Int J Biol Med Res. 2013; 4(2) : 3057- 3061

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International Journal of Biological & Medical Research

Journal homepage: www.biomedscidirect.com

Original Article

Heart Rate Variability In Prolonged Head Up Tilt In Healthy Adults

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ARTICLE INFO

Keywords:
HRV
Prolonged Tilt
Early Tilt
Late Tilt

ABSTRACT

Tilt table testing is taken as a safe and effective modality for subjecting a person to strong orthostatic stimulus. HRV (Heart rate variability) has the potential to provide valuable insight into physiological variations occurring in relation to postural changes. This study compares the supine basal, entire 30 minutes (Prolonged tilt), early 10 and last10 minutes (early and late tilt respectively) tilt HRV among themselves.13 healthy adults were subjected to 30 minutes head up tilt at 60 degree angle. 10 minutes basal supine HRV was compared with entire 30 minutes, early 10 minutes and last 10 minutes tilt HRV. Stastical analysis was done using one way Anova with repeated measures and LSD post hoc tests. Among the time domain measures Mean±SEM RR interval in seconds showed significant decrease during prolonged, early and late tilt (0.73±0.02,0.72±0.02,0.69±0.02 respectively) as compared to the basal (0.81±0.02).The Mean±SEM heart rate in beats per minute showed significant increase during prolonged, early and late tilt (84.13±2.49, 84.64 ±2.71, 87.69±2.70 respectively) as compared to basal (75.22±2.60). The parametric frequency domain measures showed significant difference between basal and late tilt. The Mean±SEM LF power in normalised units or LFNU was 40.95±5.31 and 70.20±6.75 between basal and late tilt respectively, and LF/HF%was 2.27±0.50 and 11.33±1.92 between basal and late tilt respectively. They showed significant increase during the late tilt. The HF power in percentage or HF % (35.41±5.23 and 9.80±2.14 between basal and late tilt respectively) and HF power in normalised units or HFNU (32.19±6.13 and 8.68±1.74 between basal and late tilt respectively) showed significant decrease during late tilt. The non parametric frequency domain measures showed similar significant difference between late tilt and basal, late tilt and prolonged tilt as well as between late tilt and early tilt. This indicates sympathetic predominance during prolonged HUT.

1. Introduction

The manner in which human body responds to various changes in position is of interest for scientific enquiry since the 1940s.During this period tilt table testing was first utilized as a controlled method with which the body's response to changes in position could be measured (1). Heart rate variability (HRV) represents one of the most promising markers of autonomic function. This is the oscillation in the intervals between consecutive heart beats (2). HRV is a functional indicator of several physiologic processes most important of which are sympathetic and parasympathetic drives on the sinus node (3). In 1981 power spectral analysis of heart rate fluctuations were introduced to quantitatively evaluate beat to beat CVS control (4). With the advent of new digital 24 hours multichannel ECG recorders, HRV has the potential to provide valuable insight into physiological variations occurring in relation to postural changes. To be able to determine a particular individual's predisposition towards change in posture, tilt table testing has been utilized as a standard procedure (5, 12). It is taken as a safe and effective modality for subjecting a person to strong orthostatic stimulus and observing the response (12).

Various workers have dealt with the HRV changes with passive head up tilt. Tomi Laitinen et al in 1996 studied the cardiovascular autonomic responses to head up tilt in healthy adults with respect to age. They studied the HRV parameters in 5 minute supine position and after 70 degree HUT for 13 minutes. They reported an increase in heart rate, decrease in HF power and increase in LF/HF ratio which were more pronounced in the young (6). Burklow et al

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in 1999 studied the HRV in head up tilt, 80 degrees for 30 minutes, in patients having a history of syncope and control group during tilt table testing. They studied the HRV changes in early (within the first few minutes), mid (a few minutes preceding syncope) and late tilt (last 5 min of a 30-min tilt) and compared with supine rest HRV. In the control there was an initial increase followed by a progressive decrease in low frequency power (7). Hiranayagi K et al in 1999 studied HRV changes in 12 healthy adult males during incremental head up tilt at 14.5, 30, 48.6, 61 and 90 degrees. This was compared with baseline supine HRV. They concluded that LF/HF, LFNU and HFNU are important indices of sympathovagal balance (8). SJ Brown et al in 2008 studied HRV in 8 healthy adults. Baseline supine ECG was recorded for 11 minutes followed immediately by passive head up tilt at 80 degrees for 45 minutes. They reported increase in heart rate, increase in LF/HF ratio and decrease in the HF component of HRV (9). SJ Brown et al in 2009 studied HRV in 14 healthy adults. 5 minutes of supine basal data and 10 minutes of 80 degree head up tilt data was recorded. Last 5 minutes of tilt HRV data was compared with basal data. They found an increase in heart rate, consistent decrease in HF component with head up tilt in healthy adults (10).

HRV analysis has thus been documented in controls and patients having history of syncope where early, mid and late tilt HRV have been compared with basal supine HRV (7). HRV in healthy young adults has been studied where the basal HRV has been compared with entire tilt period HRV or early 10 minutes HRV (6, 9, 10). HRV analysis has also been done during incremental head up tilt and compared with basal (8).

The aim of the present study is to compare the basal supine 10 minutes, 30 minutes tilt (prolonged tilt) , early 10 minutes and last 10 minutes HRV, amongst themselves and look into the changes.

2. Materials and Methods

13 healthy adult human volunteers, 7 females and 6 males with a mean age of 27.23± 0.610 yrs , mean height of 159.076±0.760 cms and mean weight of 58.07±1.320 kgs having no history of syncope, cardiovascular or respiratory ailment were included in the study. One volunteer who developed syncope during the test was not considered later for the analysis.

Patient Preparation

Subject was instructed to fast for 2 or more hours prior to the test. The procedure for each subject was done during the same time of the day in order to avoid diurnal variations. The procedure was explained and the subject was securely strapped to the tilt table prior to the test. During the test the subject was instructed to avoid movements of the lower extremities to maximize venous pooling. (11)

Procedure

The available evidence suggests that tilt angles between 60 to 80 degrees are optimal in creating sufficient orthostatic stress (2, 11). ECG recording was taken in the basal horizontal position for 10 minutes after 20 minutes of supine rest and 60 degree tilt for 30 minutes (7,11,12,13) using ADI power lab instrument (2). Most recent reports favour prolonged passive head up tilt for 30-45 minutes (13).

EQUIPMENT

The tilt table used was of the foot plate support type, electrically powered, was able to achieve the upright posture within 15 s[3], and allowed calibrated tilt angles of between 60 and 80 degrees (Fig A). The test was carried out in a quiet dimly lit room at a comfortable temperature in order to minimize stimuli affecting autonomic nervous function (11). Resuscitation equipment was kept ready up to the standard required in exercise tolerance testing facilities. The test was continuously monitored by a technician experienced in the management of the test and its potential complications (14).

Figure A. Head up tilt maneuver

DATA ACQUISITION

ECG recording was done by using ADI power lab instrument and analogue signal of subject in a continuous mode was digitalized and stored in a personal computer with a sampling rate of 1024/sec using DT 3030 AD card with 12 bit resolution. The signals were acquired by applying standard surface electrodes to the chest wall. The stored ECG data were screened for body movements and other artifacts. A low pass filter of 50 Hz and high pass filter of 0.3 Hz was applied for removal of noise and artifacts. The stored data was redisplayed and categorized into four parts. Data length of 10 minutes for basal, early 10 minutes of tilt and late 10 minutes of tilt (early and late tilt data) and entire 30 minutes for prolonged tilt. The RR interval of 10-minutes segment of the basal data, early 10 minutes, last 10 minutes and whole 30 minutes of the tilt ECG data were obtained by special programme using HRV analysis software V 1.1(Biomedical signal analysis group, Deptt of applied physics, University of Kuopio, Finland) (15). Time and frequency domain HRV parameters were measured and computed as per the MATLAB. The program was originally developed using Matlab 6.1 .The final version of the program has been compiled to a stand-alone C-language application using the Matlab Compiler Suite 2.3 and the free Borland C-Builder 5.5 compiler. Time domain measures were calculated using standard statistical methods. Methods for calculating the frequency domain measures were divided into parametric [e.g. based on autoregressive (AR) models] and nonparametric [e.g. fast Fourier transform (FFT) based] (15). The advantage of the parametric methods are (a) smoother spectral components which can be easily distinguished independent of preselected frequency bands (b) easy post processing of the spectrum with an automatic calculation of low and high frequency frequency power components and easy identification of the central frequency of each component, and (c) an accurate estimate of power spectral density even on a small number of samples on which the signal is supposed to maintain stationary. While the advantages of the non parametric method are (a) simplicity of the algorithm employed (b) High processing speed (2).

The Power spectral density was analyzed by calculating powers and peak frequencies for different frequency bands. The commonly used frequency bands are low frequency (LF, 0.04-0.15 Hz), and high frequency (HF, 0.15-0.4 Hz). The most common frequency-domain parameters include the powers of LF and HF bands in absolute and relative values, the normalized power of LF and HF bands, and the LF to HF ratio. The representation of LF and HF in normalised units (LFNU and HFNU) emphasizes the controlled and balanced behavior of the two branches of the autonomic nervous system.Normalisation also tends to mininise the effect on the values of LF and HF components of the changes in total power (2).

Statistical analysis was done by SPSS 10 software using one way ANOVA with repeated measures and LSD post hoc tests.

3. Results

Time and frequency domain measures (parametric and non parametric) showing significant difference between the study groups have been shown in the results. The time domain measures (Mean±SEM RR interval, Heart rate and RR triangular index) showing significant difference between the study groups have been shown in table 1.The parametric frequency measures (Auto regressive model based) which show significant difference between the study groups have been shown in table 2.Graph (fig1, 2, 3 and 4) show comparison of non parametric frequency domain (Fast Fourier transform based) measures which showed significant difference.

TABLE 1 . Comparison of Time domain measures between basal and different phases of tilt

Mean±SEM n=13	BASAL	PROLONG TILT	EARLY TILT	LATE TILT
RR(Sec)	0.81±0.0	0.73±0.02*	0.72±	0.69±0.02*†
HR(Beats per	275.22±2.60	84.13±2.49*	0.02*84.64±	87.69±2.70*†
Minute)			2.71*	0.10±
RRTI	0.08±0.01	0.08±0.01	0.09±0.01	0.01†

*** =P Value<0.01 Significant change as compared to basal**
†= P Value<0.01 significant change as compared to prolonged tilt

TABLE 2. Comparison of Frequency domain measures (parametric) between basal and different phases of tilt (AR method)

Mean±SEM n=13	BASAL	PROLONG TILT	EARLY TILT	LATE TILT
LF(normalized unit)	40.95±5.31	64.53±6.67	60.48±5.54	70.20±6.75
HF (%)	35.41±5.23	20.07±3.56	17.33±2.91	9.80±2.14
HF(normalized unit)		19.39±3.96	15.96±3.21	8.68±1.74
LF/HF (%)	32.19±6.13	6.13±1.43	6.03±1.34	11.33±1.92

P Value<0.01(Significant change as compared to basal)

GRAPH: X axis in all the four figures represents the four groups under comparison. Y axis represents the mean ± SEM of the non-parametric frequency domain measures(FFT METHOD BASED) like LF in normalized units (Fig.1), HF% (Fig.2),HF in normalized units (Fig.3),and LF/HF% (Fig.4).

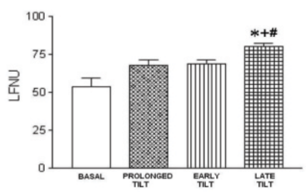

Figure. 1

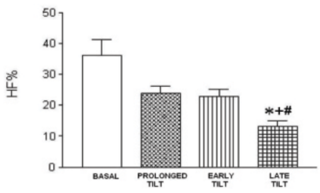

Figure. 2

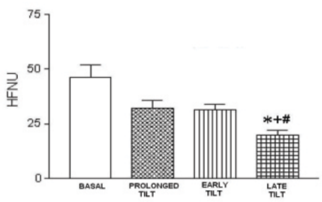

Figure. 3

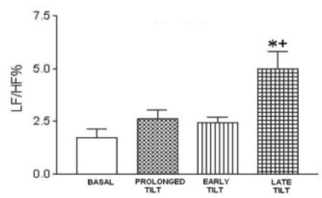

Figure. 4

* P< 0.01 (significant difference as compared with basal)

+ P< 0.01 (significant difference as compared with Prolonged Tilt)

# P< 0.01 (significant difference as compared with Early Tilt)

Discussion

The results indicate that the RR interval shows significant decrease in prolonged, early and late tilt as compared to the basal values. The heart rate at the same time shows significant increase in all the phases of tilt as compared to basal values. These findings well correlate with those of previous workers (7, 9, 10, 16, 17). The RR Triangular index however showed significant difference only between prolonged and late tilt values with an increase during the late tilt. Yoshiharu etal (20) however have reported a decrease in RRTI with tilt. The spectral power in the parametric LFNU and LF/HF% showed significant difference between basal and late tilt with an increase during late tilt phase. Spectral power in the non parametric LFNU and LF/HF%showed significant changes during the late tilt phase as compared to the other study groups. The non parametric LFNU showed significant changes between basal and late tilt, prolonged tilt and late tilt, early tilt and late tilt with an increase during the phase of late tilt. The nonparametric LF/HF% showed significant difference between basal and late tilt and prolonged tilt and late tilt with an increase during late tilt. Alterations in LF power are principally dominated by changes in sympathetic tone.These findings are consistent with previous research on young healthy individuals (6, 17, 19, 21, 22, 23, 24, 25, 29). Ziad Mallat et al (18) have reported increase in heart rate and sympathetic response with diminished parasympathetic activity during the first 6 minutes of tilt. These findings well correlate with the early tilt HRV of the present study. The low-frequency component of HRV (LF 0.04–0.15 Hz) probably reflects the effects of both respiration and baroreflex-mediated sympathetic outflow on the heart. In addition, the LF/HF ratio is considered to be a measure of the reciprocal changes of the sympathetic and vagal modulation of the sinoatrial node discharge (sympathovagal balance) (30). Head-up tilt caused a greater change in LF normalized units and LF/HF ratio. This is probably caused by activation of the sympathetic nervous system produced by the postural change. The changes are maximal during the phase of late tilt. Burklow et al (7) however reported an initial increase of the LF power and LF/HF ratio during early tilt followed by subsequent decrease during late tilt. Some other studies have been carried out in the past where no change of LF component with tilt has been documented (9, 10, 16, 26, 27).

The spectral power in the parametric HF% and HFNU showed significant decrease during late tilt as compared to basal values. The spectral power in the non parametric HF% and HFNU showed significant change between basal and late tilt, prolonged tilt and late tilt, early tilt and late tilt with a decrease during the phase of late tilt. Similar findings were documented in some studies in the past (6, 9, 10, 16, 20, 21, 22, 24, 25, 26, 29). However Koukam et al (19) did not find any alteration in HF power during any phase of tilt. The high-frequency component (HF,0.15–0.4 Hz) of HRV is believed to result almost exclusively from the respiratory-related vagal modulation of the sinoatrial node, and its amplitude has been used as an index of vagal tone (30).The findings are indicative of vagal withdrawal during prolonged head up tilt. The findings of the present study however are in contrast to those of Burklow et al (7) who reported an initial decrease of HF power during early tilt and subsequent increase during late tilt.In another study both low and high frequency spectral components of the HRV increased markedly in the control group with most significant changes occurring during the late tilt (28).The changes in the present study indicate a shift from parasympathetic control during basal state to sympathetic control during tilt with maximal changes occurring during the phase of late tilt. On the whole frequency domain analysis has been observed to show sympathetic predominance with most of it occurring during last 10 minutes of the prolonged passive head up tilt.

ACKNOWLEDGEMENT

The authors thank Mrs Bindu Balakrishnan for her assistance in statistical analysis. And Dr. N. Pradhan, Prof & Head, Dept. of Psychopharmacology, NIMHANS, Bangalore for his help and guidance throughout the study conducted.

References

[1] Allen SC, TaylorCL, Hall VE.A Study of orthostatic insufficiency by the tilt board method. American Journal of Physiology. 1945; 143: 11-20.

[2] Malik M. For the task force of the European Society of Pacing and Electrophysiology. Heart rate variability; Standards of measurements, physiological interpretation and clinical use. Circulation 1996; 93:1043-1065.

[3] Buchman TG, SteinPK, Goldstein B.Heart rate variability in critical illness and critical care. Current Opine crit care2002; 8:311-315.

[4] Akselrod S,Gordon D,Ubel FA,Shannon DC,Barger AC,Cohen RJ.Power spectral analysis of heart rate fluctuation: a quantitative probe of beat to beat cardiovascular control. Science 1981; 213:220-222.

[5] Parry SW, Kenny RA.The role of tilt table testing in neurocardiovascular instability in older adults. European Heart Journal.2001; 22:370-372.

[6] Tomi Laitinen,Leo Niskanen,Ghislaine Geelen,Esko Lansimies,Juha Hartikainen.Age dependency of cardiovascular autonomic responses to head up tilt in healthy subjects. Journal of Applied Physiol 2004; June 96(6):2333-2340.

[7] Burklow Thomas R, Moak Jeffrey P, Bailey James J, Makhlouf Fairouz T. Neurally mediated cardiac syncope: autonomic modulation after normal saline infusion. Journal of the American College of Cardiology1999, June33 (7):2059-2066.

[8] Hiranayagi K,Iwasaki K,Sasaki T,Kinugasa H,Miyamato A,Yajima K.Sensitivity analysis of heart rate variability variables by an incremental, passive head up tilt.Uchu Koku Kankyo Igaku.1999 June;36(2):67-74

[9] Brown SJ, Bryant M, Mundel T, Stannard SR.Human ventillatory efficiency and respiratory sinus arrhythmia during head up tilt. Journal of physiology and pharmacology .2008 Dec; 59(4)771-780

[10] Brown SJ,Mundel T,Barnes M,Brown JA.Indirect measures of human vagal withdrawal during head up tilt with and without respiratory acidosis.Journal of physiological science.2009;59:31-36

[11] Victor J.Tilt Test: Environment, material, patient preparation. In: Blanc jj, Bendit D, Sutton .Neurally Mediated Syncope: Pathophysiology, investigations and treatment. The Bakken Research Centre Series. Armonk, NY, Futura 1996; (10), 77-78.

[12] Blanc J, Victor J, Mansourati J, Le Davay M, Dupuis JM, Meheu B.Accuracy and mean duration of different protocols of head up tilt testing. Am J of Cardiology 1996; 77:310-313.

[13] R A Kenny, D O'Shea, S W Parry. The Newcastle protocols for head-up tilt tabletesting in the diagnosis of vasovagal syncope, carotid sinus hypersensitivity, and related disorders. Heart. 2000; 83:564–569.

[14] Benditt DG,Ferguson DW,Grubb BP,Kapoor WN,Kugler J,Lerban BB.Tilt table testing for assessing syncope.ACC Expert Consensus Document Am Coll Cardiol 1996;28:263-75.

[15] Niskanen J, Tarvainen M, Ranta-aho P ,Karjalainen P. Software for advanced HRV analysis. Computer Methods and Programs in Biomedicine. 2004; 76(1): 73-81.

[16] Cooke WH, Hoag JB, Crossman AA, Kuusela TA, Tahvanainen KUO, Eckberg DL. Human responses to upright tilt: a window on central autonomic integration. J Physiol. 1999; 517:617–628

[17] Jasson S, Claire M, Pierre MB, Nicola M, Laurent M, Christophe V, Pascale M Philippe C, Malliani A, Bernard S.Instant Power Spectrum Analysis of Heart Rate Variability During Orthostatic Tilt using a Time-/Frequency-Domain Method. Circulation. 1997; 96:3521-3526.

[18] Ziad Mallat, Eric Vicaut, Adama Sangaré, Jordanka Verschueren, Guy Fontaine, Robert Frank. Prediction of Head-Up Tilt Test Result by Analysis of Early Heart Rate Variations.Circulation. 1997; 96:581-584.

[19] Kouakama C, Lacroixa D, Zghala N, Logierb R , Kluga D , Le Franca P, Jarwea M, Kaceta S. Inadequate sympathovagal balance in response to orthostatism in patients with unexplained syncope and a positive head up tilt test .Heart .1999;82:312-318

[20] Yoshiharu Yamamoto, John J. LaManca , Benjamin H Natelson .Measure of Heart Rate Variability Is Sensitive to Orthostatic Challenge in Women with Chronic Fatigue Syndrome .Experimental Biology and Medicine. 2003; 228:167-174

[21] Wolfram Grimm , Andreas Wirths , JurgenHoffman , Volker Menz , Bernhard Maisch .Heart Rate Variability During Head-up Tilt Testing in Patients with Suspected Neurally Mediated Syncope. Pacing and Clinical elctrophysiology.2006June; 21(11); 2411 – 2415

[22] Kochiadakis GE, Kanoupakis EM, Rombola AT, Igoumenidis NE, Chlouverakis GI, Vardas PE.Reproducibility of tilt table testing in patients with vasovagal syncope and its relation to variation in autonomic system activity. Pacing and clinical electrophysiology. 1998May; 21(5):1069-76.

[23] Sanderson JE, Yeung LY, Yeung DT, Kay RL, Tomlinson B,Critchley JA, Woo KS, Bernardi L .Impact of changes in respiratory frequency and posture on power spectral analysis of heart rate and systolic blood pressure variability in normal subjects. 1996Jul; 91(1):35-40.

[24] Tyler AB, Chris LK, Eric BW, Daniel AD and Donald RD. Comparison of changes in heart rate variability and blood pressure during nitroglycerin administration and head-up tilt testing. Clinical Autonomic Research .2009Feb; 19:46–50.

[25] Piccirillo G, Fimognari F, Viola E, Marigliano V. Age adjusted normal confidence intervals for heart rate variability in healthy subjects during head-up tilt. Int J Cardiol.1995; 50:117–124

[26] Kamiya A, Hayano J, Kawada T, Michikami D, Yamamoto K,Ariumi H, Shimizu S, Uemura K, Miyamoto T, Aiba T, SunagawaK, Sugimachi M. (2005). Low-frequency oscillation of sympathetic nerve activity decreases during development of tilt induced syncope preceding sympathetic withdrawal and bradycardia.Am J Physiol Heart Circ Physiol 2005; 289:H1758–H1769.

[27] Mukai S, Hayano J. Heart rate and blood pressure variabilities during graded head-up tilt. J Appl Physiol.1995; 78:212–216.

[28] Monther Boulos, Stephen Barron, Eugenia Nicolski, Walter Markiewicz.

Power Spectral Analysis of Heart Rate Variability during Upright Tilt Test: A Comparison of Patients with Syncope and Normal Subjects .Cardiology. 1996; 87:28-32

[29] Liao D, Barnes RW, Chambless LE,Simpson RJ, Sorlie P, Heiss G (1995)

Age, race, sex differences in autonomic cardiac function measured by spectral analysis of heart rate variability: the ARIC study. Am J Cardiol 76:906–912.

[30] Censi F, Calcagnini G,Strano S, Bartolini P, Barbaro V. Nonlinear Coupling Among Heart Rate, Blood Pressure, and Respiration in Patients Susceptible to Neuromediated Syncope. Annals of Biomedical Engineering.2003 ; 31: 1097–1105.