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# IMMEDIATE HEART RATE RESPONSES TO HEAD-UP TILT IN HEALTHY HUMAN SUBJECTS: RESPONSE CHARACTERISTICS AND VARIABILITY

M. VAZ, R. N. KULKARNI, D. RODRIGUES AND P. S. SHETTY*

*Nutrition Research Centre,*
*Department of Physiology,*
*St. John's Medical College,*
*Bangalore - 560 034*

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**Abstract:** Eight healthy adult males underwent three 70* head-up tilts within a nine day period. Immediate heart rate responses were monitored for 30 beats following completion of change to upright posture. The pooled data demonstrates a clearly demarcated bimodal heart rate response with a rise in heart rate by the 20th beat and a subsequent fall by the 30th beat. There is a secondary rise in heart rate with continuation of the tilted position. The bimodal response is at variance with several earlier reports. There is a large variability in the immediate heart rate responses, both between subjects of a homogeneous group and within subjects with repeated measurements. The large variability precludes the use of the immediate heart rate responses to passive tilting in autonomic testing.

**Key words :** variability heart rate head-up tilt

## INTRODUCTION

A large number of tests have been described to assess parasympathetic cardiovascular control (1). While many of these tests are easy to perform they evoke complex alterations of afferent and efferent autonomic activity and may have sympathetic and parasympathetic components. This has led most investigators to recommend multiple tests while assessing autonomic function (2) Most tests of parasympathetic function are based on physiological or pharmacological manoeuvres which induce a withdrawal of vagal efferent activity to the heart such as the Valsalva manoeuvre, heart rate variation during deep breathing, immediate heart rate responses to standing and baroreflex sensitivity tests. Most of these tests are advocated in the assessment of autonomic failure associated with various disease states (3), although some of these such as the heart rate response to deep breathing may be sensitive to changes within the physiological range of normality (4).

Since multiple tests are usually performed to assess autonomic function, tests like the Valsalva manoeuvre and cardiovascular responses to standing which have measureable and clearly delineated parasympathetic and sympathetic components are particularly useful. The head up tilt (HUT) has usually been used to assess sympathetic nervous activity, the absence of tachycardia indicating a lesion at the level of sympathetic efferents to the heart (5). The present study focuses on the immediate heart rate responses (*i.e.* within 30 beats) to HUT in a group of healthy, adults with a view to describing the characteristics of immediate heart rate responses, evaluating its inter and intra-individual variability and assessing the possible use of the initial heart rate responses in autonomic function testing.

## METHODS

Eight healthy, young (22-31 yrs) adult males were recruited for the study and underwent three measurements within a nine day period. The test was performed at the same time of day on all three occasions, in the fasted state, 12 hours after the last

*Corresponding Author

meal. Smoking and caffeinated beverages were disallowed for 12 hours prior to the experiment. All subjects reported on the evening prior to the experiment and slept in the laboratory.

On the day of the experiment the subject was transferred to the tilt table soon after awakening. A 70° HUT for 10 min was performed after a mandatory rest period of 1 hour following transfer to the tilt table. The change from supine to 70° HUT was accomplished in 5 secs. The tilt table incorporated a bicycle seat as well as transversely placed straps which supported the subject in the head-up position. ECG was recorded in the basal state just prior to tilting, continuously for 30 secs following the change from supine to 70° HUT and at the end of 10 mins of tilting.

Ethical approval for the study was obtained from a duly constituted Human Investigation Committee of the Medical College and all subjects gave fully informed written consent.

All results are expressed as mean ± SD. For the calculation of the Coefficient of Variation (CV) the 'true variance' was obtained from the Two-way ANOVA table as previously described for cardiovascular and catecholamine responses to sustained tilting (6). Where the error MS (Mean Square) was greater than the between subject or between occasion MS, the exact CV could not be obtained, hence an upper level was calculted as (error MS/mean) × 100. Serial heart rate measurements and the possibility of a training effect were assessed for significance using an Analysis of Repeated Measures; differences between heart rates at different time points/ocasions were identified using a paired 't' test with the Bonferroni correction.

## RESULTS

Table I summarises the subject characteristics. The subjects were chosen from within a small Body Mass Index (BMI: weight/height$^2$) range and had similar anthropometric profiles.

The results indicate that in response to HUT there is an immediate rise in heart rate with a demonstrable fall by the 30th heart beat following change of position from supine to 70° HUT (Fig.1). The rise in heart rate over baseline values was 34.3 ± 10.9 beats per min for the pooled data with a fall from peak to the 30th beat of 16.4 ± 9.9. The ratio of the heart rate in the 15th beat to that of the 30th beat was 1.2 ± 0.12 for the pooled data. There is a secondary rise in heart rate over the remainder of the tilt as indicated by a significant increase in the heart rate measured in the 10th minute of tilt as compared to the 30th heart beat. Despite this clear trend which is seen from the pooled data, individual responses appear to be highly variable as indicated by the four representative responses in Fig.2, and is exemplified by the high inter-individual variability of immediate heart rate responses to tilting. Intra-individual variability on the other hand is much lower (Table II). There does not appear to be any effect of familiarisation with the procedure as indicated by similar heart rate responses across occasions, both in the basal as well as the stimulated state (Table III).

TABLE I : Anthropometric characteristics of the subjects.

| *Parameter* | *Mean ± SD* | *Range* |
|---|---|---|
| Height (cm) | 177·3 ± 4·6 | 169·5 – 185·0 |
| Weight (kg) | 66·8 ± 5·9 | 58·9 – 75·5 |
| Body Mass Index | 21·3 ± 1·5 | 18·9 – 23·5 |
| Mid-arm circumference (cm) | 29·8 ± 2·7 | 27·5 – 35·5 |
| Percent fat | 17·6 ± 3·6 | 13·2 – 23·8 |
| Fat free mass (kg) | 55·1 ± 5·2 | 45·1 – 60·3 |

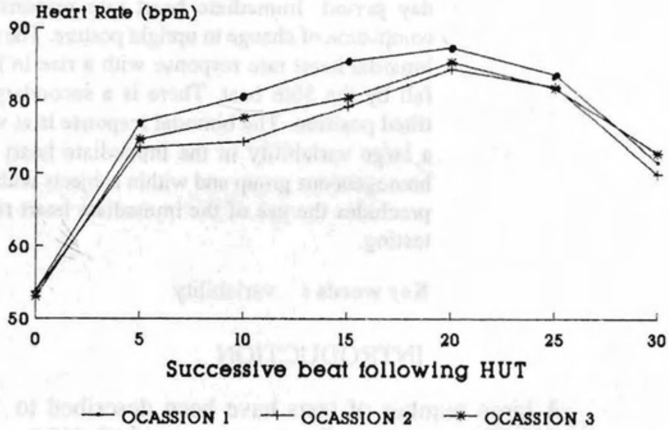


Fig. 1 : Mean heart rate responses for the entire study group, during the first 30 beats following passive tilting on three separate occasions.

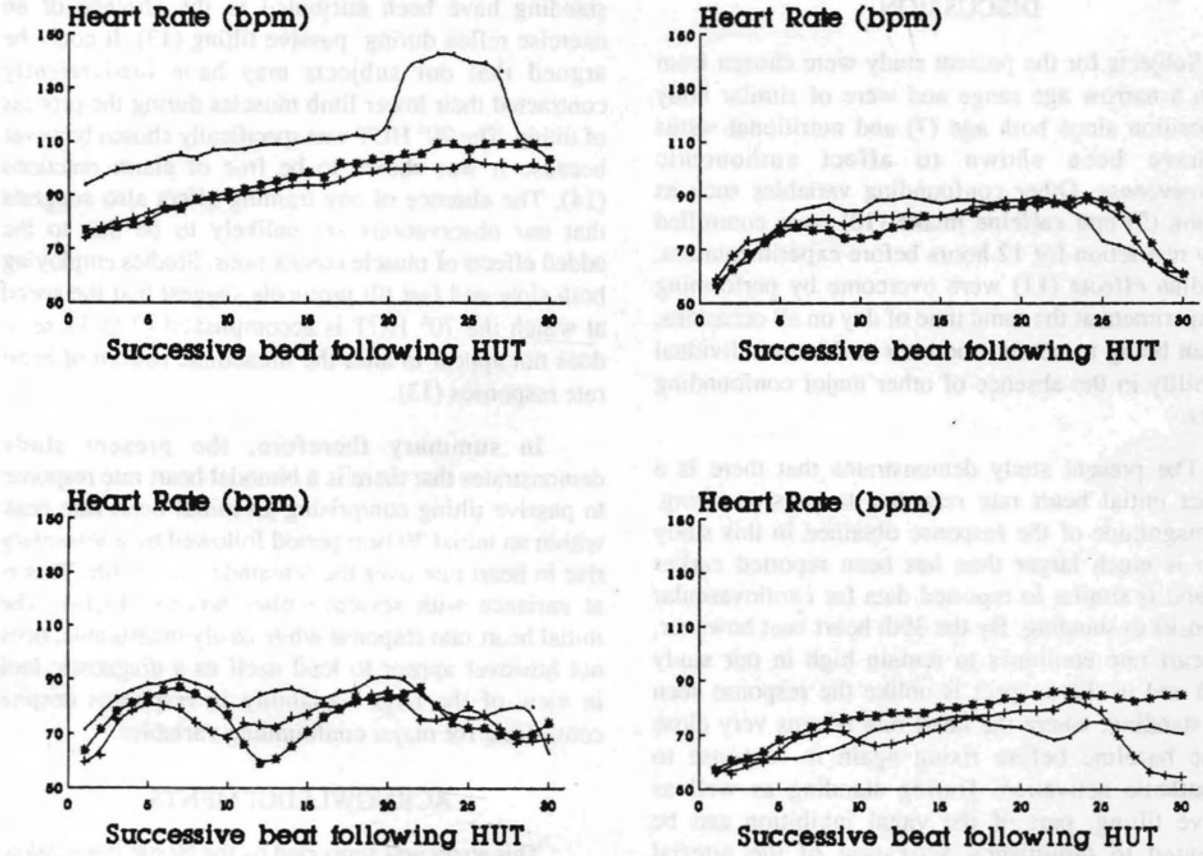


Fig. 2 : Heart rate responses for four different subjects during the first 30 beats of passive tilting highlighting the within-subject variability in response characteristics.

TABLE II : Intra and inter-individual variability in immediate heart rate responses (first 30 heart beats) to 70° HUT.

| | *Mean ± SD* | *Inter-individual CV%* | *Itra-individual CV%* |
|---|---|---|---|
| Basal HR (bpm) | 53·6 ± 5·6 | 9·7* | <4·8# |
| Peak HR (within the first 30 beats) | 88·0 ± 14·3 | 13·5* | 1·9 |
| HR: 15th beat | 81·4 ± 9·6 | 10·1* | 3·1 |
| HR: 30th beat | 71·6 ± 14·3 | 18·0* | <10·8# |
| HR: 10th min | 81·6 ± 10·9 | 8·7 | <12·2# |
| Occurence of peak HR (beat) | 19·5 ± 4·6 | 13·4 | 8·9 |

Statistical analysis: Two-way ANOVA without replicates * = $P<0{\cdot}05$.
Mean ± SD obtained from the pooled data i.e. 8 × 3.
# the exact CV has not been calculated as the error term is greater than the mean square.

TABLE III : Basal and immediate heart rate responses to 70° HUT: a comparison of responses on the three occasions.

| | *Occasion 1* | *Occasion 2* | *Occasion 3* |
|---|---|---|---|
| Basal HR (bpm) | 54·1 ± 6·9 | 53·6 ± 5·4 | 53·2 ± 5·0 |
| Peak HR (within the first 30 beats) | 91·8 ± 21·6 | 85·1 ± 9·0 | 87·0 ± 9·6 |
| HR: 15th beat | 84·9 ± 12·0 | 79·2 ± 7·0 | 79·9 ± 9·2 |
| HR: 30th beat | 71·0 ± 16·3 | 71·1 ± 13·8 | 72·7 ± 15·3 |
| HR: 10th min | 81·5 ± 14·1 | 78·3 ± 8·9 | 84·9 ± 9·7 |
| Occurence of peak HR (beat) | 17·4 ± 5·4 | 21·0 ± 3·9 | 20·0 ± 4·1 |

All results are mean ± SD.
No statistically significant differences were observed between occasions.

## DISCUSSION

Subjects for the present study were chosen from within a narrow age range and were of similar body composition since both age (7) and nutritional status (8) have been shown to affect authonomic responsiveness. Other confounding variables such as smoking (9) and caffeine intake (10) were controlled for by restriction for 12 hours before experimentation. Circadian effects (11) were overcome by performing the experiment at the same time of day on all occasions, the aim being to obtain true inter and intra-individual variability in the absence of other major confounding factors.

The present study demonstrates that there is a distinct initial heart rate response to passive tilting. The magnitude of the response obtained in this study group is much larger than has been reported earlier (12) and is similar to reported data for cardiovascular responses to standing. By the 30th heart beat however, the heart rate continues to remain high in our study group and in this respect is unlike the response seen with standing, where the heart rate returns very close to the baseline before rising again in response to sympathetic activation. During standing as well as passive tilting, part of the vagal inhibition can be attributed to diminished activation of the arterial baroreceptors associated with a temporary fall in arterial blood pressure. The distinct differences in initial heart rate responses upon passive tilting as opposed to standing have been attributed to the absence of an exercise reflex during passive tilting (13). It could be argued that our subjects may have inadvertently contracted their lower limb muscles during the process of tilting. The 70° HUT was specifically chosen however because it was shown to be free of alarm reactions (14). The absence of any training effect also suggests that our observations are unlikely to be due to the added effects of muscle contractions. Studies employing both slow and fast tilt protocols suggest that the speed at which the 70° HUT is accomplished (2 to 12 secs) does not appear to alter the immediate pattern of heart rate responses (13).

In summary therefore, the present study demonstrates that there is a bimodal heart rate response to passive tilting comprising an initial heart rate peak within an initial 30 beat period followed by a secondary rise in heart rate over the remainder of the tilt. This is at variance with several earlier reports (13,14). The initial heart rate response while easily measurable, does not however appear to lend itself as a diagnostic tool in view of the large variability in responses despite controlling for major confounding variables.

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