Effect of water intake on fluctuations in blood pressure and heart rate induced by postural changes in healthy subjects

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Abstract

Blood pressure fluctuates in response to different factors, whether internal or external. Different body positions have been shown to cause changes in blood pressure; however, there are in-built mechanisms that correct these fluctuations. A defect or delay in these inherent mechanisms to prevent postural-induced blood pressure changes results in postural hypotension. Volume depletion has been implicated as one of the conditions that bring about postural hypotension. The purpose of this study was to assess the impact of water intake on fluctuations in blood pressure induced by postural changes in healthy subjects. 20 female subjects were randomly divided into two groups: the control group and the test group, with each group having 10 subjects. Before the experiment commenced, the subjects were asked to rest by sitting comfortably for 15 minutes, and then their blood pressure and heart rate were measured, which served as the baseline. The test group was given 600 mL of water after baseline blood pressure and heart rate measurements. A digital sphygmomanometer was used for measuring the blood pressure and heart rate at 15 minutes of lying, 0, 5, 10 minutes of sitting, and 0, 5, 10 minutes of standing. The result showed a significant decrease in systolic blood pressure, diastolic blood pressure, and heart rate after 15 minutes of lying down compared to the baseline measurement, and a significant increase was also observed in the sitting position compared to the lying position in both groups. The blood pressure and heart rate recorded in all the positions in the test group were not significantly different from those of the control group. In conclusion, water intake did not alleviate the fluctuations in blood pressure and heart rate induced by postural changes.

Keyword: Postural changes; Water; Blood pressure; Heart rate

1. Introduction

Blood pressure is the force the circulating blood exerts on the vascular walls. The blood pumping action of the heart is the principal factor responsible for blood pressure (Grim and Grim, 2016). Blood pressure is modulated and controlled by some factors. These factors can be intrinsic or extrinsic. The intrinsic factors, also known as determinants of blood pressure, encompass cardiac output, peripheral vascular resistance, viscosity of blood, elasticity and diameter of vessel walls, and venous return (Magder, 2018). In addition, blood volume is also a major intrinsic factor that regulates the pressure of blood flow. Blood volume is a key factor in the renal mechanism of blood pressure control. It modulates blood pressure through venous return and cardiac output (Cowley, 1992). The renal filtration-reabsorption mechanism is the principal mechanism that regulates the blood volume. The filtration of blood in the kidney glomerulus allows solutes and water to be filtered with the help of inherent mechanisms in the nephron. The filtrate courses through the tubules of the nephron, allowing the reabsorption of water and some of the filtrates (Sharma and Sharma, 2022). The reabsorption of water and solute is the mechanism that actually modulates blood volume and, consequently, blood pressure. The molecular mechanisms in the nephron regulate the amount of solutes and water reabsorbed at the tubules, which increases or decreases the blood volume and, by doing so, alters the blood pressure.

There are three most frequently adopted body positions that we engage in: the lying position (supine position), the sitting position, and the standing position. Body positions can actually alter or modulate blood pressure. In supine position, a study reported an increase (Eşer et al., 2007), while another study reported a decrease (Nesrine and Thoraya, 2020), whichever way the literature has documented a change in blood pressure in supine position. Furthermore, changing position from lying down to standing causes a temporal reduction in blood pressure, which is attributed to venous pooling at the lower extremities of the body (Fabrizio et al., 2015). Positional change from supine to standing position increases heart rate by 10 to 15 beats per minute in healthy humans (Cicolini et al., 2011).

There is an in-built mechanism in the body that is responsible for acute changes in blood pressure, such as changes in blood pressure in response to postural changes. However, the immediate rectifying of the blood pressure changes might sometimes be delayed for certain reasons and conditions, such as dehydration, autonomic neuropathy, and stiffness of the blood vessels (Ricci et al., 2015; Mol et al., 2019), which may cause lightheadedness and fainting; this is generally called orthostatic hypotension or postural hypotension (Freeman et al., 2011). Orthostatic hypotension is the major effect of body positional changes. The elderly, postnatal mothers, individuals who have been on bed rest, and juveniles are especially susceptible to orthostatic hypotension (Jeffrey et al., 2011). Age is a principal factor that has been documented to increase the incidence of postural hypotension (Rutan et al., 1992; Sarasin et al., 2002; Low, 2008). Rose and co-workers (2006) reported a high incidence of orthostatic hypotension in the elderly and discovered that the elderly who are institutionalised have a higher propensity for orthostatic hypotension than elders who are living in the community. The special cells (baroreceptors) that modulate acute changes in blood pressure can weaken with age (Gary, 1999). Orthostatic hypotension has been documented as an indication of volume depletion and/or peripheral vasoconstriction impairment (Nikolaos et al. 2019). Furthermore, some factors have been suggested to reduce orthostatic hypotension, which include less restriction on salt consumption, intake of water, muscular activity, and so on (Christoph et al., 2002; Anders et al., 2010).

Water intake has a significant effect on blood volume (Yutaka et al., 2001). Blood volume is particularly influenced and modified by sodium concentration and hydration level (Sharma and Sharma, 2022). Increasing fluid intake can increase the blood volume, which in turn will increase the venous return to the heart and cardiac output and might consequently increase blood pressure. Postural changes cause fluctuations in blood pressure, which are often experienced in a lying-down position and when transiting from a lying position to a standing position. It has been suggested that water intake modulates blood pressure through the blood volume mechanism; besides, intake of water has been hypothesized as a remedy to cushion the effect of postural changes. This study therefore assessed the impact of water intake on blood pressure fluctuations induced by postural changes in healthy young individuals.

2. Materials and Method

2.1 Subject selection/subject selection criteria

The female volunteers were selected at random from the University of Uyo. The volunteers had an age range of 18 to 23 years, a weight range of 45 to 70 kg, and a height range of 1.50 m to 1.75 m.

33 female participants were recruited for the study, and they were all duly informed about the protocol of the study.

The study was approved by the University of Uyo teaching hospital, and written consent was obtained from all volunteers before screening.

The criteria listed below were used to accept a subject as fit for the study;

Subjects should not have any history of cardiovascular disorder such as hypertension, cardiac failure or cardiac arrest.

Blood pressure must not be above 120/80. The blood pressure of all the volunteers was measured to ensure that it was within the acceptable range.

Subjects should not be on any special medication

Subjects must be medically fit

No alcohol intake

No smoking history

Be readily available and cooperate adequately during the period of the experiment; the duration and procedures of the experiment were properly explained to the subjects.

After prior examination, 20 female subjects were certified fit to participate in the study.

2.2 Experimental design

The experiment was carried out at the Medical Physiology Lab of the University of Uyo, Annex Campus, Uyo, Akwa-Ibom State. The 20 certified volunteers were randomly divided into two groups (groups A and B). Group A was the control group, while Group B was the test group. Each group was made up of 10 subjects. After this protocol, the subjects were allowed to void their bladders and were then allowed to rest for 15 minutes while comfortably seated before the commencement of the experiment. Baseline blood pressure and heart rate were measured after the 15-minute rest. 600 mL of water was given to the experimental group. Then, the subjects were asked to lie down for 15 minutes on a clinical cot. Blood pressure and heart rate were measured after 15 minutes of lying down. The subjects changed to a sitting position, and readings were taken immediately and after 5 minutes and 10 minutes of sitting. The subjects were helped to stand, and readings were taken immediately and after 5 minutes and 10 minutes of standing.

2.3 Blood pressure and heart rate measurement

The blood pressure and heart rate measurements were taken using a digital sphygmomanometer with a cuff size of 12 x 26 cm. The handcuff of the digital sphygmomanometer was wrapped around the left arm of the subject, one inch (2–3 cm) away from their cubital fossa, and the arm was held close to the heart. The subjects were asked to remain calm and composed and not move their arms or talk during the measuring process, so as not to alter the readings. The switch of the digital sphygmomanometer was pressed, and in about 1–2 minutes, the cuff was inflated and deflated automatically, displaying the blood pressure and heart rate simultaneously on the screen of the sphygmomanometer. The blood pressure and heart rate were measured three consecutive times at a 1-minute interval between measurements, and the average was recorded.

2.4 Statistical analysis

The data were presented as mean ± SEM. Analysis of variance (ANOVA) was used to analyze the data using Graphpad Prism 7.01 (Graphpad Software, Inc., USA). Tukey's test was used to perform the post-hoc comparison following the ANOVA analysis. The level of significance for all the results was $P < 0.05$

3. Results

Change in systolic blood pressure (SBP)

The study recorded a significant decrease in systolic blood pressure in lying position in the control group and test group compared to the baseline systolic blood pressure. A significant increase was also observed in the sitting position compared to lying down in both the control group and the test group ($P<0.05$) (Table 1). When the test group was compared to the control group, no significant difference in SBP was observed (Figure 1).

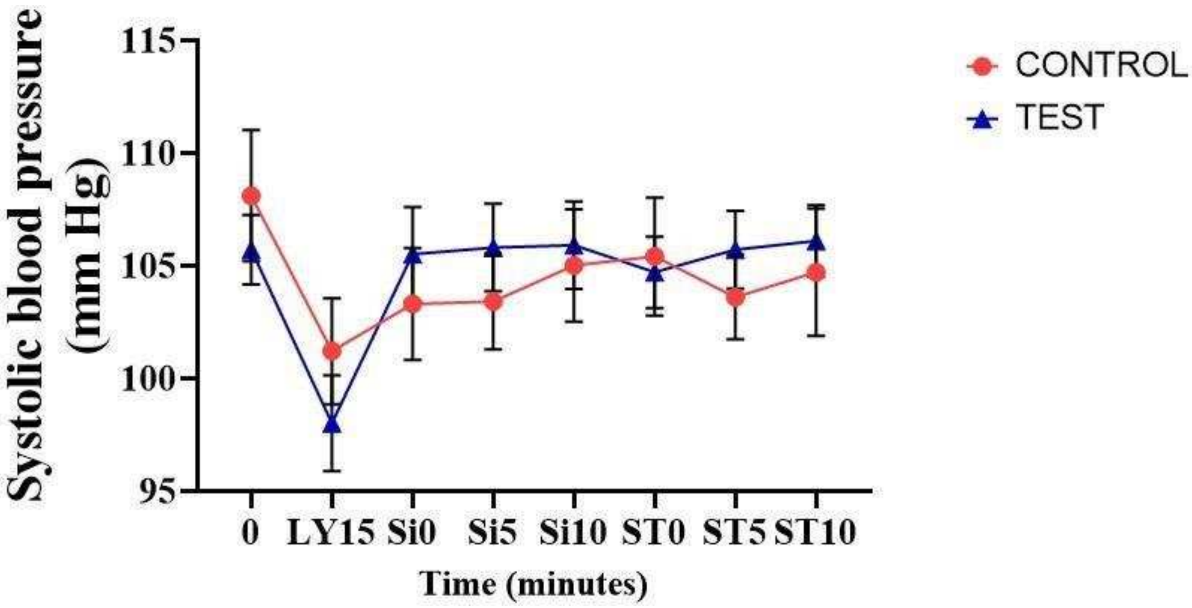

Figure 1: Systolic blood pressure (SBP)
The result was presented as mean±SEM, n = 10. All the subjects were exposed to different body postures; however, the test group received 600 mL of water prior to the postural adjustments.

Change in diastolic blood pressure (DBP)

A significant decrease in diastolic blood pressure was observed at the lying position in the control group and test group compared to the baseline diastolic blood pressure. The study also recorded a significant increase in the sitting position compared to lying position in both the control group and the test group. At 5 minutes of sitting, a significant increase was noted compared to the DBP recorded at the immediate transition to the sitting position from the lying position in the test group ($P<0.05$) (Table 1). The study noted no significant difference when the DBP of the test group was compared to that of the control group (Figure 2).

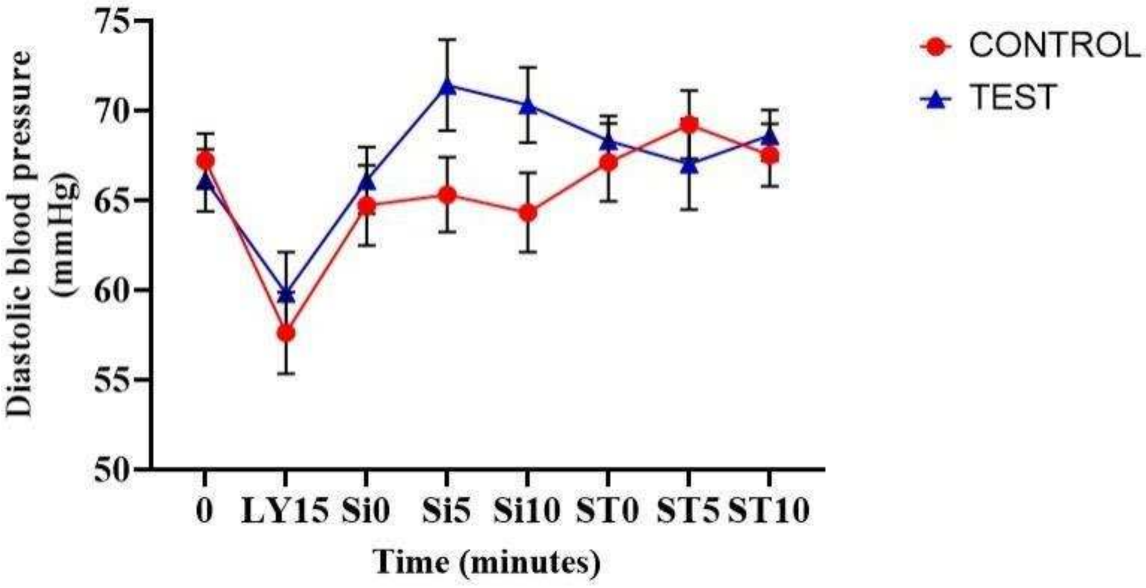

Figure 2: Diastolic blood pressure (DBP)
The result was presented as mean±SEM, n = 10. All the subjects were exposed to different body postures; however, the test group received 600 mL of water prior to the postural adjustments.

Change in mean arterial pressure (MAP)

A significant decrease in MAP was observed at the lying position in the control group and test group compared to the baseline MAP. The study also recorded a significant increase in the sitting position compared to lying position in both the control group and the test group. At 5 minutes of sitting, a significant increase in MAP was noted compared to the MAP recorded at the immediate transition to the sitting position from the lying position in the test group ($P<0.05$) (Table 1). The study noted no significant difference when the MAP of the test group was compared to that of the control group (Figure 3).

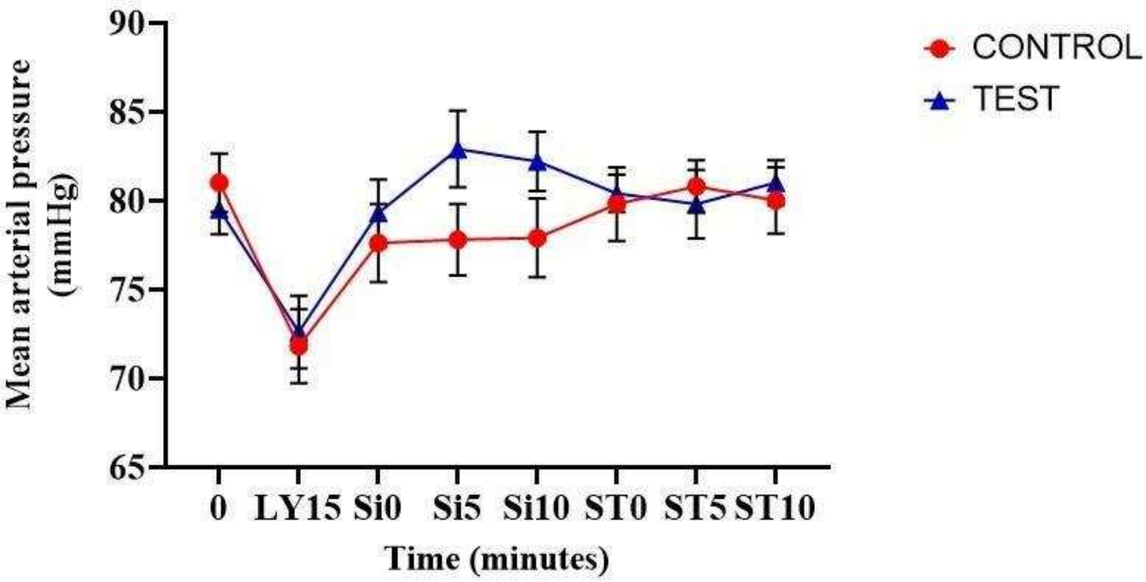

Figure 3: Mean arterial pressure (MAP)
The result was presented as mean±SEM, n = 10. All the subjects were exposed to different body postures; however, the test group received 600 mL of water prior to the postural adjustments.

Change in heart rate (HR)

The study observed a significant decrease in HR at the lying position in the control group and test group compared to the baseline HR. A significant increase in HR was also noticed in the sitting position compared to the lying position in both the control group and the test group. At 0 and 5 minutes of standing, a significant increase in HR was noted compared to the HR recorded at 10 minutes of sitting and 0 minutes of standing, respectively, in the test group ($P<0.05$) (Table 1). The study observed no significant difference when the HR of the test group was compared to that of the control group (Figure 4).

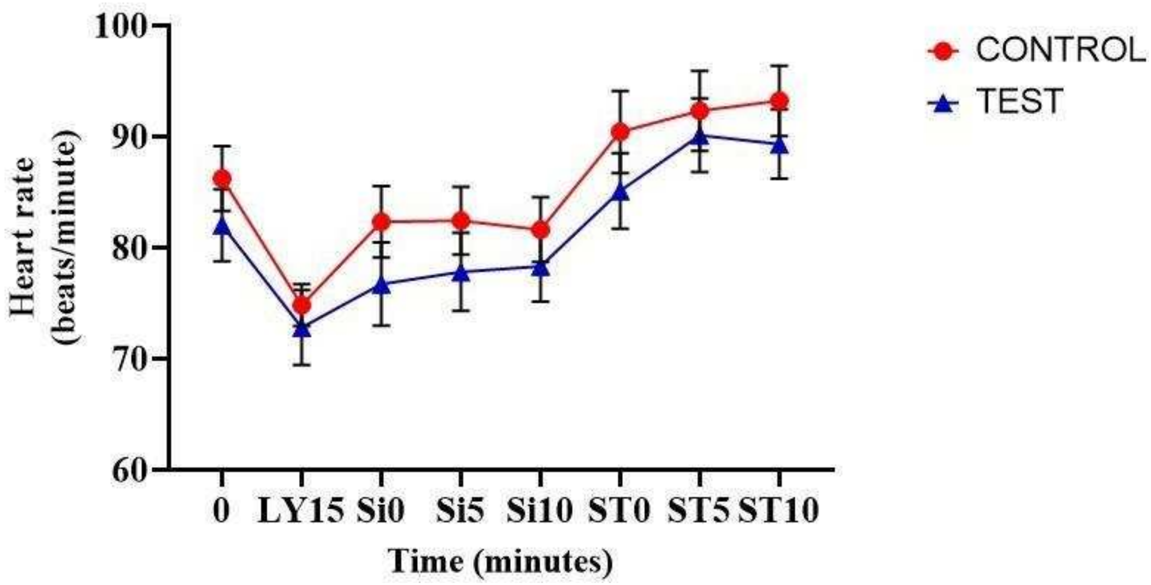

Figure 4: Heart rate (HR)

The result was presented as mean±SEM, n = 10. All the subjects were exposed to different body postures; however, the test group received 600 mL of water prior to the postural adjustments.

Table 1: Changes in blood pressure and heart rate

Positions Time (minutes)	Control Group				Test Group			
	SBP	DBP	MAP	HR	SBP	DBP	MAP	HR
Baseline	108±2.04	67±1.50	81±1.62	86±2.92	106±1.54	66±1.72	79±1.39	82±3.23
Lying-down (15)	100±1.76[#]	58±2.27[#]	72±2.04[#]	75±1.87[#]	98±2.12[#]	60±2.28[#]	73±2.06[#]	73±3.37[#]
Sitting (0)	103±2.48 *	65±2.23 *	78±2.18 *	82±3.23 *	106±2.10 *	66±1.85 *	79±1.87 *	77±3.76 *
Sitting (5)	103±2.13	65±2.08	78±1.98	82±3.04	106±1.94	71±2.53[a]	83±2.14[a]	78±3.51
Sitting (10)	105±2.49	64±2.20	78±2.20	82±2.91	106±1.94	70±2.10	82±1.65	78±3.18
Standing (0)	105±2.62	67±2.17	80±2.03	90±3.70	105±1.58	68±1.38	80±1.03	85±3.41[b]

Standing (5)	104±1.87	69±1.90	81±1.54	92±3.60	106±1.73	67±2.52	80±1.93	90±3.31[c]
Standing (10)	105±2.83	68±1.74	80±1.87	93±3.17	106±1.59	69±1.42	81±1.27	89±3.10

The result was presented as mean±SEM, n = 10. All the subjects were exposed to different body postures; however, the test group received 600 mL of water prior to the postural adjustments. [#] =p<0.05 compared to baseline; * = p<0.05 compared to lying-down; [a] = p<0.05 compared to 0 minutes of sitting; [b] = p<0.05 compared to 10 minutes of sitting; and [c] = p<0.05 compared to 0 minutes of standing.

4. Discussion

Different body positions have been documented to modulate blood pressure (BP), and there are three most frequently adopted body positions: the lying position (supine position), the sitting position, and the standing position. There is an in-built mechanism in the body that is responsible for acute changes in blood pressure, such as changes in blood pressure in response to postural change. However, the immediate rectifying of the blood pressure changes might sometimes be delayed, which may cause light-headedness and fainting; this is generally called postural hypotension (Freeman et al., 2011). Orthostatic hypotension is the major effect of body positional changes. The intake of water has been hypothesised as a remedy to cushion the effect of postural change. This study therefore assessed the impact of water intake on blood pressure fluctuations induced by postural changes in healthy young individuals.

The study observed a significant decrease in systolic blood pressure, diastolic blood pressure, mean arterial pressure, and heart rate in the lying position and a rise in blood pressure and heart rate towards the values recorded at baseline at the immediate transition from lying to sitting in both the control group and the test group. However, the study recorded no significant changes in blood pressure during the transition from sitting to standing in both groups. The trend was different for heart rate in the test group; the transition from sitting to standing resulted in an increase, and the increase persisted even after 5 minutes of standing. The result of the study is similar to the findings of Nesrine and Thoraya (2020), who reported that lying reduces blood pressure. However, the study by Eser et al. (2007) negates our findings. Eser and co-workers demonstrated that the supine position increases blood pressure. The increase in blood pressure observed from the transition from lying to sitting and then to standing is in agreement with the study of Cicolini and colleagues (2011). They reported that positional change from supine to standing position increases blood pressure and heart rate in healthy individuals. However, Fabrizio et al. (2015) documented that the transition from lying down to standing causes a transient reduction in blood pressure, which they attribute to venous pooling at the lower extremities of the body.

Orthostatic hypotension has been documented as an indication of volume depletion and/or peripheral vasoconstriction impairment (Nikolaos et al., 2019). Water intake has been proposed to be beneficial in reducing the impact of postural change. In the present study, the intake of 600 mL of water had no significant effect on the fluctuations in blood pressure in response to postural change. Although the study observed an increase in heart rate in standing position compared to sitting position in the test group, the comparison of this result with that of the control group showed no significant difference.

Cardiovascular adjustment to acute changes in BP in response to postural change involves complex synergy between the autonomic nervous system that modulates BP and the autoregulation mechanism in the cerebral circulation, which maintains the perfusion of the brain (Olufsen et al., 2005). The transition from lying down to standing causes a transient reduction in blood pressure due to venous pooling in the lower extremities in response to gravitational forces. As a result of gravitational venous pooling, the venous return to the heart is reduced, which decreases stroke volume and cardiac output. Consequently, the arterial BP falls, and this instantly decreases brain perfusion. The fall in BP activates the baroreceptors located in the aortic arch and the carotid sinuses. The baroreceptors send signals to inhibit the parasympathetic system and activate the sympathetic system. The inhibition of the parasympathetic system and the activation of the sympathetic system increase the contractility of the heart, heart rate, and tone and resistance of the blood vessels. Furthermore, the autoregulation mechanism induced by elevated partial pressure of CO_2, increased metabolic demand, and myogenic tone in the cerebral circulation system brings about vasodilation of the cerebral arterioles and thereby increases cerebral perfusion. This instantaneous adjustment of blood pressure might sometimes be delayed as a result of dehydration, autonomic neuropathy, and stiffness of the blood vessels (Mol et al., 2019).

The findings of the present study might be due to the individuals assessed, who are healthy and young adults. Harris et al. (1991) documented that the prevalence of postural change in blood pressure increased with older age and with higher blood pressure levels, regardless of age. Sarasin et al. (2002) and Low (2008) reported that age is a principal factor that increases the incidence of postural hypotension. This is attributed to an age-related decline in the effectiveness of the baroreceptors (Gary, 1999). In addition, Jeffrey et al. (2011) documented that the elderly, postnatal mothers, individuals who have been on bed rest, and juveniles are the individuals that are susceptible to orthostatic hypotension.

5. Conclusion

The findings of this study showed that the supine position reduces blood pressure and heart rate, while the transition from supine to sitting position and then to standing position resulted in an increase in blood pressure and heart rate in both individuals that drank water before the postural adjustments and those that did not. Furthermore, the intake of water did not have a significant impact on postural-induced fluctuations in blood pressure.

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