Effect of Graded Head-Up Tilt & Head-Reverse Tilt on the Sympathetic Nervous System Versus Parasympathetic Nervous System

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Abstract

The study was undertaken on 150 healthy human subjects of both the sexes in the age group of 18-38 years to assess the effect of graded head-up tilt (HUT) and head-reverse tilt (HRT) on sympathetic nervous system Vs parasympathetic nervous system. The tilt positions used were 0^{0} , 30^{0} , 60^{0} , 30^{0} R and 0^{0} R. The parameters and test performed were pulse rate, blood pressure, cold pressor test, QTC interval, valsalva ratio and expiratory-inspiratory (E:I) ratio. On graded head-up tilt (60^{0}) pulse rate and diastolic blood pressure showed significant increase. Cold pressor test and QTc interval showed significant increase from 30^{0} to 60^{0} tilt. The valsalva and E:I ratios did not show any significant change on graded HUT. On reversal of tilt all the parameters showing significant increase returned to near pre-tilt values. These responses clearly indicate that graded HUT leads to decrease in parasympathetic reactivity but increase in sympathetic reactivity, which is more significant during higher tilt levels (30^{0} to 60^{0}). On reversal of tilt both the parasympathetic reactivity and the sympathetic reactivity i.e. autonomic reactivity return to normal pre-tilt level.

Key words

Head-up tilt, Head-reverse tilt, Autonomic reactivity, Parasympathetic & Sympathetic reactivity

Introduction

Upright posture in human beings is an important step in its development. Standing appears to be a simple act but it involves a lot of changes in the different systems of the body. Of all the systems the autonomic nervous system is affected the most.

During head-up tilt (HUT) the changes occurring in the body are almost the same as those during standing like pooling of the blood in the lower parts of the body and low pressure in the carotid sinus (1). This removes stretch from the baroreceptors leading to increase in heart rate through withdrawal of vagal tone initially followed by increased sympathetic activity which leads to sustained tachycardia (2). The biphasic immediate heart rate response has been observed to be more intense after 90° tilt than 70° tilt. Faster tilts as those of 2 seconds and 5 seconds augment the haemodynamic responses of 90° tilt (3). There is activation of the sympathetic nervous system on progressive increase in HUT from 0° to 90°, which leads to discharge of nor-adrenaline from the sympathetic nerve terminals. There is increase in plasma nor-adrenaline levels in response to increase in the angle of tilt (4).

It has been observed by Mukai and Hayano that during low-level passive tilt, from 0° to 30° , there is an increased sympathetic activity, while during high-level tilt from 30° to 90° , there is change in both the sympathetic and

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parasympathetic tone (5). This makes it clear that postural change leads to a sustained change in autonomic tone.

Jahan *et al* observed that the mechanism of alteration in parasympathetic responsivity during tilt position appears due to decrement in parasympathetic tone rather than enhancement in the sympathetic tone (6).

Selvamurthy et al tried to reactivate the sluggish baroreflex mechanism in patients of essential hypertension by a three weeks course of orthostatic tilt or selected yogic exercises, thereby restoring blood pressure to normal levels (7). Few exhaustive studies have been done on the effect of graded HUT and head-reverse tilt on the sympathetic nervous system and parasympathetic nervous system even though there are many studies on the individual parameters with varied results (2, 5, 7-14). The objectives of the present study were to make a comparative study of the effects of the graded head-up tilt and head-reverse tilt on the two components of the autonomic nervous system i.e. sympathetic and parasympathetic nervous system and to evaluate if there is any significance/co-relationship of the effects, to the different degrees of tilts.

Material & Methods

The study was conducted on 150 subjects, out of whom 57 were females and 93 were males in the age group of 18-38 years (mean \pm S.D.; 24.98 \pm 5.89 yrs). Selection of subjects was done on the basis of a detailed medical history and general physical examination. They were medical students, doctors and paramedical staff members of Govt. Medical College, Jammu. Subjects who were alcoholic, smoker or suffered from any past or present cardiovascular disease, diabetes mellitus, neuropsychiatric disorders or any other illness known to affect the functioning of the autonomic nervous system (i.e. sympathetic and parasympathetic nervous systems) were excluded in the present study.

Each subject was explained about the procedure of the tests to eliminate fear and apprehension and informed consent was also taken. All the tests were performed between 9.00 a.m. to 2.00 p.m. at a room temperature between 25°C and 28°C, two hours after the meal. Only two subjects fainted while performing valsalva manoeuvre at 60°.

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Physical parameters noted in each subject were age (years), height (cms) and weight (kgms). Body surface area was calculated from Dubois nomogram and expressed in square meters. The tests were performed during different tilt positions to see the effect of these positions on the sympathetic and parasympathetic nervous systems. The tilt positions used were of different grades of head-up tilt i.e. from lying position to 30° ; 30° to 60° and also head-reverse tilt i.e. from 60° to 30° R and 30° R to 0° R (suffix 'R' indicates reverse position). The tilt table used had a footboard support with degrees of tilt indicated on it. The table had a non-slipping mattress and the table was tilted manually at a speed of 5° /sec. Five minutes rest was given at 0° and two minutes in all other positions before the tests were performed.

Electrocardiogram (ECG) was recorded by a simple compact electrocardiograph (BPL-Cardiart) unit. All the ECG recordings were carried out with lead II. For assessing sympathetic nervous system activity following parameters and tests were undertaken:-

- 1. Pulse rate was recorded by an electronic monitor (Hewlett Packard).
- 2. Blood pressure was recorded by an electronic monitor (Hewlett Packard).
- 3. Cold pressure test Blood pressure was recorded at the end of thirty seconds of immersion of hand in cold water at 4°C and again at the end of sixty seconds thereafter (15).
- 4. Corrected QT interval (QTc) QT interval was measured from the ECG and then standardized by converting it to QTc. For this Bazett's formula was used (16,).

QTc = QT interval

 $\sqrt{R-R}$ interval

QT interval, R-R interval and QTc interval were expressed in seconds.

For assessing parasympathetic nervous activity parameters and tests used were:

- **1. Pulse rate:-** It can be used for both parasympathetic and sympathetic reactivity as there is dual innervation (autonomic) of heart (4).
- **2. Valsalva ratio:-** Calculated as ratio between maximal R-R interval after the valsalva manoeuvre and minimal R-R interval during the manoeuvre (6).

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3. Expiratory-Inspiratory ratio (E:I):- taken as the ratio of the longest R-R interval during expiration to shortest R-R interval during inspiration (17, 18).

Statistical analysis of five sets of recordings $(0^0, 30^0, 30^0)$ 60°, 30°R and 0°R) of each mean of variables was carried out by 'Analysis of Variance' (ANOVA) and F ratios obtained and were compared with the table value to see their significance. Further statistical analysis between the means of variables was done by Bonferrani - 't' procedure with 'z' transformation. Critical values on comparison with table value of 'z' were considered significant if 'p' was < 0.0025.

Results

Table I and II show the results of parameters and tests reflecting the sympathetic and parasympathetic activities respectively.

The two baseline parameters which showed a significant change on graded HUT were pulse rate and diastolic blood pressure. The mean values of pulse rate showed a significant increase from 75.31 ± 11.04 b/min (at 0^{0}) to 86.72 ± 11.75 b/min (at 60^{0}) (p < 0.0025) when subjects were gradually tilted from supine to head-up position. On head-reverse tilt from 60° to 0°R there was a significant decrease in mean value of pulse rate from 86.72 ± 11.75 b/min (at 60°) to 72.92 ± 9.81 b/min (at 0° R) (p<0.0025). Significant changes were also observed between 0° and 30°; 30° and 60°; 60° and 30°R & 30°R and 0^{0} R (p< 0.0025). In the case of diastolic blood pressure its mean value significantly increased on graded

HUT from 0^{0} [66.11 ± 6.87 mmHg] to 60^{0} [80.11 ± 7.56 mmHg] (p<0.0025) and significantly decreased (p < 0.0025) from 60° [80.11 \pm 7.56 mmHg] to 0°R [67.54 \pm 7.17 mmHg]. Significant changes were also observed between 0^{0} and 30^{0} ; 30^{0} and 60^{0} ; 60^{0} and $30^{0}R$ & $30^{0}R$ and 0°R. On graded HUT from 0° to 60° mean values of systolic blood pressure did show significant increase [p<0.0025] and there was also a significant decrease [p<0.0025] on head-reverse tilt from 60° to 0°R. The in between tilt positions from 0° to 30° ; 30° to 60° ; 60° to 30°R; and 30°R to 0°R did not show any significant change in mean value of systolic blood pressure (p>0.0025).

Other sympathetic parameters which did show any significant change were corrected QT interval (QTc) and blood pressure response in cold pressor test (CPT) on graded HUT (0° to 60°) and graded head-reverse tilt (60° to 0^{0} R)(p<0.0025). The parasympathetic parameters i.e. valsalva ratio and expiratory-inspiratory ratio (E:I ratio) were not significantly affected on graded HUT and graded head-reverse tilt (p>0.0025).

Discussion

Head-up tilt is considered to be a passive change of upright posture (9). HUT like standing leads to pooling of blood in the lower parts of the body and low pressure in the carotid sinus (1) and this affects the baroreceptor reflex.Extensive study of the literature revealed very scant data on the effect of graded head-up tilt and headreverse tilt on those parameters of sympathetic activity Table 1: Results of parameters and tests reflecting predominantly sympathetic activity i.e. pulse rate, BP, Cold Processor Test & QTc interval.

					Cold Proc	cessor Test	ssor Test		
Degree of tilt	Pulse rate (beats/min.)	Blood Pressure (mm Hg)		BP after 30 sec (mmHg)		BP after 1 min (mmHg)		QTc interval (in sec.)	
		Systolic	Diastolic	Systolic	Diastolic	Systolic	Diastolic		
00	75.31 ± 11.04	113 ± 8.45	66.11 ± 6.87	120.61 ± 8.61	72.67 ± 8.62	126.67 ± 8.80	76.79 ± 8.74	0.37 ± 0.03	
30 ⁰	80.43 ± 10.87	$115{\cdot}08\pm8{\cdot}28$	71.59 ± 6.33	122.52 ± 8.23	76.64 ± 7.53	128.97 ± 8.84	$81{\cdot}68\pm 8{\cdot}48$	0.37 ± 0.03	
60 ⁰	86.72 ± 11.75	117.25 ± 8.74	$80{\cdot}11\pm7{\cdot}56$	128.71 ± 8.63	83.87 ± 7.95	135.88 ± 9.25	$89{\cdot}78\pm8{\cdot}46$	0.38 ± 0.03	
30° R	77.40 ± 10.48	$115{\cdot}19\pm8{\cdot}57$	70.54 ± 7.99	$128{\cdot}78\pm8{\cdot}92$	75.57 ± 7.98	126.93 ± 9.64	78.89 ± 8.90	0.36 ± 0.03	
$0^{0} R$	72.92 ± 9.81	112.93 ± 8.06	67.54 ± 7.17	119.11 ± 8.33	$72 \cdot 11 \pm 8 \cdot 14$	123.6 ± 8.45	75.74 ± 8.03	0.36 ± 0.03	
P value									
Between 0° & 30°	(S)	(NS)	(S)	(NS)	(NS)	(NS)	(S)	(NS)	
Between 30° & 60°	(S)	(NS)	(S)	(S)	(S)	(NS)	(S)	(S)	
Between 0° & 60°	(S)	(S)	(S)	(S)	(S)	(S)	(S)	(S)	
Between 60°&30°R	(S)	(NS)	(S)	(NS)	(S)	(S)	(S)	(S)	
Between 60° & 0°R	(S)	(S)	(S)	(S)	(S)	(S)	(S)	(S)	
Between 0° & 0°R	(NS)	(NS)	(NS)	(NS)	(NS)	(S)	(NS)	(NS)	
Results are expressed as mean \pm S.D. NS: Not significant (p>0.0025) S: significant (p<0.0025)									

Degree	Pulse Rate (beats/min)	Valsava Ratio	E:I Ratio
00	$75{\cdot}31 \pm 11{\cdot}04$	1.67 ± 0.37	1.44 ± 0.27
30 ⁰	$80{\cdot}43 \pm 10{\cdot}87$	1.78 ± 0.48	1.42 ± 0.26
60 ⁰	$86{\cdot}72 \pm 11{\cdot}75$	1.79 ± 0.45	$1{\cdot}40\pm0{\cdot}26$
30° R	$77{\cdot}40 \pm 10{\cdot}48$	1.72 ± 0.42	1.41 ± 0.27
$0^{0} R$	$72{\cdot}92\pm9{\cdot}81$	1.68 ± 0.40	$1{\cdot}46\pm0{\cdot}28$
P value	(S)	(NS)	(NS)
Between 0º & 30º	(S)	(NS)	(NS)
Between 30° & 60°	(S)	(NS)	(NS)
Between 60° & 30°R	(S)	(NS)	(NS)
Between 30° & 0°R	(S)	(NS)	(NS)
Between 60° & 0°R	(S)	(NS)	(NS)
Between 0º & 0ºR	(NS)	(NS)	(NS)

Table 2: Results of parameters and tests reflecting predominantly sympathetic activity i.e. pulse rate, valsava ratio & expiratoryinspiratory ratio (E:I ratio).

Results are expressed as mean \pm S.D. NS : Not significant (p>0.0025) S : Significant (p<0.0025).

and parasympathetic activity as have been observed in the present study. In the present study, it was attempted to find the effect of graded HUT and head-reverse tilt on sympathetic nervous system versus parasympathetic nervous system functioning. The speed of tilting used was 5^{0} /sec, as it was close to most commonly used tilt speeds (3, 6) and it was easy for manual tilting (6).

On graded HUT there was significant increase in baseline pulse rate. Same findings have been documented by many workers (2, 3, 4, 6, 7, 10, 12, 13, 14, 19). On head reverse tilt pulse rate returned back almost to its original value (at 0^o 75.31 ± 11.04 b/min and at 0^oR 72.92 ± 9.81 b/min; p>0.0025). During HUT there is an increase in sympathetic tone due to increase in sympathetic flow from brain-stem centers, while there is a decrease in parasympathetic tone due to an associated release of vagal tone (2, 6, 13).

The mean values of baseline systolic blood pressure showed a significant increase on HUT and decrease on head-reverse tilt reaching pre-tilt values. Some workers have also reported similar findings (8, 14, 19) while others reported no change or decrease in baseline systolic blood pressure on graded HUT (5-7, 12). The change in mean values of systolic blood pressure was not significant between tilt positions like 0° to 30°; 30° to 60°; 60° to 30°R and 30°R to 0°R. The reason for this increase in systolic blood pressure on graded HUT might have been the mild supine rest and also rest in every tilt position, which could have led to increase in right atrial pressure and thus increase in cardiac output. Borst *et al* (8) have also reported somewhat similar findings in their study. Regarding baseline diastolic blood pressure, its mean value significantly increased on graded HUT from 0° to 30° and then to 60° . On head-reverse tilt, it significantly decreased from 60° to 30° R and then to 0° R reaching nearly to pre-tilt values. Thus, HUT and head-reverse tilt affected the pulse rate, systolic blood pressure and diastolic blood pressure with same magnitude in the present study.

The QT interval includes both ventricular depolarization and repolarisation times and varies inversely with heart rate. When this interval is corrected (QT_c) it can become a measure of sympathetic activity (16). QT_{c} interval significantly increased on graded HUT and decreased on head-reverse tilt showing that sympathetic activity is increased during graded HUT and returns to near normal level on reversal of tilt. Under conditions of stress of physical or psychological origin, there is activation of sympathetic nervous system. In cold pressor test, cold is the painful stimulus leading to activation of sympathetic nervous system. In the present study the blood pressure response to cold showed a significant increase on graded HUT from 0° to 60° . The increase was also significant at higher tilts i.e. 30° to 60° but not at lower tilts i.e. 0° to 30° . On head-reverse tilt similar pattern of response was observed in reverse order. It indicates that at low levels of tilt the sympathetic activity is not as much affected as by higher levels of tilt.

In the present study the heart rate reactivity to different degrees of tilt was measured by valsalva manoeuvre and expiratory-inspiratory ratio. Valsalva ratio is employed to assess both low and high pressure baroreceptors' integrity during and after valsalva manoeuvre. Valsalva manoeuvre elicits a complex series of haemodynamic events that result in activation of sympathetic and parasympathetic neurons, being independent of basal heart rate (20). It involves passive changes in the blood pressure leading to reflex heart rate change and it can be used as an effective measure of parasympathetic integrity but it may not be used as a reliable index of sympathetic integrity (6, 21).

The E:I ratio is a good index of cardiac efferent parasympathetic function (22). In the present study valsalva ratio and E:I ratio were not significantly affected on graded HUT and head-reverse tilt. In the present study the increase in pulse rate and diastolic blood pressure showed the increasing sympathetic activity with the graded HUT. The plasma nor-adrenaline levels show a

graded increase on progressive increase of tilt angle and under such conditions reflect the increased degree of sympathetic nervous system activity (4). In the present study the results of cold pressor test and QT_c interval also showed an increase on graded head-up tilt and the increase being significant during graded HUT from 30° to 60° as compared to during 0° to 30°. These finding suggest that the sympathetic reactivity is increased more during 30° to 60° HUT.

The valsalva ratio and E:I ratio did not show any significant change on graded HUT in the study. These results along with increase in pulse rate on graded HUT clearly suggest that there is decreasing parasympathetic reactivity during graded head-up tilt. These findings are consistent with the increased sympathetic activity with low level tilts and an interaction between increasing sympathetic activity and decreasing parasympathetic activity at high level tilts (5). On graded head-reverse tilt from 60° to 0°R all the parameters of sympathetic reactivity and parasympathetic reactivity returned to almost pre-tilt values significantly. These findings suggest that both the parasympathetic reactivity and sympathetic reactivity return to normal pre-tilt levels on graded head-reverse tilt. One can conclude from this study that :-

- * The graded head-up tilt in general leads to decrease in parasympathetic reactivity but increase in sympathetic reactivity.
- * At lower levels of head-up tilt i.e. 0° to 30°, there is decrease in parasympathetic reactivity but increase in sympathetic reactivity.
- * At higher levels of tilt i.e. 30⁰ to 60⁰, there is further increase in sympathetic reactivity but with further decrease in parasympathetic reactivity.
- * On reversal of tilt (i.e. head-reverse tilt from 60° to 0°R) the sympathetic reactivity as well as the parasympathetic reactivity return to normal pre-tilt levels on reaching the lying down position.

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