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Orthostatic blood pressure and heart rate responses within hypovolemic and normovolemic populations

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The University of Arizona, 1994

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ORTHOSTATIC BLOOD PRESSURE AND HEART RATE RESPONSES WITHIN HYPOVOLEMIC AND NORMOVOLEMIC POPULATIONS

by

Fran Dolores Patterson

A Thesis Submitted to the Faculty of the

COLLEGE OF NURSING

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

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STATEMENT BY AUTHOR

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Associate Professor of Nursing

4/15/94
Date

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To my children, Devon and Skyler: Never lose perspective of your goals. Priorities may change, but if something is important to you, go for it even if it means taking care of your priorities (playing with you two) during the day and working long hours at the computer at night! Remember, Mommi loves you.

To my sister Klaire: Thanks for finishing first.

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To my husband Mike: I thank you for all the patience, support and stability. I wavered at times but you helped me through. I love you: Now let's have some fun!

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ABSTRACT

A descriptive study was conducted comparing the blood pressure and heart rate responses to position change among hypovolemic and normovolemic subjects. A convenience sample of 32 men and women from an emergency room with complaints of diarrhea, vomiting, vaginal or rectal bleeding for ≥12 hours duration were recruited. The normovolemic group consisted of a convenience sample of 30 men and women from the community. Data analysis included a mixed design analysis of variance.

Compared to supine baseline measurements, between group changes in the systolic, diastolic, and mean arterial blood pressure were not statistically significant ($p>.05$). Once the subject stood, heart rate increased statistically significant in both groups ($p<.05$). The data suggest orthostatic hypotension can be considered when the supine resting heart rate is ≥87 beats per minute, and if upon standing, heart rate increases by ≥19.33 or is ≥110 beats per minute. Heart rate measurements should be taken at one minute after standing.

CHAPTER 1

INTRODUCTION

Many individuals arrive in the emergency room with the complaints of feeling weak and dizzy. These complaints commonly occur after prolonged episodes of vomiting, diarrhea or blood loss which results in a reduced intravascular volume or hypovolemia. These complaints intensify when the person is standing and improve after the person assumes a supine position (Schatz, 1984). Recurrent dizziness, weakness, and eventual loss of consciousness, influenced by gravitational forces, are symptoms commonly seen in orthostatic hypotension suggest inadequate cerebral perfusion due to hypovolemia (Bookman & Simoneau, 1977; Thomas & Schirger, 1968). Orthostatic hypotension can be defined as a change in blood pressure and heart rate associated with a change in body position. This change in body posture can cause dizziness, faintness, dimness of vision, generalized weakness, ataxia, and perhaps syncope (Thomas & Schirger, 1968). The postural changes include moving from the supine position to the erect position.

Optimum medical management requires the recognition of hypovolemia before it becomes clinically significant (Bookman & Simoneau, 1977). It should be standard procedure to obtain vital signs in the supine and standing position when ever an individual presents to the emergency room with

a condition that might contribute to a hypovolemia (Bookman, 1977).

The measurement of orthostatic blood pressure and heart rate is a valuable nursing technique for evaluating a patient problem related to intravascular volume reduction or poor autonomic reflexes. Frequent assessments of orthostatic trends, by nurses, assist in differentiating underlying disorders such as orthostatic hypotension related to hypovolemia. In addition, the patient's response to a specific therapeutic modality, i.e. intravenous fluids can be evaluated. However, clinical information must be gathered by nurses in a systematic and organized manner to support the validity of the information. The detection and investigation of orthostatic blood pressure disorders are dependent on nurses' use of a standardized and valid technique.

Ordinarily, the baroreceptor response counteracts gravitational forces upon the blood and to maintain systemic arterial pressure and cerebral circulation (Schrier, 1990). With assumption of the standing position and with the fall in blood pressure, afferent impulses from the baroreceptors to the cardiovascular center in the medulla, increase heart rate. This change in heart rate increases stroke volume and blood pressure for the purpose of restoring mean arterial blood pressure and cerebral perfusion pressure. Corrective

adaptive mechanisms occur in 30 to 45 seconds and the blood pressure reaches the values present in the supine position (Thomas & Schirger, 1968).

Orthostatic hypotension as a clinical diagnosis can be determined by a series of vital sign measurements. Moreover, diagnosing the presence of orthostatic hypotension usually does not require a great deal of time, nursing care, of orthostatic hypotension is the association of the orthostatic change in systolic and diastolic blood pressure with clinical symptoms. The extent and persistence of the blood pressure drop, as well as frequency and severity of symptoms, vary greatly from person to person that this may have little value as diagnostic criteria.

The procedure commonly referred to as the "tilt test," "tilts," "posturals" or "orthostatics" has been widely used to determine orthostatic hypotension. The procedure consists of blood pressure and heart rate measurements obtained in various gravitational positions at specified intervals. Observations regarding the patient's mentation level are noted for signs of changes in cerebral perfusion during the vital sign measurements. The time interval at which the blood pressure and heart rate are measured and recorded is unclear in the literature. Therefore, the question that this clinical study investigates was: At what point over time is the change in blood pressure and heart

rate, secondary to a postural change, associated with the compensatory mechanisms in hypovolemic-induced orthostatic hypotension?

Overview of the Problem

Measuring various hemodynamic parameters after placing the body in different gravitational positions has been the subject of multiple studies: (Borst, Wieling, van Brederode, Hond, De Rijk & Dunning, 1982; Clochesy, 1986; Howard & Leathart, 1951). For healthy subjects, Mortensen (1923), in a classic study, stated that measurements should be taken 30 seconds after the upright position is assumed to limit the influence of gravity on blood volume. Von Hahn (1975) recommended that measurements be taken in three positions: supine, sitting, and standing. In the supine position, measurements should be taken every minute for five minutes or until several readings are similar; with a position change, the measurements should be taken immediately, 90-180 seconds later, and sometimes as much as to 10 minutes later. Kennedy and Crawford (1984) stated that measurements should be obtained first from the supine to sitting position and, if no change is noted, measurements should be made in the standing position. Few studies have been conducted to replicate and support any of the above recommendations.

One reason why orthostatic hypotension's measurement procedure is poorly detailed may be the terminology which

describes orthostatic hypotension. Orthostatic hypotension is one of many diagnostic terms used to describe symptoms of cerebral ischemia after a postural change from the supine to the upright body position. The term orthostatic hypotension was used by Thomas, Schirger, Fealey and Sheps (1981); however, other terms used include the venous pooling syndrome by Streeten, Anderson, Richardson and Thomas (1988), postural hypotension by Wandel (1990), orthostatic and postural hypotension as synonymous terms by Wilcox (1983) and Valle and Lemberg (1989), constitutional hypotension by Duprez, Standaert, Vertongen, Depue and Clement (1990), and hyperadrenergic orthostatic intolerance by Mader, Mackall and Emert (1990). Schatz (1984) described orthostatic hypotension as the term used when the "detection of a decline in upright blood pressure is a substantial diagnostic clue in patients who complain of dizziness and fainting when standing" (p. 773). Since agreement on a universal term defining the orthostatic condition varies, it is not surprising that the procedure to measure orthostatic changes also varies.

Statement of the Problem

Within the patient population who arrive at the emergency room with complaints of being dizzy secondary to hypovolemia, it is necessary for the health care staff to measure the systolic, diastolic, and heart rate responses of

hypovolemic subjects as the body position is changed from a supine to a standing position. It has been assumed that differences occur in the systolic, diastolic, and heart rate responses of hypovolemic subjects as the body position is changed from a supine to a standing position when compared to a normovolemic population with similar characteristics. However, the problem that has not been satisfactorily resolved is related to identifying point(s) in time, if any, during the change in position from supine to standing that the cardiovascular compensatory mechanisms correspond to the clinical signs of orthostatic hypotension. Furthermore, there is no agreement related to whether the clinical manifestations of the systolic, diastolic, and heart rate associated with orthostatic hypotension in the hypovolemic population dissipate when the patient returns to the supine position from the standing position.

Purpose of the Study

The purpose of this study was to describe the differences in systolic, diastolic and mean arterial blood pressures and heart rate between normovolemic and hypovolemic subjects as they move from a supine to a standing position. Therefore, the following research questions were generated to identify relationships between the systolic blood pressure, diastolic blood pressure and heart rate to position change and the timing of that change

Table 1. summarizes the blood pressure and heart rate measurements per time interval based upon the research questions.

Research Question 1. Are there statistically significant within subject differences in systolic blood pressure when comparing a baseline supine systolic blood pressure to systolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 2. Are there statistically significant within group differences in systolic blood pressure when comparing a baseline supine systolic blood pressure to systolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 3. Are there statistically significant differences in measurement of the systolic blood pressure between normovolemic subjects and hypovolemic subjects at baseline (established after 5 minutes in the supine position), .5 minute, 1 minute, minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Table 1. Summary of the blood pressure and heart rate measurements per time interval based upon the research questions.

Group	Position	Time in minutes
Normovolemic	supine	5 min. (baseline)
Hypovolemic	supine	5 min. (baseline)
Normovolemic	standing	0.5,1,2, 3, 4, & 5 min.
Hypovolemic	standing	0.5,1,2, 3, 4, & 5 min.
Normovolemic	supine	after 5 min. supine
Hypovolemic	supine	after 5 min. supine

Research Question 4. Are there statistically significant within subject differences in diastolic blood pressure when comparing a baseline diastolic blood pressure to diastolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 5. Are there statistically significant within group differences in diastolic blood pressure when comparing a baseline supine diastolic blood pressure to diastolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 6. Are there statistically significant differences in measurement of the diastolic blood pressure between normovolemic subjects and hypovolemic subjects at baseline (established after 5 minutes in the supine position), .5 minute, 1 minute, minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 7. Are there statistically significant within subject differences in heart rate when comparing a baseline supine heart rate to the heart rates measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 8. Are there statistically significant within group differences in heart rate when comparing a baseline heart rate to heart rates measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 9. Are there statistically significant differences in measurement of the heart rate between normovolemic subjects and hypovolemic subjects at baseline (established after 5 minutes in the supine position), .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 10. Are there statistically significant within subject differences in mean arterial blood pressure when comparing a baseline supine mean arterial blood pressure to mean arterial blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 11. Are there statistically significant within group differences in mean arterial blood pressure when comparing a baseline mean arterial blood pressure to mean arterial blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 12. Are there statistically significant differences in measurement of the mean arterial blood pressure between normovolemic subjects and hypovolemic subjects at baseline (established after 5 minutes in the supine position), .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Significance of the Problem to Nursing

Nurses often are the first members of the health care team who encounter and assess patients who exhibit significant orthostatic changes. Nurses' initial recognition of a pathophysiologic process is the hallmark of effective triage in any urgent or emergency setting (DeMars, 1985). Physical changes that may not present in the early stages of a disorder may be identified by astute assessments and continuous patient monitoring by the emergency room nurse. Nursing interventions to relieve the symptoms of

orthostatic hypotension are clearly within the domain of nursing. Carpenito (1987) outlined the application of the nursing diagnosis "potential for injury related to vertigo secondary to orthostatic hypotension" and its nursing plan of care. In support of this potential safety problem, Kenny, Ingram, Bayless and Sutton (1986) reported that 53% of patients have injured themselves by the time they seek medical advice secondary to hypotension. It would be clinically important that emergency room nurses recognize that the patient's physiological processes and medical treatment course may present a potential safety risk if orthostatic hypotension is present.

Several studies have documented that many orthostatic disorders of blood pressure and heart rate persist or increase in severity as the body's position is changed from a supine position to an upright posture (Fitzpatrick & Sutton, 1989; Green & Metheny, 1947; Kennedy & Crawford, 1984; Knopp, Claypool & Leonardi, 1980). Unfortunately, there are few specific guidelines in the literature describing the timed intervals after a position change that would reflect orthostatic changes secondary to hypovolemia. Moreover, there is an absence of an orthostatic test protocol in the policies and procedure manual at some hospitals

By anticipating orthostatic responses, nurses may be more effective in helping the patient with self care while also assisting in the diagnostic process. Nurses whose practice is based on knowledge of the physiologic reasons underlying orthostatic symptoms can more quickly recognize manifestations of orthostatic intolerance and intervene early in the process. Recognition of the orthostatic process is based upon careful assessments and understanding of clinical problems and their sequelae.

Conceptual Framework

The conceptual framework for this study is based on principles of adaptive cardiovascular physiology in which the adjustments to the upright state occur in response to hypovolemia or a fluid deficit state (Figure 1). Processes leading to hypovolemia may include vomiting, diarrhea, blood loss, diuresis, excessive insensible losses, and extracellular fluid shifts. When the blood pressure regulation becomes altered by a postural position change, during the physiologic states of hypovolemia and normovolemia, the body's cardiovascular system adapts with appropriate orthostatic changes in the systolic and diastolic blood pressure and heart rate. To understand cardiovascular responses and adaptation to hypovolemia, blood pressure regulation is reviewed including postural

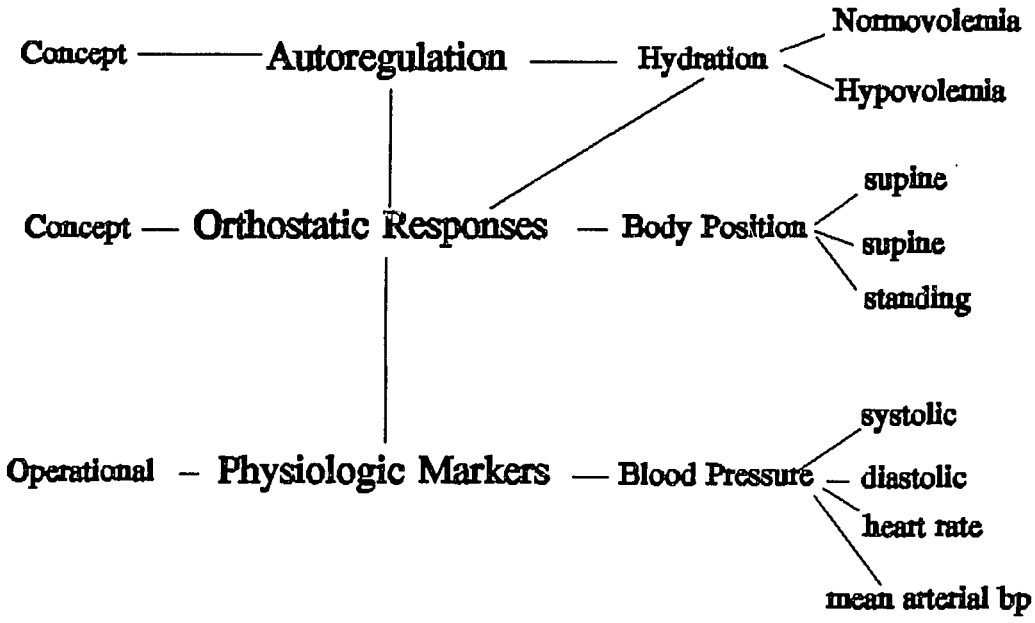


Figure 1. Conceptual framework of the relationships between the concepts autoregulation and orthostatic responses as measured by physiologic markers.

gravitational effects in normovolemic and hypovolemic states.

Blood Pressure Regulation

Arterial blood pressure can be thought of as blood flow through a vessel (artery) that is dependent upon a pressure head (cardiac output) acting as the driving force and the resistance (peripheral resistance and venous capacitance) that it meets. The arterial pressure pulse results from the ejection of a small volume of blood into a partly filled container (left ventricle) of limited distensibility. This ejection at first distends only the proximal aorta, but the pressure wave generated is then rapidly transmitted to the rest of the arterial tree, with a velocity inversely proportional to the distensibility of the vessels involved (Tarazi & Gifford, 1985).

As with any fluid, blood flow through vessels depends on two factors--the pressure head driving it and the resistance it meets. These factors can be calculated from Newton's principles on laminar movement of fluids (Cromer, 1974). The relationship between the arterial pressure or the pressure head to the peripheral resistance can be seen in the equation MAP = CO X TPR where MAP is the mean arterial pressure, CO is the cardiac output, and TPR is the total peripheral resistance (Tarazi & Gifford, 1985). All systemic vessels, arteries, veins, and capillaries,

participate in determining the arterial blood pressure and thus play a role in either the cardiac output, peripheral resistance or both. The quantitative definition of a normal arterial blood pressure is so individual that it is not uncommon to see wide fluctuations in both systolic and diastolic pressures encountered from moment to moment. Variability in the blood pressure can be related to such obvious causes as body movement, position (Clochesy, 1986), pain, emotional stress (Memmer, 1988), and talking (Freed, Thomas, Lynch, Stein & Friedmann 1989). Thus, arterial blood pressure is only one aspect in a highly integrated cardiovascular control system.

Control of circulatory pressure is closely associated with control of the volume distending the circulation. This central pressure control is regulated by the interaction of vascular innervation, neurogenic mechanisms, and various circulating hormones (Tarazi & Gifford, 1985). Vascular innervation is not restricted to arteries and is present in all vessels except capillaries. The inherent myogenic activity of vessel walls is responsible for a basal vascular tone that is locally regulated by the vasodilator action of tissue metabolites on the sympathetic receptor sites (Tarazi & Gifford, 1985). The main effects of sympathetic stimulation are increases in resistance and enhancement of venous return. Vasodilator fibers are less

widespread and not tonically active. Beta-adrenergic receptors are found in arteries and probably in veins (Tarazi & Gifford, 1985). Cholinergic sympathetic vasodilator nerves supply only the larger resistance vessels of skeletal muscles and are activated mainly when the defense reaction is activated and when most other regions are vasoconstricted so that the muscles may thus be provided with near maximum blood supply. Neurogenic mechanisms exert their own control to adjust the circulation to the requirements of the body as a whole. Neural circulatory reflexes act mainly to stabilize arterial pressure at the levels set for a particular individual. They help buffer the impact of stimuli by raising arterial pressure when it is lowered or decreasing it when it rises. These reflexes play a major role in circulatory adjustments to postural change. Hormonal influences result in increasing the circulating epinephrine from the adrenal medulla, which stimulates both alpha- and beta-receptors so that a redistribution of blood flow results (Blomqvist & Stone, 1983).

Physiologic Responses to Gravity

The effect of gravity on the cardiovascular system is a valuable identifier when evaluating the hemodynamic status. Blomqvist and Stone (1983) stated that all intravascular pressures have a gravity-dependent hydrostatic component and

that the interaction between the gravitational field, the position of the body, and the functional characteristics of the blood vessels determines the distribution of intravascular volume. Were it not for a predictable homeostatic chain of events, standing would invariably produce a decline in arterial blood pressure. The result would be a syncopal episode. The interaction between the downward gravitational forces, the position of the body, and the functional characteristics of the blood vessels determines the distribution of intravascular volume. The degree of the volume shift is an important determinant of the physiological response. Sjostrand (1952) emphasized that it is the distribution of blood volume rather than its absolute amount that seems to determine cardiac output.

The principal hemodynamic effect of posture change is redistribution of venous volume with marked secondary changes in ventricular filling and stroke volume (Blomqvist & Stone, 1983). Tarazi, Melsher, Sustan and Frohlich (1970) identified that when changing from a supine to an upright position, plasma volume remained essentially the same but the venous volume in the legs increased approximately by 500 ml associated with a reduction in cardiac output (Tarazi, 1970). They concluded that the distribution of blood volume rather than its absolute amount seemed to determine cardiac output.

The blood volume distribution is determined through physiologic compensatory mechanisms which perform quite adequately to adjust to the fall in arterial pressure and prevent an impaired cerebral perfusion and loss of consciousness. These physiologic mechanisms include reflex arteriolar constriction, mediated through pressor receptors and reflex acceleration of the heart rate to increase effective cardiac output; the venous role in central pressure maintenance; and release of sympathetic chemicals and hormones (Blomqvist & Stone, 1983). A brief description of the actions of each of these physiologic mechanisms follows.

Reflex arteriolar constriction and acceleration of the heart rate are central physiological adjustments to upright position and are mediated through the mechanoreceptors, also known as baroreceptors, and the responsiveness of target organs to sympathetic activation (Tarazi & Gifford, 1985). The mechanoreceptors primarily involve carotid and aortic mechanoreceptors, cardiopulmonary mechanoreceptors and hypothalamic osmoreceptors, and angiotensin II receptors (Blomqvist & Stone, 1983). The third group of receptors interacts with the first two in the control of blood volume and is less important in the acute stages of posture change.

The function of the arterial mechanoreceptors reflects the fact that an action potential generated in the receptors

themselves inhibits the tonic discharge of the vasoconstrictor nerves and excites the cardioinhibitory center, producing vasodilation, venodilation, a drop in blood pressure, bradycardia, and a decrease in cardiac output. During orthostasis, there is a decreased stimulation of the mechanoreceptors in the aorta arch intima, carotid sinus and to a lesser extent, in the four cardiac chambers. The physiological response is the attempt by the body to produce vasoconstriction, a limited venoconstriction, tachycardia, and an increase in cardiac output. When left ventricular filling pressure is insufficient to stretch myocardial fibers adequately during diastole, reductions in cardiac output will occur. Thus, any condition that causes a loss of volume from the circulation may produce orthostatic hypotension which results in an instantaneous alteration in the central blood pressure. Compensatory mechanisms are initiated to maintain a relatively constant arterial pressure for the sake of cerebral perfusion.

The venous role in central pressure maintenance includes both the arterial and venous compartments that are affected by sympathetic reflexes and circulating catecholamines. Characteristically, these effects are different. The arterial segment has limited distensibility, is maintained at high pressure and low volume, and contains

about 20% of the total blood volume (Tarazi & Gifford, 1985). In contrast, the venous side of the circulation is a low pressure, highly distensible compartment that contains about 75% of the intravascular volume (Tarazi, 1985).

Veins add little to peripheral resistance but accommodate the larger portion of blood volume and thus play an important role in circulatory regulation (Tarazi, 1985). They are well supplied by sympathetic nerves and may react differently from resistance vessels to nervous and humoral stimuli. However, sympathetic vasomotor activity does play a large role in determining venous capacity, controls venous return, and influences cardiac output via both passive and active control mechanisms that combine to regulate central venous pressure, and the regional distribution of venous volume. Thus, the main effects of sympathetic stimulation are increases in arterial vascular resistance and enhancement of venous return.

Muscle veins respond weakly to neural stimulation, including mechanoreceptor mediated reflexes, but the venoconstriction that does result from sympathetic stimulation alters peripheral resistance by decreasing venous capacity. This action enhances a translocation of blood out of systemic veins into the cardiopulmonary area, raises cardiac output, and thus helps prevent or correct falls in arterial pressure due to volume loss secondary to

pooling (Tarazi, 1985). Progressive pooling with decreasing stroke volume and cardiac output eventually causes a fall in arterial pressure with compensatory tachycardia, increased contractility, and further vasoconstriction mediated by the arterial mechanoreceptors.

Whatever the reflex effects that occur on the veins upon standing, the capillary vessels in the dependent areas must contend with an increase in volumetric pressure generated by gravity. To offset the potential in plasma loss by diffusion, counterpressures develop in dependent areas to prevent overdistension of veins and help balance some of the rise in capillary pressure. "Muscular pumping" helps lower both venous pressure and effective capillary filtering pressure (Tarazi, 1985).

Releases of sympathetic chemicals and hormones affect both the arterial and venous compartments. These effects are influenced directed by circulating hormones, namely epinephrine and norepinephrine from the adrenal medulla which stimulates both alpha and beta receptors. Like the posterior pituitary, the adrenal medulla is a functional extension of the nervous system. Tepperman and Tepperman (1987) regard the adrenal gland as a specialized sympathetic ganglion, innervated by a long preganglionic, cholinergic neuron that forms synaptic connections with chromaffin cells within the adrenal cortex. When stimulated, the chromaffin

cells discharge their contents directly into the blood stream. The adrenal substances or "adrenergics" are also known as epinephrine and norepinephrine.

Epinephrine and norepinephrine are both associated with sympathetic activity. The increase in epinephrine is due to reflex sympathetic stimulation of the adrenal medulla, and the increase in norepinephrine is mostly due to increased activity of the sympathetic vasomotor nerves (Tarazi & Gifford, 1985). The concentration of both these catecholamines induces a redistribution of blood flow so that the myocardium, muscles, liver, and brain receive more blood at the expense of other circuits such as the kidneys, skin, and gastrointestinal tract via vasoconstriction. The resultant sympathetic stimulation increases heart rate and stroke volume as well as limiting the fall in diastolic pressure. Other circulating hormones also may influence the degree of vasoconstriction. These hormonal influences include angiotensin, prostaglandins, histamine, serotonin, and vasopressin; however, the level of alpha-adrenergic stimulation is the primary control mechanism in hypovolemic orthostasis.

In summary, when man assumes an upright posture, blood shifts from the thorax to the lower limbs. The reduction in thoracic blood volume reduces ventricular filling, causing an immediate fall in arterial pressure. The carotid sinus

and aortic arch baroreceptors consequently reduce their inhibitory drive to the vasomotor center which results in increased heart rate and sympathetic tone. Sympathetic stimulation of the chemoreceptors causes a release of circulating catecholamines which exert a tonic inhibition of the vasomotor center and results in an increase in vascular resistance, tachycardia and stroke volume.

Hypovolemia

Blood pressure is dependent upon the body's total fluid volume and the distribution of that volume. Any mechanism that reduces the dissemination of that volume will reduce blood pressure by directly affecting the cardiac output. Such mechanisms include any condition that leads to a direct loss of blood or plasma from the circulation. Hypovolemia may be induced by gastrointestinal losses such as diarrhea and/or vomiting, excessive sweating, bleeding, edema, dialysis, renal sodium losses due to diuretic therapy or intrinsic renal disease, or fluid losses from hypoaldosteronism. In addition to these forms of absolute hypovolemia, where there is actual loss of blood or fluid, relative hypovolemia also may occur. In this situation, a massive decrease in venous tone produces venous pooling with a resultant decrease in venous return to the heart (Billhardt & Rosenbush, 1986).

Total body fluid exists in two major compartments: intracellular and extracellular fluids. By definition, the extracellular fluid includes all body water which is external to the cells such as the plasma and interstitial compartments. These two fluid compartments of the body do not exist as fixed spaces of water with identical compositions. They are in constant interchange with each other. But they differ strikingly in their composition due to several features of cell structure and function.

A dynamic exchange of fluid continuously occurs among the intracellular, plasma and interstitial compartments. Of these three compartments, only the plasma is directly influenced by the intake or elimination of fluid from the body (Chenevey, 1987). Changes in the intracellular and interstitial fluid compartments occur in response to changes in the volume or concentration of the plasma.

The major forces responsible for water movement between body compartments are hydrostatic and osmotic pressure (Maxwell & Kleeman, 1980). Hydrostatic pressure is provided by the mechanical pressure of the heart, while osmosis can be viewed as the movement of water from a region of higher to a region of lower chemical potential, across an intervening semipermeable membrane (Maxwell & Kleeman, 1980). Osmotic pressure develops as solute particles collide against each other.

Schrier (1990) states that the arterial circulation is the primary body fluid compartment modulating total body fluid status and therefore, it can be concluded that orthostatic hypotension is probably the most reliable physical indicator of serious volume depletion. Upon standing, changes of 15 to 20 mm Hg systolic and 10 mm Hg of diastolic pressures suggest the loss of about 20 percent or more of body water (Shoemaker, Ayres, Agrenvik, Holbrook & Thompson, 1989). Therefore, changes in systolic and diastolic blood pressures in response to a postural change are investigated and treated aggressively.

With the fall in blood volume, there is diminished venous return to the right heart, low central venous pressure, tachycardia, reduced stroke volume, low cardiac output, and a drop in peripheral blood pressure. Multiple mechanisms come into play to support the falling blood volume and blood pressure. Reflex sympathetic vasoconstriction triggered by baroreceptors initiates peripheral and splanchnic vasoconstriction and increased peripheral resistance; however, the sympathetic medicated vasoconstriction does not cause significant constriction of either the cerebral or coronary arteries (Robbins, 1974). In this manner, blood is shunted from noncritical areas to the heart and brain. The sympathetic peripheral vasoconstriction is supported by mechanisms involving the

integrating cardiovascular centers (Tarazi & Gifford, 1985), adrenal catecholamines (Conway, Boon, Davies, Vann Jones & Sleight, 1983), aldosterone, antidiuretic hormone, and the renin-angiotensin system (Blomqvist & Stone, 1983). These compensations act both to conserve fluid and support the falling blood volume and blood pressure (Shoemaker, 1971). Thus, while the heart and brain are temporarily protected, the widespread vasoconstriction further compromises the perfusion of the periphery. As perfusion diminishes, cellular metabolism is deranged, with resultant reduction in mitochondrial high-energy phosphate compound generation and increasing accumulation of lactate and other anaerobic products (Billhardt & Rosenbush, 1986). Normal cellular processes diminish, furthering organ dysfunction and eventually causing cellular death.

Although diminished tissue perfusion in hypovolemia often is preceded by systemic hypotension, all patients who become hypotensive are not clinically progressing toward disaster. The hypotensive state may not last long enough for a significant diminution in tissue flow to occur, or compensatory increases in cardiac output and/or peripheral vascular resistance may maintain metabolic integrity.

Classically, hypotension is emphasized in the recognition of the hypovolemic state. It is difficult to define an absolute blood pressure reading that constitutes

hypotension. Jorden (1985) reports that beyond a 25 to 30 percent volume deficit, blood pressure and cardiac output experience a rapid deterioration. Since blood pressure is a function of total peripheral resistance and cardiac output, the pressure can be maintained by a rise in either or both of them.

By definition, cardiac output is stroke volume multiplied by heart rate. The change from recumbency to upright positions is accompanied by a partial redistribution of blood volume to the dependent parts of the body, causing a decrease in cardiac output. Nonneurogenic orthostatic hypotension usually results from inadequate cardiac filling related to absolute or relative hypovolemia or to interference with venous return (Fouad, Tarazi, & Bravo, 1985). Compared with recumbency, the average cardiac output on standing in normal man falls 19% (Tuckman & Shillingford, 1966). In hypovolemia, compensatory mechanisms may not be able to respond to a further volume reduction resulting in syncope. Unless intrinsic sinus node dysfunction or drug effects are present, hypovolemia is accompanied by compensatory tachycardia. It is produced by increased levels of circulating catecholamines, increased sympathetic and decreased parasympathetic activity, and increased metabolic demands of the tissues.

The compensatory mechanisms are designed to preserve blood flow to the most vital areas such as the heart and brain. The tissues of the central nervous system are acutely sensitive to the effects of circulatory insufficiency. Complete interruption of the cerebral circulation is followed within seconds by a loss of consciousness and within minutes by irreversible pathologic changes within the brain (Rossen, Kabat, & Anderson, 1943). With the progression of shock and resultant inadequate cerebral perfusion, mental status may progress from normal to a state of anxiety, restlessness, and agitation. In hypovolemia, the most important management goals include recognizing and controlling blood or fluid loss and restoring lost volume to ultimately restore adequate tissue perfusion.

Cerebral perfusion is maintained when assuming the upright posture by several mechanisms, such as, reflex arterial vasoconstriction, increased venous return via venous constriction, and increased respirations. Tachycardia, increased muscle tone and tissue pressure in the legs and abdominal muscles, and secretion of norepinephrine and antidiuretic hormone also contribute to maintaining perfusion pressures (Thomas & Schirger, 1968). The movement from the lying to standing position may result in a drop of up to 25 mm Hg levels (Siegel, 1982). Thomas

et al. (1981) describe a decrease of as much as 25 mm Hg in systolic pressure and an increase of up to 10 mm Hg in diastolic pressure as acceptable. When compensation is incomplete or absent, the persistent drop in pressure may result in dizziness, blurred vision, ataxia, and ultimately in syncope. These symptoms can be relieved by lying down but are exacerbated upon arising from a sitting or supine position.

Summary of Physiological Adaptations

Patients with volume depletion often present to an emergency room with orthostatic hypotension and, if recognized, respond quickly to treatment. The maintenance of normal cardiac output and blood pressure is dependent on both adequate peripheral vascular resistance and sufficient blood volume. When the filling pressure of the left ventricle falls below certain critical levels, not enough volume is available to stretch myocardial fibers during diastole and therefore a reduction in cardiac output occurs. Any condition that leads to a direct loss of blood or plasma from the circulation may induce orthostatic or postural hypotension. Hypovolemia becomes apparent on a careful patient interview, physical examination and assessment.

Physical findings may be either minimal or severe. Minimal findings may consist of only slight tachycardia but severe findings may include hypotension, presenting with

marked peripheral vasoconstriction, diaphoresis, anxiety, and restlessness. In a patient who appears to be well compensated, measurement of blood pressure and heart rate in positions of varying degrees of gravitational stress can be helpful in recognizing risk for personal safety and cellular deterioration.

Knowledge of pathophysiology is the basis for understanding human responses to stress. The conceptual framework for this study is diagrammed in Figure 1. The dominant construct for the study is the regulation of blood pressure. The interrelationships of hydration and body position within the concepts of autoregulation and orthostatic responses are examined.

Definition of Terms

Orthostatic Hypotension: also known as postural hypotension involves an inadequate blood pressure and heart rate after assuming an erect position resulting in a decrease in cerebral perfusion. The response to standing reveals a greater than normal fall in systolic pressure, sometimes an abnormal increase or decrease in diastolic pressure and a marked acceleration of the pulse rate. Along with the changes in the vital signs, clinical symptoms of cerebral hypoxia are present such as light-headedness, syncope, blurring or loss of

vision, weakness, and dizziness. For purposes of the study, the following terms were operationally defined.

Orthostatic Diastolic Hypotension: fall in diastolic blood pressure of ≥10 mm Hg with or without an excessive fall in systolic pressure (Streeten, 1987).

Orthostatic Systolic Hypotension: fall in systolic pressure from by ≥20 mm Hg, or to < 94 mm Hg (Streeten, 1987).

Orthostatic Hypertension (Diastolic): diastolic blood pressure of ≥90 mm Hg in recumbent position and ≥98 mm Hg in the standing position (Streeten, 1987).

Orthostatic Narrowing of Pulse Pressure: pulse pressure of ≤18 mm Hg in the standing position (Streeten, 1987).

Orthostatic tachycardia: heart rate increased by ≥28 beats/minute or to ≥110 beats /minute after standing for three minutes (Streeten, 1987).

Systolic Blood Pressure: the pressure generated by the contraction of the ventricles of the heart by which the blood is forced into the aorta and the pulmonary trunk. In this study, the systolic blood pressure is the first number recorded by the electronic monitoring device.

Diastolic Blood Pressure: the pressure within the circulatory system during the relaxation phase of the ventricles, during which, passive filling of the atria occurs. In this study, the diastolic blood pressure is the second number recorded by the electronic monitoring device.

Mean Arterial Blood Pressure: is the average pressure throughout the cardiac cycle. Because the systole is shorter than diastole, the mean pressure is slightly less than the value halfway between systolic and diastolic pressure. As an approximation, the mean arterial blood pressure is determined by the diastolic pressure plus one-third of the pulse pressure.

Pulse Pressure: the difference between the systolic and diastolic pressures.

Hypovolemia: a state of depleted intravascular volume in which there is an abnormally decreased volume of circulating fluid in the body. This state may be caused by primary metabolic, cardiovascular and renal disorders and result in fluid losses through vomiting, diarrhea, bleeding, insensible water losses, poor fluid intake and extravascular fluid shifts. In this study, a specific gravity over 1.024 identifies a hypovolemic state (Sheets & Lyman, 1986).

Tilt Test, Orthostatic Test, Tilts, Orthostatics:

Synonymous terms are used to describe the procedure to determine orthostatic hypotension. In this study, the procedure consists of a series of heart rate and blood pressure measurements taken in the supine position and in the standing position in a specific timed sequence.

Summary

The effects of gravity on the cardiovascular system are important in the recognition of a health problem. All intravascular pressures have a gravity-dependent hydrostatic component. The interaction between the downward gravitational forces, the position of the body, and the functional characteristics of the blood vessels determines the distribution of the intravascular volume. This study was undertaken to describe the differences, if any, in postural responses in the systolic and diastolic blood pressures and heart rate between normovolemic and hypovolemic subjects as they move from a supine to a standing position. The conceptual framework of the study was based on principles of adaptive cardiovascular physiology related to blood pressure regulation in normovolemic and hypovolemic states. Nurses who recognize and anticipate orthostatic responses are more effective in accurate assessment, early intervention, and prevention of injuries.

CHAPTER 2

REVIEW OF THE LITERATURE

The literature related to orthostatic hypotension is voluminous and often the results are confusing. Much of the past research has been undertaken on a tilt table and extrapolated to the ambulatory population. Schatz (1986) observes that measuring the blood pressure while the patient is on the tilt-table is unwarranted and may be misleading. Borst, Wielding, Van Brederode, Hond, De Rijk and Sunning (1982) concluded that active changes (standing) and passive changes (tilt-table) of posture are fundamentally different. Standing causes involuntary contraction on skeletal muscles, probably influencing afterload and venous return, while a passive passage to the upright position, does not impose the same skeletal stresses. Literature is reviewed that relates to orthostatic hypotension's definitions.

Literature Review of Orthostatic Definitions

Definitions of orthostatic hypotension contribute to the confusion. Streeten (1987) offers the most comprehensive set of definitions that delineate subcategories of orthostatic hypotension. He states that these definitions differ from the more variable, and sometimes admittedly arbitrary, definitions of orthostatic hypotension, that were proposed by other investigators, but

which lacked documentation of the normal ranges on which they were presumably based.

Orthostatic hypotension has been defined by a postural fall in systolic blood pressure of 30 mm Hg or 20 mm Hg, by a fall in systolic and diastolic blood pressure of 30 mm Hg and 20 mm Hg respectively, or 25 and 10 mm Hg respectively, or 30 mm Hg and 10 mm Hg respectively and by a fall in mean blood pressure of more that 15 mm Hg (Kuroiwa, Wada & Tohgi, 1987). By default, definitions begin the process of understanding a new concept. The numerical standards which define orthostatic hypotension and orthostatic heart rate contribute to the basis of the confusion regarding the technique of measuring an orthostatic response and interpreting the results in various clinical situations. Wandel (1990) notes that very few studies evaluate unusual responses as indicators of patients' fluid volume status.

Orthostatic Changes in Healthy Populations

To understand an abnormal orthostatic response to a position change, it is necessary to understand a normal response. Vital sign changes secondary to gravitational volume redistribution had been recognized by such early researchers as Knox (1815, 1837) and Guy (1838) as cited by Streeten (1987, p. 116). More recently, Borst et al. (1982) described normal transient orthostatic changes within a healthy population of 43 subjects. They explored the

mechanisms of the initial heart rate response to standing by comparing free standing heart rates with that of a 70° head up tilt. Their results indicated that standing evokes an immediate, large, increase of heart rate of about 20 seconds duration that far exceeds the gradual heart rate rise induced by 70° head up tilt. They found that the immediate heart rate increase with active standing is due to the exercise reflex and results in a first peak about 3 seconds after standing briskly with a secondary, more gradual heart rate increase after 5 seconds of standing. Subsequently, a rapid decrease of heart rate between about 12 and 20 seconds corresponds through the baroreceptor reflex with a striking fall, recovery, and sometimes overshoot of arterial pressure. Finally, the results indicated that the maximum heart rate increase found after about 12 seconds of standing is augmented and delayed after rest.

To further explain the gravitational effects of postural change, Borst et al. (1982) described that during the first 0.5-3 seconds after a change from the reclining to the upright posture, the contraction of postural muscles compress the arteries and veins in the abdomen and legs, causing a rise in systolic pressure (+29 or ± 26 mm Hg). These changes are followed, at 6-7 seconds after standing, by a transient fall in systolic and diastolic blood

pressures to the extent of about 28/15 mm Hg, after which there is a rise to or toward the control levels within 30 seconds. After the immediate transient fall in blood pressure in the standing position, both the blood pressure and the heart rate stabilize in healthy subjects and remain substantially unchanged.

Kennedy and Crawford (1984) studied postural blood pressure and heart rate effects to position change in a sample of 10 healthy subjects. The purpose of their study was to determine the time course of blood pressure and heart rate changes following the assumption of an upright position before and after the administration of a nitrate preparation in patients with ischemic heart disease.

They recorded supine to sitting and supine to standing responses before and after ingestion of 5 mg of chewable isosorbide dinitrate. The upright positions constituted sitting with legs dangling or standing without support. The upright position that was performed first was randomly selected for each subject before the study began. First, the subject assumed the supine position for five minutes; at minutes four and five in this position, blood pressure and were measured. The patient was then asked to assume one of the upright positions, sitting or standing, and blood pressure and heart rate measurements were once again taken at the fourth and fifth minutes. After these measurements

were obtained, the patient returned to the supine position for another five minutes, and blood pressure and heart rate measurements were once again taken at the fourth and fifth minutes. Subsequently, the subjects assumed the second upright position, and the measurements were repeated at described above. This sequence was repeated after the administration of 5 mg of chewable isosorbide dinitrate.

The data demonstrated that although the initial orthostatic changes occurred at 0.5 minutes, the maximum orthostatic response usually occurs at two minutes after the position change and that orthostatic changes are most marked in the standing position. Therefore, Kennedy and Crawford (1984) recommended that blood pressure and heart rate should be measured at 0.5 minutes and 2 minutes after position change. The researchers recommended measuring the supine to sitting response first and, if no change occurs, measuring the sitting to standing response. Shoemaker, Ayres, Grenvik, Holbrook, and Thompson, (1989) support this technique. They state that because orthostatic hypotension is caused largely by blood pooling in the large vessels of the thighs, a false positive may be caused by the sitting position; therefore, the change in blood pressure and heart rate should always be recorded when the patient is standing.

Streeten (1987) conducted a similar study using 92 healthy male and female subjects aged 17-61 years of age.

Measurements of blood pressure and heart rate were recorded after recumbency for 3-4 minutes and after standing for 3 minutes. There was a slight but significant fall in systolic blood pressure, a rise in diastolic blood pressure, a fall in pulse pressure, and a rise in heart rate in the upright posture. In addition, the change in mean arterial blood pressure was not significant.

Using a 95% confidence limits for each parameter, Streeten (1987) identified the following types of orthostatic blood pressure and heart rate abnormalities: 1). orthostatic systolic hypotension, defined by a fall in the systolic blood pressure by 20 mm Hg or more, or to below 94 mm Hg., 2). orthostatic diastolic hypotension, characterized by a fall in the diastolic blood pressure by 10 mm Hg or more; 3). orthostatic diastolic hypertension, manifested by a rise in diastolic blood pressure from 90 mm Hg in recumbency to 98 mm Hg or higher in the standing position; 4). orthostatic narrowing pulse pressure, defined by a fall in pulse pressure to 18 mm Hg or lower, when standing, and 5). orthostatic tachycardia, defined as an increase in heart rate by at least 28 beats/min or to at least 110 beats/min. after standing three minutes.

Thomas and Schirger (1968) describe the important criterion in the diagnosis of orthostatic hypotension as the concomitance of the orthostatic fall in systolic and

diastolic blood pressure with the clinical symptoms of dizziness and faintness. They admit that the drop in the blood pressure, frequency and severity of symptoms vary so much from case to case that they have small value as a diagnostic criteria. Thomas and Schirger (1968) offer justification of the procedure without the benefit of specific guidelines for the technique. Their recommendation to measure orthostasis is to test in the lying and standing position; and then record the blood pressure and pulse at 60 second intervals throughout at least 5 minutes of standing. This procedure was thought to be best "since the greatest fall in blood pressure may not occur immediately upon assumption of the erect position" (p. 811).

Measurements of Orthostatic Changes in Blood Loss

In a classic study, Green and Metheny (1947) attempted to use the tilt test post hemorrhage to determine the amount of blood required for transfusion to restore circulatory volume to normal. They noted that the fundamental therapeutic problem in hemorrhage, other than direct arrest of bleeding, is the determination of the amount of blood required to restore circulatory volume to normal. Hypovolemic patients who are able to maintain a relatively normal blood pressure while lying flat often showed symptoms of cardiovascular instability on sitting or standing up

(Warren, Brannon, Stead, & Merrell, 1945). The frequency with which these effects were observed suggested "that cardiovascular reaction to change in posture could be related quantitatively to blood loss and diminished circulatory volume" (p. 1045). In other words, the presence of a hypovolemic induced orthostasis could correlate to the overall loss of intravascular volume and from this, a quantitative fluid restoration might be determined. This hypothesis was later supported by Shoemaker (1989). He states that changes of 15 to 20 mm Hg in systolic pressure and 10 mm Hg in diastolic pressure suggest the loss of about 20 percent or more of body water.

A comparison was undertaken between a total population of 46 bleeding patients and a control of 56 nonbleeding patients. All the subjects were placed supine on a tilt table. Blood pressure and pulse rate measurements were taken until stable readings were obtained in three trials. The table then was tilted to minus 30^0, plus 30^0 and plus 75^0 and similar measurements carried out. The subjects were maintained in a position of plus 75^0 for 3 minutes. The blood pressure and pulse rates were determined at intervals of 1 minute, unless the occurrence of syncope interrupted the study. The 46 patients who experienced bleeding were further divided in a control group of 35 who experienced a

controlled acute blood loss of varying amounts: 19 subjects who underwent venesection of 5-9 cc/kg.(approximately 500 cc), 11 subjects who underwent venesection of 9-14 cc/kg. (approximately 1000 cc), and 5 subjects who underwent venesection of 12-21 cc/kg (approximately 1500 cc). This group was compared to 11 individuals who were admitted because of recent gastrointestinal hemorrhage.

The tilting responses were measured in the three groups of individuals before and immediately following rapid removal of blood by venesection. The time which elapsed between the start of venesection and completion of posthemorrhagic tilting varied from 30 minutes to 1 hour.

The results of Green and Metheny's (1947) study support the physiologic phenomena which results from a depleted intravascular volume and indicate that significant differences in the tilting among the subjects were associated only with acute blood loss exceeding 9 cc/kg (1000 cc). The pulse rate increase on tilting individuals in the normal, aged, cardiovascular or anemic groups never exceeded 25 beats per minute but always exceeded 25 beats per minute following a blood loss of 1000 cc; therefore, an increase in cardiac rate less than 25 beats per minute on tilting indicates either a negligible or a compensated acute blood loss.

Knopp, Claypool and Leonardi (1980) examined the accuracy of the tilt test in detecting acute blood loss before and after phlebotomizing two groups of healthy volunteers. One hundred volunteers with no serious medical problems were phlebotomized a specific amount of blood (Group I, 450 cc; Group II, 1000 cc in 500 cc increments). Orthostatic vital signs were recorded at timed intervals comparing the supine to sitting and supine to standing techniques.

Knopp, Claypool and Leonardi (1980) agreed that the tilt test could be used as a screening test for detecting the presence of acute blood loss as reported by Green and Metheny (1948); however, they reported that Green and Metheny's data were not applicable to the emergency department setting for the following reasons: tilting was accomplished by passive means; subjects were tilted to a maximum of 75° (as opposed to 90° with standing or sitting); and the study population was small. To validate the tilt test's usefulness within the emergency room, Knopp, Claypool and Leonardi believed that three questions needed to be addressed: 1). What are the sensitivity and specificity of the tilt test in detecting the presence of acute blood loss? 2). What is the comparison of body positioning such as the supine to sitting and the supine to standing techniques?,

and 3). What is the most appropriate time interval after postural change to measure pulse and blood pressure?.

The results of their study indicated that in the supine to standing test, a pulse increase >30 beats per minutes distinguished a 1000 cc blood loss from no blood loss but the test was unable to accurately detect blood loss of 500 cc. Knopp, Claypool and Leonardi (1980) found that the supine to sitting test did not duplicate the usefulness of the supine to standing test in distinguishing between 1000 cc of blood loss and no blood loss, and that neither systolic nor diastolic blood pressure was useful in predicting whether blood loss was present using the supine to sitting or supine to standing tests. Finally, they found that the comparison of timed values showed one minute to be the best time to record pulse changes. Their recommendations for a standardized tilt test technique included using the supine to standing procedure with measurements recorded after the subject has been standing for one minute.

Despite multiple studies that have measured orthostatic responses using a tilt table (Green & Metheny, 1947; Knopp, Claypool & Leonardi, 1980;, Shvartz & Meyerstein, 1970) Schatz (1986) observed that measuring the blood pressure while the patient is on the tilt-table is unwarranted and may be misleading. Borst, Wielding, Van Brederode, Hond, De

Rijk and Dunning (1982) concluded that active changes (standing) and passive changes (tilt-table) of posture are fundamentally different because standing causes involuntary contraction on skeletal muscles. These cause and effect probably influences afterload and venous return while a passive passage to the upright position does not impose the same skeletal stresses.

Gender Differences

Research examining orthostatic responses and possible gender differences in their responses were limited (Shvartz & Meyerstein, 1970; Tuckman & Shillingford, 1966). Previously, it had been reported that men respond to tilting by an increase in heart rate and diastolic blood pressure, by a slight fall in systolic blood pressure, and by a decrease in pulse pressure (Stead, Warren, Merrell & Brannon, 1945; Howard & Leathart, 1951). The results of these two studies indicate that women's overall response to tilting are similar to those of men. No suggestions regarding the timing or position sequencing were given.

Shvartz and Meyerstein (1970) studied the tilt responses among healthy young men and women by using a tilt table. A 20-minute tilt table test was given to 18 young men, mean age of 20.5 years, and 18 young women, mean age of 19.8 years. Subjects who displayed heart murmurs and a history of rheumatic heart disease were excluded. Every

subject was given a 20-minute tilt table test. Heart rate and blood pressure were first determined after the subjects had been in a horizontal position for 0.5 minutes. The subject was then tilted, within 5 seconds, to 70^0 head up tilt maintained for 20 minutes unless syncope occurred. After tilting, heart rate and blood pressure measurements were taken every 2 minutes.

The results of their study showed unusual changes occurring upon tilting: an increase in heart rate and in diastolic blood pressure, a slight fall of the systolic blood pressure, and a narrowing of the pulse pressure. Women showed a significantly higher mean heart rate and significantly lower mean blood pressure values than men in reclining. Women also showed a significantly higher mean heart rate and significantly lower mean systolic and diastolic blood pressures in orthostasis; however, the orthostatic pulse pressure difference between men and women was not significant.

Moore and Newton (1986) attempted to compare the orthostatic responses of women and men during active standing. The purpose of their study was to describe and compare the orthostatic heart rate and blood pressure responses in a group of 25 healthy men and 25 healthy women between 25-35 years of age.

Subjects had no history of major illness, no psychiatric illnesses, no physical handicaps, were not pregnant, were of normal weight for height, nonsmokers and were taking no medications. Each subject was asked to lie down and rest, supine without a pillow, for 20 minutes at which time a baseline heart rate and blood pressure were taken. Upon standing, a continuous 5-minute electrocardiographic rhythm strip was recorded, blood pressures were auscultated immediately, and at 2 and 4 minutes of standing. The subject was then asked to lie down for another 20 minutes. The protocol was repeated. Following the second trial, each subject was asked if he or she had experienced dizziness after either of the trials.

The results showed that the heart rate responses attained a relatively steady state after an average 45 seconds of standing for both women and men. From baseline to 45 seconds of standing, there was a mean increase of 12.6 beats/min. for the sample, 12.4 beats/min. for the women and 12.9 beats/min for the men. Moore and Newton (1986) noted that the mean heart rate of each population was far from typical for all individuals. The range of individual changes was from an increase of 35 beats/min. to a decrease of 17 beats/min.; however, when the overall heart rate responses of all subjects were compared, the orthostatic heart rate responses of men and women over time were the

same. Analysis of variance yielded no significant difference between the men and women's systolic and diastolic blood pressures.

In support of the findings by Shvartz (1970), Moore and Newton (1986) found women and men did not show statistical differences in orthostatic responses and can, therefore, be regarded as the same. Of particular interest, their findings suggest that orthostatic heart rate increases as great as 30 beats/min and orthostatic systolic blood pressure decreases as great as 26 mm Hg are normal. In addressing the issue of timing of the orthostatic response, the heart rate curve reached a steady state after position change at approximately 45 seconds. Blood pressures, measured on standing and at 2 and 4 minutes, had reached their maximum change response by 2 minutes. Thus, Moore and Newton (1986) suggested that the heart rate be measured 45 seconds after standing followed by blood pressure measurement at 2 minutes.

Pre/Post Operative Orthostatic Changes

Lester (1990) compared the preoperative and postoperative orthostatic responses in systolic blood pressure, diastolic blood pressure and heart rate of coronary artery bypass graft surgical patients. The sample consisted of 30 men and women undergoing elective coronary artery bypass graft surgery. In addition, the responses

among normotensive and hypertensive patients were specifically evaluated. Comparisons were made from the supine to standing position, and the supine to sitting position using 0.5, 1, 2, 3, 4, and 5 minutes as the time intervals.

In the preoperative and postoperative groups, the change noted in the systolic blood pressure from moving from a supine to a sitting position was identical. The change in systolic blood pressure from a supine to a standing position followed the same pattern as from supine to sitting with an initial steep drop at 0.5 minutes followed by a gradual increase and plateau at minutes 4 and 5.

The diastolic blood pressure did not follow a consistent pattern. The diastolic blood pressure did not change significantly when moving from a supine to a sitting or a supine to a standing position for all 30 subjects. Normotensive subjects did not exhibit a significant change for either position change; the postoperative movement caused a rise in diastolic blood pressure, the preoperative movement did not. The hypertensive subject exhibited a rise in diastolic blood pressure when moving from a supine to standing.

The heart response showed an acceleration of heart rate that peaked at 1 minute and remained elevated for 5 minutes in the supine to sitting position. This response was

further increased with supine to standing movements. Normotensive subjects exhibited a main effect between subjects for both position changes. A preoperative to postoperative effect was found only when moving from supine to sitting. The hypertensive subjects did not exhibit a change for minutes or pre/post effect in the supine to sitting movement. Moving from the supine to standing resulted in a significant change over time for the hypertensive subject.

Lester (1990) did not make any recommendations about time intervals or sequences of body positions in the postoperative cardiac bypass graft patient. She states that moving from supine to sitting will be tolerated better than supine to standing and suggests that the nurse would allow 1 to 2 minutes per position change for stabilization of vital signs.

Summary

In summary, the measurement of postural blood pressure and heart rate is a valuable technique for evaluating an orthostatic response. However, despite the numerous research studies conducted on the topic of orthostatic blood pressures, few specific guidelines were found that nurses could use to assist them in measuring physiologic parameters related to postural changes. Despite the use of the tilt test in determining the status of orthostatic changes,

little research has been devoted to the proper sequencing of time and body positions. Furthermore, few studies have been replicated.

In this chapter, a review of the literature was presented relating orthostatic responses to body position changes in normovolemic, healthy adults and the measurement of the orthostatic responses in the assessment of hypovolemia. In a few studies, the orthostatic responses in healthy men and women and in pre/post operative patients were compared. Research recommendations regarding optimal body positioning and timing of the orthostatic procedure were reviewed.

CHAPTER 3

DESIGN AND METHODOLOGY

In this chapter, the design of the study, the setting and sample selection, protection of human subjects, data instruments, data collection procedure and data analysis are presented.

Research Design

The purpose of the study was to describe the differences in systolic, diastolic, mean arterial blood pressures, and heart rate between normovolemic and hypovolemic subjects as they move from a supine to standing position.

A descriptive design using two comparative groups and a timed sequence intervention was used to support the purpose of the study and examine the relationships among the variables. A descriptive design was chosen because the conceptual framework relationships of variables have been established in prior studies, (Kenny, Bayliss, Ingram, & Sutton, 1986; Knopp, Claypool, & Leonardi, 1980; Shvartz & Meyerstein, 1970). The projected study was built upon the findings of previous research Koziol-McLain, 1991; Lester, 1990; Moore & Newton, 1986; Kennedy & Crawford, 1984.

The independent variables to be manipulated were the body positions confounded with a sequence of timed measurements and the groups to which subjects belonged. The

body positions that subjects assumed were supine and standing. The sequence of the blood pressure and heart rate measurements occurred at timed intervals in supine and standing positions. The second independent variable was categorized as the group to which a subject belongs, normovolemic or hypovolemic. A hypovolemic group of subjects was compared to a normovolemic group in relation to blood pressure and heart rate measurements associated with body position changes. The dependent variables were the systolic and diastolic blood pressures, mean arterial blood pressure and the heart rate measurements.

The following research Questions were generated to identify relationships of the systolic blood pressure, diastolic blood pressure, mean arterial blood pressure and heart rate to position change and the timing of that change.

Research Question 1. Are there statistically significant within subject differences in systolic blood pressure when comparing a baseline supine systolic blood pressure to systolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 2. Are there statistically significant within group differences in systolic blood pressure when comparing a baseline supine systolic blood pressure to systolic blood pressures measured at .5 minute,

1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 3. Are there statistically significant differences in measurement of the systolic blood pressure between normovolemic subjects and hypovolemic subjects at baseline (established after 5 minutes in the supine position), .5 minute, 1 minute, minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 4. Are there statistically significant within subject differences in diastolic blood pressure when comparing a baseline diastolic blood pressure to diastolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 5. Are there statistically significant within group differences in diastolic blood pressure when comparing a baseline supine diastolic blood pressure to diastolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 6. Are there statistically significant differences in measurement of the diastolic blood pressure between normovolemic subjects and hypovolemic subjects at baseline (established after 5 minutes in the

supine position), .5 minute, 1 minute, minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 7. Are there statistically significant within subject differences in heart rate when comparing a baseline supine heart rate to the heart rates measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 8. Are there statistically significant within group differences in heart rate when comparing a baseline heart rate to heart rates measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 9. Are there statistically significant differences in measurement of the heart rate between normovolemic subjects and hypovolemic subjects at baseline, .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 10. Are there statistically significant within subject differences in mean arterial blood pressure when comparing a baseline supine mean arterial blood pressure to mean arterial blood pressures

measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 11. Are there statistically significant within group differences in mean arterial blood pressure when comparing a baseline mean arterial blood pressure to mean arterial blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Research Question 12. Are there statistically significant differences in measurement of the mean arterial blood pressure between normovolemic subjects and hypovolemic subjects at baseline, .5 minute, 1 minute, minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline?

Setting and Sample

The study was conducted in an emergency room of a rural regional medical center that provides emergency health care to southwestern Virginia and northeastern Tennessee. This emergency room services approximately 64,000 patient visits per year.

The convenience sample for the hypovolemic group was drawn from patients who sought emergency assistance with the primary complaint of hypovolemia. Thirty-two hypovolemic

subjects were recruited. Causes of body fluid loss included diarrhea, vomiting, bleeding from a vaginal, rectal, epistatic source, excessive diuresis from medications, and excessive perspiration during the previous 12 or more hours. The convenience sample for the normovolemic group was drawn from the community. Thirty subjects were recruited. All subjects received the same treatment in the same setting. All subjects were assessed by the same researcher.

Criteria for Subject Selection for the Hypovolemic Group

1. Subjects were able to read and understand written and spoken English to sign an informed consent and to safely follow instructions during the study.
2. Subjects reported a minimum of a 12-hour loss of body fluid and complained of dizziness when standing.
3. Subjects were >18 years of age but less than 50 years of age.
4. Subjects had a preliminary screening urine specific gravity of 1.025 or higher.
5. Subjects were be able to stand with minimal assistance for five minutes.
6. Subjects were alert and cooperative.
7. Subjects were not taking any blood pressure and/or heart rate altering medications on a regular basis or within 24 hours of participating in the study.

8. Subjects who were pregnant were under 20 weeks gestation.
9. Subjects had abstained from alcoholic beverages within the previous 24 hours before participating in the study.
10. Subjects had abstained from cigarettes within the previous 24 hours before participating in the study.

Criteria for Subject Selection for the Normovolemic Group

1. Subjects were able to read and understand written and spoken English to sign an informed consent and to safely follow instructions during study.
2. Subjects were > 18 years of age but less than 50 years of age.
3. Subjects had a preliminary screening urine specific gravity of 1.024 or lower.
4. Subjects were be able to stand with minimal assistance for five minutes.
6. Subjects were alert and cooperative.
7. Subjects were not taking any blood pressure and/or heart rate altering medications on a regular basis or within 24 hours of participating in the study.
8. Subjects who were pregnant were under 20 weeks gestation.
9. Subjects had abstained from alcoholic beverages within the previous 24 hours before participating in the study.

10. Subjects had abstained from cigarettes within the previous 24 hours before participating in the study.

Criteria for Subject Exclusions

Individuals were excluded from participating in the study who:

1. had sustained blunt or penetrating trauma to the head, chest, abdomen or extremity.

2. had sustained amputation to an extremity.

3. had taken an overdose of a medication or a substance that produces bradycardia, hypotension and/or altered level of consciousness.

4. were clinically toxic from a medication or substance that produces bradycardia, hypotension and/or altered level of consciousness.

5. were actively in labor or whose gestational age was >20 weeks.

6. had a known history of Shy-Drager syndrome (idiopathic autonomic insufficiency).

7. had a heart transplant or had a pacemaker.

8. were a diabetic and whose urine was 2+ or greater with glycosuria as per urine dip indicated by the Ames Multistix reagent strips.

9. had used a phosphate cathartic within 24 hours.

10. had been given intravenous radiographic contrast media within 24 hours.

Protection of Human Subjects

Approval to conduct this study was obtained from the Ethical Review committee of the College of Nursing and from the University of Arizona Human Subjects Committee. In addition, approval to conduct this study at the Bristol Regional Medical Center, previously known as the Bristol Memorial Hospital, was obtained from the Institutional Review Board of that Institution (Appendix A).

A description of the study was provided to each subject before obtaining informed consent. Subject were informed verbally and in writing that they were free to withdraw from the study any time before, during, or after the collection of data. If the subject chose to withdraw from the study, there were no negative consequences. Signed consent forms were completed before data collection (Appendix B). Anonymity was assured on the data collection sheets by use of code numbers. Only group data were reported. However, results of the procedure were shared with the emergency room physician on duty in the event that information could have been beneficial to the subject's medical diagnosis and treatment.

It was explained to each subject that: the subject might experience a slight pulling sensation as electrocardiographic electrodes were applied and removed, that the possibility existed that a subject could have an

allergic reaction to the electrocardiographic electrodes, that a pressure sensation might be felt as the blood pressure cuff was applied and the blood pressure taken, and that during changes in posture, the subject may experience feelings of fainting, dizziness, weakness, "hot" or "cold" sensations, and nausea. If these symptoms were experienced and not relieved within one minute of the position change, the subject would be returned to the supine position and the participation in the study terminated. The investigator would remain with the subjects until all symptoms were relieved and vital signs returned to a baseline level. The emergency room physician and an emergency room nurse would be notified.

Data Instruments

Two data collection instruments were used for data collection:

1. a Demographic data form (Appendix C).
2. a Clinical Data Form (Appendix C).

Equipment used included:

1. a PROPAQ 106 vital signs monitor by Protocol Systems, Inc.
2. the Ames N-Multistix SG reagent strips to screen for urine specific gravity and glucose.

Demographic Data Form

A Demographic data form (Appendix C) was used to record information related to age, gender, presenting complaint, duration of complaint, and urine specific gravity, which was collected and measured by the researcher. Each subject received verbal instructions on how to obtain a clean catch urine specimen. After the urine was collected, the researcher measured the specific gravity of the urine using the Ames Multistix reagent strips for urine. The subject then had a non-invasive blood pressure monitoring (NIBP) cuff applied to the right arm. Three electrocardiogram (EKG) patches were applied to the chest. Both the NIBP cuff and the EKG leads were connected to the PROPAC 106.

Clinical Data Sheet

The clinical data (Appendix D) included measurements of systolic and diastolic blood pressures, heart rate at baseline, 0.5, 1, 2, 3, 4, and 5 minutes post postural position change and 5 minutes after returning to baseline. These measurements were recorded and printed by the ProPac 106. Each printed set of measurements were stapled to each clinical data sheet. The mean arterial blood pressure was internally calculated by the ProPac 106. Subjective field notations related to the physical descriptions of skin color, skin temperature, skin turgor, and condition of mucous membranes were included.

Reliability of the Instruments

The N-MULTISTIX SG Reagent strips (Ames Division Miles laboratories, Inc., Elkart, IN) uses a colorimetric method to indirectly detect urine specific gravity. This reagent strip is capable of determining urinary specific gravity with an accuracy adequate for many clinical uses (Burkhardt, Johnston, Waszak, Jackson & Shafer, 1982). The strip provides an indirect measurement of urinary specific gravity, relying on the correlation between ionic solute concentration and the specific gravity of the specimen. The color chart on the dip stick shows a change from dark blue at specific gravity of 1.000, to yellow at specific gravity of 1.030. Urine specific gravity obtained with the Ames Multistix Reagent strips was within 0.005 of laboratory industry standards using the urinometer and total-solids meter (Becker, 1982).

The PROPAQ 106 with software version 6.0 meets the following AAMI (American Association of Medical Instrumentation) category for heart rate metering: heart rate accuracy of ±3 beats per minute or 3%, whichever is greater (ANSI/AAMI EC13-1983). The noninvasive blood pressure (cuff) meets AAMI standards for electronic or automated sphygmomanometer: numeric accuracy ±3 mm Hg or 2%, whichever is greater, pulse rate accuracy of 6 beats per minute or 6%, whichever is greater (ANSI/AAMI SP10-1987).

Procedures

The following procedure was adapted from a study by Lester (1990). Preparation: hypovolemic subjects who met the selection criteria were first triaged into the emergency department by an emergency room staff nurse who notified the researcher. The emergency room record of these subjects was flagged so that the treating emergency room physician would be aware that the presenting patient was a study candidate. If the physician determined that it was appropriate to perform the test procedure on the patient/subject, the researcher approached the patient/subject. The study was explained and if the subject agreed to participate in the study, the EKG pads and the NIBP cuff were applied to an upper arm according to American Heart standards. A bedside table was positioned at the phlebostatic axis level for each blood pressure and was read and repositioned with each position change.

Three EKG electrodes were applied in a Lead II configuration and connected to the ProPac vital signs monitor. A non-invasive blood pressure cuff conforming to size of the American Heart Association guidelines for blood pressure determination was applied and inflation/deflation was controlled by the Propac 106. The same ProPac 106 vital signs monitor was used throughout the study. The ProPac monitor was programmed to record the heart rate, systolic

and diastolic, and mean arterial blood pressure at 0.5 minutes, 1 minute, 2 minutes, 3, 4, and 5 minutes. Baseline recording of the systolic and diastolic, mean arterial blood pressures and heart rate were manually initiated by the researcher by pressing the start button.

Data collection began after the subject rested in the supine position for five minutes. The subject's blood pressure and heart rate measurements were taken at the antecubital space at minutes five and six or until two systolic readings were within 10 mm Hg of each other. The mean arterial blood pressure was calculated from the systolic and diastolic blood pressures by the Propac 106. Immediately after baseline blood pressure and heart rate readings were obtained, the subject assumed a sitting position with legs dangling for 8 seconds. This measure was for safety purposes and for the subject to obtain spatial orientation. The bedside table was positioned at the right atrium. The subject was asked to verbally relate symptoms of dizziness that he/she may have experienced. If dizziness occurred, the researcher used her clinical judgement whether to continue or terminate the study. Subjective information was recorded by the researcher for each subject on the clinical data sheet (Appendix D).

Once the subject was in the standing position, measurements were taken according to protocol. Upon

completion of the protocol, the subject returned to the supine position where heart rate, systolic and diastolic blood and mean arterial pressures were measured after five minutes in the supine position and until two systolic blood pressure measurements were within 8 mm Hg of each other.

The minimum time required during the data collection phase of the study for each subject was 16.5 minutes. After the data from the hypovolemic subject were collected according to protocol, the emergency room physician and the assigned emergency room nurse were notified. Specific vital sign changes and subjective symptoms of orthostatic changes were communicated to both the emergency room physician and the emergency room nurse. This information may have included skin color, skin moisture levels and skin temperature changes, the appearance of nausea with or without vomiting, changes in level of consciousness and/or the withdrawal of the subject from the study.

In the normovolemic population, data were collected according to protocol. Once completion of the test protocol had been achieved, the subject returned to normal activities.

Data Analysis Plan

Data were analyzed using descriptive statistics to examine whether significant differences occurred over time among and between groups (normovolemic and hypovolemic)

during position changes for each dependent variable. The analysis of variance (ANOVA) was a mixed design analysis with one grouping variable having two levels (normovolemic and hypovolemic) and one within-subjects repeated measure having eight levels (measurement occasion). The multivariate one-factor repeated-measures analysis of variance was appropriate for this type of study since repeated measures within the same subject are not independent (Shott, 1990). This technique provides estimates of variability among multiple measures of a subject's systolic blood pressure, diastolic blood pressure, heart rate and mean arterial blood pressure according to a factor or characteristic used to classify observations (Shott, 1990). Body position is the factor in this study used for classification. A separate ANOVA was calculated for each of the four dependent variables (systolic blood pressure, diastolic blood pressure, mean arterial blood pressure and heart rate). The mean for each group at each time point was calculated. Significant F statistics followed by planned pairwise comparisons within-group contrasts of the baseline measurement against each subsequent measurement were calculated. According to the presence of a significant F value as determined from the ANOVA, within-group and/or group by occasion contrasts for each point in time was done to determine the particular

point in time that significance occurs. The term "occasion" refers to the point in time that a measurement occurred. The contrasts were adjusted by the Bonferroni procedure (Shott, 1990). The alpha level was set at .05. Independent t-tests were used to assess if differences existed among the plotted means of continuous data such as age, urine specific gravity and color of the urine between each subject. Chi-square test of independence was calculated on frequency data occurring in both populations such as "group by sex" to determine between population differences.

Limitations of the Study

Limitation of the study include:

1. The use of a small convenience sample limits the ability to generalize across populations.

2. Age, stress, anxiety and any known or unknown medical history may have altered the physiologic responses between a fluid deficit state and posture changes.

3. The specific gravity of a subject's urine may suggest a false fluid volume deficit if cardiovascular compensation has occurred secondarily to the ingestion of fluids immediately before the study.

Summary

A descriptive study in which systolic blood pressure, diastolic blood pressure, mean arterial blood pressure, and

heart rate responses of normovolemic and hypovolemic groups in relation to postural changes has been presented. Several research questions were posited to examine the responses in blood pressure and heart rate over time prior to, during, and following a change in position from supine to standing in hypovolemic and normovolemic subjects. The independent variables to be manipulated were the body positions confounded with the sequence of timed measurements and the subject group: normovolemic and hypovolemic. The body positions that subjects assumed were supine and standing. The sequence of the blood pressure and heart rate measurements were at timed intervals in supine and standing positions. The dependent variables were the systolic and diastolic blood pressures and the heart rate measurements. Hypovolemic subjects were recruited from an emergency room population. The normovolemic population were recruited from the community. The design limitations were discussed. The plan for data analysis included descriptive statistics, a one-factor multivariate analyses of variance with repeated measures, and Bonferroni posthoc test.

Chapter 4

ANALYSIS OF THE DATA

In this chapter, the characteristics of the sample, and results of the statistical analysis of data are presented. Data analysis was accomplished using SPSS for Windows version 6.0 and SPSS/PC+.

Characteristics of the Sample

The convenience sample consisted of 62 subjects from a southwestern Virginia and northeastern Tennessee community. This community straddles the border of each state. Thirty subjects were recruited from the community at large and 32 subjects were recruited from the emergency room of a northeastern Tennessee community hospital.

Thirty subjects comprised the normovolemic group and 32 subjects comprised the hypovolemic group. Seven subjects in the hypovolemic group could not complete the by protocol and were eliminated from the analysis. Therefore, data were analyzed for 25 hypovolemic subjects. Of the seven hypovolemic subjects unable to complete the study, three subjects became hemodynamically unstable and required termination of the test procedure. Four of the seven subjects required changing to a sitting position after assuming the standing position; they stated that they physically felt unable to continue in the standing position.

All seven of the eliminated subjects walked into the emergency room unassisted. Prior permission from the treating emergency room physician was obtained prior to the procedure. Table 2. presents the demographic data for the seven hypovolemic subjects who were unable to complete the study.

The normovolemic group consisted of 73.3% (n=22) females and 26.7% (n=8) males. The hypovolemic group consisted of 76% (n=19) females and 24% (n=6) males. The total sample was composed of 74.5% (n=41) females and 25.5% (n=14) males. In SPSS, the CROSSTABS procedure was used to analyze frequency data and determine the percentages for the variable, "group" by gender. The value of the Chi-square test of independence for gender was not statistically significant between the two groups (χ^2=6.364; p=.82115). It can be concluded that the percentages of females and males in the normovolemic group does not differ from the percentages of females and males the hypovolemic group.

Table 2. Demographic data of subjects unable to complete study protocol.

Subject #1: 49 yr old male presented with GI bleed symptoms X 2 weeks.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject began vomiting immediately upon standing.
Final diagnosis: esophageal varices.

Subject #2: 48 yr old male presented with GI bleed symptoms X 16 hrs.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject experienced syncope immediately upon standing. Final diagnosis: duodenal ulcer.

Subject #3: 29 yr old female presented with vaginal bleed symptoms X 14 hrs.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject experienced severe dizziness and weakness immediately upon standing. Final diagnosis: threatened abortion.

Subject #4: 24 yr old female presented with vomiting X 16 hrs.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject experienced nausea and abdominal pain after 1 min. in the standing position. Final diagnosis: gastritis.

Table 2. (continued) Demographic data of subjects unable to complete study protocol.

Subject #5: 22 yr old female presented with vomiting X 48 hrs.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject vomited X 1 and ↑ dizziness after standing 2 minutes. Final diagnosis: gastroenteritis.

Subject #6: 22 yr old female presented with vomiting X 12 hrs.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject began vomiting after 3 min. in the standing position. Final diagnosis: gastroenteritis.

Subject #7: 19 yr old female presented with vomiting X 48 hrs.
UNABLE TO COMPLETE PROTOCOL 2° TO: subject became dizzy and hypotensive after standing 2 min. Final diagnosis: urinary tract infection.

Frequencies related to the ages of the subjects in the normovolemic group ranged from 18 years to 47 years of age. The mean age of the normovolemic group was 31.6 years (S.D.=9.27). The median was 30 years. The age range of the hypovolemic group was 21 years to 50 years old. The mean age of the hypovolemic group was 30.4 years (S.D.=9.051). The median age was 27 years. In the normovolemic group, 12 (40%) of the subjects were between 18-25 years of age, 5 (16.7%) of the subjects were 26-35 years old, 12(40%) of the subjects were 36-45 years of age and 1 (3.3%) of the population were between 46-50 years old. In the hypovolemic group, 12 (48%) of the subjects were between 18-25 year of age, 5 (20%) were between the ages 26-35, 6 (24%) of the subjects were between the ages 36-45 and 2 (8%) of the subjects were between the ages 45-50. There were no differences in the mean age of the normovolemic group and the mean age of the hypovolemic group (t-test for equality of means, t=.5; mean difference=1.2750; p=0.763).

Urine specific gravity was used as part of the criteria for subject selection. t-tests for equality of means for independent samples by group for the variable urine specific gravity between groups was statistically significant (t-value=-9.26; mean difference= -.0092; p=000). It can be concluded that the urine specific gravity mean of the normovolemic group is different than the urine

specific gravity mean of the hypovolemic group. The findings indicate with 95% confidence that the difference in the urine specific gravity mean between groups is clinically important.

As a field note, urine color was recorded and analyzed. The color was categorized as either yellow (#1), amber (#2) or (#0) unable to void. t-tests for equality of means for independent samples by group for the variable urine color was statistically significant (t-value=-4.16; mean difference= -.3750; p=<001). It can be concluded that the urine color mean of the normovolemic group is different from the urine color mean of the hypovolemic group. The findings indicate with 95% confidence that the difference in the urine color between groups is clinically important. Table 3. presents frequency data related to gender, age, urine specific gravity, and urine color.

Table 3. Frequency of gender, age, urine specific gravity and urine color in normovolemia, hypovolemia and total group.

	Normovolemic	Hypovolemic	Total
Gender			
female	22 (73.3%)	19 (76%)	41 (74.5%)
male	8 (26.7%)	6 (24%)	14 (25.5%)
Age			
	18-47 yrs	21-50 yrs	55 yrs
18-25 yrs	12 (40%)	12 (48%)	24 (43.6%)
26-35 yrs	5 (16.7%)	5 (20%)	10 (18.2%)
36-45 yrs	12 (40%)	6 (24%)	18 (32.7%)
46-50 yrs	1 (3.3%)	2 (8%)	3 (5.5%)
Urine color			
yellow	30 (100%)	15 (60%)	45 (81.8%)
amber	0 (0%)	9 (36%)	9 (16.4%)
No urine	0 (0%)	1 (4%)	1 (1.8%)
Urine specific gravity			
≤1.024	30 (100%)	0 (0%)	30 (54.5%)
≥1.025	0 (0%)	19 (72%)	19 (34.6%)
≥1.030	0 (0%)	6 (24%)	6 (10.9%)

Other data, collected by means of field notes, were gathered as dichotomous data: the event either occurred or did not occur. Each field notation was analyzed as a value label. Percentages of the occurrences were calculated according to the size of the group population. Inclusion criteria for both groups included the value labels "dizziness", "urine specific gravity", and "duration of symptoms". Dizziness occurred in 25 subjects (100%) of the hypovolemic group. Dizziness was not reported in the normovolemic group (n=30). Urine specific gravity of ≥1.025 occurred in 19 (72%) and of ≥1.030 in 6 (24%) in the hypovolemic group (n=25). Thirty (100%) in the normovolemic group had a urine specific gravity ≤1.024. The seven hypovolemic subjects who were unable to complete the protocol had urine specific gravities of >1.030.

Duration of complaint occurred in 4 (16%) subjects for >12 hrs<24 hrs; in 7 (28%) for 48 hrs; in 3 (12%) for 72 hrs; in 6 (24%) for 144-168 hrs; and in 5 (20%) for >336 hrs within the hypovolemic group (n=25). The normovolemic subjects 30 (100%) did not report any symptoms.

Among the hypovolemic subjects (n=25), symptoms occurring during the test procedure were dizziness, syncope, weakness and other. Dizziness occurred in 25 subjects (100%); syncope occurred in 1 subject (4%); and weakness occurred in 12 subjects (48%). Other symptoms occurred in

17 subjects (68%) and included diaphoresis, nausea, paleness of skin, vomiting, "hot flashes" and abdominal pain.

Results Related to Research Questions

The research questions investigated three types of data variability: within-subject variability, within-group variability by occasion, and group by occasion variability. Occasion is defined by the time interval 0.5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, and end-baseline. Using the one-factor repeated measure analysis of variance, the variability of a subject's systolic blood pressure, diastolic blood pressure, heart rate, and mean arterial blood pressure within each gravitational position can be partitioned from total variability. The multivariate analyses of variance with repeated measures provides for the capacity to distinguish within-group systolic blood pressure, diastolic blood pressure, heart rate, and mean arterial pressure variability from between-occasion variability (Thomas, Liehr, DeKeyser & Friedmann, 1993).

Calculations for multivariate one-factor repeated-measures ANOVA are done by the MANOVA procedure in the SPSS program. The level of significance is determined by the multivariate tests of significance or the averaged tests of significance. The Bonferroni adjustment posthoc test is used to determine which population means are significant

when contrasting for the interaction effect using posthoc contrast coefficient matrixes (Shott, 1990).

Research Question 1: Are there statistically significant within subject differences in systolic blood pressure when comparing a baseline supine systolic blood pressure to systolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The multivariate tests of significance involving within-subject effect by occasion for the systolic blood pressure was not statistically significant (F=.63; df=7; p=.732). On the basis of this analysis, it can be concluded that none of the systolic blood pressure means per time interval within each subject is different when compared to the baseline systolic blood pressure mean.

Research Question 2: Are there statistically significant within group differences in systolic blood pressure when comparing a baseline supine systolic blood pressure to systolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The averaged tests of significance using Unique sums of squares involving within group effect by occasion for the systolic blood pressure was not statistically significant (F=.13; df=1; p=.716). On the basis of this analysis, it can be

concluded that none of the systolic blood pressure means compared to the baseline systolic blood pressure mean within each group is different.

Research Question 3: Are there statistically significant differences in measurement of the systolic blood pressure between normovolemic subjects and hypovolemic subjects at baseline, .5 minutes, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The multivariate tests of significance involving group by occasion for the systolic blood pressure was not statistically significant ($F=.90038$; $df=7$;$p=.514$). On the basis of this analysis, it can be concluded that the systolic blood pressure means of the normovolemic group are not different over time when compared to the systolic blood pressure means of the hypovolemic group over time. Table 4 compares the systolic means within the normovolemic and hypovolemic groups. Figure 2 compares the pattern of change in the systolic blood pressure over time between the normovolemic and hypovolemic populations.

Table 4. Systolic blood pressure means and standard deviations between the normovolemic and hypovolemic groups.

	Normovolemic	Hypovolemic
Interval	Sys. BP S.D.	Sys. BP S.D.
supine*	124.83 (16.29)	118.48 (16.20)
0.5 min.	120.83 (20.19)	120.36 (20.81)
1 min.	121.56 (20.49)	123.88 (18.01)
2 min.	121.73 (19.89)	118.48 (22.74)
3 min.	120.50 (22.27)	118.36 (19.17)
4 min.	119.63 (18.09)	121.12 (20.49)
5 min.	119.90 (21.48)	119.48 (22.24)
end-baseline#	123.96 (15.86)	119.17 (20.53)

*Measurements obtained in supine position for a minimum of five minutes

#Measurement obtained five minutes after returning to the supine position

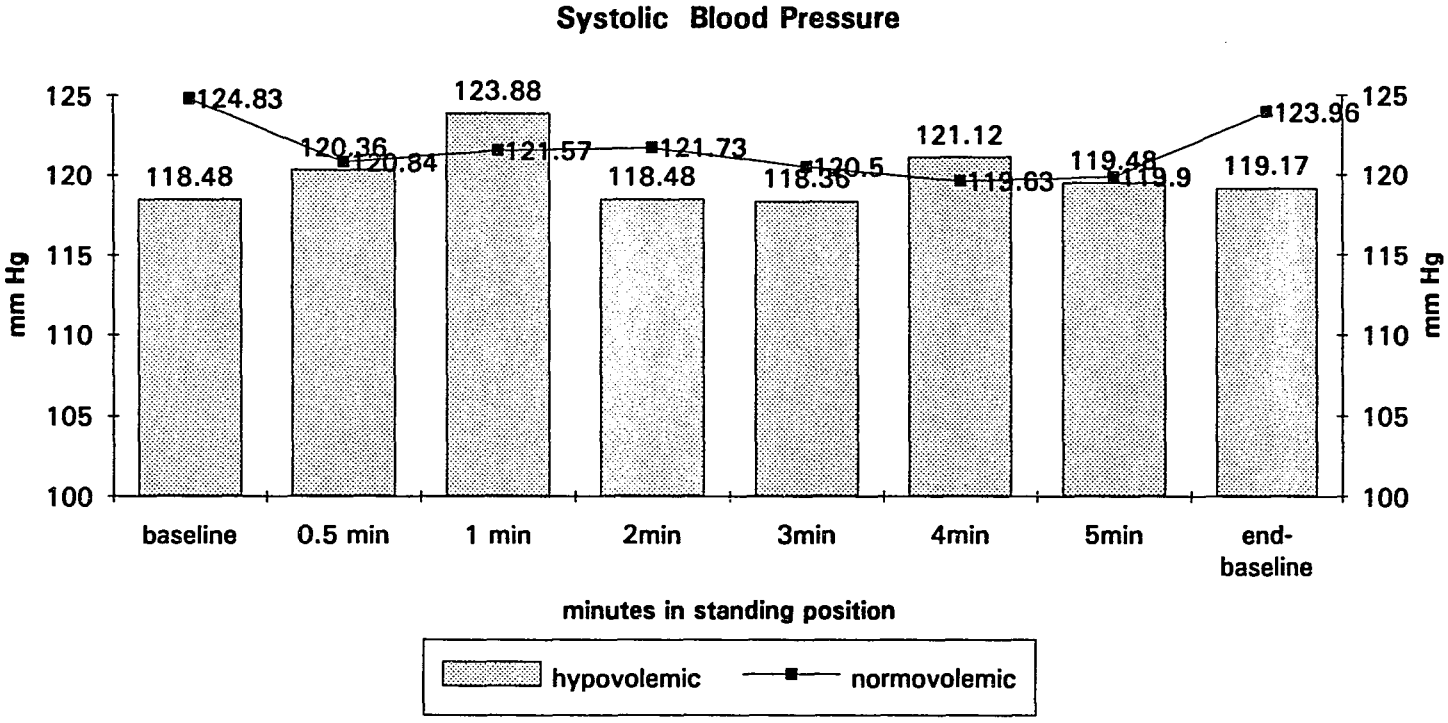


Figure 2. Comparison of the pattern of change in the systolic blood pressure over time between the normovolemic and hypovolemic populations.

Research Question 4. Are there statistically significant within subject differences in diastolic blood pressure when comparing a baseline diastolic blood pressure to diastolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The averaged tests of significance involving within subject effect by occasion for the diastolic blood pressure was statistically significant ($F=3.59$; $df=7$; $p=.001$). On the basis of this analysis, it can be concluded that there may be diastolic blood pressure means per time interval within each subject that are different when compared to the baseline diastolic blood pressure mean within each subject.

Research Question 5: Are there statistically significant within group differences in diastolic blood pressure when comparing a baseline supine diastolic blood pressure to diastolic blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The tests of significance within group effects using UNIQUE sums of squares were not statistically significant ($F=.28$; $df=1$;$p=.602$). On the basis of this analysis, it can be concluded that none of the diastolic blood pressure means within each group compared to the baseline diastolic blood pressure mean within each group are different.

Research Question 6: Are there statistically significant differences in measurement of the diastolic blood pressure between normovolemic subjects and hypovolemic subjects at baseline, .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The multivariate tests of significance involving group by occasion effects were not statistically significant ($F=1.17801$; $df=7$; $p=.334$). On the basis of this analysis, it can be concluded that the diastolic blood pressure means of the normovolemic group are not different over time when compared to the diastolic blood pressure means of the hypovolemic group over time. Table 5 compares the diastolic blood pressure means between the normovolemic and hypovolemic groups. Figure 3 compares the pattern of change over time for the diastolic blood pressure between the normovolemic and hypovolemic groups.

Table 5. Comparisons of the diastolic blood pressure means and the standard deviations between the normovolemic and hypovolemic groups.

	Normovolemic		Hypovolemic	
Interval	DBP	S.D.	DBP	S.D.
supine*	74.23	(10.54)	73.71	(11.62)
0.5 min.	74.53	(12.21)	77.79	(11.34)
1 min.	73.80	(11.29)	78.13	(12.01)
2 min.	72.93	(12.55)	75.58	(13.79)
4 min.	74.10	(10.07)	76.12	(11.42)
4 min.	74.00	(10.96)	76.29	(13.79)
5 min.	73.77	(11.57)	73.71	(10.49)
end-baseline#	72.63	(10.73)	70.49	(11.36)

*Measurements obtained in supine position for a minimum of five minutes

#Measurement obtained five minutes after returning to the supine position

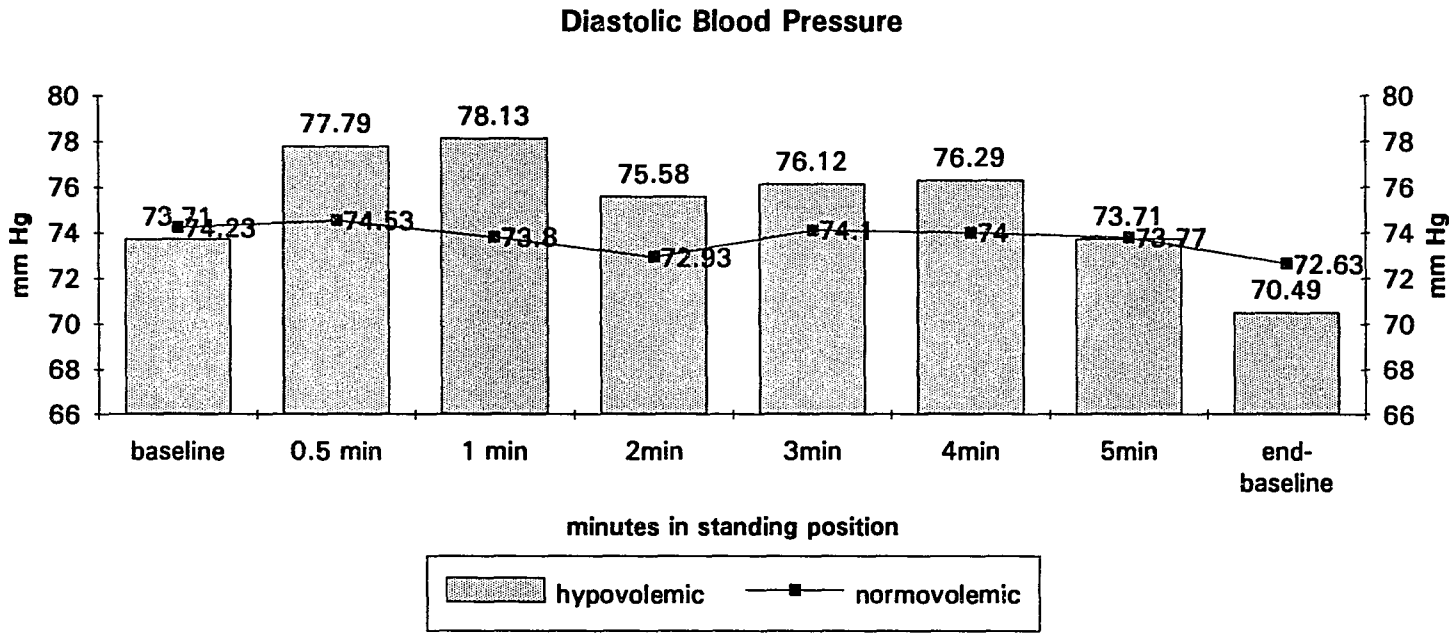


Figure 3. Comparisons of the patterns of change over time for the diastolic blood pressure within the normovolemic and hypovolemic groups.

Research Question 7: Are there statistically significant within subject differences in heart rate when comparing a baseline supine heart rate to the heart rates measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The multivariate tests of significance involving within-subject effect by occasion for heart rate were statistically significant ($F=32.75817$; $df=7$; $p=.000$). On the basis of this analysis, it can be concluded that there may be heart rate means per time interval within each subject that are different when compared to the baseline heart rate mean.

Research Question 8: Are there statistically significant within group differences in heart rate when comparing a baseline heart rate to heart rates measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The tests of significance using UNIQUE sums of squares for heart rate effects within group was statistically significant ($F=36.69$; $df=1$; $p=.000$). On the basis of this analysis, it can be concluded that there may be heart rate means over time that are different within each group when compared to the baseline heart rate mean.

Research Question 9: Are there statistically significant differences in measurement of the heart rate between normovolemic subjects and hypovolemic subjects at baseline, .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The multivariated tests of significance for heart rate effect for group by occasion is statistically significant (F=3.18689; df=7; p=.008). On the basis of this analysis, it can be concluded that the heart rate means of the normovolemic group may be different over time when compared to the heart rate means of the hypovolemic group over time. Table 6 compares the heart rate means, standard deviations and changes from baseline between the normovolemic and hypovolemic groups. Figure 6 compares the pattern of change of the heart rate between the normovolemic and hypovolemic groups.

Table 6. Comparison of the heart rate means, standard deviations and changes from baseline within the normovolemic and hypovolemic groups.

Heart Rate

	Normovolemic			Hypovolemic		
Interval	HR	S.D.	Δ's	HR	S.D.	Δ's
supine*	70.41	(11.82)		87.71	(15.36)	
0.5 min.	81.73	(12.09)	11.32	107.04	(17.56)	19.33
1 min.	85.37	(15.64)	14.96	107.28	(16.03)	19.57
2 min.	83.83	(15.62)	13.42	106.92	(16.86)	19.21
3 min.	84.03	(14.51)	12.62	108.36	(17.68)	20.65
4 min.	86.07	(15.71)	15.66	111.80	(20.00)	24.09
5 min.	84.40	(15.42)	13.99	112.76	(19.06)	25.05
E-B	68.44	(10.39)	1.97	87.07	(14.42)	.66

E-B end-baseline measurement

*Measurements obtained in supine position for a minimum of five minutes

#Measurement obtained five minutes after returning to the supine position

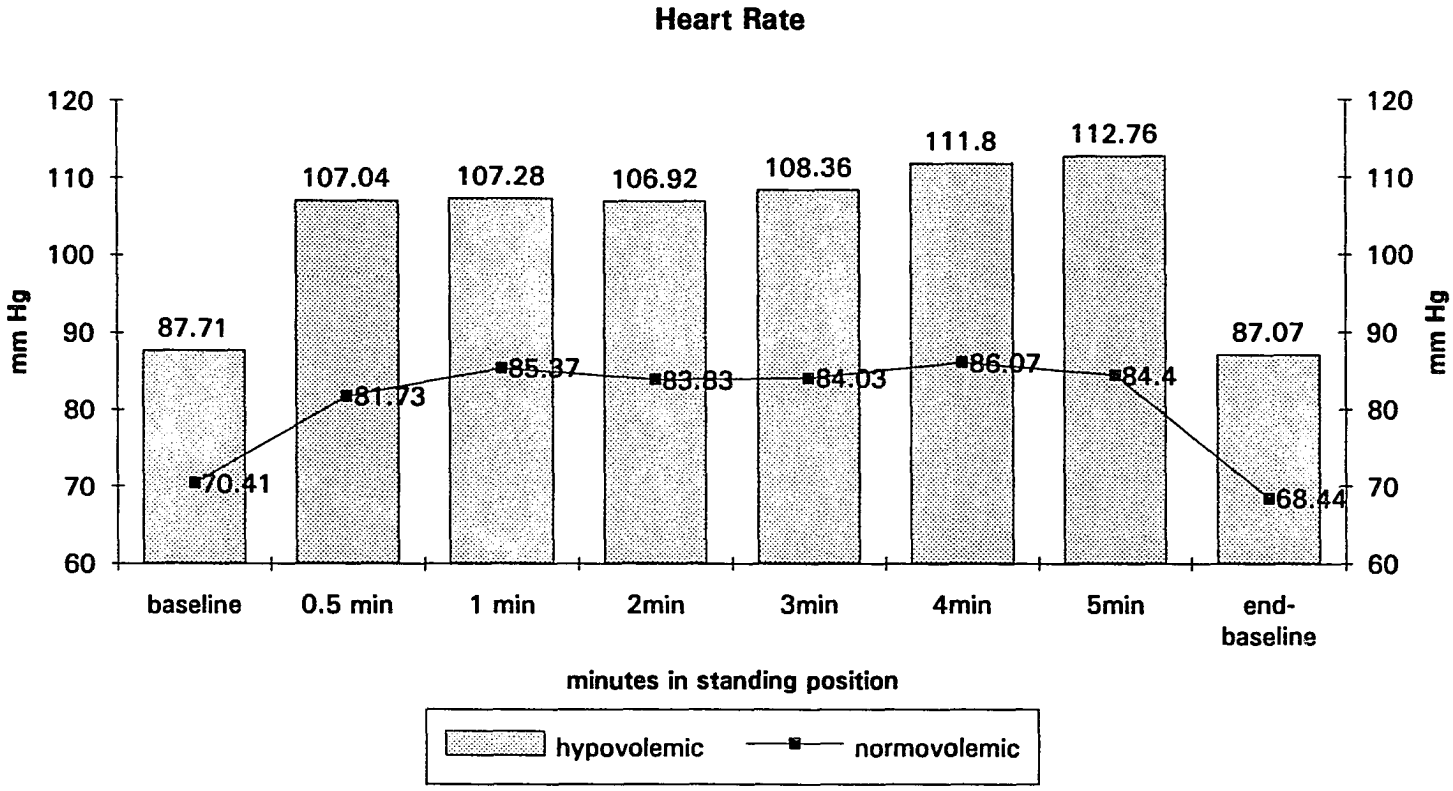


Figure 4. Comparison of the pattern of change over time for the heart rates within the normovolemic and hypovolemic groups.

Research Question 10: Are there statistically significant within subject differences in mean arterial blood pressure when comparing a baseline supine mean arterial blood pressure to mean arterial blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The averaged tests of significance using UNIQUE sums of squares involving within subject effect by occasion was not statistically significant ($F=1.72$; $df=7$; $p=.104$). On the basis of this analysis, it can be concluded that none of the mean arterial blood pressure means per time interval within each subject are different when compared to the baseline mean arterial blood pressure within each subject.

Research Question 11: Are there statistically significant within group differences in mean arterial blood pressure when comparing a baseline mean arterial blood pressure to mean arterial blood pressures measured at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? Tests of significance using UNIQUE sums of squares for within group effects for the mean arterial blood pressure was not statistically significant ($F=.37$; $df=1$; $p=.547$). On the basis of this analysis, it can be concluded

that none of the mean arterial blood pressure means within each group across each time interval are different.

Research Question 12: Are there statistically significant differences in measurement of the mean arterial blood pressure between normovolemic subjects and hypovolemic subjects at baseline, .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes in the standing position and after a return to baseline? The multivariate tests of significance involving the mean arterial blood pressure for group by occasion effect was not statistically significant ($F=.99893$; $df=7$; $p=.444$). On the basis of this analysis, it can be concluded that none of the mean arterial blood pressure means of the normovolemic group were different over time when compared to the mean arterial blood pressure means of the hypovolemic group over time. Table 7 compares the mean arterial blood pressure means and standard deviations between the normovolemic and hypovolemic groups. Figure 7 compares the pattern of change of the mean arterial blood pressure over time between the normovolemic and hypovolemic groups. Table 8 summarizes the p-values of the systolic blood pressure, the diastolic blood pressure, heart rate and mean arterial pressure according to the within subject effects, within group by occasion effects, and group by occasion.

Table 7. Comparison of the mean arterial blood pressure means and standard deviation between the normovolemic and hypovolemic groups.

Mean Arterial Blood Pressure

	Normovolemic		Hypovolemic	
Interval	art.bp	S.D.	art. bp	S.D.
supine*	86.84	(11.05)	87.01	(12.78)
0.5 min.	86.53	(14.53)	89.20	(12.66)
1 min.	87.20	(13.52)	90.40	(12.39)
2 min.	85.13	(12.89)	88.56	(15.59)
3 min.	85.87	(11.34)	88.24	(13.28)
4 min.	86.70	(12.33)	88.32	(14.90)
5 min.	85.00	(12.47)	88.48	(15.81)
end-baseline#	85.51	(11.29)	83.63	(12.68)

*Measurements obtained in supine position for a minimum of five minutes

#Measurement obtained five minutes after returning to the supine position

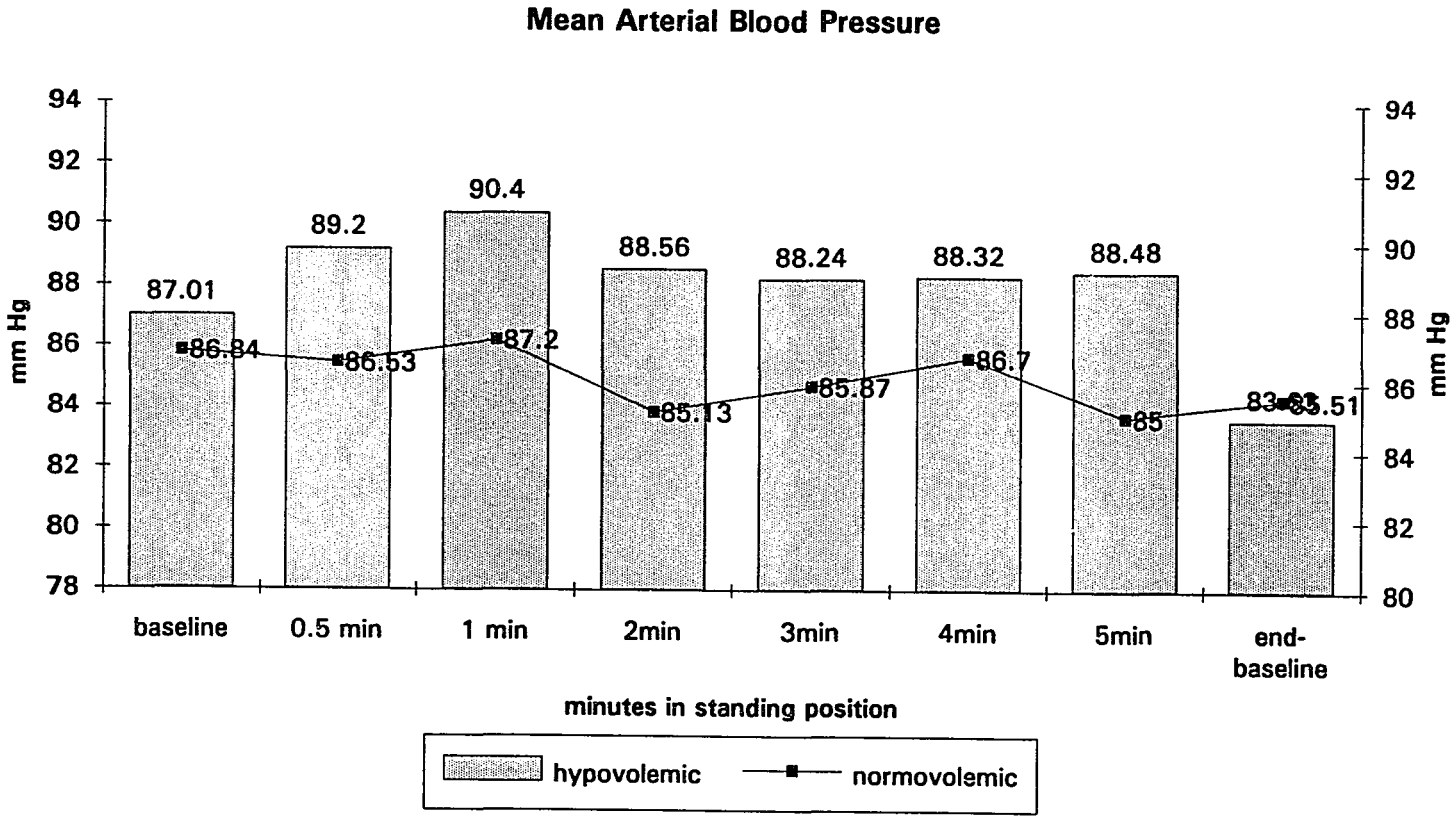


Figure 5. Comparison of the pattern of change in the mean arterial blood pressure between the normovolemic and hypovolemic groups.

Table 8. Comparison of hypovolemic and normovolemic groups in relations to overall significance for systolic and diastolic blood pressure, heart rate and mean arterial blood pressure.

ANOVA	Sys. BP	Dia. BP	HR	Mn Art. BP
Within subject effects	.732	.001*	.000*	.104
Within group by occasion effects	.716	.602	.000*	.547
Group by occasion effects	.514	.334	.008*	.444

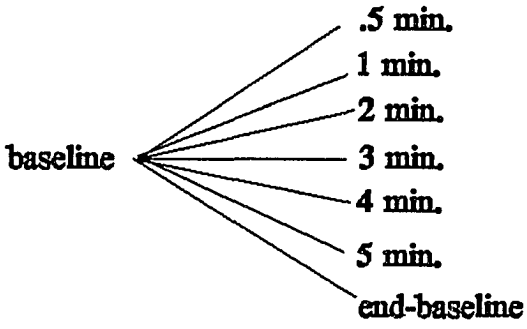
*denotes significance at ∝=.05

To summarize, use of one-factor repeated-measures ANOVA for the variables systolic blood pressure, diastolic blood pressure, mean arterial pressure and heart rate data demonstrated that the differences between the sample means for diastolic blood pressure and heart rate were significant at p=.05. Significance of F value was noted in relation to research question four that deals with the diastolic blood pressure regarding within subjects effects by occasion. Research questions seven, eight and nine relate to the heart rates for within subjects effects by occasion, between subjects effects, and within group by occasion.

To determine at which time intervals the population means were different, population means were compared using the one-way ANOVA and the pooled-variance t test. Testing the equality of means with a general contrast coefficient matrix for the interaction effects within and between groups determined the specific time intervals of significance. The matrix contrasts compares means with an increased sensitivity using the pooled variance estimate (Morrison, 1972).

The posthoc coefficient contrasts analyses for the interaction effect cannot use the predetermined alpha value of .05. Since a multiple-comparison procedure must be used whenever a comparison is selected after examining the sample means, the Bonferroni adjustment guarantees an overall

confidence level which includes the differences between the population means (Shott, 1990). The confidence level determined by the Bonferroni adjustment procedure corrects the alpha level to p=.0036 for the diastolic blood pressure. This was accomplished by dividing the original confidence level p=.05 by the total number of posthoc contrasts or comparisons which is 14. Each contrast occurs between the diastolic baseline mean and each diastolic time interval mean within the normovolemic group. An identical contrast matrix was applied to the diastolic blood pressure means for the hypovolemic group. The entire analysis involves 7 contrasts for each group or a total of 14 contrasts for both groups. This same procedure was performed with the heart rate means for the between subject by occasion effects that were identified as statistically significant by the one-factor repeated measures ANOVA. Figure 6. demonstrates the contrast design for the diastolic blood pressure and heart rate means for within-subject effects between the baseline mean and the means of the time intervals 0.5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, and end-baseline.



Within-subject effects contrasts

contrast 1: baseline values vs. 0.5 min. values

contrast 2: baseline values vs. 1 min. values

contrast 3: baseline values vs. 2 min. values

contrast 4: baseline values vs. 3 min. values

contrast 5: baseline values vs. 4 min. values

contrast 6: baseline values vs. 5 min. values

contrast 7: baseline values vs end-baseline values

Figure 6. Contrast design for the diastolic blood pressure and heart rate means for within-subject effects between the baseline mean and each time interval.

Using the corrected alpha level .0036, the oneway ANOVA for the diastolic blood pressure means between the normovolemic and hypovolemic groups were not statistically significant ($F=2.7787$; $df= 15$; $p=.004$). The results of the pooled variance estimate using the contrast coefficient matrix for the normovolemic group were not statistically significant. The results of the pooled variance estimate using the contrast coefficient matrix for the hypovolemic group were not statistically significant. On the basis of this analysis, it can be concluded that the diastolic blood pressure means per time interval within each group were not different when compared to the baseline diastolic blood pressure mean within each group. Table 9 lists the pooled variance estimate results for each diastolic blood pressure contrast comparing the baseline mean with each time interval mean within the normovolemic group and the hypovolemic group.

Table 9. Pooled variance estimate results for each diastolic blood pressure contrast comparing the baseline mean with each time interval mean within the normovolemic and the hypovolemic group.

Diastolic blood pressure

	Normovolemic			Hypovolemic		
Contrasts	t-values	df	p-values	t-value	df	p-value
contrast 1	0.203	371	.839	2.371	371	.018
contrast 2	-0.293	371	0.770	2.642	371	.009
contrast 3	-0.879	371	0.380	1.185	371	0.237
contrast 4	-0.090	371	0.928	1.827	371	0.068
contrast 5	-0.158	371	0.875	1.704	371	0.089
contrast 6	-0.315	371	0.753	0.321	371	0.748
contrast 7	-1.082	371	0.280	-2.066	371	0.039

adjusted α level=.0036

The statistical significance identified in research questions seven, eight and nine involve differences in the means of the heart rate across time within each subject, in the means of the heart rate within each population, and in the means of heart rate between groups. A total of 16 contrasts were performed to compare the time interval means using the pooled-variance t tests. The corrected alpha level determined by the Bonferroni adjustment procedure for the heart rate is p=.0031. Figure 7 illustrates the contrast design for the heart rate means for the baseline measurement, and each time interval between the normovolemic and hypovolemic groups.

Using the corrected alpha level p=.0031, the ANOVA for the heart rate means between the normovolemic and hypovolemic groups were statistically significant (F=114.9995;df= 15; p≤.000). Within the hypovolemic group, the results of the pooled variance estimate using the contrast coefficient matrix for the hypovolemic group are statistically significant. The contrast of the baseline heart rate mean with the heart rate means at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes were p≤.000, p≤.000, p≤.000, p≤.000, p≤.000, p≤.000 respectively. The contrast of the baseline heart rate mean and the end-baseline heart rate mean was not significant (p=.750). On the basis of this analysis, it can be concluded that the

heart rate means per time interval between subjects in each group were different when compared to the baseline heart rate mean in each group with one exception; when comparing the means of the baseline to the end-baseline.

Within group effects for the normovolemic group, the contrast of the baseline heart rate mean with the heart rate means at .5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes were $p \leq .000$, $p \leq .000$, $p \leq .000$, $p \leq .000$, $p \leq .000$, $p \leq .000$ respectively. The contrast of the heart rate baseline mean and the end-baseline heart rate mean was not significant ($p = .283$). On the basis of this analysis, it can be concluded that the heart rate means per time interval within each group were different when compared to the baseline heart rate mean within each group with one exception; when comparing the mean of the baseline heart rate to the mean end-baseline heart rate.

Between subject effects:

contrast #8: NV baseline hr vs. HV baseline hr

contrast #9: NV 0.5 min. hr vs. HV 0.5 min. hr

contrast #9: NV 1 min. hr vs. HV 1 min. hr

contrast #9: NV 2 min. hr vs. HV 2 min. hr

contrast #9: NV 3 min. hr vs. HV 3 min. hr

contrast #9: NV 4 min. hr vs. HV 4 min. hr

contrast #9: NV 5 min. hr vs. HV 5 Min. hr

contrast #9:NV end-baseline hr vs. HV end-baseline hr

NV = normovolemic group HV = hypovolemic group

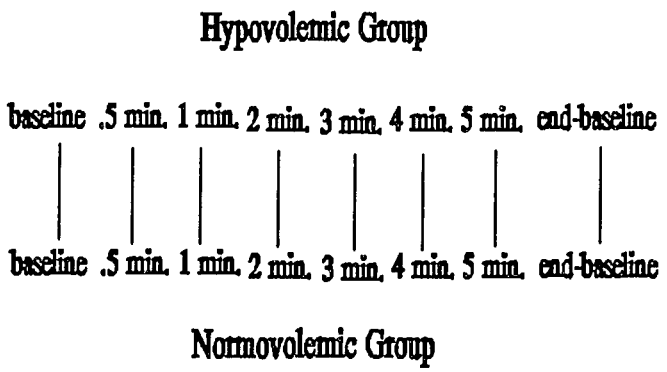


Figure 7. Contrast design for the heart rate means for the baseline measurement, and each time interval between the normovolemic and hypovolemic groups.

Contrast #8 comparing the mean baseline heart rate of the normovolemic group compared to the mean baseline heart rate of the hypovolemic group was statistically significant ($t=4.106$; $df=424$; $p\leq.000$). Contrast #9 comparing the heart rate means at .5 minutes, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes between the normovolemic and hypovolemic groups were statistically significant ($t=15.015$; $df=424$; $p=\leq.000$). On the basis of this analysis, it can be concluded that the heart rate mean at baseline, the heart rate means per each time interval while standing, and the heart rate mean at end-baseline of the normovolemic group and the heart rate mean at baseline, the heart rate means per each corresponding time interval while standing, and the end-baseline heart rate mean of the hypovolemic group are different. Table 10 summarizes the pooled variance estimate results for the heart rate means within the normovolemic and hypovolemic groups.

Table 10. Pooled variance estimate results for the heart rate means within the normovolemic and hypovolemic groups.

Heart Rate per time interval within subject effects

	Normovolemic			Hypovolemic		
Contrasts	t-values	df	p-values	t-value	df	p-value
contrast 1	6.182	371	0.000*	9.637	371	0.000*
contrast 2	8.167	371	0.000*	9.756	371	0.000*
contrast 3	7.329	371	0.000*	9.577	371	0.000*
contrast 4	7.438	371	0.000*	10.295	371	0.000*
contrast 5	8.549	371	0.000*	12.009	371	0.000*
contrast 6	7.639	371	0.000*	12.488	371	0.000*
contrast 7	-1.074	371	0.283	-0.319	371	0.750

*significance at new adjusted α=.0031

Summary

The results of the data analysis were presented in this chapter. There were no statistically significant differences between the normovolemic and the hypovolemic groups regarding age, sex, systolic blood pressure, diastolic blood pressure or mean arterial blood pressure. However, the heart rate mean responses for .5 minutes, 1 minute, 2 minutes, 3 minutes, 4 minutes, and 5 minutes were significant within each subject, within each group and between groups when the subjects' body position was changed from the supine position to a standing position. Posthoc tests using the more stringent corrected alpha level identified which means were difference. Within the normovolemic and hypovolemic groups, the contrasts between baseline heart rate and the heart rate of each time interval were statistically significant except baseline and end-baseline comparisons. Within the normovolemic and hypovolemic groups, the contrasts between the mean baseline heart rate and the mean heart rate of each time interval in the standing position were statistically significant. Contrasts between the normovolemic and hypovolemic groups at baseline, per time interval, and end-baseline were statistically significant.

CHAPTER 5

DISCUSSION OF FINDINGS

Included in this chapter are interpretation of findings as they relate to the conceptual framework and previously reported orthostatic hypotension literature, implications for patient care, limitations of the study, and recommendations for future research. The present study attempted to describe the differences in systolic, diastolic, and mean arterial blood pressures and heart rate between normovolemic and hypovolemic subjects as they move from a supine to a standing position and return to a supine position. These differences were examined in context to a baseline supine position, changing to a standing position for a specified time period and returning to the supine position.

Normovolemic and Hypovolemic Responses to Position Change

The results of this study demonstrate that the systolic, diastolic, mean arterial blood pressure, and heart rates response react in similar patterns in normovolemic and hypovolemic populations. Minimal changes in systolic, diastolic and mean arterial blood pressure were observed in the standing position for the time intervals 0.5, 1, 2, 3, 4, and 5 minutes when compared to the supine baseline measurements. The only variable found to have a statistically significant response to changes in the body's

position was the heart rate. Statistically significant changes in the heart rate occurred in both the normovolemic and hypovolemic groups. The differences between the two populations involve both the baseline heart rate in the supine position and the magnitude of the heart rate changes as the subjects moved from supine position to standing and returned to supine. Neither the systolic, diastolic nor mean arterial blood pressure was useful in distinguishing between hypovolemic and normovolemic subjects.

Systolic, Diastolic and Mean Arterial Blood Pressure Responses

Streeten's (1987) categories defining orthostatic hypotension were selected for the present study. These categories account for the wide range in variability that may be evident in the blood pressure and heart rate measurement associated with hypovolemia. Streeten (1987) addressed five types of orthostatic disorders of blood pressure control:

> Orthostatic diastolic hypotension: orthostatic fall in diastolic blood pressure of ≥10 mm Hg, with or without an excessive fall in systolic pressure.

Orthostatic systolic hypotension: excessive orthostatic fall in systolic pressure only, by ≥20 mm Hg, or to < 94 mm Hg.

Orthostatic hypertension (diastolic): diastolic BP of ≤90 mm Hg in recumbency and ≥98 mm Hg in the standing position.

Orthostatic narrowing of pulse pressure: pulse pressure of ≤18 mm Hg in the standing position.

Orthostatic tachycardia: heart rate increased by ≥28 beats/minute or to ≥110 beats/ minutes, after standing 3 minutes.

Findings from the study indicated that mean heart values in the hypovolemic group exhibited a rise in heart rate ≥110 beats per minutes after three minutes in the standing position and, therefore, support the definition of orthostatic tachycardia described by Streeten (1987). Findings related to systolic blood pressure and diastolic blood pressure measurements did not meet Streeten's criteria for orthostatic hypotension. However, affirmation of one category is sufficient to define orthostatic hypotension (Streeten). Therefore, mean heart rate value changes in the

hypovolemic group indicated the presence of an orthostatic disorder in the hypovolemic group.

When compared to baseline supine measurements, the systolic, diastolic, and mean arterial blood pressures exhibited minimal changes upon standing in both the normovolemic and hypovolemic groups. The changes that occurred were not statistically significant. Any changes that may have occurred after assuming the upright position in the systolic, diastolic, and mean arterial blood pressures did not extend beyond 0.5 minutes.

Data related to the systolic blood pressure measurements support the findings of Tuckman and Shillingford (1966) who reported that the systolic pressures did not change significantly when subjects were passively placed in six different tilt positions using a tilt table. The tilt positions were 10°, 20°, 30°, 40°, 55°, and 60°. Furthermore, findings related to the diastolic data in the normovolemic group are in agreement with Newton and Moore (1986) who reported minimal changes in supine diastolic blood pressure measurements in healthy young men and women upon standing. It may be argued that the agreement with the Tuckman and Shillingford (1966) and the Newton and Moore (1986) studies may not be applicable due to the passive use of a tilt table in one study and the exclusive use of healthy, young subjects in another study.

Findings from one of few studies that evaluated orthostatic body positioning in blood-loss induced hypovolemia are in similar to findings of the current study. Knopp, Claypool and Leonardi (1980) concluded that neither the systolic nor diastolic blood pressure were useful in predicting whether blood loss was present. Blood pressure measurements in the current study did not distinguish between normovolemic and hypovolemic subjects.

In accordance with normal physiologic adaptations to gravitational changes and allowing for individual variations in the normal changes of blood pressure when assuming the standing position, Thulesius (1976) reported that, for practical purposes, the normal values for the systolic blood pressure should not change more than ± 10 mm Hg upon standing. This conclusion is substantiated by Thomas and Schirger (1968) and Siegel (1982). Both stated that the initial fall in blood pressure is corrected promptly by adaptive mechanisms usually within 30 to 45 seconds. Within this time interval, the blood pressure corresponds to the values present at recumbency. The results of the present study support these conclusions. Because no changes in blood pressure were noted, the mean arterial blood pressure did not change when compared to baseline. These findings were demonstrated in both normovolemic and the hypovolemic groups, i.e., neither the normovolemic nor the hypovolemic

group demonstrated a statistically significant change from baseline systolic, diastolic or mean arterial blood pressures when placed in the standing position over the course of 5 minutes.

Zachariah, Krier, Schwartz (1991) reported that before a diagnosis of orthostatic hypotension can be made, the patient must first demonstrate a drop in blood pressure with changes in position. However, Thomas and Schirger (1968) reported that a few casual normal readings do not disprove the diagnosis if clinical symptoms are present. In the present study, blood pressure changes did not occur when compared to baseline blood pressures, however, several clinical symptoms were noted. These symptoms include dizziness, pallor, weakness, nausea, vomiting, diaphoresis and abdominal pain.

In contrast to the findings of this study, Kennedy and Crawford (1984) reported that subjects with ischemic heart disease exhibited a decrease in systolic blood pressure. The normovolemic and the hypovolemic populations subjects in the present study did not report any cardiovascular disease that might have interfered with their physiological adjustments to postural changes. Subjects taking any medication that had any cardiovascular effect were excluded from participating in the study. The research protocol prohibited cigarette smoking and alcohol use by subjects

within 24 hours of the orthostatic measurements and therefore, was eliminated as physiological influences. Other than one group of subjects being classified as normovolemic and one group of subjects being classified as hypovolemic based upon the selection criteria, both groups could be viewed as "normal" from the perspective of their cardiovascular medical history. Neither group reported experiencing other serious disease processes that might have influenced cardiovascular response.

The findings of this study regarding the range of the blood pressure and heart rate responses within the normovolemic and hypovolemic groups suggest that these subjects' responses varied considerably from the mean (±2 standard deviations). The standard deviation and the range of responses of both the hypovolemic and the normovolemic subjects upon standing, demonstrate the wide variability found in individual responses. Lester (1990), studying responses in postoperative cardiac subjects, and Moore and Newton (1986), studying responses in healthy men and women, also noted a similar wide range in responses in blood pressure and heart rate upon standing. Streeten's (1987) findings of the wide range in individual responses are the basis of his defining parameters regarding orthostatic hypotension.

In an emergency room setting, findings from two studies also demonstrated a great deal of variability to position change. Koziol-McLain et al. (1991) reported similar findings of variability in orthostatic vital signs among euvolemic subjects. Furthermore, Levitt, Liebermann, Lopez and Sutton/Jefferson (1989) summarized their results by suggesting that there is too much individual variation in a patient's orthostatic response to dehydration and blood loss to determine the degree or presence of dehydration or blood loss. The purpose of the Levitt et al. research was to evaluate orthostatic hypotension and dehydration percentage.

Heart Rate Response

To briefly review, cardiac output is heart rate multiplied by stroke volume. Since blood pressure is a function of total peripheral resistance and cardiac output, the arterial blood pressure can be maintained by a rise in either or both of them. It is possible that the increase in heart rate demonstrated by subjects in both groups was sufficient to maintain cardiac output without initiating changes in the blood pressure parameters. The data show an increase in heart rate occurred at 0.5 minutes after assuming the standing position and remained elevated across time in both the normovolemic and hypovolemic groups. This significant increase in heart rate may have minimized any physiologic need for blood pressure changes. The data

suggests that hypovolemic subjects who completed the procedure were able to autoregulate their cardiovascular status by increases in the heart rate thus maintaining cerebral perfusion pressure. Those subjects who did not complete the orthostatic procedure could not compensate adequately by the autoregulation mechanisms associated with increase in heart rate.

One difference between the heart rate responses between the normovolemic and hypovolemic groups was the mean baseline level in the supine position as well as the magnitude of the change in the standing position. Hurst (1978) uses 40 - 85 beats per minute as guidelines to define a normal range of baseline heart rates in the adult population. The mean heart rate baseline for the hypovolemic group was 87.71 (15.36) beats per minute while the normovolemic group's mean heart rate baseline was 70.41 (11.82) beats per minute. The mean difference in baseline heart rate was 17 beats per minute higher in the hypovolemic group than the baseline mean for the normovolemic group. Further research may indicate that a baseline heart rate of $\geq$87 beats per minute may preclude a positive tilt test. The difference in beginning baseline heart rate levels has not been previously reported.

The second area of difference in the heart rate noted between the normovolemic and hypovolemic groups is the magnitude of the response to positional change. The mean increase in the heart rate for the normovolemic group was ≤15.66 beats per minute while the mean increase in the hypovolemic group was ≥19.33 beats per minute. The hypovolemic group's increase in heart rate approximates the clinically accepted norm of 20 beats per minute increase on position change as defining orthostatic hypotension (Halpern, 1987).

The changes in heart rate occurred in similar patterns within the normovolemic and hypovolemic populations. An initial steep increase in heart rate response is seen within 0.5 minutes upon standing with a leveling period occurring at 1 minute in both populations. This finding supports those of Knopp et al. (1980), whose comparison of timed values showed one minute to be the best time to record pulse changes. Based upon previous findings, Moore and Newton (1986) recommended that the heart rate be measured 45 seconds after standing, while Kennedy and Crawford (1984) suggested that the heart rate be measured at 30 seconds after standing. From a clinical perspective, 30 seconds to 1 minute may account for the same peak in heart rate. The timing of heart rate measurement needs further investigation.

Other Symptoms

Dizziness has been reported in the literature as a diagnostic indicator of orthostatic hypotension. Newton and Moore (1986) found 12 subjects (n=50) who reported dizziness but further analysis did not find dizziness correlated with systolic and diastolic blood pressures upon standing. They left the issue unresolved. Koziol-McLain et al. (1991) reported 26% (n=132) of their sample of euvolemic subjects complained of dizziness. There were no statistically significant differences for orthostatic heart rate and systolic blood pressure between those who experienced dizziness than in those who did not.

Dizziness was reported in 100% (n=25) of the hypovolemic group in the present study but was not reported by any subjects (n=30) in the normovolemic group. Dizziness occurred with varying degrees of severity to suggest that it may be an important if not a critical component in orthostatic hypotension. Of the seven subjects who could not complete the study protocol, six complained of severe dizziness with spatial wavering. In order to stand, these subjects required holding onto the researcher. After termination of the protocol and resumption of the supine position, the dizziness abated and the subjects stated that they felt much better.

Sympathomimetic responses to position change have been recognized as additional symptoms of orthostatic hypotension. Field notes and anecdotal data from this study identified several symptoms suggestive of hypovolemia and orthostatic hypotension such as weakness in varying degrees, diaphoresis, nausea, pallor, vomiting, "hot flashes" and abdominal pain. Schatz (1984) explained that contracted volume is indicated if a patient has a brisk tachycardia, pallor, sweating, and other sympathetic responses to a drop in pressure on standing.

Supine to Standing versus. Standing to Supine

Comparisons between the responses in blood pressure and heart rates from the supine baseline measurements and the supine end-baseline measurements in the normovolemic and hypovolemic groups indicate that the mean end-baseline measurements in the blood pressure and heart rate return to baseline measurements. In other words, the responses seen in baseline to standing measurements equal the standing to end-baseline measurements. This finding substantiates Blomqvist and Stone's (1983) assumption that the hemodynamic responses to the supine-standing and the standing-supine transitions are mirror images.

Implications for Nursing

The data in this study suggest that resting heart rates ≥87 beats per minute after 5 minutes in the supine position may be a sign of orthostatic hypotension in patients with a history of a fluid loss. Other supporting symptoms may include dizziness, weakness, diaphoresis, nausea, pallor, vomiting, "hot flashes", and abdominal pain. Analysis of the data further suggests that orthostatic hypotension may be considered to be present if, on moving to the standing position from supine, the rise in heart rate increases by ≥19.33 beats per minute or is ≥110 beats per minute. Heart rate measurements should be taken at one minute in the standing position.

In relation to the sequence of measurements taken during the orthostatic procedure, blood pressure and heart rate measurements in the supine to standing sequence were essentially identical to those taken in the standing to supine sequence. Using this information in the emergency room setting may be possible with further study. For example, an ambulatory individual who seeks out treatment within the emergency room setting is hemodynamically compensated if that individual can safely function in activities of daily living. Blood pressure and heart rate measurements obtained in the triage area and then repeated in the supine position in an examination room may

conceptually be equated to the standing to end-baseline measurements obtained in this study. If orthostatic hypotension is suspected in triage, repetition of the blood pressure and heart rate measurements in the supine position should be a mirror image of blood pressure and heart rate measurements taken supine to standing. The changes noted by this standing to supine body position sequence especially in the heart rate may identify orthostatic hypotension without subjecting the individual to further comfort and safety risks by the traditional method of supine to standing positions.

When caring for patients in a clinical setting, attention to urination needs and trends are often required. Documentation of urine and its characteristics by nurses is part of their assessment process. Urine specific gravity values of ≥ 1.025 and color of amber may be the first indication of a fluid deficit process. These findings may alert nurses to the potential risks involved in caring for a patient who may exhibit orthostatic hypotension.

Suggestions regarding the development of a nursing policy for the orthostatic procedure include placing the patient in the supine position for 5 minutes and recording a systolic and diastolic blood pressure and heart rate. These measurements would act as the baseline references for comparison. The patient should then be placed in the

sitting position for 10 seconds prior to moving to the standing position. This short delay allows for the patient to adjust to being upright. Upon standing, the patient should be observed for the symptoms dizziness, weakness, pallor, and diaphoresis. In addition, complaints of pain, nausea and vomiting should be noted. Measurements of the heart rate should be taken at one minute in the standing position. Measurements of the systolic and diastolic blood pressure can be taken after one minute.

Limitations of the Study

There are several limitations of this study. They include:

1. The size of the sample (n=30) for the normovolemic group and (n=31) for the hypovolemic group was small. Because of the number of study variables and a small sample size, generalization to other populations cannot be made.
2. The use of a convenience sample limits the inferences that can be made about populations. A randomized sample may narrow the variability reflected by the large standard deviations that occurred for all of the study variables.
3. Subjective influences associated with dizziness, stress, anxiety, nausea, vomiting, and pain that

some of the subjects experienced pre-procedure and during the procedure may have influenced the physiologic responses between the hypovolemic state and posture change.

4. Knowledge deficit by the community population and emergency room population to the benefits of nursing research reduced the sample size of both the normovolemic and hypovolemic groups.
5. The identification process of potential hypovolemic subjects lacked full cooperation by emergency room nursing and physician staff.

Recommendations for Future Study

The recommendations for future study include:

1. Replication of this study using a larger, random sample size.
2. Replication of this study using the same protocol with the exception of increasing the urine specific gravity of ≥1.030 as a selection criteria to identify hypovolemic subjects.
3. Comparison of orthostatic responses of ambulatory subjects hemodynamically assessed in the emergency room's triage area and reassessed after being supine for 5 minutes.

4. Random ordering of position changes to improve the validity of the test.
5. The Propac 104 could not be externally programmed to record the noninvasive blood pressure at 0.5 minutes. Software to increase user programmability is currently not available. Therefore, the researcher needed to be aware of the time interval for the blood pressure measurement and manually request the measurement from the instrument. This was accomplished while concurrently observing the subject for changes in comfort and safety.
6. Continuous measurement of the heart rate and blood pressure would ensure a complete data base of postural responses. Although not feasible, the use of arterial blood pressure lines would reflect a more accurate second by second change over time.

Summary

Systolic, diastolic, and mean arterial blood pressure and heart rate were examined across time when moving from supine to standing in normovolemic and hypovolemic populations. The time intervals at which the blood pressure and heart rate measurements were recorded were 0.5 minute, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, and end-

baseline (5 minutes after returning to the supine position. When compared to baseline measurements in the systolic, diastolic and mean arterial blood pressures, no statistically significant changes were noted. This occurrence has been previously noted in the literature.

Analysis of the data in this study suggests that resting heart rates ≥87 beats per minute after 5 minutes in the supine position may indicate hypovolemia. In addition to the change in heart rate, other accompanying symptoms may include dizziness, weakness, diaphoresis, nausea, pallor, vomiting, "hot flashes", and abdominal pain. The data further suggest that orthostatic hypotension can be considered present if upon moving to the standing position from supine, the rise in heart rate increases by ≥19.33 beats per minute or is ≥110 beats per minute. Heart rate measurements should be taken at one minute in the standing position.

Despite the lack of statistical significance among the variables systolic blood pressure, diastolic blood pressure and mean arterial blood pressure when the hypovolemic subjects changed from a supine to a standing position, the findings suggest that these parameters may be meaningful only within the context of the patient's ongoing clinical status. Normal arterial blood pressure and heart rate are so individual that it is not uncommon to see wide

fluctuations in both systolic, diastolic and mean arterial blood pressures and heart rate encountered from moment to moment. The wide variations in blood pressure and heart rate measurements should remind us of the premise of health care: "treat the patient and not the numbers."

APPENDIX A: BRISTOL REGIONAL MEDICAL CENTER INSTITUTIONAL REVIEW BOARD: APPROVAL TO CONDUCT RESEARCH INVOLVING HUMAN SUBJECTS

Form # 103

BRISTOL REGIONAL MEDICAL CENTER
INSTITUTIONAL REVIEW BOARD

Request for Review of Project Involving Human Subjects

1. TITLE OF GRANT OR PROJECT: ORTHOSTATIC BLOOD PRESSURE AND HEART RATE RESPONSES WITHIN HYPOVOLEMIC AND NORMOVOLEMIC POPULATIONS

2. PRINCIPAL INVESTIGATOR: FRAN D. PATTERSON RN
   Address: 3165 Benhams Rd Bristol VA 24201
   Phone: (703) 466-6762
   Department: Nursing

3. CO-INVESTIGATORS (Name, Department):
   Anne Woodtli PhD. RN
   Associate Professor
   College of Nursing/ University of Arizona
   Tucson AZ 85721

4. DATE SUBMITTED: 25 August 1993
   ESTIMATED DATE OF ACTIVATION OF PROJECT: 1 September 1993
   ESTIMATED DATE OF COMPLETION OF PROJECT:15 October 1993

5. FUNDING SOURCE (Requested or Granted): none

   a.___ Federal (Agency): _____
   b.___ Extramural, Non-Federal: _____
   c.___ Departmental Grant:
   Contract Application Deadline: _____

NOTE: If the source of funds is a federal grant you do not need to delay the submission of your grant application while committee approval is pending. Inform the agnecy that you have filed a project proposal with the IRB and then forward the special assurance to the agency after you obtain approval for your project.

If your proposal involves a contract and you face an immediate deadline make a telephone request tot he Chairman of the IRB for an extraordinary meeting of the IRB. Your proposal will then be considered by the IRB whenever a quorum can be assembled.

6. NEW PROJECT CONTINUATION Date of Last Review _____

7. TYPE OF REVIEW REQUESTED

   XX Full Review (Required if 5a or b, or if subject risk involved)
   ___ Short Review (If no-risk, 5c project)
   ___ Re-Evaluation

8. SPECIAL RISK SUBJECT INVOLVED: (Check applicable groups)

   XX Pregnant females
   ___ Fetuses
   ___ Prisoners
   ___ Persons under age 18 years
   ___ Mentally Incompetent subjects

9. TYPE OF SUBJECT OR STUDY (Check most applicable type)
   a. ___Medical-Therapeutic (Evaluation of drugs, treatment protocol, surgical procedure, etc.)
   b. XXMedical-Non-Therapeutic (Physiological studies, laboratory analysis of normal blood or other substances)

c. ___ Behavioral, Non-Manipulative (Evaluation of subject response to educational methods or material, Psychological profiles, Attitudinal survey, etc.)

d. ___ Behavioral, Manipulative (Behavior modification, response to stressful stimuli, etc.)

10. Attachment Checklist

XX A. Narrative Description of Project: (Concise, but must include each of the following areas:)

1. Project Title
2. Place to be conducted
3. Specific objectives of project
4. Summary of project, and copies of any questionnaires, etc. to be administered.
5. Specific role of human subject involved, i.e. characteristics of study population, procedures used in selection, what will be done to them.
6. Specific risks to subjects, including physical, psychological and social risks.
7. Benefits expected to subjects, investigators, community, etc.
8. What inducements, if any, will be offered to the subjects.
9. Subject confidentiality (will subject identification be kept confidential; if so, how).
10. Informed consent procedure to be utilized.
11. Procedure to be followed in handling and reporting adverse reactions.
12. Pertinent literature references (maximum of ten)
13. A description of the location where the records of the study will be kept as well as plans for the transfer of thse records, should it prove necessary to provide for institutional storage of records as provided in the Bylaws of the Bristol Memorial Hospital IRB.: "b. The records are to be retained by Bristol Memorial Hospital for a minimum of ten (10) years after completion of the research, and the records shall be accessible for inspection and copying by authorized persons at reasonable times and in a reasonable manner."...

XX B. Completed Copy of Informed Consent Form (See IRB Form No. 106)

___ C. Statement of Approval from Subcommittee on radioactive materials, if applicable.

___ D. Investigational Drug Information Summary, if applicable.

11. Assurance of Principal Investigator

The information contained in this project review proposal accurately represents the activities of this project involving human subjects.

I will promptly inform the Institutional Review Board of (1) any significant changes in the project with respect to human subject participation; (2) any adverse reactions or unexpected responses observed involving human subjects; (3) any continuation of the project activities beyond the period stated in this request.

DATE: 25 August 1993 Jean D. Patterson
Principal Investigator

IRB Form No. 102 Page 3

Bristol Memorial Hospital
IRB Assurance # M1194
XYZ Agreement #

CERTIFICATE OF SPECIAL ASSURANCE

FULL TITLE: ORTHOSTATIC BLOOD PRESSURE AND HEART RATE RESPONSES WITHIN HYPOVOLEMIC AND NORMOBOLEMIC POPULATIONS

PROJECT #

PROJECT DIRECTOR: Anne Woodtli PhD. RN

MULTI-INSTITUTIONAL PROJECTS:

Sponsoring Organizations: University of Arizona
College of Nursing

Principal Investigator: Fran Dolores Patterson RN

GENERAL DESCRIPTION OF RISKS AND BENEFITS: Dizziness, weakness, a feeling of faintness, sweating, and nausea may be experienced when moving from a lying position to a sitting then standing position. A slight pulling sensation may be felt when electrocardiographic electrodes are applied then remeoved. The possibility exists that an allergic reaction to the EKG pads may occur.

INFORMED CONSENT PROCEDURES: There are no benefits in participating in this study. Medical treatment will be given irregardless of study.
See attached Informed Consent

PROCEDURES FOR PROMPT REPORTING:

Any changes or adverse reactions will be reported to the Chairman of the Institutional Review Board utilizing standard reporting procedures. See policy statement on next page.

The Board will review this project at twelve (12) month intervals.

I, Terrell C. Fetzer MD, Chairman of the Institutional Review Board, endorse the above Certificate of Special Assurance and certify that Bristol Memorial Hospital has established an Institutional Review Board satisfying the requirements of the 45 C.F.R. Sec. 46.

Terrell C. Fetzer MD 9/8/93
Chairman Date

APPENDIX B: SUBJECT'S CONSENT

Subject's Consent

ORTHOSTATIC BLOOD PRESSURE AND HEART RATE RESPONSES WITHIN HYPOVOLEMIC AND NORMOVOLEMIC POPULATIONS

Lay Title: Blood Pressure and Heart Rate Responses within dehydrated and non-dehydrated populations when changed from a lying position to a standing position.

I AM BEING ASKED TO READ THE FOLLOWING MATERIAL TO ENSURE THAT I AM INFORMED OF THE NATURE OF THIS RESEARCH STUDY AND OF HOW I WILL PARTICIPATE IN IT, IF I CONSENT TO DO SO. SIGNING THIS FORM WILL INDICATE THAT I HAVE BEEN SO INFORMED AND THAT I GIVE MY CONSENT. FEDERAL REGULATIONS REQUIRE WRITTEN INFORMED CONSENT PRIOR TO PARTICIPATION IN THIS RESEARCH STUDY SO THAT I CAN KNOW THE NATURE AND THE RISKS OF MY PARTICIPATION AND CAN DECIDE TO PARTICIPATE OR NOT PARTICIPATE IN A FREE AND INFORMED MANNER.

PURPOSE

I am being invited to voluntarily participate in the above titled project. The purpose of this project is to describe the blood pressure and heart rates between subjects as they move from a lying to standing position. The results may assist the physicians and nurses in providing improved care to people who are dehydrated and those who are not dehydrated.

SELECTION CRITERIA

I am being invited to participate because I am dizzy upon standing and may be dehydrated after my recent history of fluid loss over the past 12 hours or more. A urine sample from me will confirm if I am dehydrated. Although I am dizzy upon standing, I will be able to stand for 5 minutes with minimum assistance. I have not taken any medicines that may affect my blood pressure and/or heart rate on a regular basis or within the past 24 hours. If pregnant, I am not over 20 weeks along. I have refrained from any alcohol and/or cigarettes within the past 24 hours. I have not sustained any type of injury that has caused my dehydrated condition.

A minimum of 60 subjects will be enrolled in this study.

STANDARD TREATMENT

If I agree to participate, Fran Patterson RN will ask me to lie quietly flat on the bed or stretcher with my head flat for about 5 minutes. Ms Patterson will cleanse my skin with an alcohol swab and apply 3 electrodes to my chest to monitor my heart rate during the procedure. My blood pressure and my heart rate will be taken while I am are lying flat. Next, I will be asked to sit on the edge of the bed for 10 seconds, then I will be asked to assume the standing position. While standing, my blood pressure and heart rate will be measured several times over the course of 5 1/2 minutes. Then I will be asked to lie flat again for 5 minutes at which time my heart rate and blood pressure will be measured. The time for the entire procedure will be about 16 minutes. The results of the measurements will be shared with the nurse and the physician.

RISKS

I may experience dizziness, weakness, a feeling of faintness, sweating, and nausea when moving from a lying position to a sitting then standing position. My blood pressure may drop and my heart rate may increase. A nurse will be with me at all times. I will be helped to return to a lying position on the stretcher or bed should the above symptoms be severe. The nurse will remain with me until my symptoms have resolved and my vital signs return to normal.

BENEFITS

There are no benefits in participating in this study. My participation will not increase or reduce my hospital bill. I will receive the necessary medical attention regardless of my decision to participate.

CONFIDENTIALITY

I may refuse to participate and may withdraw from this study at any time without penalty or loss of benefits to which I am otherwise entitled. My decision will not affect the care that I receive.

My identity is confidential. Only Fran Patterson RN, my nurse and physician will have access to the study data. Data that my physician feels is necessary to be recorded on my medical chart will become part of the permanent record. Data compiled for the study will be retained for one year.

LIABILITY

I understand that side effects or harm are possible in any research program despite the use of high standards of care and could occur through no fault of mine or the investigator involved. Known side effects have been described in this consent form. however, unforeseeable harm may also occur and require care. I understand that money for research-related side effects or harm, or for wages or time lost, is not available. I do not give up any of my legal rights by signing this form. There will be no additional cost to my bill for participating in this study. I can obtain further information from Fran D. Patterson RN, Graduate Student at (615) 968-6058. If I have questions concerning my rights as a research subject, I may call the Human Subjects Committee, The University of Arizona at (602) 626-6721 or Terrell C. Estes, M.D., Bristol Regional Medical Center, (615) 968-1121.

AUTHORIZATION

BEFORE GIVING MY CONSENT BY SIGNING THIS FORM, THE METHODS, INCONVENIENCES, RISKS AND BENEFITS HAVE BEEN EXPLAINED TO ME AND MY QUESTIONS HAVE BEEN ANSWERED. I UNDERSTAND THAT I MAY ASK QUESTIONS AT ANY TIME AND THAT I AM FREE TO WITHDRAW FROM THE PROJECT AT ANY TIME WITHOUT CAUSING BAD FEELINGS OR AFFECTING MY MEDICAL CARE. MY PARTICIPATION IN THIS PROJECT MAY BE ENDED BY THE INVESTIGATOR OR BY THE SPONSOR FOR REASONS THAT WOULD BE EXPLAINED. NEW INFORMATION DEVELOPED DURING THE COURSE OF THIS STUDY WHICH MAY AFFECT MY WILLINGNESS TO CONTINUE IN THIS RESEARCH PROJECT WILL BE GIVEN TO ME AS IT BECOMES AVAILABLE. I UNDERSTAND THAT THIS CONSENT FORM WILL BE FILED IN AN AREA DESIGNATED BY THE HUMAN SUBJECTS COMMITTEE WITH ACCESS RESTRICTED TO THE PRINCIPAL INVESTIGATOR, FRAN D. PATTERSON RN, OR AUTHORIZED REPRESENTATIVE OF THE COLLEGE OF NURSING DEPARTMENT. I UNDERSTAND THAT I DO NOT GIVE UP ANY OF MY LEGAL RIGHTS BY SIGNING THIS FORM. A COPY OF THIS SIGNED CONSENT FORM WILL BE GIVEN TO ME.

_____ _____

Subject's Signature Date

_____ _____

Parent/Legal Guardian (if necessary) Date

INVESTIGATOR

I have carefully explained to the subjects the nature of the above project. I hereby certify that to the best of my knowledge the person who is signing this consent form understands clearly the nature, demands, benefits, and risks involved in his/her participation and his/her signature is legally valid. A medical problem or language or educational barrier has not precluded this understanding.

_____ _____

Signature of Investigator Date

_____

Name (please print)

_____

Phone Number

APPENDIX C: DEMOGRAPHIC DATA SHEET

DEMOGRAPHIC DATA FORM

Group HYPOVOLEMIC_____ NORMOVOLEMIC_____
Code Number _____
Age _____
Sex M____F____
Date of ER/Clinic Visit_____

History:

1. Presenting complaint:_____

2. Duration of complaint:_____

3. What kinds of treatments if any were done prior to seeking medical help?_____

4. Medications taken within the last 24 hrs._____

5. Medical diagnosis after medical evaluation:_____

Symptoms experienced during procedure

1. Dizziness: yes____ No_____

Explain:_____

2. Syncope/Fainting: Yes____ No____

Explain: _____

_____

4. Extreme Weakness: Yes____ No____
Explain: _____

_____

5. Other: Yes____ No____
Explain: _____

_____

APPENDIX D: CLINICAL DATA SHEET

CLINICAL DATA FORM

Subjective Notes

Group: HYPOVOLEMIC _____ NORMOVOLEMIC _____
Code Number: _____
Date of Test: _____
Age_____ Sex_____

**NOTE: IF SYNCOPE OCCURS, RECORD POSITION & TIME
IF STUDY IS TERMINATED SECONDARY TO NEAR SYNCOPE, RECORD POSITION & TIME

Urine Color: _____
Condition of mucous membranes: Moist_____ Dry_____
Skin Turgor: Normal_____ Abnormal_____ Describe:

POSITION	MINUTES	SC	ST	SML	NAUSEA	LOD	VC	SYN
Supine	5							
Standing	0.5							
	1							
	2							
	3							
	4							
	5							
Supine	5							

LEGEND: SC=skin color
ST=skin temperature
SML=skin moisture level
SYN=syncopal episode
NAUSEA=presence or absence of nausea
LOD=level of dizziness (based on a subjective scale between 1-10)
VC=presence or absence of vision changes

Additional Observations:

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