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Original Research Article

Evaluation of Cardiovascular Responses to Valsalva Maneuver in Different Body Position - An Observational Study

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ABSTRACT

Background: Valsalva maneuver is regarded as a simple method to assess the baroreceptor and chemoreceptor regulated reflex activities of the autonomic nervous system. It is also advocated for the treatment of cardiovascularly stable patients. But there is a lack of integrated information which can accurately represent the response of autonomic system while performing valsalva in response to the commonly used different position.
Objective: To determine the cardiovascular responses in different position and compare the response to those positions, while performing a valsalva maneuver.
Methods: Thirty healthy were recruited as a sample of convenience. Different positions were assumed in the tilt table and autonomic responses were obtained before and during performance of valsalva.
Results: There was a significant change in cardiovascular responses before and during the valsalva.
Conclusion: Head low position caused decrease pulmonary functional parameter and supine and standing caused increase cardiac response

Key words: Valsalva maneuver, cardiovascular response, autonomic system, body position.

Abbreviation: BP- Blood pressure, SBP- Systolic blood pressure, DBP- Diastolic blood pressure, RPP- Rate pressure product, DOP- Double product.

INTRODUCTION

Cardiovascular and respiratory system are the most vital system in the body and responds to any alteration in physical, mental and social changes. [1] Regulation of these vital systems are under the influence of autonomic nervous system, which consists of sympathetic, parasympathetic and enteric system. While Sympathetic system has strong influences on the myocardial contractility i.e. chronotropic, ionotropic and dromotropic action and some influence on controlling heart rate, the vagal control is essentially over the heart rate. [2] The autonomic system also have link to peripheral receptor and central command responsible to control the breathing. [3] Valsalva maneuver is regarded as a simple method to assess these baroreceptors and chemoreceptor regulated reflex activities of the autonomic nervous system. [4]

The Valsalva maneuver is a coordinated muscular movement, which may occur as a result of natural muscle movements during defecation, coughing and gagging or as an induced maneuver. [5] The induced maneuver is performed by blowing against the mercury column of sphygmomanometer and maintaining the pressure at 40 mmHg for 15 seconds. [6] Valsalva maneuver responds in 4 phases. [7,8]

The study has also advocated the valsalva maneuver as the treatment of cardiovascularly stable patients with paroxysmal supra ventricular tachycardia with different modification, [9] as a method to reduce pain from venous cannulation and for the relief from angina. [10,11] As evidence suggest, the valsalva is a method of assessment and treatment. However, studies have reported that change in the cardiovascular response with change in the position while performing valsalva maneuver. [8,12] Change in posture cause changes in intrathoracic and intravascular volumes and pressures, and also change in the neurohumoral activity which have the significant impact on cardiovascular response similar to valsalva manuever.13In autonomic laboratory valsalva maneuver is performed in supine but this position prevent adequate preload reduction result in "flat top" response. [8] The maneuver performed in a sitting or standing position has shown the reduction in the flat top response. However these positions have also resulted in the increase risk of fainting, greater orthostatic stress an increase in patient discomfort. [13] Valsalva maneuver and its response was also determined following head down position, but it was failed to predict blood pressure control which is related to a broad range of clinical and neurohormonal parameters [14,15] Performing valsalva during upright tilt testing in individual without history of syncope has reported the provocation of hypotension and bradycardia.[16] These above mentioned studies are performed in different setting, in varying population and with the variable outcome. So, there is a lack of integrated information which can accurately represent the response of autonomic system while performing valsalva in response to the commonly used different position. Given this gap in the literature, study is needed to elucidate the cardiovascular response in different positions, while performing valsalva maneuver. Therefore, the objective of this study was to determine the cardiovascular responses in different position and compare the response to those positions, while performing a valsalva maneuver.

MATERIALS AND METHODS

Participants: Total 30 participants (15 male and 15 female), whom the physician declared as healthy were recruited as a sample of convenience. Participants were considered healthy if they report no history of chronic medical condition, without any health related complain during recruitment and with normal vital parameters. The study was approved by institutional ethical committee. Written informed consent was obtained from all the participants. Exclusion criteria; person having any of Cardio respiratory problem, hypertension, metabolic problems, mentally unstable person, pre existing neurological conditions, Physically handicapped, fever, pain, anemia, Pregnancyand with any musculoskeletal problems.

Clinical Evaluation Procedure: Prior to baseline assessment of outcome measures, all participants were underwent a physical examination. Demographic details of the participants were obtained. The life-style of individuals was also taken into consideration.

Experimental Paradigm: All the participants were asked to perform Valsalva maneuver in each of the four body position; 20^0head low, supine, 45^0 head up and standing up. Each position was assumed in the tilt table for at least ten minute before performing the maneuver, to allow the cardiovascular system to reach a steady state. [13] To perform the valsalva maneuver, participants were asked to blow through the wide bore disposable syringe fixed at the end of the sphygmomanometer tube and sustain it for 15 seconds such that the mercury column shows a reading of 40mmHg. [17] The wide bore syringe was used to avoid any leakage from the attached site.

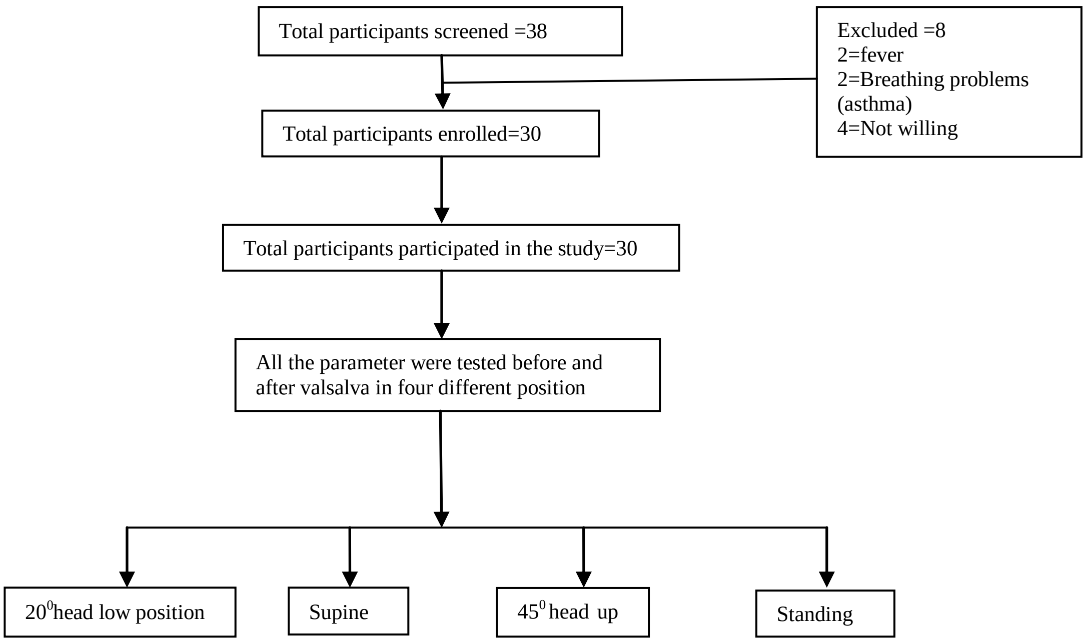

Fig: 1 Flow diagram of the study.

Measurement Of Cardiovascular Responses: It was assessed, before and during the Valsalva maneuver. The PR was recorded by using palpation method. SBP and DBP was assessed using digital BP machine. [18] Rate pressure product, Respiratory rate, Double product (was assessed by DOP= HR X MP [19]) was assessed.

Statistical Analysis: The data were analyzed using ANOVA for all outcome variables in all testing positions. Pair wise comparison was done in all positions with all the six outcome measures using Newman-Keuls multiple post hoc procedure. The difference in outcome, before and during the valsalva maneuver was determined using paired t test and percentage change. The correlation between demographic variable with all testing conditions and outcome was determined by Karl Pearson's correlation coefficient method.

RESULTS

30 participants of which 15 male and 15 female formed the study group. Participant's demographic data, physical fitness level and their diet preference were summarized. The mean age of the participants was 22.1 ±2.3 years. Mean height was 167.67 ± 6.9cm, weight was 63.5±14.4 kg and BMI was19 ± 4.3.

16participants were physically active, 14 were veg, and 16 used to take mixed diet.

The comparison was made for a change in pulse rate and respiratory rate before and after performing valsalva (TABLE 1). This showed a significance difference in PR during 20^0 head low supine and standing position, with greater changes in supine and minimum change during 45^0 upright positions. There was an increase in pulse rate during and before valsalva with increase upright position. When we compare the pulse rate in all testing positions, before and during the maneuver it was clinically significant in both situations. But a pair wise comparison showed statistical significance only during 20^0 head low vs. standing upright and supine vs standing position. (Data for pair wise comparison with all outcomes in different positions are presented in annexure). Even though there was no significance difference in respiratory rate before or during the maneuver in any of the testing position; it was increased from supine to upright to the standing position. RR was increased while performing maneuver compare to before performing it and it was increased with increase upright. There was no statistical significance noted with ANOVA and post hoc procedure.

Table 1: Comparison of four positions with respect to pulse rate and respiratory rate before and during valsalva score using paired t test and ANOVA

Outcomes	Position	Before maneuver	During maneuver	% change	P value
Pulse rate	200head low	79.27 ± 9.55	74.87±11.3	5.55	0.0054*
	Supine	77.87±10.4	73±11.4	6.25	0.009*
	450upright	82±11.1	80.5±15.6	1.87	0.4108
	Standing up	87.27±11.2	83.07±14.4	4.81	0.0262*
	F value	4.4498	3.75		
	p- value	0.005*	0.01*		
Respiratory rate	200head low	22.4±3.6	23.1±5.9	-3.12	0.52
	Supine	22.7±4.9	22.87±6.8	-0.88	0.8005
	450upright	20.23±4.4	21.4±5.4	-5.8	0.12
	Standing up	22.03±4.7	23.2±5.6	-5.14	0.0749
	F value	1.8703	0.6		
	p- value	0.13	0.61		

When we compared the SBP and DBP before and during maneuver, there was a significance difference in DBP during 20^0head low position (TABLE 2).Significant difference in DBP in Pair wise comparison was found, while comparing 20^0 head low vs 45^0 upright, 20^0 head low vs standing, supine vs standing and supine vs 45^0 upright. Decrease in SBP and DBP was noted during 20^0 head low, but in all others position there were increase in these outcome during valsalva then before performing it.

Table 2: Comparison of SBP and DBP in four different positions before and during valsalva maneuvers using paired t test and ANOVA.

Outcomes	Position	Before maneuver	Duringmaneuver	% change	P value
SBP	200head low	118.7±12.6	116.9±13.8	1.5	0.18
	Supine	115.5±13.9	117.6±13.2	-1.8	0.16
	450upright	116.9±13.2	122.3±14.3	-4.6	0.054
	Standing up	120.2±15.7	121.7±16.2	-1.2	0.57
	F value	0.67	1.09		
	p- value	0.57	0.35		
DBP	200head low	70.4±7.4	67.8±8	3.74	0.0304*
	Supine	66.8±8.25	68.7±8.8	-2.79	0.065
	450upright	75.3±6.7	79.5±13.3	-5.62	0.0824
	Standing up	82.7±15.24	82.17±12.5	0.68	0.7
	F value	14.24	13.2		
	p- value	0.0001*	0.0001*		

The comparison of RPP and DOP was made in all positions (TABLE 3). Among all positions tested, DOP was significantly decreased during supine and 20^0head low position before and during the maneuver. The ANOVA showed a significance difference, when comparing DOP in all testing condition before and after valsalva. When a pair wise comparison between each position was carried out for DOP, significance differences noted between 20^0 head low vs 45^0 upright, 20^0 head low vs standing up, supine vs 45^0 upright, supine vs standing and 45^0 upright vs standing.

RPP measure was significantly different during 20^0 head low, when comparing before and during maneuver by paired t test. It was significant before performing maneuver, while comparison was made by ANOVA with a different position. Significant difference was noted when pair wise comparison was made between 20^0 head low vs standing, supine vs standing and 45^0upright vs standing was during each position with respect to change in RPP.

Table 3: Comparison of RPP and DOP in four different positions before and during valsalva maneuvers using paired t test and ANOVA.

Outcomes	Position	Pre maneuver	During maneuver	% change	P value
RPP	200head low	93.4±14.8	86.6±13.6	7.25	0.0001*
	Supine	89.3±15.1	113.5±15.8	-27.11	0.4058
	450upright	95±15.3	97.6±21.6	-2.77	0.43
	Standing up	103.4±18.2	99.9±21.1	3.32	0.249
	F value	4.1597	0.5622		
	p- value	0.0077*	0.6410		
DOP	200head low	6839.5±1122.7	6269.9±955.3	8.33	0.0005*
	Supine	6443.4±1052.4	6158.5±1099.6	4.42	0.0202*
	450upright	7280.4±1179.8	7659.7±2074	-5.21	0.254
	Standing up	8305±1839.3	1697±447.1	5.38	0.1055
	F value	10.8	10.3689		
	p- value	0.0001*	0.000*		

Association of age, BMI, diet type and physical exercise in relation to all 6 outcome measures with all 4 position was obtained by karl pearson's corelation coffecient method. The age and BMI was posetively corelated and diet type and physical exercise was negatively associated in majority of testing condition.

DISCUSSION

The present study was performed to identify the cardiorespiratory response in various positions while performing valsalva. The pulse rate was increased as the participants attained more vertical position i.e. from supine to standing. A similar effect was reported in previous studies also. [20,21] This is because; the effect of gravity on body is increased during upright position, which causes decrease in venous return. Hence there is increase in work load to the heart, which subsequently leads to increase in heart rate [22,23] Thandani and Parkes suggest that shifting the individual from supine to half lying position is associated with increase in the heart rate, which compensate for the decrease in the stroke volume which is, in line with our study [24] In our study, the RPP which is the indicator of the myocardial O_2 consumption and DPP which is the indicator of work load on heart was maximum during standing position, suggesting standing upright position increase the work demand on heart.

There was a significant increase in pulse rate when comparison was done during and after the valsalva in supine, but RPP and DPP during valsalva was not increased which suggest, no increase in myocardial work load. So, change in pulse rate between before and during valsalva in supine, may be due to altered vagal sensitivity with position.

RR was increased from supine to 45^0 inclined to the standing position, which may be due to increase in CO2 content of the alveolar air in an upright position. In the upright position, gravity induces perfusion gradient, so perfusion is increases in basal and decrease in the apical region. In standing position, expired air from active alveoli is diluted by the air from the underperfused apical lung segments result in decrease in end tidal partial pCO2. Due to alveolar expansion because of weight of the lungs and lowering of diaphragm, functional residual capacity and tidal volume increase, which also results in a decrease in end tidal partial pCO2 [25] Hence supine and standing position limit the optimal cardiopulmonary responses.

Yoshifumi Kadono et al studied the effects of various degrees of head down on cardio respiratory response and concluded that, as the angle of head down increase mean arterial pressure, respiratory rate, peak inspiratory pressure and end tidal CO2 pressure (PetCO2) tend to increase. [26] In our study, SBP and DBP during head down position were more than that of supine position, but less than that of the standing position, which goes with the previous study in which an increase in diastolic BP at 60° head down position was noted. [27] In our study, even though there was increase in SBP it was not statistically significant between before and during valsalva and in pair wise comparison. Increase BP during head low compare to supine position may be due to the activation of reactive vasoconstrictive mechanism. Myocardial O2 demand and consumption both were lower in head down position compare to standing position even though heart rate was same, which reflect reflex increase in heart rate.

There was a significant change in diastolic BP then the systolic BP from supine to standing, which is in line with the others study, which suggests that, increase head tilt causes significant increase in DBP [22,23] This is because in addition to adaptation to gravity during standing, 10-25% shifts of plasma volume from the vasculature into the interstitial tissue occurs in standing position compare to supine. This causes decrease in venous return, results in transient decrease in cardiac filling and arterial pressure. This trigger compensatory sympathetic activation through baro-receptors, resulted in an increase in heart rate and systemic vasoconstriction. Subsequently leads to increase in blood pressure. [25]

There was a significant lower DBP during head low, while pair wise comparison was made between head low with 45^0 upright and standing positions, which is in line with the previous study. [28] Decrease heart rate and BP during head low position compare to upright position is due to increase in venous return because of assistance from gravity. The myocardial demand during the head low position was less than the standing position, but more than the supine position which may be due to increase in work of breathing. During 20^0 head down position we determine the increase in RR which was more than the standing upright position. Studies have reported that decrease in FEV1 and FVC during head low position. [28,29] These changes in pulmonary function may be caused due to increase in pulmonary resistance and decrease in lung compliance. [30]

Even though valsalva cause increase in BP, change in BP before and during the valsalva was minimum which is related to neurohumoral response. [31] With 45^0 upright myocardial work load and oxygen demand was also lower compared to standing position. The study has also suggested that the flat top response associated with supine position due to preload reduction also improve with head up position. [8] Respiratory rate was also lower in 45^0 head up position compare to all others position, which signifies that the work of breathing was less during this position. Half lying position causes downward displacement of diaphragm, increases the vertical dimensions of the thoracic cavity hence resulting in positive alteration in arterial blood composition. [32] So, this may be the safe position to perform valsalva.

Study has reported that the resting heart rate is not influenced by age. [33] In our study even though it was positively correlated we did not found statistical significance with age. In our study pulse rate was positively correlated with the heart rate and BMI, which is in line with other study, where lower resting heart rate is consider a marker of more favorable fitness. [34] This was supported by another parameter of our study where physical exercise was negatively correlated with PR. Diet was negatively correlated with pulse rate in this study. Vegetarian diets have been linked to lower risk for heart disease and diabetes. But we did not determine significant correlation of diet with BP, RR and myocardial work load. In our study RPP and DPP were positively correlated with BMI and it was statistically significant. Suggesting, obesity is associated with increased work load on heart, which goes with similar finding from other study35. Our study also demonstrates negative correlation of physical exercise with RPP and DPP, so support the positive correlation of BMI with work load. There was a significant positive correlation between SBP and DBP with BMI. Study have reported, increase BP and increase risk of heart disease in obese which support by our study. [35,36]

A limitation of this study was the lack of using various degree of upright position with small fixed range of increment. Further study with various angle of upright position with more objective measure for cardiac and respiratory response. More ever, further study should carry out with more adequate sample size.

CONCLUSION

Head low position caused decrease pulmonary functional parameter and supine and standing caused increase cardiac response.

Conflict of interest: None

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REFERENCES

1. Marino Nino, Depasquale Eugene Physiology in sports. Text principles of sports medicine. 1993. Williams and Wilkins. 1-13.
2. Rajesh K Sharma, K K Deepak, R L Bijlani, P S Rao. Short-term physical training alters cardiovascular autonomic response amplitude and latencies. Indian journal of physiology and pharmacology 2004; 48(2):165-73.
3. Guilleminault C, Briskin JG, Greenfield MS, Silvestri R. The impact of autonomic nervous system dysfunction on breathing during sleep.Sleep. 1981 Sep; 4(3):263-78.
4. Baldwa VS, Ewing DJ. Heart rate response to Valsalva manoeuvre. Reproducibility in normals, and relation to variation in resting heart rate in diabetics.Br Heart J. 1977 Jun; 39(6):641-4.
5. John Train. Valsalva's maneuver: Mots justes and indispensable terms Harpercollins 1990

6. Bhatia SG, Sainani GS, Nayak NJ, Diwate PG. Valsalva manoeuver as a test of autonomic neuropathy in diabetes mellitus.J Assoc Physicians India. 1976 Feb;24(2):89-93.
7. Schlegel TT, Benavides EW, Barker DC, Brown TE, Harm DL, DeSilva SJ, Low PA. Cardiovascular and Valsalva responses during parabolic flight.J Appl Physiol. 1998 Nov;85(5): 1957-65.
8. Vogel ER, Corfits JL, Sandroni P, Sletten DM, Benarroch EE, Fealey RD, Suarez GA, Gehrking TL, Gehrking JA, Low PA. Effect of position on valsalva maneuver: supine versus 20 degree position.J Clin Neurophysiol. 2008 Oct;25(5):313-6.
9. Walker S, Cutting P. Impact of a modified Valsalva manoeuvre in the termination of paroxysmal supraventricular tachycardia. Emerg Med J. 2010 Apr;27(4):287-291.
10. Federici A, Ciccone M, Gattullo D, Losano G. Systolic and diastolic changes in human coronary blood flow during Valsalva manoeuvre.Clin Physiol. 2000 Jan;20(1):19-29.
11. Basaranoglu G, Basaranoglu M, Erden V, Delatioglu H, Pekel AF, Saitoglu L. The effects of Valsalva manoeuvres on venepuncture pain.Eur J Anaesthesiol. 2006 Jul;23(7):591-3
12. Priyanshu V. R., Savita R, Veena KN. Cardiovascular responses with Valsalva maneuver during activities of daily livings in healthy adults.NJIRM. 2010; 1(2): 6-11
13. Singer W, OpferTL, Mcphee BR, Hilz MJ, Low PA. Influence of posture on the Valsalva manoeuvre.Clin Sci (Lond). 2001 Apr;100(4):433-40.
14. Hans P, Brunner LR, Daniel W, Hans R, Ferenc F, Woldgang K. Is blood pressure response to the Valsalva maneuver related to neurohormones, Exercise Capacity, and clinical findings in Heart failure.chestjournal. 1999;116(4);861-867.
15. Shoemaker JK, Hogeman CS, Sinoway LI. Sympathetic responses to Valsalva's manoeuvre following bed rest.Can J Appl Physiol. 2003 Jun;28(3):342-55.
16. Kapoor WN, Brant N. Evaluation of syncope by upright tilt testing with isoproterenol. A nonspecific test.Ann Intern Med. 1992 Mar 1;116(5):358-63.
17. Gautschy B, Weidmann P, Gnädinger MP. Autonomic function tests as related to age and gender in normal man.Klin Wochenschr. 1986 Jun 2;64(11):499-505.\
18. Thomas G. Pickering, John E. Hall, Lawrence J. Appel, Bonita E. Falkner, John Graves,MarthaN. Hill, Daniel W. Jones, Theodore Kurtz, Sheldon G. Sheps and Edward J. Roccella Recommendations for blood pressure measurement in humans and experimental animals Part 1.Circulation.2005;111:697-716
19. Bisen VS, Salgar DC. Valsalva manoeuver and Harvard step test with reference to body parameters in females.Indian J Med Sci. 1975 Apr-May;29(4-5):112-5.
20. Platts SH, Tuxhorn JA, Ribeiro LC, Stenger MB, Lee SM, Meck JV. Compression garments as countermeasures to orthostatic intolerance. Aviat Space Environ Med. 2009 May;80(5):437-42.
21. StengerMB,Brown AK,Lee SM, LockeJP, Platts SH. Gradient compression garments as a countermeasure to post spaceflight orthostatic intolerance. Aviat space Environ. Med.2010 Sep;81 (9):883-7.
22. Vaddadi G, Esler MD, Dawood T, Lambert E. Persistence of muscle sympathetic nerve activity during vasovagal syncope.Eur Heart J. 2010 Aug;31(16):2027-33.
23. Chen GY, Kuo CD.The effect of the lateral decubitus position on vagal tone.Anaesthesia. 1997 Jul;52(7):653-7.
24. Thadani U, Parker JO. Hemodynamics at rest and during supine and sitting

bicycle exercise in normal subjects.Am J Cardiol. 1978 Jan;41(1):52-9.
25. Gisolf J, Wilders R, Immink RV, V, Karemaker JM. Tidal volume, cardiac output and functional residual capacity determine end-tidal CO2 transient during standing up in humans.J Physiol. 2004 Jan 15;554(Pt 2):579-90.
26. Kadono Y, Yaegashi H, Machioka K, Ueno S, Miwa S, Maeda Y, Miyagi T, Mizokami A, Fujii Y, Tsubokawa T, Yamamoto K, Namiki M. cardiovascular and respiratory effects of the degree of head down angle during robot assisted laparascopic radical prostatectomy. Int J Med Robot. 2013 Mar;9(1):17-22
27. Goodman LS, Lesage S. Impairment of cardiovascular and vasomotor responses during tilt table simulation of "push-pull' maneuvers.Aviat Space Environ Med. 2002 Oct;73(10):971-9.
28. Galanis DS, Naka KK, Veziraki P, Simos YV, Kalfakakou V, Evangelou AM. Cardiovascular and pulmonary adaptations during short-term 15° and 30° head-down posture in healthy male volunteers.Hellenic J Cardiol. 2013 Jul-Aug;54(4):273-80.
29. Lu LL, Zhong CF, Yang JS, Tao Y, Zhao GX. Effects of -30 degrees head down tilt on lung function.Space Med Med Eng (Beijing). 2000 Jun;13(3):187-90.
30. Montmerle S, Spaak J, Linnarsson D. Lung function during and after prolonged head-down bed rest.J Appl Physiol (1985). 2002 Jan;92(1):75-83.
31. Brunner-La Rocca HP, Weilenmann D, Rickli H, Follath F, Kiowski W. Is blood pressure response to the Valsalva maneuver related to neurohormones, exercise capacity, and clinical findings in heart failure?.Chest. 1999 Oct; 116 (4):861-7.
32. Hardie JA, Mørkve O, Ellingsen I. Effect of body position on arterial oxygen tension in the elderly. Respiration. 2002;69(2):123-8.
33. Richardson JF. Heart rate in middle aged man. Am j clin Nutr. 1971 Dec;24(12):1476-1481
34. Blomqvist CG, Saltin B.cardiovascular adaptation to physical training. 1983; 45:169-189
35. Poirier P, Giles TD, Bray GA, Hong Y, Stern JS, Pi-Sunyer FX, Eckel RH. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss. Arterioscler Thromb Vasc Biol. 2006 May;26(5):968-76.
36. Contaldo F, Pasanisi F, Finelli C, de Simone G. Obesity, heart failure and sudden death. Nutr Metab Cardiovasc Dis. 2002 Aug;12(4):190-7.

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