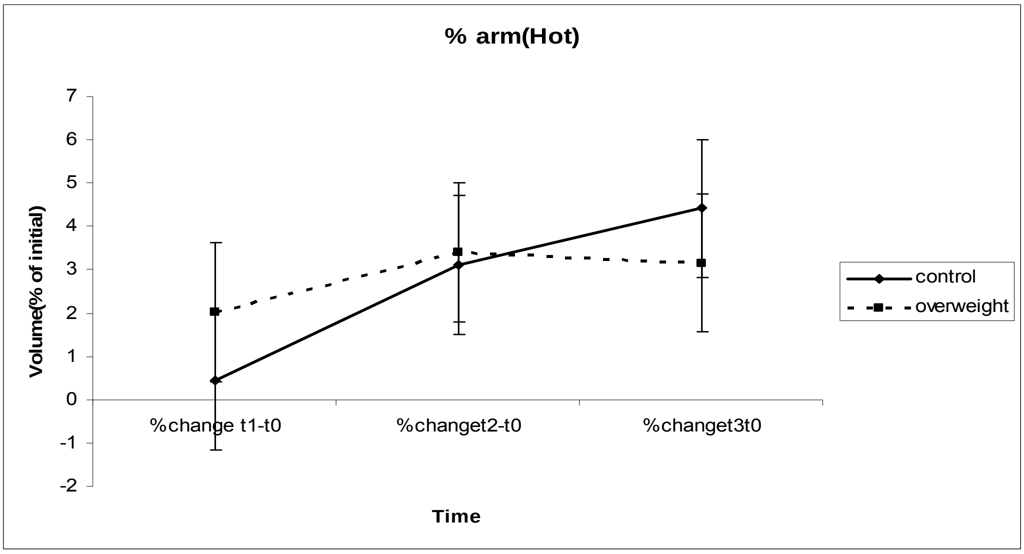


Figure 31 Comparison of the left arm percent volume change from initial of control group and overweight group in immersion in hot water (42ºC)presented as mean ± SEM , t0 = pre-test , t 1= immediately post – test , t2 = post-test at 6th minute, t3 = post-test at 12th minute , significant value < 0.05, each interval = 2 minute

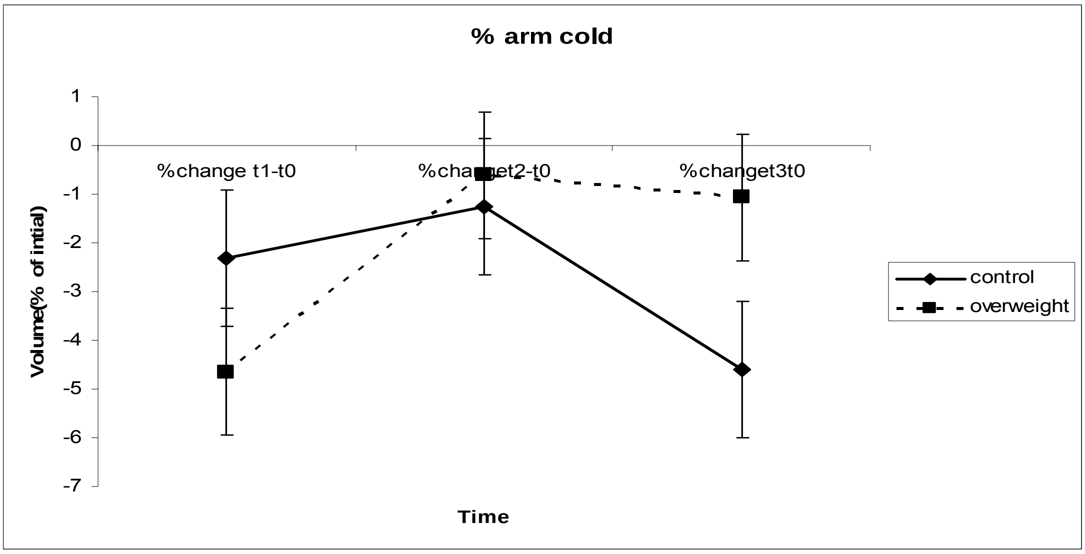


Figure 32 Comparison of the left arm percent volume change from initial of control group and overweight groimmediately post – test , t2 = post-test at 6th minute , t3 = post-test at 12th minute, significant value < 0.05, each interval = 2 minute

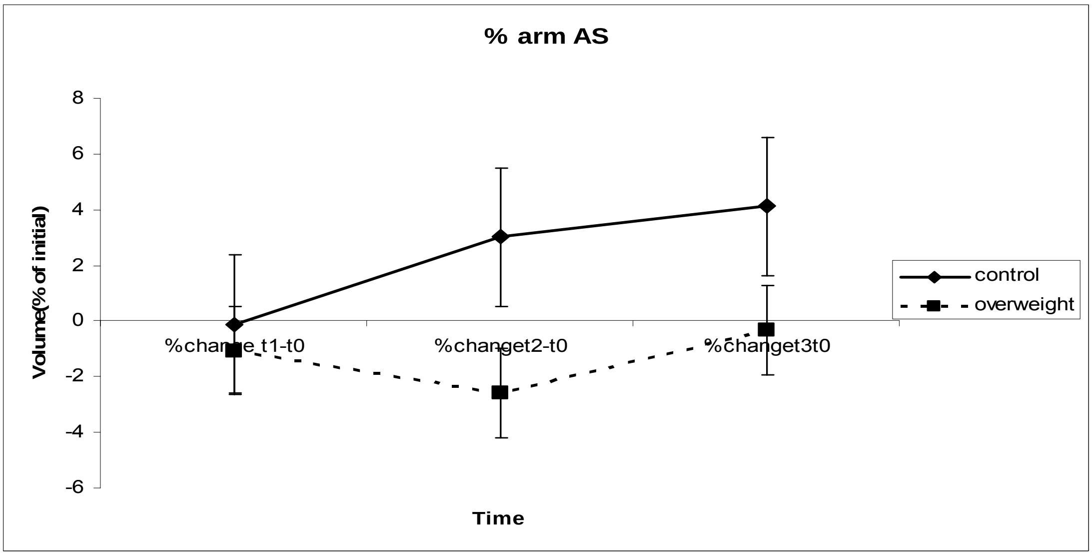


Figure 33 Comparison of the left arm percent volume change from initial of control and overweight groups during immersion in normal water (30ºC)condition post Astrand exercise. Data were presented as mean ± SEM , t0 = pre-test , t 1= immediately post – test , t2 = post-test at 6th minute , t3 = post-test at 12th minute , significant value < 0.05, each interval = 2 minute

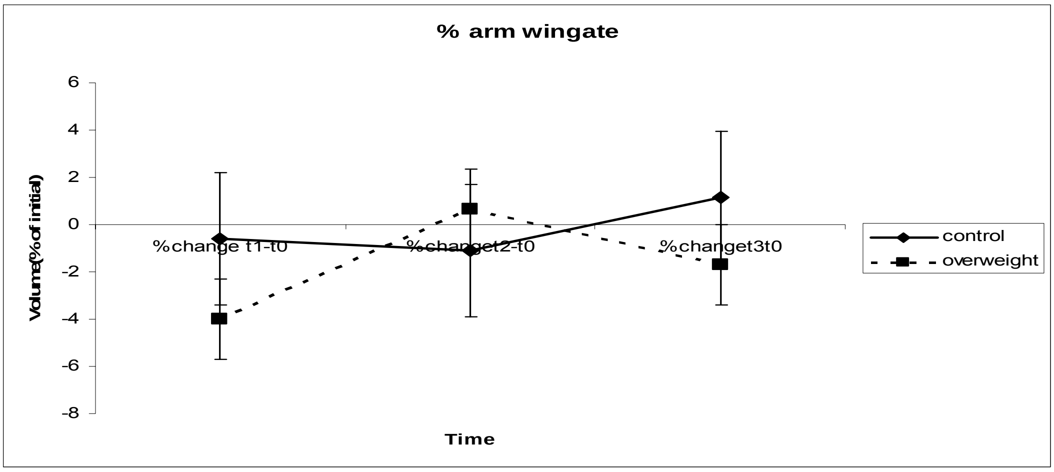
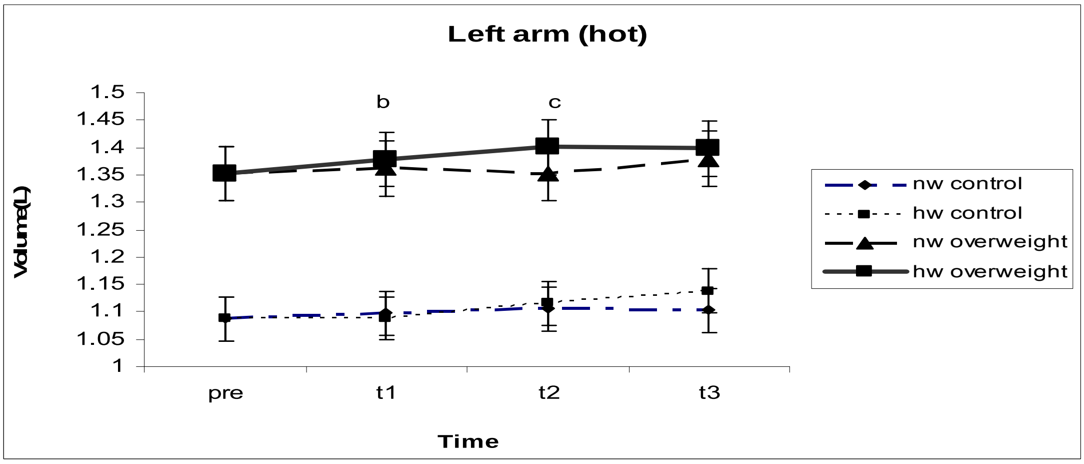
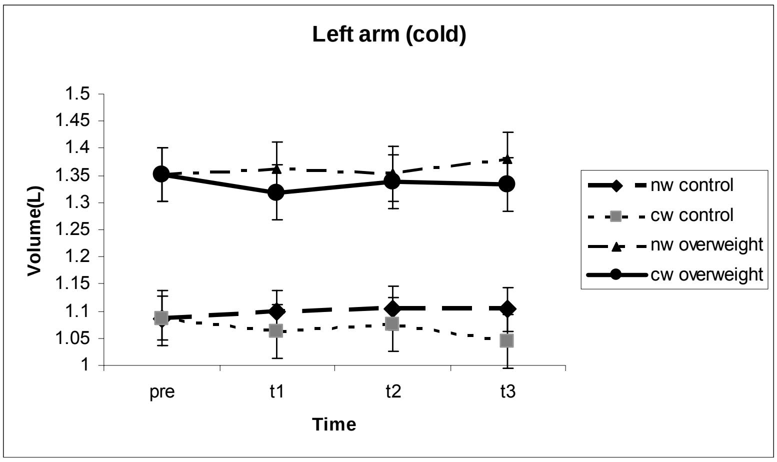


Figure 34 Comparison of the left arm percent volume change from initial of control and overweight groups during immersion in normal water (30ºC) condition post Wingate exercise. Data were presented as mean ± SEM, t0 = pre-test , t 1= immediately post – test , t2 = post-test at 6th minute , t3 = post-test at 12th minute , significant value < 0.05, each interval = 2 minute



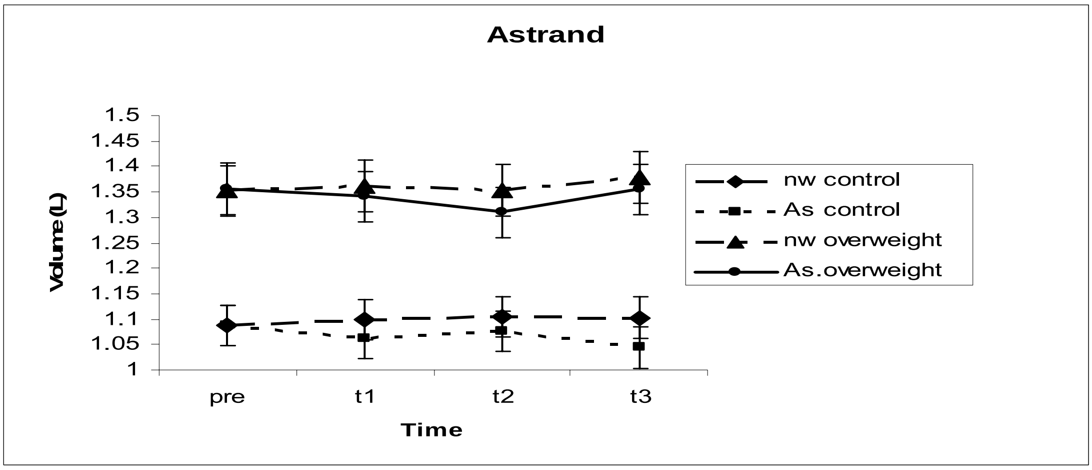
a Different from pre
b Different from t 1
c Different from t 2

Figure 35 Comparison of the left arm pre and post volume of normal and overweight groups in immersion in hot water (42º C) condition. Data were presented as mean ± SEM , Pre = pre- test , t 1= immediately post – test , t2 = post-test at 6th minute , t3 = post-test at 12th minute , significant value < 0.05 each interval = 2 minute



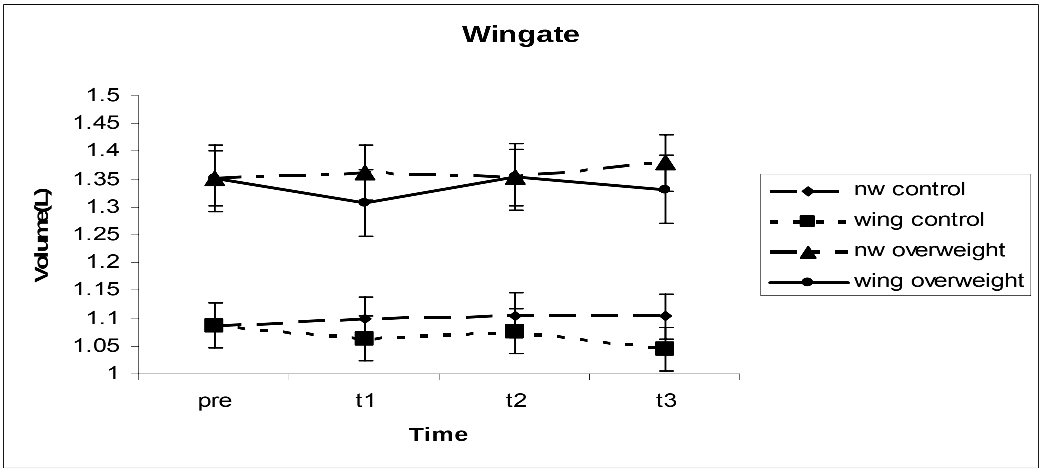
a Different from pre
b Different from t 1
c Different from t 2

Figure 36 Comparison of the left arm pre and post volume of normal and overweight groups during immersion in cold water (12º C) condition. Data were presented as mean ± SEM , Pre = pre-test , t 1= immediately post – test , t2 = post-test at 6th minute, t3 = post-test at 12th minute , significant value < 0.05 each interval = 2 minute



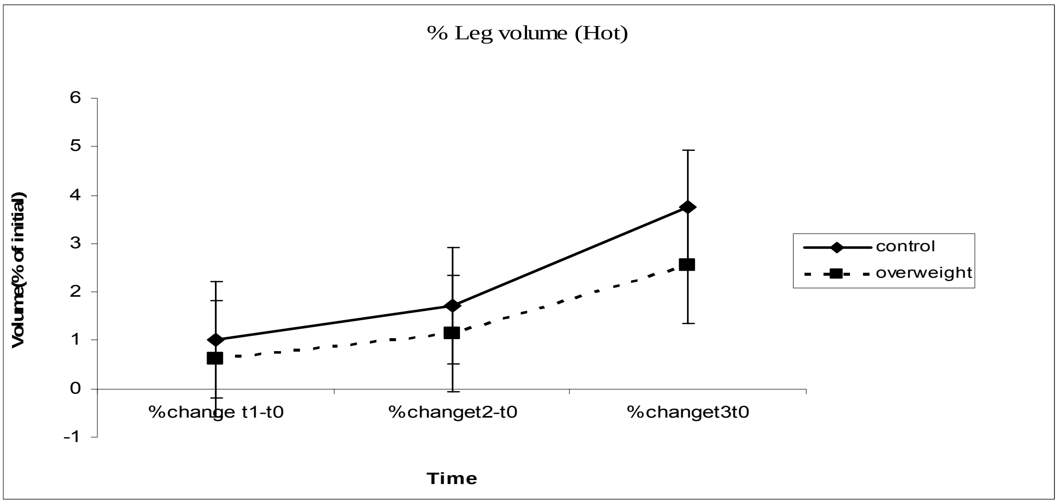
a Different from pre
b Different from t 1
c Different from t 2

Figure 37 Comparison of the left arm pre and post volume of normal and overweight groups during immersion in normal water (30º C) condition post Astrand exercise. Data were presented as mean ± SEM, Pre = pre test, t 1= immediately post – test, t2 = post-test at 6th minute, t3 = post-test at 12th minute, significant value < 0.05 each interval = 2 minute



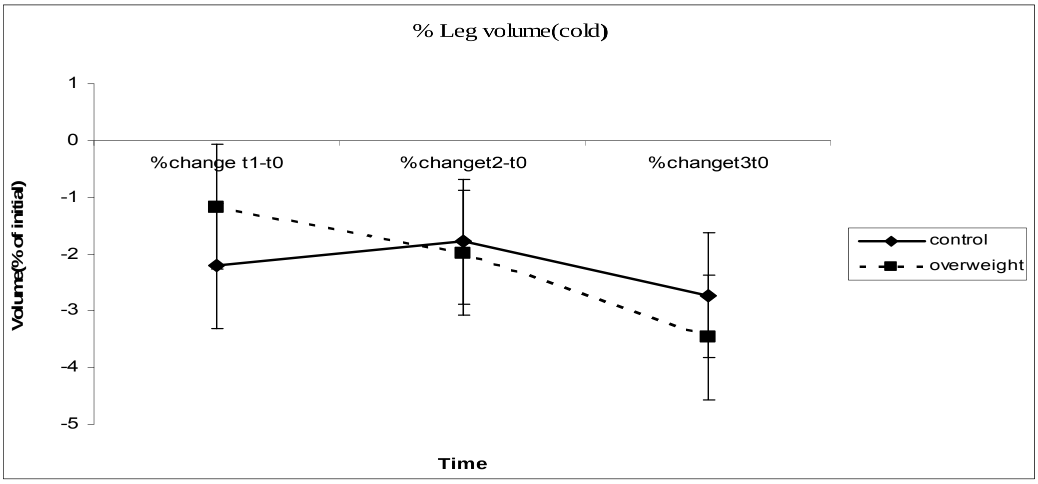
a Different from pre
b Different from t 1
c Different from t 2

Figure 38 Comparison of the left arm pre and post volume of normal and overweight groups during immersion in normal water (30º C) condition post Wingate exercise. Data were presented as mean ± SEM, Pre = pre test, t 1= immediately post – test, t2 = post-test at 6th minute , t3 = post-test at 12th minute , significant value < 0.05 each interval = 2 minute



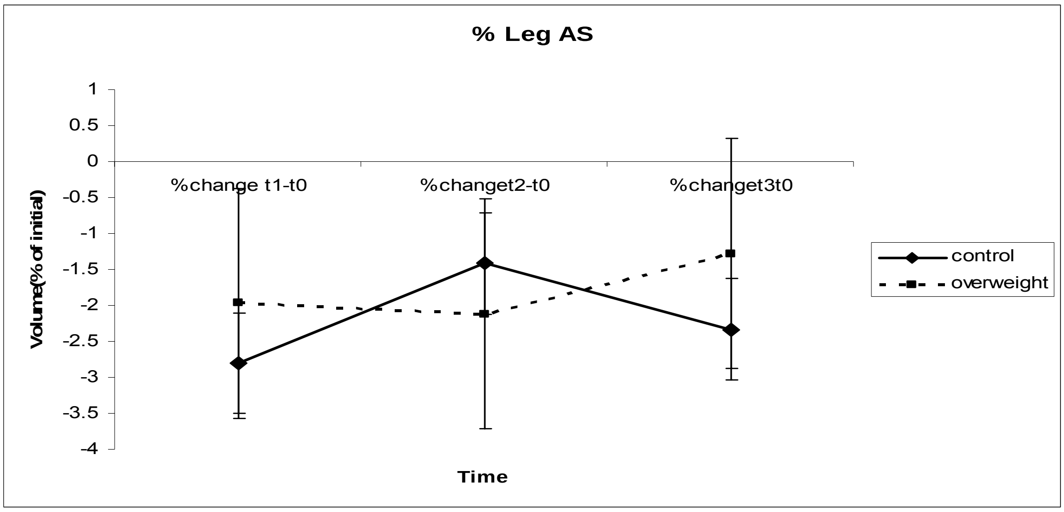
* Different from control group

Figure 39 Comparison of the left leg percent volume change from initial of control and overweight groups during immersion in hot water (42ºC) condition. Data were presented as mean ± SEM, t0 = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. Significant value p< 0.05, each interval = 2 minute



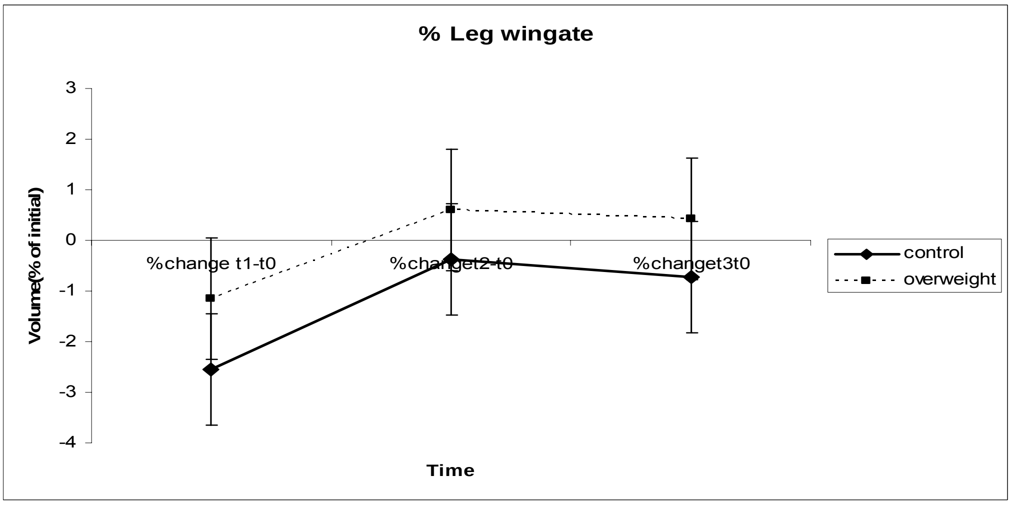
* Different from control group

Figure 40 Comparison of the left leg percent volume change from initial of control and overweight groups during immersion cold water(12ºC) condition.Data were presented as mean ± SEM , t0 = pre-test , t1 = immediately post-test , t2 = post-test at 6th minute , t3 = post-test at 12th minute. Significant value p< 0.05, each interval = 2 minute



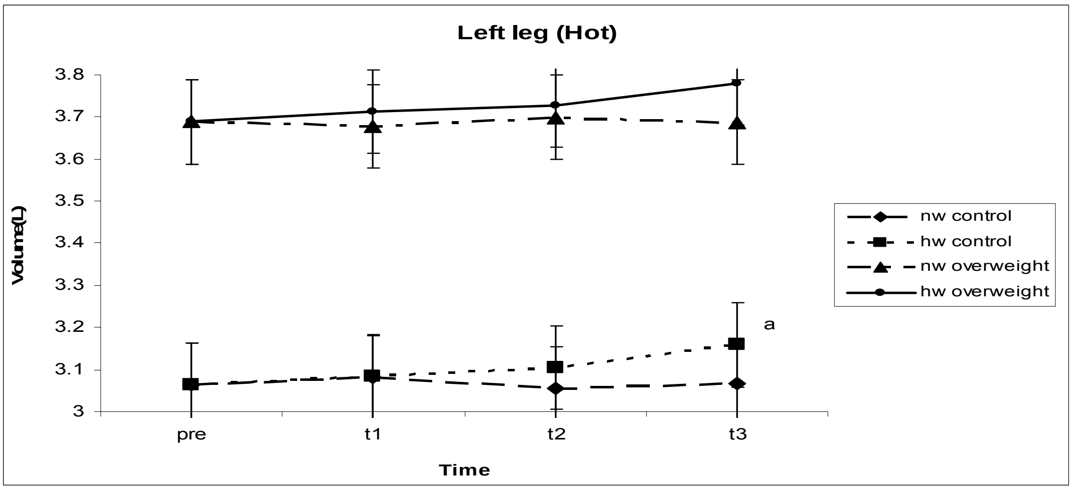
* Different from control group

Figure 41 Comparison of the left leg percent volume change from initial of control and overweight groups in normal water (30ºC) condition post Astrand exercise. Data were presented as mean ± SEM, t0 = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. Significant value $p< 0.05$, each interval = 2 minute



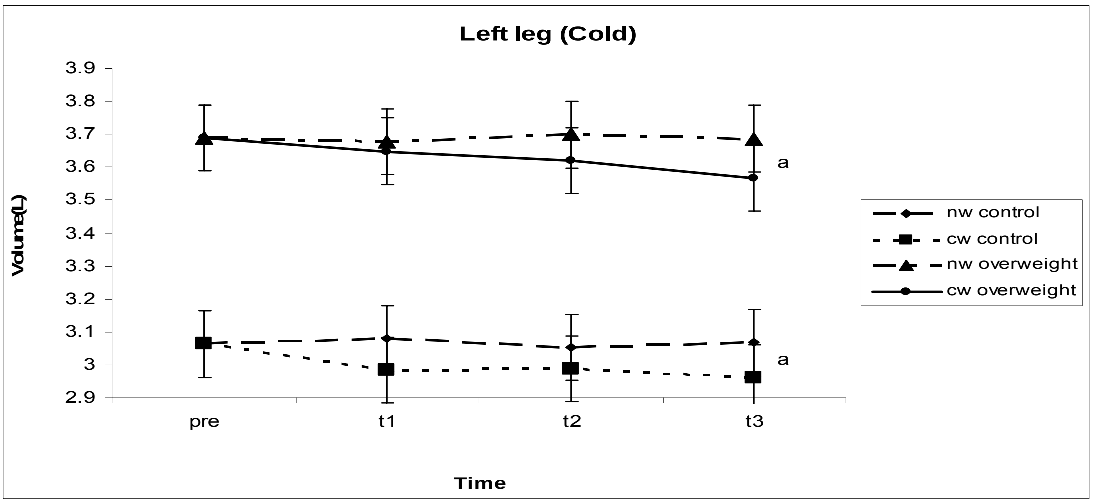
* Different from control group

Figure 42 Comparison of the left leg percent volume change from initial of control and overweight groups in normal water(30ºC) condition post Wingate exercise presented as mean ± SEM, t0 = pre-test , t1 = immediately post-test , t2 = post-test at 6th minute , t3 = post-test at 12th minute . Significant value $p< 0.05$, each interval = 2 minute



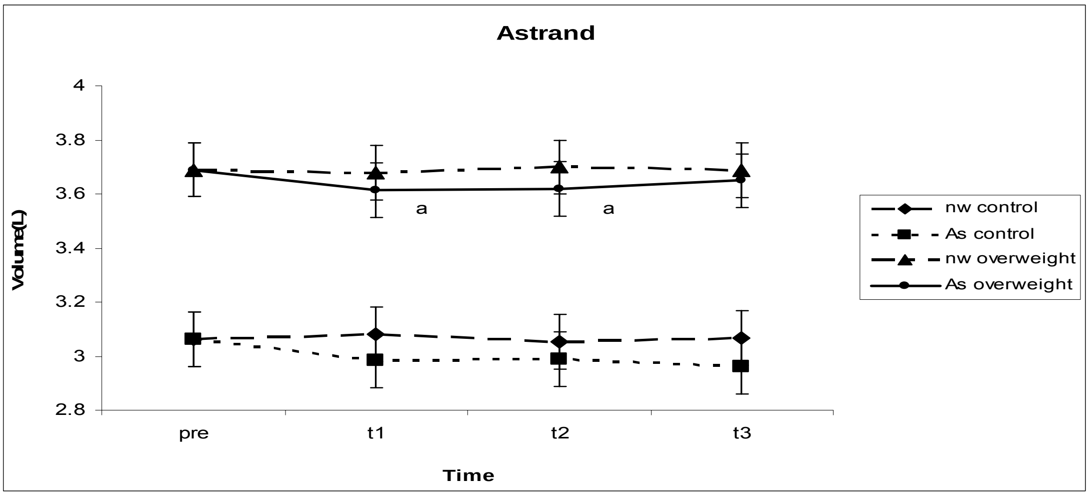
a Different from pre
b Different from t 1
c Different from t 2

Figure 43 Comparison of the left leg volume of control and overweight groups during pre- and post immersion in hot water (42ºC). Data were presented as mean ± SEM, pre = pre-test t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. nw = normal water , hw = hot water . Significant value $p< 0.05$, each interval = 2 minute



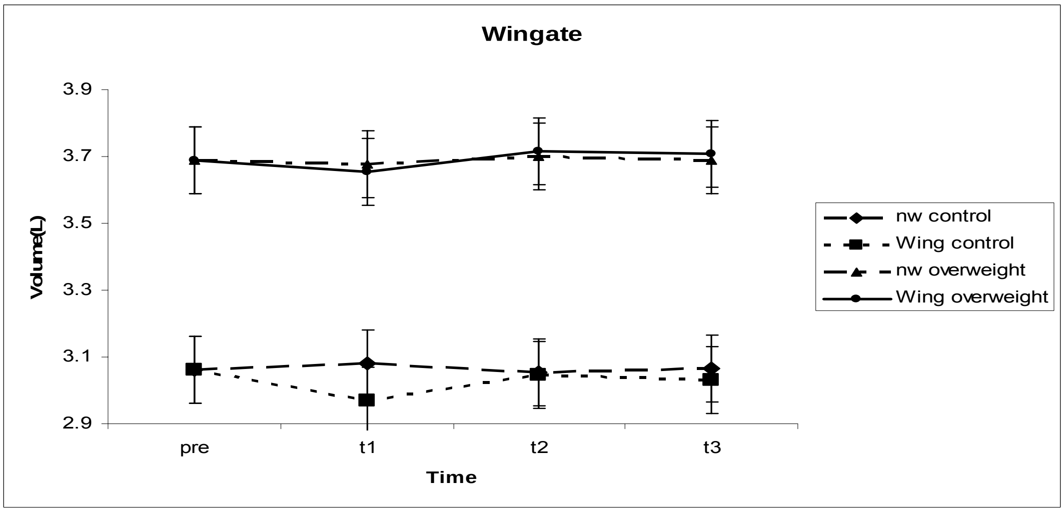
a Different from pre
b Different from t 1
c Different from t 2

Figure 44 Comparison of the left leg volume of control and overweight groups during pre- and post immersion in cold water (12ºC). Data were presented as mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. nw = normal water , cw = cold water . Significant value $p< 0.05$, each interval = 2 minute



a Different from pre
b Different from t 1
c Different from t 2

Figure 45 Comparison of the left leg volume of control and overweight group during pre- and post immersion in normal water (30ºC) condition post Astrad exercise 2 minutes. Data were presented as mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. nw = normal water , As = Astrand . Significant value $p < 0.05$, each interval = 2 minute



a Different from pre
b Different from t 1
c Different from t 2

Figure 46 Comparison of the left leg volume of control and overweight groups during pre-and post volume immersion in normal water (30ºC) condition postWingate exercise 2 minutes. Data were presented as mean ± SEM, pre = pre-test, t1 =

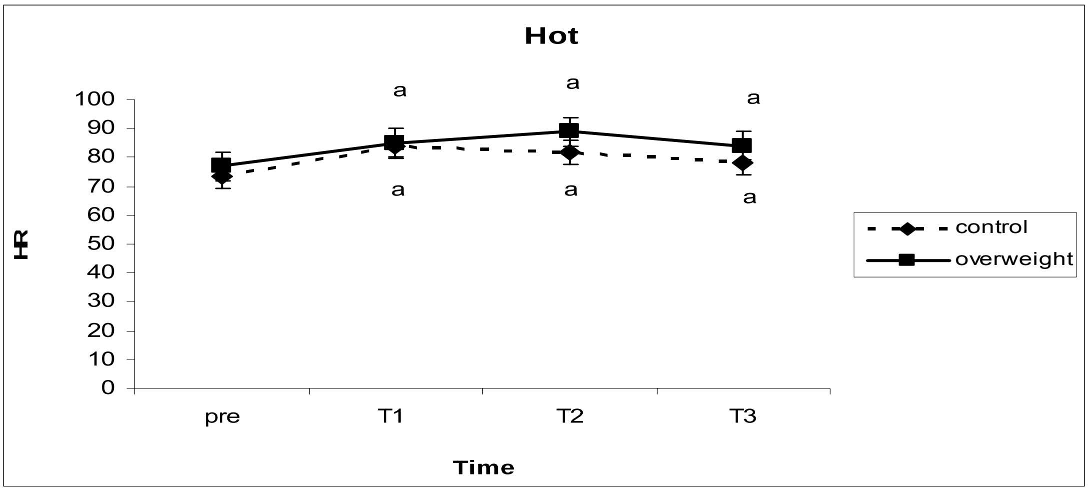
immediately post-test, t2 = post-test at minute 6th ,t3 = post-test at minute 12th . nw = normal water , Wing=Wingate . Significant value $p< 0.05$, each interval = 2 minute

The comparison of heart rate between groups showed that the overweight showed significantly higher compare to control at immersion left leg into cold water(12°C) at 6th and 12th minute and in immersion in normal water (30°C) post Astrand exercise at immediately post exercise .The comparison of the heart rate in pre and post- test in repeated measure ANOVA method in the same condition , the result show that ; First, immersion the left arm and the left leg in hot water (42ºC) condition; values of the heart rate(Figure 47) of the overweight group showed significantly higher at all time compare to pre-test ($p<0.05$),in control group found significantly higher at all time compare to the pre-test similar to the overweight group.

Second condition, immersion the left arm and the left leg in cold water (12ºC) condition; values of heart rate (Figure 48) showed that the control group found significantly higher at immediately post-test and 6th minute post- test compared to pre-test and found significantly higher at 12th minute compare to immediately post-test and 6th minute post-test as well ($p<0.05$), in overweight group showed significantly higher at all times compared to pre-test ($p<0.05$).

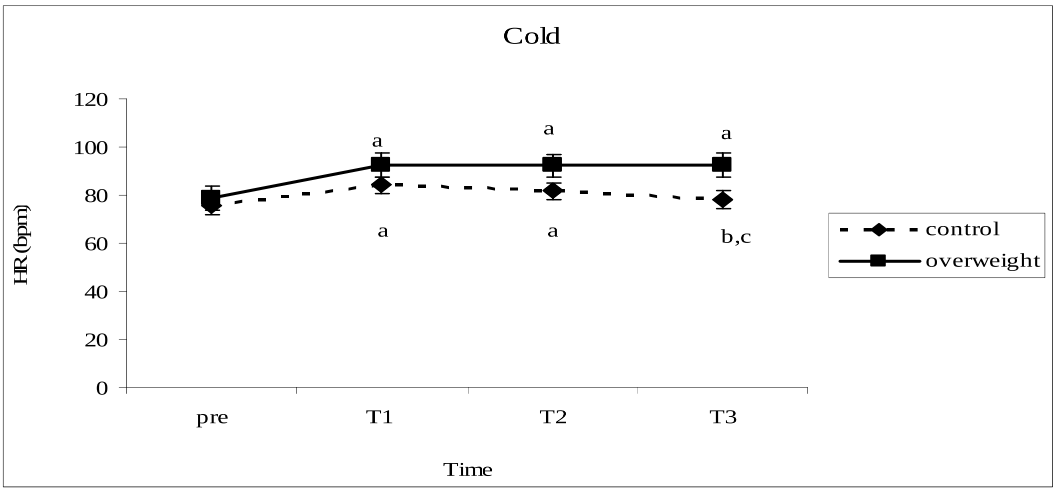
Third condition , immersion the left arm and the left leg in normal water (30ºC) post Astrand exercise 2 minutes condition; values of heart rate (Figure 49) showed that both groups showed significantly higher at all times compare to pre-test ($p<0.05$) . Finally condition, immersion the left arm and the left leg in normal water (30ºC) post Wingate exercise 2 minutes condition ; values of heart rate (Figure 50) showed that both groups found significantly higher at all times compare to pre-test ($p<0.05$)

The comparison of percent change of the heart rate between group showed significantly differences between the two groups in immersion the left arm and the left leg in normal water (30ºC) post Astrand exercise 2 minutes condition and immersion the left arm and the left leg in cold water (12ºC) condition but the comparison of the percent change of the heart rate in pre and post test in repeated measure ANOVA method in the same condition , the result showed that ; First , immersion the left arm and the left leg in hot water (42ºC) condition; percent change values of the heart rate (Figure 51) showed that both groups showed no significant differences between pre and post test of the same subject at all time. Second condition, immersion the left arm and the left leg in cold water (12ºC) condition; percent change values of the heart rate (Figure 52) showed that in the control group found significantly lower at 12^{th} minute compare to immediately post test and at 12^{th} compare to 6^{th} minute showed that significantly lower as well whereas the overweight group showed no significant differences between pre- and post-test of the same subject at all time. Third condition , immersion the left arm and the left leg in normal water(30ºC) post Astrand exercise 2 minutes condition; percent change values of the heart rate (Figure 53) showed that both groups showed significantly lower at 6^{th} minute compare to immediately post-test , significantly lower at 12^{th} minute compare to immediately post-test and 6^{th} minute ($p<0.05$) . Finally condition , immersion the left arm and the left leg in normal water (30ºC) post- Wingate exercise 2 minutes condition percent change values of the heart rate (Figure 54) showed that control groups found significantly lower at 6^{th} minute compared to immediately post-test ($p<0.05$) ,significantly lower at 12^{th} minute compared to immediately post-test($p<0.05$), in overweight group found significantly lower at 6^{th} minute compared to immediately post-test, significantly lower at 12^{th} minute compared to immediately post-test and 6^{th} minute ($p<0.05$)



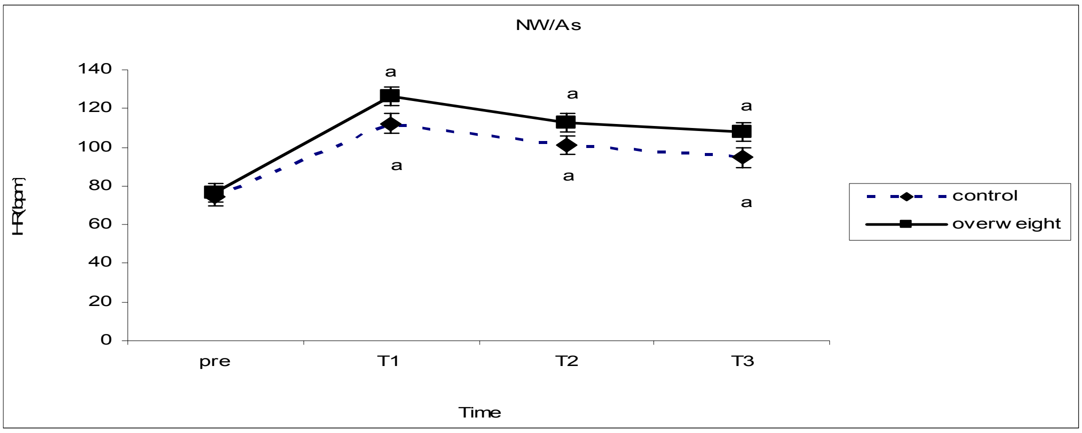
a Different from pre
b Different from t 1
c Different from t 2

Figure 47 Comparison of pre-and post-heart rate during immersion of the left leg in hot water(42ºC) condition. Data were presented as mean ± SEM , pre = pre-test , t1 = immediately post-test , t2 = post-test at 6th minute , t3 = post-test at 12th minute . nw = normal water , cw = cold water . Significant value $p < 0.05$, each interval = 2 minute



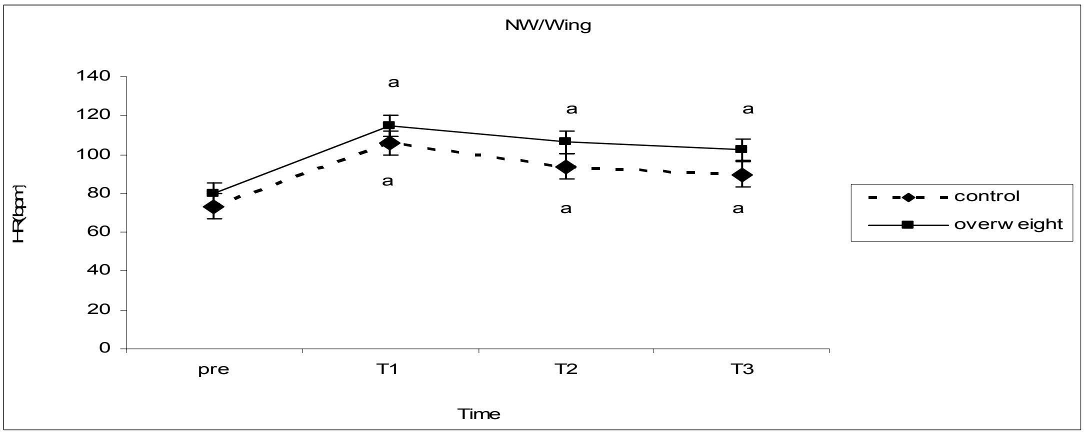
a Different from pre
b Different from t 1
c Different from t 2

Figure 48 Comparison of pre- and post- heart rate during immersion of the left leg in cold water (12ºC) condition. Data were presented as mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. Nw = normal water , cw = cold water . Significant value $p < 0.05$, each interval = 2 minute



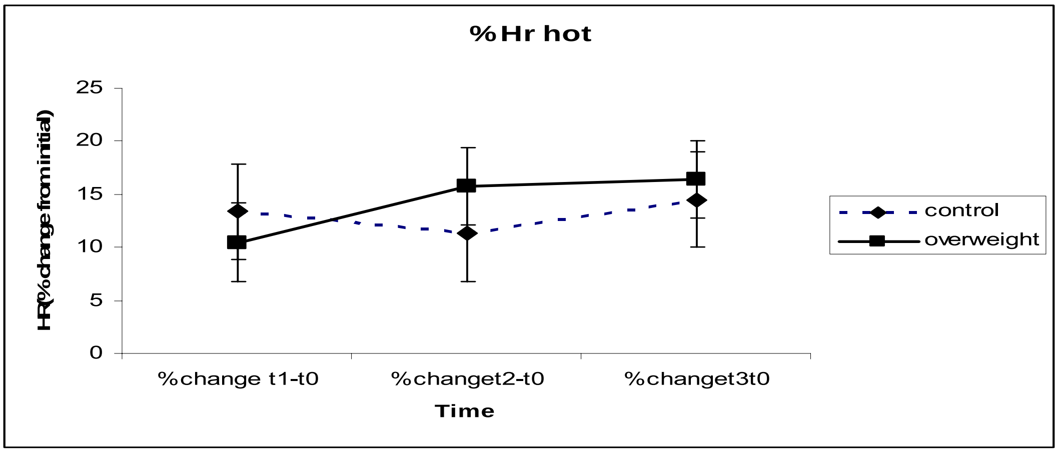
a Different from pre
b Different from t 1
c Different from t 2

Figure 49 Comparison of pre- and post-heart rate during immersion of the left leg in normal water (30ºC) post Astrand exercise 2 minute condition. Data were presented as mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th volume minute. nw = normal water , cw = cold water . Significant value $p < 0.05$, each interval = 2 minute



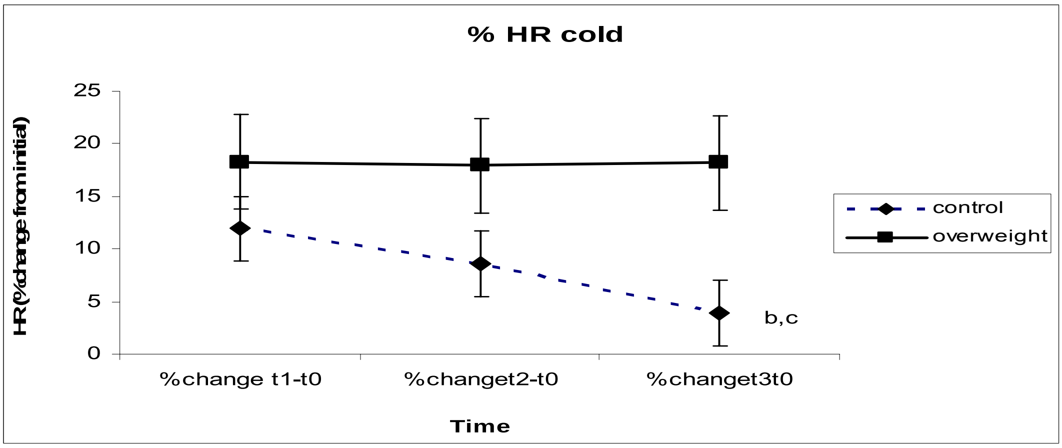
a Different from pre
b Different from t 1
c Different from t 2

Figure 50 Comparison of pre-and post-heart rate during immersion of the left leg in normal water (30ºC) post Wingate exercise 2 minute conditions. Data were presented as mean ± SEM, statistical comparison shown was repeated measure ANOVA, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. nw = normal water , cw = cold water . Significant value $p < 0.05$, each interval = 2 minute



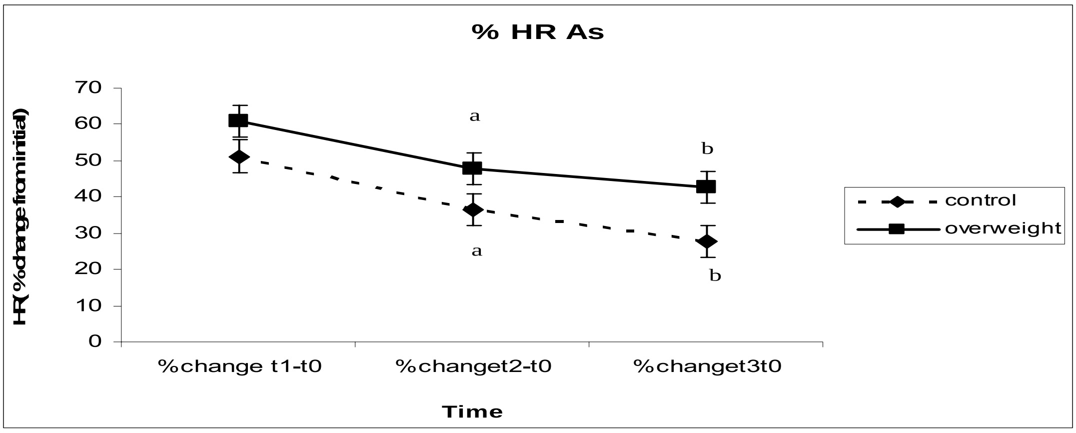
a Different from pre
b Different from t 1
c Different from t 2

Figure 51 Comparison of percent changes of heart rate of control and overweight groups pre-and post test during immersion of the left leg in hot water (42ºC) condition. Data were presented as mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. Significant value p< 0.05, each interval = 2 minute



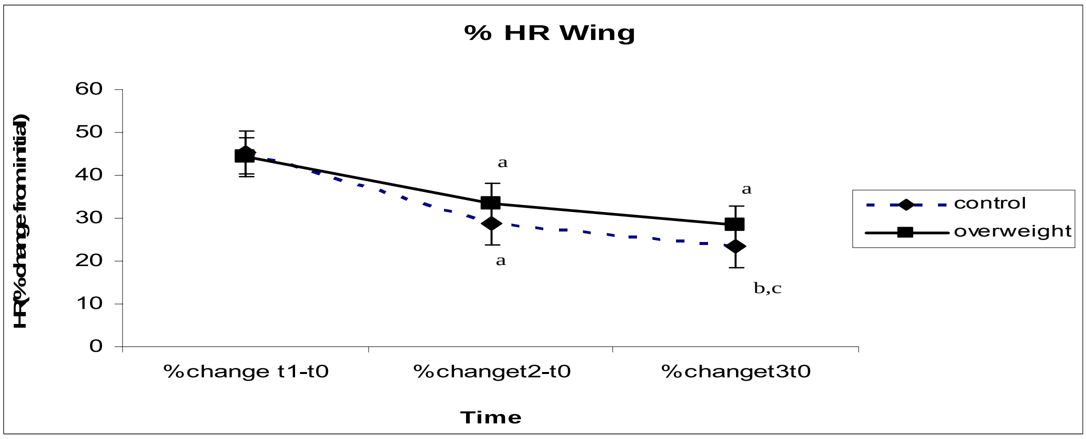
a Different from pre
b Different from t 1
c Different from t 2

Figure 52 Comparison of percent changes of heart rate of control and overweight groups pre-and post test during immersion of left leg in cold water (12ºC) condition. Data were presented as mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at minute 6th , t3 = post-test at minute 12th. Significant value p< 0.05, each interval = 2 minute



a Different from pre
b Different from t 1
c Different from t 2

Figure 53 Comparison of percent changes of heart rate of control and overweight groups pre-and post test during immersion of left leg in normal water (30ºC) post- Astrand exercise 2 minute condition. Data were presented by mean ± SEM, pre = pre-test, t1 = immediately post-test, t2 = post-test at 6th minute, t3 = post-test at 12th minute. Significant value p< 0.05, each interval = 2 minute



a Different from pre
b Different from t 1
c Different from t 2

Figure 54 Comparison of percent changes of heart rate of control and overweight groups pre-and post test during immersion of left leg in normal water (30ºC) post-Wingate exercise 2 minute condition.Data presented as mean ± SEM , pre = pre-test , t1 = immediately post-test , t2 = post-test at 6th minute, t3 = post-test at 12th minute. Significant value p< 0.05, each interval = 2 minute

Ankle Brachial Pressure Index (ABPI)

The Ankle Brachial Pressure Index of control group and overweight group calculated from measure the brachial systolic blood pressure and the ankle systolic blood pressure are showed in Table.23

First, the descriptive values of ABPI in the first evaluation showed no significant different between the two groups of subjects ($p > 0.05$). The repeated measure ANOVA test within groups showed that the control group had a similar ABPI during pre- and post-exercise after Astrad and Wingate tests,however, the overweight group had significantly lower ABPI in both condition of the two types of exercise exercise compared to the pre exercise($p<0.05$)

Table 23 The ABPI (Ankle Brachial Pressure Index) values.

Variable	ABPI		
	Pre exercise	Post-Astrand exercise	Post-Wingate exercise
Control	1.111±0.031	1.027±0.035	1.044±0.031
Overweight	1.076±0.026	0.974±0.039	0.980±0.036

Values are shown as mean ± SEM. Significant value ($p< 0.05$); A: significant from pre-exercise control, B: significant from post-exercise control. ABPI = Highest pressure from the ankle vessels / Highest pressure from the brachial vessels

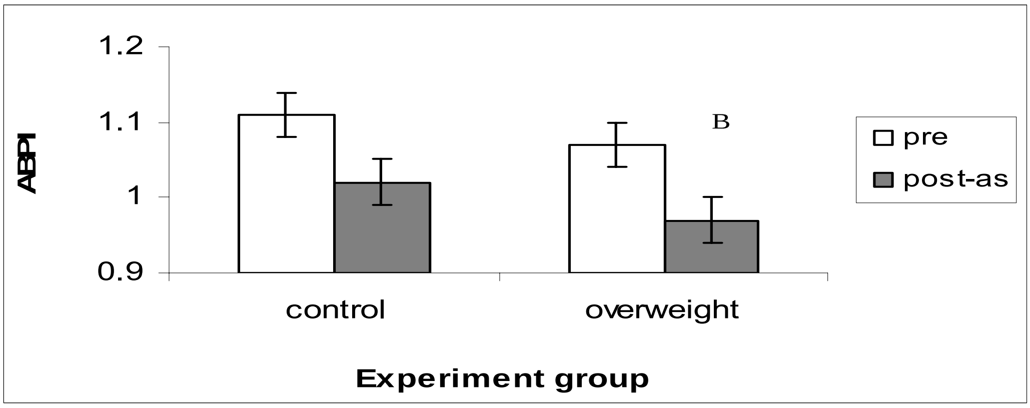


Figure 55 Comparison of the ABPI of the control and the overweight groups during pre-and post-Astrand exercise 15 minute .Data were presented as mean±SEM , Significant value p<0.05, A; different from Pre exercise control , B; different from Pre exercise overweight

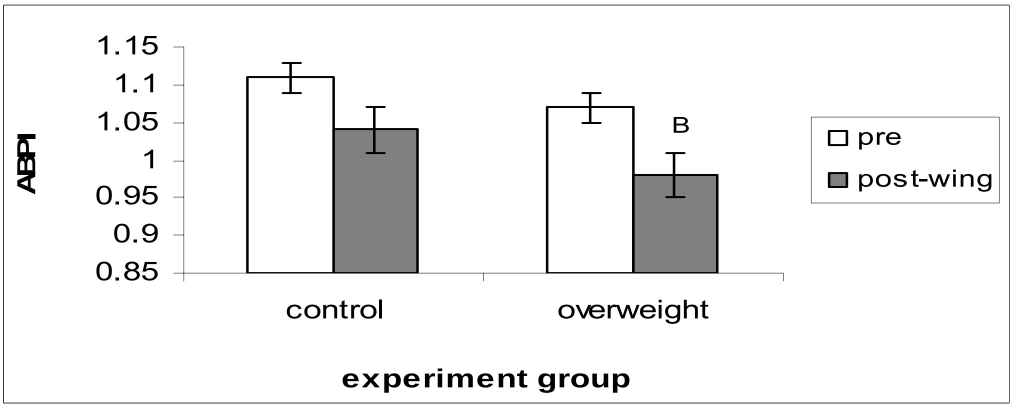


Figure 56 Comparison of the ABPI of the control and the overweight groups during pre-and post-Wingate exercise 15 minute .Data were presented as mean±SEM , Significant value p<0.05, A; different from Pre exercise control , B; different from Pre exercise overweight

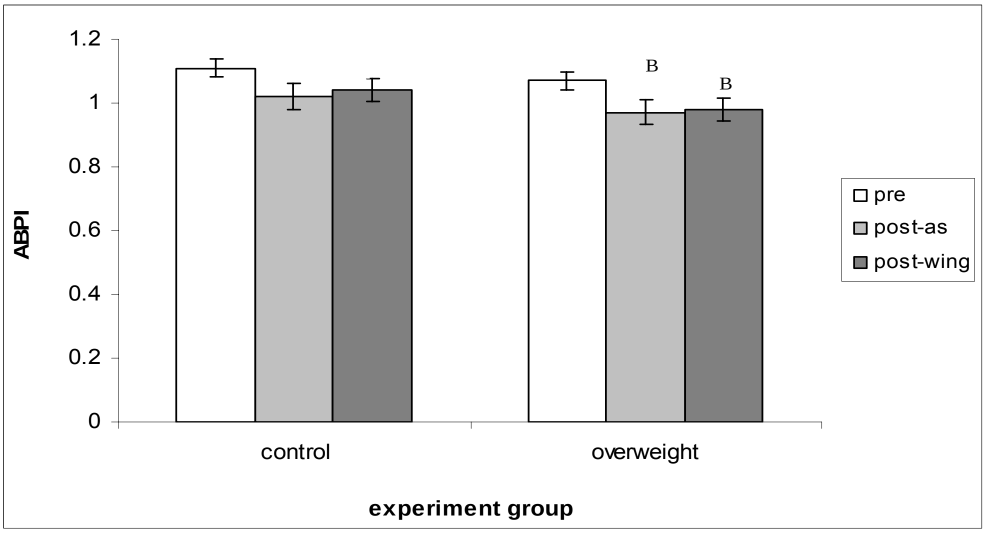


Figure 57 Comparison of the ABPI of the control and the overweight groups during pre-exercise, post-Astrand exercise and post-Wingate exercise 15 minute. Data were presented as mean±SEM , Significant value p<0.05, A; different from Pre exercise control , B; different from Pre exercise overweight

When calculate the Mean Arterial Blood Pressure (MABP) ratio of the left arm (a) and the right arm (b), the left leg (c) and the right leg (d) that showed in Table.24; the descriptive values at ratio in the left arm and the right arm (a/b) of the overweight group showed significant greater than the control group in the post Astrand exercise($p<0.05$) . The repeated measure within groups showed that; the overweight group had significantly higher in ratio of MABP of the left arm and the right arm (a/b) compare to pre exercise. ($p<0.05$). (Figure 59)

Secondly, the descriptive values of MAPR in post Wingate exercise compare pre exercise showed Table 25 no significant difference between the two groups of the subjects ($p<0.05$) . The repeated measure within group showed no significant differences of all condition.

Table 24 The MAPR values calculated from ratio of MABP (Mean Arterial Blood Pressure) in the left arm, the right arm ,the left leg and the right leg during Pre-exercise and Post Astrand exercise

Group	Pre -exercise				Post- Astrand exercise			
	a/c	b/d	a/b	c/d	a/c	b/d	a/b	c/d
Control	0.94± 0.03	0.96± 0.03	0.97± 0.02	1.00± 0.03	0.98± 0.03	1.02± 0.04	0.97± 0.02	1.01± 0.03
Overweight	0.99± 0.01	0.98± 0.01	1.01± 0.01	1.02± 0.03	1.07± 0.05	1.05± 0.03	1.05± 0.01	1.06± 0.06

Values of MABP and shown as mean± SEM. Significant value $p<0.05$; *significant from the control group A; significant different from Pre exercise control, B; significant from Pre exercise overweight a: MABP of the left arm , b:MABP of the right arm , c: MABP of the left leg and d: MABP of the right leg

Table 25 The MABP values calculated from ratio of MABP (Mean Arterial Blood Pressure) in the left arm, the right arm ,the left leg and the right leg during Pre-exercise and Post- Wingate exercise

Group	Pre exercise				Post Wingate exercise			
	a/c	b/d	a/b	c/d	a/c	b/d	a/b	c/d
Control	0.94± 0.03	0.96± 0.03	0.97± 0.02	1.00± 0.03	10.1± 0.02	0.96± 0.01	1.02± 0.01	0.96± 0.02
Overweight	0.99± 0.01	0.98± 0.01	1.01± 0.01	1.02± 0.03	1.06± 0.03	1.06± 0.05	1.03± 0.01	1.03± 0.04

Values of MAPR and shown as mean± SEM. Significant value p<0.05; *significant from the control group A; significant different from Pre exercise control, B; significant from Pre exercise overweight

a: MABP of the left arm , b:MABP of the right arm , c: MABP of the left leg and d: MABP of the right leg

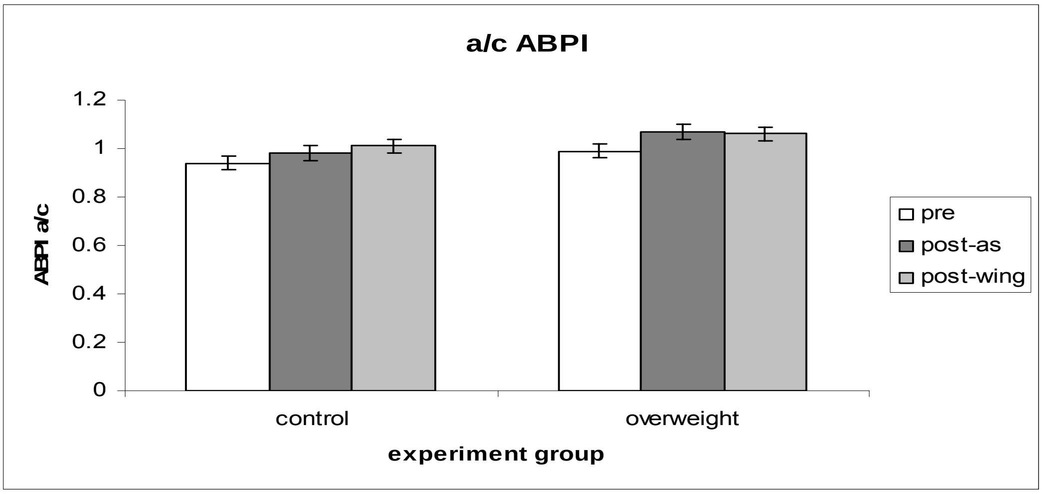


Figure 58 Comparison of the three sessions of the MABP(a/c) of the control group and the overweight group presented as mean±SEM , Significant value p< 0.05 , A : significant different from Pre-exercise control , B : significant different from Pre- exercise overweight , a : MABP of the left arm , b: MABP of the right arm ,c: MABP of the left leg and d : MABP of the right leg

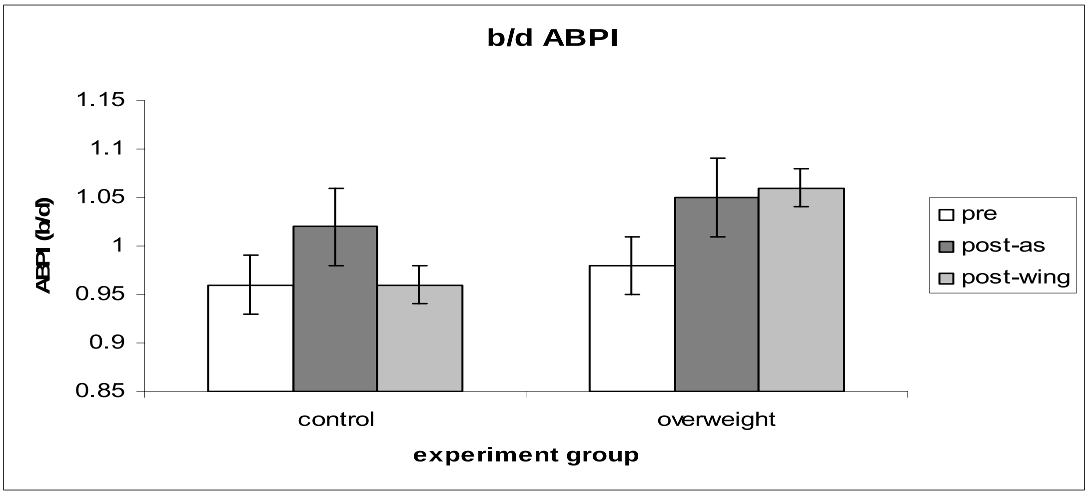


Figure 59 Comparison of the three sessions of the MABP(b/d) of the control group and the overweight group presented as mean±SEM , Significant value $p < 0.05$, A : significant different from Pre-exercise control , B : significant different from Pre-exercise overweight , a : MABP of the left arm , b: MABP of the right arm ,c: MABP of the left leg and d : MABP of the right leg

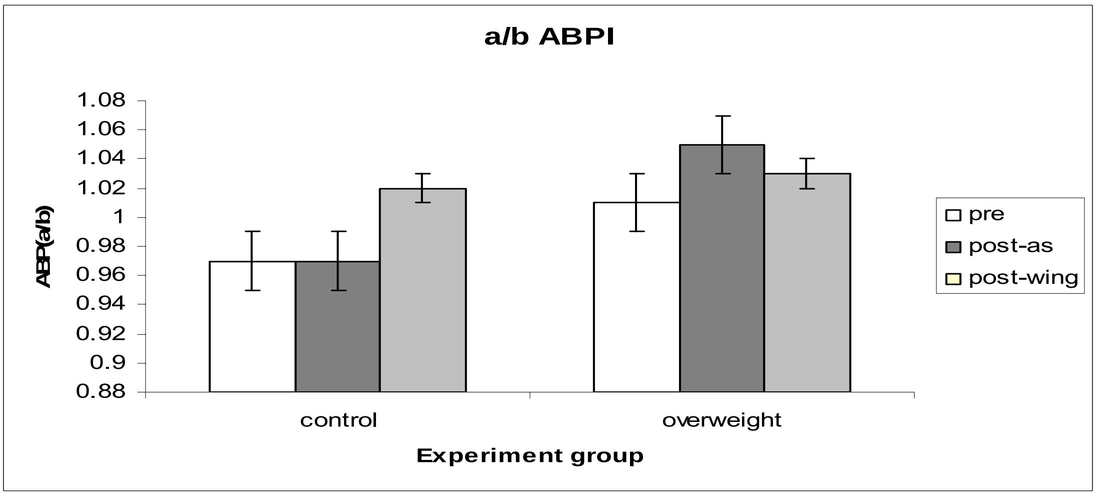


Figure 60 Comparison of the three sessions of the MABP(a/b) of the control group and the overweight group presented as mean±SEM , Significant value $p < 0.05$, A : significant different from Pre- exercise control , B : significant different from Pre-exercise overweight , a : MABP of the left arm , b: MABP of the right arm ,c: MABP of the left leg and d : MABP of the right leg

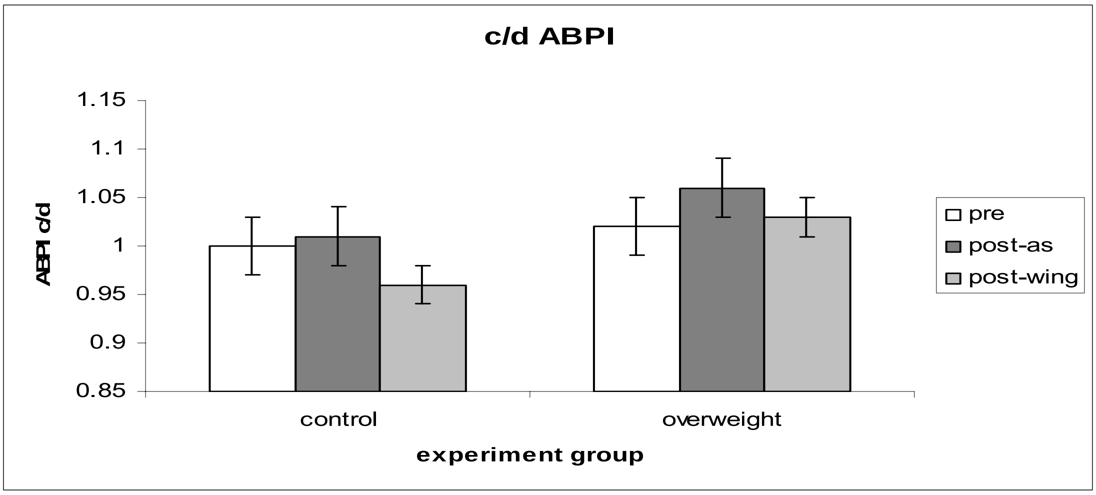


Figure 61 Comparison of the three sessions of the MABP(c/d) of the control group and the overweight group presented as mean±SEM , Significant value $p< 0.05$, A : significant different from Pre- exercise control , B : significant different from Pre-exercise overweight , a : MABP of the left arm , b: MABP of the right arm ,c: MABP of the left leg and d : MABP of the right leg

CHAPTER V
DISCUSSION

The characteristics of subjects

In this study, the basic physical characteristics of the subjects used such as age, height, heart rate (HR) and waist- hip ratio (W/H) of the overweight group and the control group were similar. Compare to the overweight group, the control group showed greater of some fitness parameter such as indicated by higher value of maximum oxygen consumption and the overweight group showed greater of systolic blood pressure, diastolic blood pressure, body mass index (BMI),percent fat, lean body mass(LBM), waist circumferences and hip circumferences. There are proposed mechanism that could explain the performance gain in the control and the overweight groups. Firstly, overweight refers to increased body weight in relation to height, when compared to some standard of acceptable weight. Overweight may or may not be due to increases in body fat. Karpe and Frayn (2002) said that where the fat gets stored may have important consequences for health(28). Fat in the upper parts of the body seems to lead to increased risk of cardiovascular disease or diabetes. Fat tissue is highly regulated by the nervous system, by the rate of blood flow through the tissue, and by a complex mixture of hormones and fats that are delivered in the blood.So, these factors may explain why the overweight group shows greater of systolic and diastolic blood pressure .Secondly, in support of this notion, Anne-Caroline Norman et al. (2006) studied the influence of excess adiposity on exercise fitness and performance in overweight children and adolescents. The result showed that overweight and non overweight adolescents had similar absolute $\dot{V}O2$ at the lactate threshold and at maximal exertion, suggesting that overweight adolescents are more limited by the increased in cardio- respiratory effort required to move their larger body mass through space than by cardio- respiratory deconditioning. The higher percentage of oxygen consumed during sub-maximal exercise indicates that overweight adolescents are burdened by the metabolic cost of their excess mass. Their greater oxygen demand during an unloaded task predicted poorer performance during sustained exercise. Exercise prescriptions for overweight adolescents should account for the limited exercise tolerance imposed by excess body mass, focusing on activities that keep demands below lactate threshold so that exercise can be sustained (6). Overweight is the situation of excess weight and found that the excess weight in the form of body fat puts a strain on the entire circulatory system. Persons with excess body fat are more likely to develop high cholesterol, high blood pressure, heart disease and stroke even if they have no other risk factors. Overweight becomes obesity when excess fat has accumulated to the extent that it may adversely affect health and is most commonly defined by the use of criteria involving the body mass index (BMI = kg/m2). BMI≥ 25 can be associated with a reduced life expectancy and a risk of exacerbating many diseases (60).

Neuropsychophysiological performance

In this study, the neuropsychophysiological performance were investigated by psychomotor tests including reaction time (RT) determination, response time task (Res T), speed of tapping (TST) in time limitation and critical flicker fusion frequency (CFFF) by visual activation. These tests compose of various physiological component ; the time spent from stimulus application plus time spent for sensory nerve impulse travel to the brain plus integration of signals and decision making plus time spent in motor pathways and muscle contractions . The psychomotor speeds data have been shown to reflect quite well with the degree of physical fitness.

Firstly, reaction time (RT) is a time between stimulus and response**:** the interval of time between the application of a stimulus to an end organ of sense and the reaction or resulting movement. This study used warned the simple reaction time (WRT) obtained from a subjects who was warned a few seconds before an actual stimulation, therefore the subject is mentally more prepared to respond to the actual stimulus. This study showed that the control group displayed significantly shorter in warned auditory reaction time of the right big toe in post exercise when compare to pre exercise .These present study may imply that the overweight may have some pathological that concern with the reaction time. There were previous reports may support these finding such as Beverly and co-worker(2006) said that reaction time is not merely an indicator of age-related physiological deteriorations but rather an indicator of the brain's more basic information processing ability, suggesting that slower and more variable processing skills are a risk factor for mortality in themselves(8). Chentanez. and co-worker (1990) suggested that the measurement of reaction time could be used in confirming the location of lesion in the patient with neuronal circuit damaged in brain, spinal cord or peripheral nerve pathways (16).

Secondly, the response time is the time elapsing between the onset of a stimulus and the onset of a response to that stimulus. In this study showed that the warned tactile reaction time at 7^{th} cervical level stimulation of the right big toe of the overweight displayed significantly shorter than the control group in post exercise .Furthermore, the overweight displayed significantly shorter than the control in warned tactile reaction time at 7^{th} cervical level stimulation of the left big toe in post exercise. This present study displayed that the overweight group in this study may not yet have an effect to the reaction time. In the previous study showed that the vascular endothelium plays an important role in the regulation of arterial tone, thrombosis, and inflammation. The common condition associated with endothelial dysfunction is overweight and obesity (52). These results may support by the finding of DeSouza, et al in 2005 suggested that if basal endothelial nitric oxide release is reduced in overweight and obese adult humans. Its may contribute to the obesity-related increase in cardiovascular risk and its clinical consequences including hypertension, coronary vasospasm, and myocardial infarction. They found that the basal endothelial nitric oxide release is not impaired in overweight and obese adults. (20)

Thirdly, the tapping test has been originally developed as part of neuropsychological tests, is a simple measure of motor speed and motor control and is used in neuropsychology as a sensitive test for brain damage (Mitrushina et al., 1999) (44). Although motor functioning in humans is controlled by many areas of the brain, the motor strip rostral to the central sulcus is most important, and the functioning of this area is reflected directly in the tapping test (Russell et al., 1970) (53). As well as direct motor effects, the speed, co-ordination, and pacing requirements of finger tapping can be affected by levels of alertness, impaired ability to focus attention, or slowing of responses. By examining both level of performance and by comparing the two sides of the body, tests of motor performance can be used as reliable indicators of the integrity of brain functions (Dodrill et al., 1978) (24). In 2004 Christianson and co-worker suggested that the higher tapping scores were obtained using the dominant hand, males obtained higher scores than females, and there was a decrease in tapping speed associated with increasing age (19). Moreover, Wilson and co-worker (1971) found that there was positive correlations and have been demonstrated between tapping speed and intelligence (64). In this study it was found that the overweight group had significantly higher speed of the left index finger than the control group in post-exercise. This result showed that the exercise can improve the motor control of psychomotor performance. Chentanez and colleague (2004) said that the response time may be also used to predict the athlete's fitness levels (17).

Fourthly, the critical flicker fusion frequency (CFFF) is the measure of the ability to distinguish discrete sensory events, it is thought by some to provide an index of central nervous system (CNS) activity .The CFFF is used in the study of human behaviours; and it is commonly applied to the study of fatigue. The critical fusion flicker frequency (CFFF) is useful for assessing the temporal characteristics of the visual system and believed to reflect activity in the central visual system. The human visual system is the threshold sensitivity for a sine wave-modulated patch of monochromatic flickering light measured as a function of its temporal frequency and average luminance level. CFFF is the lowest frequency flicker light was measured in cycles per second or hertz (Hz) that is required to produce an appearance of steady light during observing. When the light is flickered at a rate equal to or greater than the critical threshold, the individual flashes cannot be resolved and the light is indistinguishable from steady, non flickering light. At flickering rates below the CFFF threshold, each flash can be resolved and flickering lights can be discriminated from steady lights (Elizabeth and co-worker, 2001).

In this present study, the overweight had both critical flicker light low to high frequency (CFFF L-H) and high to low frequency (CFFF H-L) lower than the control group before and after exercise. These present study displayed that the overweight may not the only factor have been affected with this testing. The support of these results is Harkaitz et al (2007) studied the role of visual stimuli on the development of the vascular pattern in dark-reared rat and found that the enriched environment without the physical exercise component does not exert effects in dark-reared rats.Visual experience increases the number and size of synapses per neuron (Sirevaag et al.;1988), as well as neuronal activity (Gilbert et al;1998). These changes lead to an increase of metabolic demand (Black et al; 1990) that is satisfied by the adaptive remodelling of the vascular network (Sirevaag et al;1988) .In the other hand may need the further study to find out the degree of being overweight would be effected to CFFF.

Volume of extremities

Two common methods of determining volume in clinical practice are water displacement and circumferential measurements. Water volume is considered by some authors as the "gold standard" for volumetric measurements and provides a way of including volumetric measurements of the hand or foot in the total limb volume measurement(49,56). Boland and Adams (1966) found an intraclass correlation coefficient of .99 for reliability of measurements of the volume of the hand and forearm in 16 women and 7 men without swelling. Their method detected a change in volume as small as 10 (mL) and the temperature of water from 20° to 32°C did not affect the volume of the segments measured (11). In this present study, we found that immersion of the left arm in hot water 42ºC condition(Figure23), showed greater left arm volume vasodilatation in the overweight than in the control group in every periods. In immersion of the left arm in cold water 12ºC condition (Figure24), the overweight group also had left arm volume vasodilatation more than the control group as usual in every periods. In immersion in normal water 30ºC condition post Astrand exercise 2 minutes (Figure25), the overweight had left arm volume vasodilatation more than the control group in every periods. In immersion in normal water 30ºC condition post Wingate exercise 2 minutes (Figure26), the overweight had left arm volume vasodilatation more than the control in every periods. In this results, not shown that the blood vessels of the left arm in the overweight group had vasodilatation more than the control group. This may imply that if consider the volume the overweight group in this study should have more volume than the control because theirs bodyweight. This finding support by Woo and co-worker in 2004 that they sought to study arterial endothelial function and carotid intima-media thickness (IMT), both early markers of atherosclerosis, in overweight compared to normal children. They found that even of mild-to-moderate degree of obesity is independently associated with abnormal arterial function and structure in otherwise healthy young children (66).

Immersion of the left leg in hot water 42ºC condition (Figure27), the overweight group had greater of the left leg extremities volume vasodilatation than the control group in every period. Immersion of the left leg in cold water 12ºC condition (Figure28), the overweight group had greater the left extremities volume vasodilatation than the control group in every period. In immersion in normal water 30ºC condition post Astrand exercise 2 minutes, the overweight group had greater of the left leg extremities volume vasodilatation than the control group in every period as same as the others .In immersion in normal water 30ºC condition post Wingate exercise 2 minute, the overweight group had greater of the left leg extremities volume vasodilatation than the control group in every period. In this result showed that blood circulation of the overweight group had not vasoconstriction in cold water. This may imply that the overweight group may be having some the pathological change in blood vessels .This finding support by Huseyin Ozdemir and co-worker (2006) suggested that the overweight and obesity may lead to the cause's impaired function of the large arteries, which might be the consequence of metabolic dysregulation, inflammatory pathways, obstructive sleepapnea, or other mechanisms (35).

In percent volume changes, we found that immersion of the left arm in hot water 42°C condition (Figure31), values of the left arm of the overweight group had greater vasodilatation than the normal group in mostly period especially at minutes 6^{th} and minutes $12^{th.}$. When compare the heart rate which is a net result of balance of sympathetic and parasympathetic nervous system activity at the same time it can be seen that the overweight group had greater heart rate increase than the control group in every period and at minutes 6^{th} heart rate which is the highest .Value of the left leg of the control group had greater vasodilatation than the overweight group in every period.

Immersion of the left arm in to cold water 12ºC(Figure 32), values percent volume change of the left arm of the overweight group had greater degree of vasodilatation than the control group in every periods. When compare to the heart rate changes at the same time period, the overweight had greater heart rate increase than the control group in all period investigated and trend to increase continuously. Value of the percent volume change of the left leg of the overweight group had greater degree of vasodilatation than the control group at immediately post test and at minutes 6^{th} post test. This results has been shown that the overweight may imply have an impairment of vasoconstriction which supported by Monahan et al (2004) that found the impairment of vasoconstriction could involve numerous factors, including blunted end organ responsiveness (i.e., altered adrenergic receptor sensitivity), alterations in exposure of the end organ to neurotransmitter (i.e., norepinephrine), or altered local production of factors that may modify vasoconstriction generations (e.g., nitric oxide or prostanoids)(39).

In immersion of the left arm in normal water 30° C condition post Astrand exercise 2 minutes (Figure 33), values percent change of the left arm of the overweight group had greater degree of vasoconstriction than the control group in every period. When relate with the heart rate change which is the net result of balance sympathetic and parasympathetic nervous system activity at the same time it can be seen that the overweight group had greater heart rate increase than the control group in every periods. Which agree with the value of the left leg of the overweight group had greater degree of vasoconstriction than the control group in every period.

In immersion of the left arm in normal water 30° C condition post Wingate exercise 2 minutes (Figure 34), values of percent volume change of the left arm of the overweight group had greater degree of vasoconstriction than the control group at immediately post test period and at minutes 12^{th} post test period. When relate the data with heart rate change which is a net result of balance of sympathetic and parasympathetic nervous system activity at the same time it can be seen that the overweight group had greater heart rate increase than the control group in every period .The value of the left leg of the overweight group had greater degree of vasoconstriction than the control group in every periods.

The above findings that post of Astrand and Wingate exercise may imply that the overweight group can have greater degree of vasoconstriction in arm than the control group but the overweight group will have lesser degree of vasodilatation in the leg than the control group.

In those result may imply that the overweight is the situation of the excess fat has accumulated to the extent that it may adversely affect health and is most commonly defined by the use of criteria involving the body mass index (BMI = kg/m^2). Adiposity increases oxygen consumption through increased tissue mass and metabolic demands; therefore, it increases cardiac output, stroke volume, and total blood volume. The increase in the systemic vascular resistance leads to hypertension, and the increase in preload and post load leads to left ventricular dilatation and hypertrophy. (2) The results of all percent volume changing in the experiments may imply that there are some result showed that the overweight may have the pathology of endothelial dysfunction. The finding support by Paterick and co-workers in 2001 investigated the endothelial function relate to cardiovascular disease and they found the endothelial dysfunction includes abnormalities of vasomotor tone (constriction and dilation) and growth of vascular smooth muscle (47).

The difference of heart rate of the control group and the overweight group may imply the difference sympathetic response of control and overweight which parallel to degree of vasoconstriction and vasodilatation of each group. Therefore, the difference of vasodilatation of arm and leg in overweight may be due to vascular endothelial dysfunction. This finding support by Annemarie et al (2007) that showed the obesity may alter vascular endothelial cell protein expression of molecules that influence susceptibility to atherosclerosis. Because of the proteins's production of vascular endothelial cells that influence susceptibility to the development of atherosclerosis. These may provide novel insight into the molecular mechanisms linking obesity to increased risk of clinical atherosclerotic diseases in humans such as cardiovascular disease. (55)

The Ankle Brachial Pressure Index (ABPI)

The Ankle Brachial Index (A is a quick, simple, non-invasive method of measuring the effect that arterial disease is having on the blood pressure in the lower leg. It also known as the ankle to arm systolic pressure index is the most common diagnostic test used in the non-invasive physical examination of the suspect lower extremity. The arterial pressure measurement in the lower limb represents the single most important index for diagnosing peripheral arterial disease (PAD) (McGee, 1998) (43). The index is calculated through measuring the maximum systolic pressure at the ankle (taking the highest of either dorsalis pedis or posterior tibial) then dividing it by the systolic pressure in the brachial artery. In this study was found that the overweight group had lesser ABPI value than the control group in pre-exercise, post -Astrand exercise and post –Wingate exercise. The result of this study showed that the overweight had lower calf blood flow than the control under resting, reactive hyperaemic and maximal hyperaemic condition. The result demonstrated that the effects of overweight may indicate that significant peripheral arteries disease may be present. Mlacak and co-worker (2006) found that the peripheral arterial disease, even asymptomatic, is an important predictor of adverse cardiovascular prognosis in relatively young patients. Reduced ABPI is a strong, independent predictor of cardiovascular mortality in all patients with peripheral arterial disease. (10)

The mean arterial pressure ratio (MAPR) in this study does not find in previous studies .It managed for assumption that the values of MAPR of the extremities may be help to assess the physiological of blood vessel in the extremities. This method also may be associated to indicate the pathological of blood vessel as same as another methods.

All of the result in this study showed that the control group had more vasomotor response than the overweight group and a significant reduction of Ankle Brachial Pressure Index (ABPI) in overweight group after both exercise was found, which was similar to vasomotor response. Wild and co-worker suggested that a reduced ABPI is consistent with peripheral artery occlusive disease (PAOD). Recently several studies suggest that an abnormal ABPI may be an independent predictor of mortality, as it reflects the burden of atherosclerosis (63). Furthermore Laurin and co-worker found that the reduction of ABPI was significantly associated with an increased risk of vascular dementia. Potential mechanisms that might underlie this association include the progressive occlusion of arteries and vascular disease that leads to occlusion of the cerebral arteries, cerebral tissue loss, and cognitive decline. There also is evidence of a strong positive association between peripheral artery occlusive disease and inflammation, which has been inferred in the pathogenesis of atherosclerosis (Akiyama and co-worker in 2000) and linked to the onset of dementia (23).

Usefulness of the result of the experiment can be used general resident about the knowledge effects of overweight adverse effects on exercise performance and associated with structural blood vessel change by increase in arterial wall stiffness and immediate endothelial dysfunction of the large arteries. This study may be used for prevention the early Peripheral arterial disease (PAD) and the others disease of being overweight .Overweight is also the primary risk factor for coronary and peripheral vascular disease. Overweight people are more likely to have high blood pressure, a major risk factor for heart disease and stroke, than people who are not overweight. Very high blood levels of cholesterol and triglycerides (blood fats) can also lead to heart disease. Being overweight also contributes to angina (chest pain caused by decreased oxygen to the heart) and sudden death from heart disease or stroke without any signs or symptoms. (61)

CHAPTER VI
CONCLUSION

1. Psycho- neurological performance before Astrand exercise and Wingate exercise was not significantly different between both groups in term of visual, response time; however warned auditory reaction time was significantly shorter in overweight group after exercise of the right big toe. And the overweight group had significantly shorter in warned tactile reaction time at cervical 7^{th} level stimulation of left index finger in post exercise and the right big toe and the left big toe in post exercise had significantly shorter than control group. And in the tapping speed test overweight higher than the control group in post exercise.

2. Physical performance in control group in relation to oxygen consumption was significantly higher than the overweight

3. Vasomotor response of blood vessels of upper and lower extremities when study in percent volume change in overweight group was significantly higher than the control group when immersion the left arm in hot water. In the left leg volume immersion in hot water of control group found higher than the overweight and lower in immersion in cold water when compare to the overweight group. The immersion in normal water after exercise Astrand found that the overweight group had significantly lower than pre exercise.

4. A static reduction of Ankle Brachial Pressure Index (ABPI) in control group after exercise was found higher than the overweight group.

5. The above findings may further demonstrate the usefulness of volumetric method and ABPI index determination helping in diagnosis of vascular diseases

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APPENDIX

APPENDIX A

หนังสือยินยอมให้ทำการวิจัยโดยรับการบอกกล่าวและเต็มใจ

(Informed consent form)

ชื่อโครงการ การเปลี่ยนแปลงทางจิตสรีรวิทยาและการตอบสนองของเส้นโลหิตในผู้ป่วยความดันโลหิตสูงต่อสิ่งกระตุ้นมาตรฐานที่ใช้ทดสอบคุณสมบัติของเส้นโลหิต(PSYCHOPHYSIOLOGICAL ALTERATION AND VASOMOTOR RESPONSES OF OVERWEIGHT SUBJECTS TO STIMULI USED IN CONVENTIONAL VASCULAR RESPONSE TESTING)

วันให้คำยินยอม วันที่ ………… เดือน …………………… พ.ศ. ……………..

ก่อนที่จะลงนามในใบยินยอมทำการวิจัยนี้ ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัย รวมถึงประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

ผู้วิจัยรับรองว่า จะตอบคำถามต่างๆที่ข้าพเจ้าสงสัยด้วยความเต็มใจไม่ปิดบังซ่อนเร้น จนข้าพเจ้าพอใจ

ข้าพเจ้าเข้าร่วมการวิจัยโดยสมัครใจและมีสิทธิที่จะยกเลิกการเข้าร่วมการวิจัยนี้เมื่อใดก็ได้

ผู้วิจัยรับรองว่า จะเก็บข้อมูลเฉพาะตัวข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะในรูปแบบที่เป็นการสรุปผลการวิจัย การเปิดเผยข้อมูลที่เกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่างๆที่เกี่ยวข้อง กระทำได้เฉพาะในกรณีจำเป็นด้วยเหตุผลทางวิชาการเท่านั้น

ผู้วิจัยรับรองว่า หากเกิดอันตรายใดๆอันเนื่องมาจากการวิจัยดังกล่าว ข้าพเจ้าจะได้รับการรักษาพยาบาลโดยไม่คิดมูลค่าตามมาตรฐานวิชาชีพ และจะได้รับการชดเชยรายได้ที่สูญเสียไประหว่างการรักษาพยาบาลดังกล่าว ตลอดจนเงินทดแทนความพิการที่อาจเกิดขึ้น

ผู้วิจัยรับรองว่าหากมีข้อมูลเพิ่มเติมที่ส่งผลกระทบต่อการวิจัย ข้าพเจ้าจะได้รับการแจ้งให้ทราบโดยไม่ปิดบังซ่อนเร้น

ข้าพเจ้าได้อ่านข้อความข้างต้นและมีความเข้าใจดีทุกประการและได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ

ลงชื่อ …………………………………………………. (ผู้ยินยอม)

ลงชื่อ …………………………………………………. (พยาน)

นางสาว ฉันท์สุภา ทองจันทร์

ผู้วิจัย

APPENDIX B

แบบสอบถามเพื่อประเมินกิจกรรมในชีวิตประจำวัน

(The Questionnaire: Functional Activity in the Subject)

กลุ่มของอาสาสมัคร ……………………………หมายเลขอาสาสมัคร ……………………………

คำชี้แจง: เพื่อให้ข้อมูลจากการศึกษานี้เกิดประโยชน์ตรงตามวัตถุประสงค์ โปรดกรอกข้อมูลและตอบคำถามต่อไปนี้ตามความเป็นจริง ข้อมูลทั้งหมดในแบบสอบถามนี้จะถูกเก็บไว้เป็นความลับและใช้ในงานวิจัยเท่านั้น ผู้ศึกษาขอขอบพระคุณในความร่วมมือเป็นอย่างยิ่ง

ตอนที่ 1 ประวัติทั่วไป

วันที่ทดลอง …………………………………

ชื่อ – สกุล ………………………………………….. เพศ ☐ ชาย ☐ หญิง อายุ …………. ปี

เข้าร่วมงานวิจัยในกลุ่ม (ผู้วิจัยกรอก) ………………………Research ID Code (ผู้วิจัยกรอก) ……….

อุณหภูมิทางกาย …………. °C ชีพจร …………. ครั้ง/นาที อัตราการหายใจ …………. ครั้ง/นาที

ความดันโลหิต …..…/……. mmHg น้ำหนักตัว …………. กิโลกรัม ส่วนสูง ………เซนติเมตร

มีความรู้สึกไม่สบายในวันที่ทดสอบหรือไม่ ………………………………………………………

การศึกษาสูงสุด ☐ ระดับมัธยมศึกษา ☐ ระดับปริญญาตรี ☐ สูงกว่าระดับปริญญาตรี☐

อื่นๆ โปรดระบุ ……………………………………………………

ที่อยู่ปัจจุบัน ……………………………………………………………………………………

อาชีพ ……………………………………………………………………………………………..

ที่ทำงาน/สถานศึกษา …………………………………………………………………………..

ความสัมพันธ์ของบิดามารดา ☐ แยกกันอยู่ ☐ อยู่บ้านเดียวกัน

โรคประจำตัว ☐ มี ☐ ไม่มี

ถ้ามี ก. ป่วยเป็นโรค ………………………………………………….

ข. ระยะเวลา ………………………………………………….

ค. สถานที่รักษาพยาบาล …………………………………………

ง. อาการของโรคในปัจจุบัน (ถ้ายังมีอยู่) …………………………

ประวัติการสูบบุหรี่

ก. ☐ ไม่เคย ☐ เคย ถ้าเคยสูบวันละ ……….. มวน ระยะเวลาที่สูบ ……….. ปี

ประวัติการดื่มสุราหรือเบียร์

ก. ☐ ไม่เคย☐ เคย ถ้าเคย ดื่มมานาน……….. ปี

- ดื่มสุราครั้งละประมาณ ………(เศษส่วนของขวดกลม)
- ดื่มเบียร์ครั้งละประมาณ ………(เศษส่วนของขวดกลม)

ตอนที่ 2 ข้อมูลเกี่ยวกับงานอดิเรกและกิจกรรมอื่นๆ

2.1 กิจกรรมในชีวิตประจำวัน				**ระดับการใช้กำลังหรือความเหนื่อย**		
	ปริมาณ			**ต่ำ**	**ปานกลาง**	**สูง**
☐	งานบ้าน	……………………………	(ชั่วโมง/สัปดาห์)			
☐	ทำสวน	……………………………	(ชั่วโมง/สัปดาห์)			
☐	เดิน	……………………………	(ชั่วโมง/สัปดาห์)			
☐	อื่นๆ ได้แก่	1 ……………………….	(ชั่วโมง/สัปดาห์)			
		2 ……………………….	(ชั่วโมง/สัปดาห์)			

2.2 กิจกรรมการออกกำลังกาย			**ระดับการใช้กำลังหรือความเหนื่อย**		
		ปริมาณ	**ต่ำ**	**ปานกลาง**	**สูง**
☐	เดินช้า	ระยะเวลาที่ใช้…….... นาที/ครั้ง, ……… ครั้ง/สัปดาห์			
☐	เดินเร็ว	ระยะเวลาที่ใช้……… นาที/ครั้ง, ……… ครั้ง/สัปดาห์			
☐	วิ่ง	ระยะเวลาที่ใช้…….... นาที/ครั้ง, ……… ครั้ง/สัปดาห์			
☐	กีฬาอื่นๆ โปรดระบุ 1. …………………………………………………………….. ระยะเวลาที่ใช้……… นาที/ครั้ง, ……… ครั้ง/สัปดาห์				
	2. …………………………………………………………….. ระยะเวลาที่ใช้……… นาที/ครั้ง, ……… ครั้ง/สัปดาห์				
	3. …………………………………………………………….. ระยะเวลาที่ใช้……… นาที/ครั้ง, ……… ครั้ง/สัปดาห์				

2.3 ท่านมีข้อจำกัด (ความไม่สามารถทำหรือเคลื่อนไหวหรือเคลื่อนไหวน้อย) ในส่วนของร่างกายระหว่างทำกิจวัตรประจำวัน (เช่น การก้มหยิบของหรือเอื้อมหยิบของ) ต่างๆหรือไม่

☐ ไม่มี

☐ มี ☐ ส่วนแขน

☐ ส่วนขา

☐ หลัง

☐ อื่นๆ โปรดระบุ 1……………………..

2 ……………………..

ตอนที่ 3 ประเมินระดับกิจกรรมในชีวิตประจำวัน (Physical activity level)

	สม่ำเสมอ(4)	บ่อย (3)	บางครั้ง (2)	ไม่เคย (1)
1. ท่านเลือกที่จะเดินมากกว่านั่งรถ				
2. ท่านออกกำลังกายมากกว่า 1 ครั้ง/สัปดาห์				
3. ท่านออกกำลังกายอย่างหนัก				
4. ท่านเลือกที่จะเดินขึ้นบันไดมากกว่าใช้บันไดเลื่อนหรือลิฟท์				
5. ท่านออกกำลังกายเบาๆ				
6. ท่านมักทำกิจกรรมต่างๆด้วยตนเอง				
7. ท่านมักทำกิจกรรมในวันว่างมากกว่านอนหรือนั่งดูโทรทัศน์				
8. ท่านชอบออกกำลังกายมาก				

คะแนน กิจกรรม: 1) ………. + 4) ……….. + 6) ……….. + 7) ……… = …………

การออกกำลังกาย: 2) ………. + 3) ……….. + 5) ……….. + 8) ……… = …………

≤ 16 low activity, 17 – 23 moderate activity, ≥ 24 high activity

ตอนที่ 2 ข้อมูลเกี่ยวกับสุขภาพ

1. ปัจจุบันท่านต้องรับประทานยา, ยาบำรุง, วิตามิน เป็นประจำหรือไม่

☐ ไม่ต้อง

☐ เฉพาะเมื่อมีอาการ* <u>โปรดระบุอาการ</u> ....

☐ ต้องรับประทานยาเป็นประจำ ได้แก่

☐ ยาโรคเบาหวาน ☐ ยาลดความดันโลหิต

☐ ยาโรคหัวใจ ☐ อื่นๆ โปรดระบุชื่อยาและขนาดที่ใช้ต่อวัน

1) .... 2) ....

3)…………………… 4)…………………..

2. การใช้แว่นตา ท่านต้องใช้แว่นหรือไม่

☐ ไม่ต้อง ☐ ใช้เมื่ออ่านหนังสือ ☐ ต้องใช้ตลอดเวลา

3. ท่านมีโรคประจำตัวและปัญหาสุขภาพใดต่อไปนี้ (ตอบได้มากกว่า 1 ข้อ)

		ไม่มี	**มี**		**ปัจจุบันนี้กำลังรักษาอย่างไร เช่น กินยาอะไร ระบุ**
☐	ความดันโลหิตสูง	☐	☐	เป็นตั้งแต่	....
☐	เกี่ยวกับโรคหัวใจ	☐	☐	เป็นตั้งแต่	....
☐	เกี่ยวกับระบบขับถ่าย	☐	☐	เป็นตั้งแต่	....
☐	เกี่ยวกับระบบทางเดินอาหาร	☐	☐	เป็นตั้งแต่	....
☐	โรคเบาหวาน	☐	☐	เป็นตั้งแต่	....
☐	ปวดคอ	☐	☐	เป็นตั้งแต่	....
☐	ปวดไหล่	☐	☐	เป็นตั้งแต่	....
☐	ปวดหลัง	☐	☐	เป็นตั้งแต่	....
☐	ปวดเข่า (ซ้าย / ขวา)	☐	☐	เป็นตั้งแต่	....
☐	มีอาการเวียนศีรษะ	☐	☐	.... ครั้ง/สัปดาห์	
				ครั้งสุดท้ายเป็นเมื่อ	....
☐	มีเสียงดังในหู (ซ้าย / ขวา)	☐	☐	.... ครั้ง/สัปดาห์	
				ครั้งสุดท้ายเป็นเมื่อ	....
☐	อื่นๆ ระบุ 1	☐	☐	.... ครั้ง/สัปดาห์	
				ครั้งสุดท้ายเป็นเมื่อ	....
	2	☐	☐	.... ครั้ง/สัปดาห์	
				ครั้งสุดท้ายเป็นเมื่อ	....

1. ชั่งน้ำหนักน้ำต่อลิตรของน้ำที่อุณหภูมิต่างๆ (ใช้ทศนิยม 4 ตำแหน่งของ กก.)

น้ำ 1 ลิตร

1. ที่อุณหภูมิ 30°C (ห้อง) ………………… กก.
2. ที่อุณหภูมิ 42°C ………………… …… กก.
3. ที่อุณหภูมิ 12°C …………………..…… กก.

หาว่าขณะที่มีอุณหภูมิ 42 °C, 12 °C และ 30 °C จะมีน้ำหนัก (กก.) /ลิตรเท่ากับเท่าไร

วันที่ 1

ให้อาสาสมัครนั่งพักอย่างน้อย 15 นาที

1. วัดปริมาตรแขนโดยการแช่น้ำ (โดยตรง) ณ อุณหภูมิห้อง (น้ำมีอุณหภูมิ 30°C) ก่อนแช่แขนหรือขา ใช้ปากกาเมจิกที่ลบไม่ออกหรือปากกาหมึกแห้งขีดเส้นต่อไปนี้

ลากเส้นตรงข้อพับด้านในแขนซ้าย และลากเส้นให้รอบข้อพับ เพื่อให้มองเห็นได้ทุกมุม

ลากเส้นตรงข้อพับใต้ลูกสะบ้าและลากเส้นให้รอบเข่า เพื่อให้มองเห็นได้ทุกมุมมอง ขณะวัดปริมาตรขาให้นั่งเก้าอี้ห้อยเท้าลงในอุปกรณ์ข้างล่างนี้

t0	t1	R1	t2	R2	t3

t = measure (30 sec)

R = rest (min ดูตารางข้างล่าง)

				วัดคนละครั้งกัน			
	ครั้งที่วัด	**Lt. Arm volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP**	**MABP**
แช่น้ำ 30 °C (อุณหภูมิห้อง)	t0 (at 0 min)	……… (L) …………(%)					
ระหว่างพักรอให้แช่น้ำ 30°C ในถังสำรอง	t1 (at 0-½ min)	…………(L) …………(%)					
	t2 (at 5-5½ min)	…………(L) …………(%)					
	t3 (at 10-10½ min)	…………(L) …………(%)					

L = litre, t = measure, R = rest

2. แช่น้ำ (โดยตรง) 30°C H_2O (Lt. leg) (Mark ใต้ patella)

t0	t1	R1	t2	R2	t3

t = measure (30 sec)

R = rest (ดูตารางข้างล่าง)

				วัดคนละครั้งกัน			
	ครั้งที่วัด	**Lt. Leg volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP**	**MABP**
แช่น้ำ 30 °C (อุณหภูมิห้อง)	t0 (at 0 min)	…………(L) …………(%)					
ระหว่างพักรอให้แช่น้ำ 30°C ในถังที่ตั้งไว้สำรอง	t1 (at 0-½ min)	…………(L) …………(%)					
	t2 (at 5-5½ min)	…………(L) …………(%)					
	t3 (at 10-10½ min)	…………(L) …………(%)					

3. จุ่ม 42°C H_2O แขนซ้าย (Lt. arm) (mark ที่ข้อพับ)

				วัดคนละวันกัน			
	ครั้งที่วัด	**Lt. Arm volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP**	**MABP**
แช่น้ำ 30 °C (อุณหภูมิห้อง)	t0 (at 0 min)	………… (L) …………(%)					
ระหว่างรอให้แช่น้ำ 42°C ในถังน้ำสำรอง	t1 (at 0-½ min)	…………(L) …………(%)					
	t2 (at 5-5½ min)	………… (L) ……… (%)					
	t3 (at 10-10½ min)	………… (L) …………(%)					

4. จุ่ม 42°C H_2O โดยตรงของขาซ้าย (Lt. leg) (ใต้หัวเข่า)

t0	t1	R1	t2	R2	t3

t = measure (30 sec)

R = rest (min ดูตารางข้างล่าง)

				วัดคนละครั้งกัน			
	ครั้งที่วัด	**Lt. Leg volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP**	**MABP**
แช่น้ำ 30 °C	t0 (at 0 min) พัก 5 นาที	………… (L) ………… (%)					
ระหว่างพักรอให้แช่น้ำ 42°C ในถังน้ำสำรอง	t1 (at 0-½ min)	………… (L) ………… (%)					
	t2 (at 5-5½ min)	………… (L) ………… (%)					
	t3 (at 10-10½ min)	………… (L) ………… (%)					

5. จุ่ม 12°C H_2O โดย Lt. arm (Mark ข้อพับ)

				วัดคนละครั้งกัน			
	ครั้งที่วัด	**Lt. Arm volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP**	**MABP**
แช่น้ำ 30 °C	t0 (at 0 min) พัก 5 นาที	………… (L) …………(%)					
ระหว่างพักรอให้แช่น้ำ 12°C ในถังน้ำสำรอง	t1 (at 0-½ min)	…………(L) …………(%)					
	t2 (at 5-5½ min)	………… (L) …………(%)					
	t3 (at 10-10½ min)	…………(L) …………(%)					

6. จุ่ม 12°C H_2O ขาซ้าย (Lt. leg) (Mark ใต้สะบ้า)

				วัดคนละครั้งกัน			
	ครั้งที่วัด	**Lt. leg volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP (mmHg)**	**MABP (mmHg)**
แช่น้ำ 30 °C	t0 (at 0 min) พัก 5 นาที	……(L) ……(%)					
ระหว่างพักรอให้แช่น้ำ 12°C ในถังน้ำสำรอง	t1 (at 0-½ min)	……(L) ……(%)					
	t2 (at 5-5½ min)	……(L) ……(%)					
	t3 (at 10-10½ min)	……(L) ……(%)					

7. cuff blood flow โดยปิดกั้นการไหลเวียนบริเวณต้นแขนซ้าย ร่วมกับจุ่ม 30 °C H_2O (Lt. arm) (Mark ข้อพับ)

				วัดคนละครั้งกัน			
	ครั้งที่วัด	**Lt. Arm volume change**	**HR (bPM)**	**SP (mmHg)**	**DP (mmHg)**	**PP**	**MABP**
แช่น้ำ 30 °C (อุณหภูมิห้อง)	t0 (at 0 min)	……… (L) …………(%)					
ระหว่างพักรอให้แช่น้ำ 30°C ในถังสำรอง	t1 (at 0-½ min)	…………(L) …………(%)					
	t2 (at 5-5½ min)	…………(L) …………(%)					
	t3 (at 10-10½ min)	…………(L) …………(%)					

8. การวัด Ankle-brachial pressure index (ABPI) (บ่งชี้ถึงความสามารถในการนำโลหิตไปเลี้ยงแขนและขา หลังออกกำลังกาย แล้วนอนหงายท้องราบ วัดความดัน 4 จุดบนร่างกายดังตารางข้างล่าง

HR = ……………… b/m

		SP (mmHg)	**DP (mmHg)**	**PP (mmHg)**	**MAB**
a. ต้นแขนซ้าย (LA)					
b. ต้นแขนขวา (RA)					
c. ต้นขาซ้าย (LL)					
d. ต้นขาขวา (RL)					
คำนวณ					
e. Ankle–brachial pressure index(ABPI)	a/c				
	b/d				
f.	a/b				
g.	c/d				

APPENDIX C

แบบประเมินและวิเคราะห์ความเครียดด้วยตนเอง (Stress test)

(กรมสุขภาพจิต กระทรวงสาธารณสุข 2541)

ในระยะเวลา 2 เดือนที่ผ่านมานี้ ท่านมีอาการ พฤติกรรม หรือความรู้สึกต่อไปนี้มากน้อยเพียงใด โปรดขีดเครื่องหมาย√ ลงในช่องแสดงระดับอาการที่เกิดขึ้นกับตัวท่านตามความเป็นจริงมากที่สุด

อาการ พฤติกรรม หรือ ความรู้สึก	ระดับ อาการ			
	0	1	2	3
	ไม่เคย เลย	เป็นครั้ง คราว	เป็น บ่อยๆ	เป็น ประจำ
1. นอนไม่หลับเพราะคิดมาก หรือกังวลใจ				
2. รู้สึกหงุดหงิด รำคาญใจ				
3. ทำอะไรไม่ได้เลย เพราะประสาทตึงเครียด				
4. มีความวุ่นวายใจ				
5. ไม่อยากพบปะผู้คน				
6.ปวดหัวข้างเดียว หรือปวดบริเวณขมับทั้ง2ข้าง				
7. รู้สึกไม่มีความสุขและเศร้าหมอง				
8. รู้สึกหมดหวังในชีวิต				
9. รู้สึกว่าชีวิตตนเองไม่มีคุณค่า				
10. กระวนกระวายอยู่ตลอดเวลา				
11. รู้สึกว่าตนเองไม่มีสมาธิ				
12.รู้สึกเพลียไม่มีแรงจะทำอะไร				
13. รู้สึกเหนื่อยไม่อยากทำอะไร				
14.มีอาการหัวใจเต้นแรง				
15.เสียงสั่น ปากสั่น หรือมือสั่นเวลาไม่พอใจ				
16. รู้สึกกลัวผิดพลาดในการทำสิ่งต่างๆ				
17. ปวด หรือเกร็งกล้ามเนื้อบริเวณท้ายทอย หลัง หรือไหล่				
18. ตื่นเต้นง่ายกับเหตุการณ์ที่ไม่คุ้นเคย				
19. มึนงงหรือเวียนศรีษะ				
20. ความสุขทางเพศลดลง				

เกณฑ์การให้คะแนน รวมคะแนนไม่เกิน 60 คะแนน โดย จำนวนคำถาม 20 ข้อ ตอบว่า

ไม่เคยเลย= 0 คะแนน, เป็นครั้งคราว = 1 คะแนน, เป็นบ่อยๆ = 2 คะแนน, เป็นประจำ = 3 คะแนน

ผลการประเมินและวิเคราะห์ความเครียด

ระดับคะแนน 0-5

ท่านมีความเครียดอยู่ในระดับต่ำกว่าเกณฑ์ปกติอย่างมาก ทฤษฎีถือว่ามีความเป็นไปได้เพียงเล็กน้อยเท่านั้นที่จะมีความเครียดในระดับต่ำมากเช่นนี้ ในกรณีของท่านอาจมีความหมายว่า ท่านตอบคำถามไม่ตรงตามความเป็นจริง หรือท่านอาจเข้าใจคำสั่งหรือข้อคำถามคลาดเคลื่อนไป ท่านอาจเป็นคนที่ขาดแรงจูงใจในการดำเนินชีวิต มีความเฉื่อยชา ชีวิตประจำวันซ้ำซากจำเจ น่าเบื่อ ปราศจากความตื่นเต้น

ระดับคะแนน 6-17

ท่านมีความเครียดอยู่ในเกณฑ์ปกติ สามารถจัดการกับความเครียดที่เกิดขึ้นในชีวิตประจำวันและสามารถปรับตัวกับสถานการณ์ต่างๆได้อย่างมีชีวิตชีวา กระตือรือร้นมองสิ่งเร้าหรือเหตุการณ์รอบตัวว่าเป็นสิ่งท้าทายความสามารถ มีความสามารถในการจัดการกับสิ่งต่างๆ ได้อย่างเหมาะสม ผลผลิตของการปฏิบัติงานอยู่ในระดับสูง ความเครียดในระดับนี้ถือว่ามีประโยชน์ในการดำเนินชีวิตประจำวัน เป็นแรงจูงใจที่นำไปสู่ความสำเร็จในชีวิตได้

ระดับคะแนน 18-25

ท่านมีความเครียดอยู่ในระดับสูงกว่าปกติเล็กน้อย มีความไม่สบายใจอันเกิดจากปัญหาในการดำเนินชีวิตประจำวัน โดยที่ปัญหาหรือข้อขัดแย้งของท่านอาจจะยังไม่ได้รับการคลี่คลายหรือแก้ไข ซึ่งถือว่าเป็นความเครียดที่พบได้ในชีวิตประจำวัน อาจไม่รู้ตัวว่ามีความเครียดหรืออาจรู้สึกได้จากการเปลี่ยนแปลงของร่างกาย อารมณ์ ความรู้สึก และพฤติกรรมบ้างเล็กน้อยแต่ไม่ชัดเจน และยังพอทนได้ แม้ว่าท่านจะมีความยุ่งยากในการจัดการกับปัญหาอยู่บ้างและอาจต้องใช้เวลาในการปรับตัวมากขึ้นกว่าเดิม ท่านก็สามารถจัดการกับความเครียดได้และไม่เป็นผลเสียต่อการดำเนินชีวิต ในกรณีนี้ ท่านควรผ่อนคลายความเครียดด้วยการหาความเพลิดเพลินใจเช่น ออกกำลังกาย ดูหนัง ฟังเพลง สังสรรค์กับเพื่อน ฯลฯ

ระดับคะแนน 26-29

ท่านมีความเครียดอยู่ในระดับสูงกว่าปกติปานกลาง ขณะนี้ท่านเริ่มมีความตึงเครียดในระดับค่อนข้างสูงและได้รับความเดือดร้อนเป็นอย่างมากจากปัญหาทางอารมณ์ที่เกิดจากปัญหาความขัดแย้งและวิกฤตการณ์ในชีวิต เป็นสัญญาณเตือนขั้นต้นว่าท่านกำลังเผชิญกับภาวะวิกฤตและความขัดแย้งซึ่งท่านจัดการแก้ไขด้วยความยากลำบาก ลักษณะอาการดังกล่าวจะเพิ่มความรุนแรง ซึ่งมีผลกระทบต่อการทำงาน จำเป็นต้องหาวิธีแก้ไขข้อขัดแย้งต่างๆให้ลดน้อยลงหรือหมดไปด้วยวิธีการอย่างใดอย่างหนึ่ง และควรคลี่คลายความเครียดด้วยการพูดคุยปรึกษากับคนที่ไว้วางใจหรือปรึกษาทางโทรศัพท์ (Hotline)

ระดับคะแนน 30-60

ท่านมีความเครียดอยู่ในระดับสูงกว่าปกติมาก กำลังตกอยู่ในสภาวะตึงเครียด หรือกำลังเผชิญกับวิกฤตการณ์ในชีวิตอย่างรุนแรง เช่น การเจ็บป่วยที่รุนแรง เรื้อรัง ความพิการ การสูญเสีย ปัญหาความรุนแรงของครอบครัว ปัญหาเศรษฐกิจ ซึ่งส่งผลต่อสุขภาพกายและสุขภาพจิตอย่างชัดเจน ทำให้ชีวิตไม่มีความสุข ปรึกษากับคนที่ไว้วางใจหรือปรึกษาทางโทรศัพท์ (Hotline)

APPENDIX D

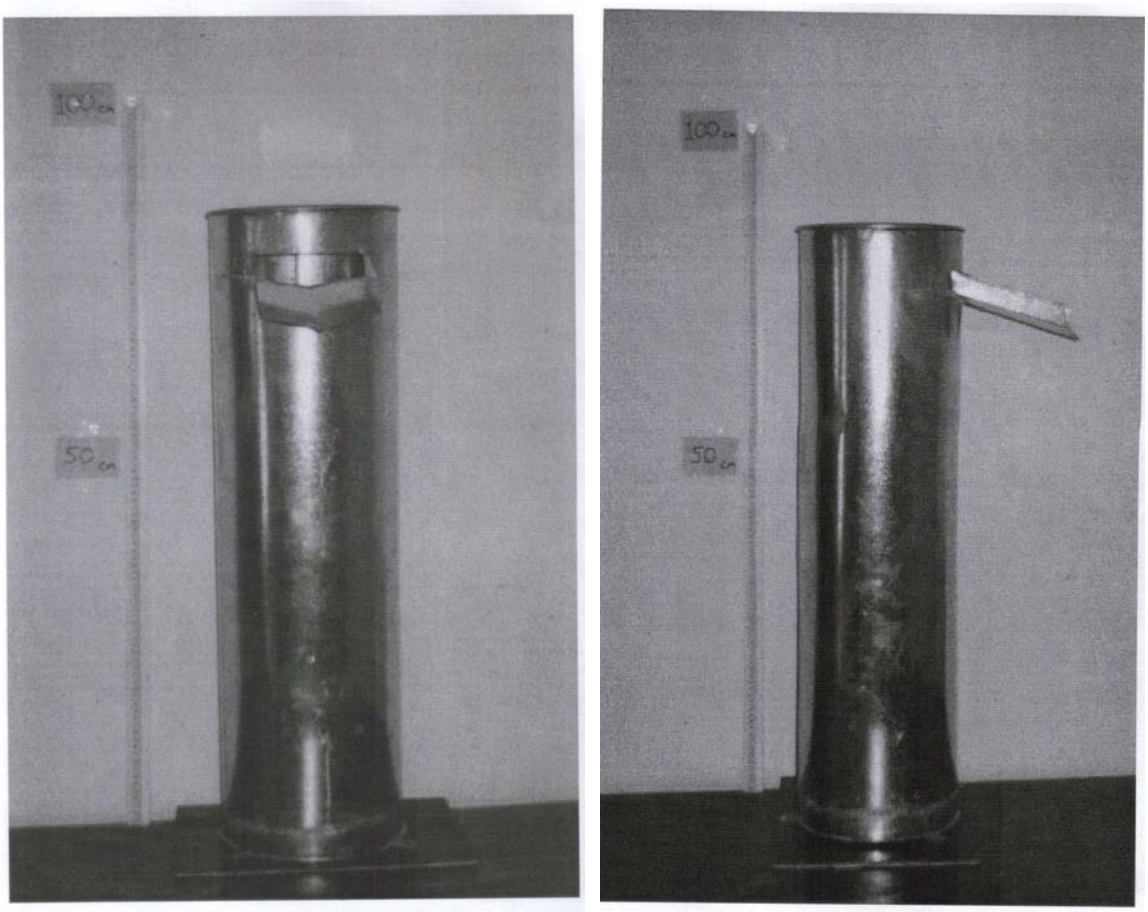

Figure 58 Volumeter (Biomedical Equipment technology, Mahidol University)

BIOGRAPHY

NAME	Miss Chansubha Thongchan
DATE OF BIRTH	30 August, 1974
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Mahidol University, 1993-1996: Bachelor of Science (Physical Therapy) Mahidol University, 2003-2008: Master of Science (Sports Science)
POSITION&OFFICE	BNH hospital Silom Bangkok, Thailand
HOME ADDRESS	53/42 Soi 19 Cheangwattana road, Tumbon Bangpood, Aumper Pakkred, Nonthaburi, 11120