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EFFECT OF DIFFERENT DEGREES OF TILT ON HEART RATE, PULSE PRESSURE AND MEAN ARTERIAL BLOOD PRESSURE IN YOUNG MALE AND FEMALE NIGERIANS

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Running title: Different degrees of tilt and cardiovascular parameters

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ABSTRACT:

It is well documented that changes in cardiac output are lower in the upright than supine positions. This study investigates the effect of different angles of tilt on the heart rate, pulse pressure and mean arterial pressure (MAP) of healthy male and female subjects in the 18 to 24 years age group and heights between 150 -180cm. All subjects were students in the University of Ilorin. Each participant was studied and the parameters were determined at the supine position and head up tilts at 15º, 30º, 45º and, 60º for 15 minutes interval. Additionally the supine position variables were taken as the resting value against each of the head up tilt angle degree. The result shows that there was progressive and significant increase in heart rate from supine 59.5±1.3beat/min to 62.2 ± 1.4beat/min ($p<0.05$) at 15º; 59.5±1.3beat/min to 63.8 ± 1.4beat/min at 30º tilt ($p<0.05$); 59.5 ± 1.3beat/min to 65.9 ± 1.4beat/min at 45º tilt ($p<0.05$); 59.5 ± 1.3beat/min and 68.2 ± 1.6beat/min at 60º tilt ($p<0.05$). The results also showed that there were significant ($p<0.05$) increases in pulse pressure at all angles which peaked at 30º tilt. Furthermore, it was observed that MAP significantly ($p<0.05$) increased with corresponding increase in the angle of tilt from supine to 60º (76.5±2.2 mmHg (supine) to 80.6±2.1 mmHg (15 º) to 83.8±2.1 mmHg (30 º) to 85.4±2.1 mmHg (45 º) to 85.4±2.2 mmHg (60 º). Our results demonstrated that the heart rate, pulse pressure and MAP were significantly ($p<0.05$) increased in males and females for all the variables.

Keywords: Tilt, heart rate; pulse pressure; mean arterial blood pressure
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INTRODUCTION:

Many workers have shown that the cardiac output in a healthy individual is less in the upright than in the recumbent position [1, 2]. During a moderate posture change in human from sitting to supine, mean arterial blood pressure (MAP) decreases [1, 2]. The mechanisms for this involve cardiopulmonary low and arterial high pressure receptor stimulation which induces peripheral vasodilatation and decrease in heart rate [3]. The muscle vascular bed is sensitive to changes in baro-receptor stimulation [4]. Many senescent individuals demonstrate an ability to regulate MAP in response to standing or head-up tilt [5]. In some individuals, sudden standing causes a fall in blood pressure, dizziness, dimness of vision and fainting. The causes of this orthostatic (postural) hypotension are multiple. The major compensation on assuming the upright positions are triggered by drop in blood pressure in the carotid sinus and aortic arch [3, 6, 7, 8]. The heart rate increases helping to maintain cardiac output. There is relatively little vasoconstriction in the periphery and arterial pressure as head level drops but jugular venous pressure falls reducing the drop in perfusion pressure (arterial pressure- venous pressure) [9].

Generally, increases in cardiac output increases the systolic pressure whereas increase peripheral resistance increases the diastolic pressure. The physiological events underlying all these aforementioned changes are complex and depend on many variables, such as the angle of tilt and length of time the patient remains at a given angle and whether the change is from recumbence to upright position or vise-versa. Posture and its relation to cardiac output is important with the introduction of hypotensive drugs [10]. This study aimed to determine the relationship between angle tilt and changes in heart rate, pulse pressure and mean arterial blood pressure in young adult Nigerians.

SUBJECTS AND METHODS:

Fifty healthy volunteers (30 males and 20 females) who were students in the University of Ilorin participated in this study. The age range was between 18 and 24 years, heights between 150 to 180cm and weights between 55 to 77kg. The volunteers were normotensive (supine blood pressures; not greater than 120/80 mmHg, were not taking medications, and had no known cardiovascular diseases. The volunteers were requested to reframe from drinking caffeine and alcohol, and not to be involved in intensive exercise 24 hours before the study if they were not accustomed to physical exercise.

This study followed the guidelines approved by the Ethical committee of the University of Ilorin,

and a written informed consent was obtained from each volunteer.

The heart rate was measured using standard (automated) digital sphygmomanometer and was confirmed manually using radial artery. The systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using the automated sphygmomanometer and the blood pressure readings confirmed by aneroid manual sphygmomanometer. The pulse pressure (PP) was estimated by the difference between systolic and diastolic blood pressure that is calculated using formula: PP= SBP-DBP. The mean arterial blood pressure was determined indirectly by DBP plus one third of pulse pressure (MAP=DBP+1/3PP) [10].

Studies were conducted three hours after breakfast or lunch [10]. The subject was weighed and height determined. Thereafter, the subject was placed on the tilt bed, maintained in a supine position and heart rate and arterial blood pressure were determined. All subjects were maintained in the supine position for thirty (30) minutes before readings were taken. The variables measured were; heart rate, systolic and diastolic pressures. The experiment was done for four (4) different degrees of tilt [10].

The tilt positions were 15º, 30º, 45º and 60º. Each subject was tilted to all these positions sequentially one after the other starting from the least angle; and readings were taken at 15 minutes interval for each angle. The passive postural changes were performed by manual tilt bed. The duration of the procedure was about two hours for each subject [10].

Percentage change was calculated as follows [10]:

$$\text{Percentage change } (\%\,\Delta) = \frac{(b-a)\ x\ 100}{a}$$

Where a= values of variables at rest (supine position) and
b= values of variables after each tilts

The mean values of heart rate, pulse pressure and MAP were determined and the standard errors of the means were calculated. Significant responses were evaluated by Student t-test for paired comparison [11]; $P \leq 0.05$ was taken as statistically significant. The Student paired t-test was used to detect whether means differed at similar points in time, comparing values of corresponding series (supine vs 15º tilt, supine

vs 30º tilt, supine vs 45º tilt and supine vs 60º tilt).

RESULTS:

Effect of different degrees of tilt on the male subjects:

All the male subjects showed significant increase in heart rate at 15º tilt after 15 minutes interval of postural change (supine to 15º tilt). The mean value increase from 59.5±1.3beat/min to 62.2 ± 1.4beat/min (an increase of 4.7 ± 1.1%, $p<0.05$, n=30). Continuous increase in heart rate was also observed as the tilt angles increases, after 15 minutes interval. The overall mean heart rate increases with changes in tilt angle, supine and 30º tilt: 59.5 ± 1.3 and 63.8 ± 1.4beat/min; supine and 45º tilt: 59.5 ± 1.3 and 65.9 ± 1.4beat/min; supine and 60º tilt: 59.5 ± 1.3 and 68.2 ± 1.6beat/min. The change in heart rate was significant as shown in the table 1.

All the male subjects also showed increase in pulse pressure at various angles of tilt and the increase was highest at angle 30º tilt.

At angle 45º and 60º tilt, the pulse pressure fell from the value obtained in 30º tilt. Hence, mean pulse pressure significantly increased from supine position to 30º tilt as shown in table 1.

As can be seen in Table 1, all the male subjects showed increase in MAP and the increase was in line with increase in the angle of tilt. Overall, MAP increases with change in angle of tilt. The changes were significant ($p<0.05$).

Table 1: Effect of different degrees of tilt on heart rate, pulse pressure and mean arterial blood pressure for the male and female subjects

Subjects		Supine (a)	15º tilt (b)	30º tilt (b)	45º tilt (b)	60º tilt (b)
Male (n=30)	**Heart Rate (bpm)**	59.5±1.3	62.2±1.4*	63.8±1.4*	65.9±1.4*	68.2±1.6*
	Pulse Pressure (mmHg)	39.0±1.1	42.4±1.2*	46.7±1.1*	44.1±1.0*	41.6±0.8*
	MAP (mmHg)	76.5±2.2	80.6±2.1*	83.8±2.1*	85.4±2.1*	85.4±2.2*
Female (n=20)	**Heart Rate (bpm)**	66.1±1.7	68.4±1.8*	69.7±1.8*	71.4±1.8*	74.3±1.7*
	Pulse Pressure (mmHg)	39.4±0.9	42.0±0.9*	44.7±0.9*	41.9±1.0*	41.0±0.9*
	MAP (mmHg)	78.4±2.1	82.7±1.8*	85.2±1.8*	85.4±2.1*	86.4±1.9*

Data are Mean ± SEM values, *P<0.05 significantly different from control: supine vs 15 º tilt, supine vs 30 º tilt, supine vs 45º tilt, supine vs 60º tilt. Where a= values of variables at rest (supine position) and b= values of variables after each tilts

Table 2: Percentage changes of heart rate, pulse pressure and mean arterial blood pressure for the different degrees of tilts compared to the supine for the male and female subjects

Subjects		15º tilt (a)	30º tilt (a)	45º tilt (a)	60º tilt (a)
Male (n=30)	Heart Rate (bpm)	4.7±1.1*	7.2±1.4*	10.8±0.7*	14.7±1.3*
	Pulse Pressure (mmHg)	8.9±1.6*	21.1±3.4*	14.4±2.8*	8.0±2.4*
	MAP (mmHg)	5.8±1.1*	10.0±0.9*	12.3±1.2*	12.1±1.3*
Female (n=20)	Heart Rate (bpm)	3.5±0.5*	5.4±0.6*	8.0±0.7*	12.6±0.8*
	Pulse Pressure (mmHg)	6.8±1.1*	13.7±1.8*	6.5±1.7*	4.2±1.4*
	MAP (mmHg)	5.8±1.2*	9.1±1.3*	11.8±1.5*	10.7±1.7*
	*p-value	<0.05	<0.05	<0.05	<0.05

Data are Mean ± SEM values, a = values of variables after each tilts.

Effect of different degrees of tilt on the female subjects:

All the female subjects showed significant increase in heart rate as the angle of tilt increases. The mean heart rate increased from supine to 15º tilt, 30º tilt, 45º tilt and 60ºtilt; the corresponding values were 66.1 ± 1.7 and 68.4 ± 1.8beat/min, 66.1 ± 1.7 and 69.7 ± 1.8beat/min, 66.1 ± 1.7 and 71.4 ± 1.8beat/min, 66.1 ± 1.7 and 74.3 ± 1.7beat/min. The changes in heart rate were significant ($p<0.05$) as shown in Table 1. Increase in pulse pressure at various angles of tilt was observed for all the female subjects; the increase was highest at angle 30º tilt (Table 1). At angle 45º tilt and 60º tilt, the pulse pressure fell from the value obtained in 30º tilt. The mean pulse pressure significantly increased ($p<0.05$) from supine position to 30º tilt as shown in tables 1 and 2. The MAP for the female subjects increased from supine to the different angles of tilts. The changes in the angles of tilts are presented in tables 1 and 2.

DISCUSSION:

The subjects were selected based on their health status. Subjects with history of cardiovascular diseases, hypertension, smokers, and history of kidney diseases were excluded from the study. This is because the major products of tobacco combustion, nicotine and carbon dioxide are potent vasoconstrictors [12, 13]. Besides, nicotine stimulation increased secretion of catecholamine. The net effect is that there will be increase in peripheral

vascular resistance and this can lead to elevation of blood pressure [13].

The results obtained for both male and female subjects showed that slight increase in heart rate occurred during the first 15 minutes of tilting to the head-up position of 15^0 and thereafter increase progressively as the angle of head up position was increased to 30^0 tilt, 45^0 tilt and 60^0 tilt as presented in table 2. When compared with the recumbent values, the average heart rate at those angles was increased. The changes were significant at $p< 0.05$. The increase in heart rate which began at 15^0 tilt and gradually increased after, and the probable simultaneous augmentation of myocardial contractility (also caused by a reflex increase of sympathetic nervous system activity) prevented further decrease in cardiac output [14]. However, the increase in heart rate is in agreement with the findings of Tuckman and Shillingford [10]. The increase might be due, in part, to withdrawal of vagal inhibition [15]. In addition, in female, the sort of heart rate maintenance could be linked with estrogen. Estrogen is said to be involved in cardio-protection in female [16, 17].

As shown in table 1, there was significant increase in pulse pressure when comparing recumbence with changes in various angles of tilts. The pulse pressure increase gradually at angle 15^0 tilt (8.0±1.1%) and peak at 30^0 tilt (18.0±2.2%) before decline at angle 45^0 tilt and 60^0 tilt (11.0±1.9% and 6.5±1.6%). Generally, the average pulse pressure increased at all positions of tilt when compared to supine. The changes were statistically significant ($p<0.05$). It is well established that a change from recumbence to the vertical is accompanied by an increase in heart rate and diastolic pressure with little or no increase in systolic pressure [18]. The fall in pulse pressure at angles 45^0 and 60^0 is in agreement with findings of Tuchman and Shillingford that “It may well be that the reflexes associated with control of diastolic pressure are more active at lesser degrees of tilt than those responsible for the increase in cardiac rate” [10]. Increase in systolic blood pressure could be due in part to increase in alpha adrenergic activity [9, 15].

There was progressive increase in MAP as the angle of tilt increases. The MAP increased gradually at 150 and markedly at other angles of tilt. When comparing supine to these angles, however, the changes were significant (Table 2). When the vascular bed of the legs are separated from circulation by arterial occlusion, the decrease in MAP during posture change from upright, sitting to supine vary similar to those during posture change without occlusion [19]. This is in central effect of water immersion, where vasodilation in the legs is necessary to prevent MAP from increasing [19]. It has been observed that during posture change from sitting to supine, with a

subsequent stimulation of arterial high and cardiopulmonary low pressure receptors, MAP decreases [20]. During orthostasis which is the maintenance of an upright standing posture, the splanchnic regions accounts for some 30% of the increase in total peripheral resistance, while skin and muscles account for some 40% of the increase in total peripheral resistance [3]. It was expected that constriction in both the vascular beds would be pivotal to inducing an increase in MAP during a moderate anti orthostatic posture change.

CONCLUSION:

The effects of different angles of head-up tilting on heart rate, pulse pressure and mean arterial blood pressure have been studied on male and female subjects in the 18 to 24 years age group. The results show that at head up tilt position of 15^0, 30^0, 45^0 or 60^0 major change of pulse pressure occurs at 30^0 and there is little change on further tilting; heart rate increase with increase in angle of tilt.

The major change of mean arterial pressure occurs at 30^0 and 45^0.

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