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Assessment of Cardiovascular Autonomic Functions in Normal Healthy Young Adults

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Abstract
The portion of the nervous system that controls most visceral functions of the body is called the Autonomic Nervous System (ANS). The effects of the ANS on heart rate are called "chronotropic effects". Briefly, sympathetic stimulation increases heart rate and parasympathetic stimulation decreases heart rate. Our cardiovascular system is governed by autonomic nervous system. Since women have a lower cardiovascular risk , this study is aimed to determine the normal values of cardiovascular functions in normal healthy individuals & to determine effects of age & gender in these values. 50 healthy young subjects (35 males and 15 females) of age 18 to 22 years are subjected to a set of cardiovascular AFTs. The results were Valsalva ratio in males is 11.13±1.12 while in females is 0.94±0.78 with a P value of 0.0009 which is very highly significant. Deep breathing ratio in males is found to be 0.99±0.79 while in females is 0.93±0.7 with a P value of 0.05. DBP change to posture was found to be more in males than in females (P=0.007). This is a very significant change indicating dominant sympathetic activity among males. DBP change to handgrip was also found to be more in males than in females (P=0.01). This is a significant change again indicating predominant sympathetic activity among males. Comparing standing and supine postures, cardiac autonomic nervous activity was so variable among participants that not much significant differences could be detected. However, heart rate and arterial systolic and diastolic blood pressures all were significantly greater in the supine position than standing, indicating sympathetic dominance during supine position and BP was also higher in supine posture.

Introduction

The portion of the nervous system that controls most visceral functions of the body is called the Autonomic Nervous System (ANS). The ANS utilizes a hierarchy of reflexes to control the functions of autonomic target organs. The ANS helps to control arterial blood pressure, gastrointestinal motility, gastrointestinal secretion, urinary bladder emptying, sweating, body temperature and many other activities, some of which are controlled almost entirely and some only partially by the autonomic nervous system. Autonomic Function Test (AFT) forms an integral part of physiological investigations and is a useful diagnostic tool in neuropsychiatric disorders[1].

The effects of the ANS on heart rate are called “chronotropic effects”. Briefly, sympathetic stimulation increases heart rate and parasympathetic stimulation decreases heart rate.

As we review the literature, Mehta et al found that parasympathetic activity is more in females than in males. It may be because of the testosterone and athletic muscular built of the males that lead to higher vagal tone which results in more parasympathetic activity[1]. Pal et al in his study found increased parasympathetic activity and decreased sympathetic activity in subjects doing regular breathing exercises [2]. Melo et al in his study found that the aging process causes a decrease in heart rate variability [3].

Our cardiovascular system is governed by autonomic nervous system. Since women have a lower cardiovascular risk , this study is aimed to determine the normal values of cardiovascular functions in normal healthy individuals & to determine effects of age & gender in these values.

Materials and Methods

The paper presents the study conducted in the undergraduate medical students. A total number of 50 healthy young subjects (35 males and 15 females) of age 18 to 22 years are subjected to a set of cardiovascular AFTs to record the Heart rate (HR) & Blood pressure (BP) responses at rest & after deep breathing, Valsalva maneuver, postural changes & isometric exercise.

Sympathetic activity is tested by recording changes in BP during Handgrip test and Postural changes (Lying to standing) while Parasympathetic activity is tested by recording changes in HR with Postural changes (lying down to standing), Deep breathing and Valsalva maneuver.

Various autonomic function tests were carried out for sympathetic and parasympathetic nervous system.

- ❖ PARASYMPATHETIC
  - ➢ Standing to Lying Ratio (S/L Ratio)

Normally when a subject lies down from the standing position, there is a brief initial rise followed by a fall in the heart rate. The initial brief rise is due to rapid decrease of vagal tone and latter fall is because of increase of vagal tone.

In this test each subject was to stand quietly and then lie down without any support while a continuous ECG was recorded from 20 beats before to 60 beats after lying down.

$$\text{S/L Ratio} = \frac{\text{Longest R-R interval during 5 beats before lying down}}{\text{Shortest R-R interval during 10 beats after lying down}}$$

- ➢ 30 : 15 Ratio

Changing from lying to standing position produces an integrated response of cardiovascular system which includes alteration in heart rate and blood pressure. There is a transient fall in blood pressure on standing with stimulation of carotid baroreceptor and consequent reflex tachycardia and peripheral constriction.

In this test each subject laid quietly for 3 minutes , then stood up and remained motionless and a continuous ECG was recorded.

$$\text{30:15 Ratio} = \frac{\text{R-R interval at beat 30 after standing}}{\text{R-R interval at beat 15 after standing}}$$

- ➢ Valsalva Ratio

Valsalva manoeuvre is a test done to assess the low and high pressure baroceptor integrity. Changes in the arterial blood pressure have been used to access the response to the Valsalva manoeuvre but heart rate changes have also been shown to be reliable .

In this each subject was made to perform Valsalva manoeuvre for 15 seconds by blowing against closed glottis through a mouth piece attached to aneroid manometer and maintained a pressure of 40 mm of Hg for 15 seconds. A continuous ECG was recorded 1 minute before the manoeuvre (resting period), during the manoeuvre (strain period, 15 seconds) and 1 minute subsequent to strain period.

$$\text{Valslava ratio} = \frac{\text{Maximum R-R interval after the strain}}{\text{Shortest R-R interval during the strain}}$$

- Tachycardia Ratio

$$\text{Tachycardia Ratio} = \frac{\text{Shortest R-R interval during the valsalva manoeuvre}}{\text{Longest R-R interval before the valsalva manoeuvre}}$$

- SYMPATHETIC
- Blood Pressure Response to Static Exercise (Hand Grip Test)

During sustained isometric exercise the blood pressure increases due to increased peripheral resistance. There is also increase in cardiac output. In this the subject was asked to apply pressure on a standardized hand grip for one minute and simultaneously blood pressure was observed. The diastolic blood pressure increase of less than 15mm Hg was considered as abnormal i.e. an indicator of sympathetic insufficiency.

Result

When the different parameters are compared among males and females, the following results came out. Resting heart rate in males is 75.2±4 while in females is 80.2±2 with a P value of 0.045. Valsalva ratio in males is 11.13±1.12 while in females is 0.94±0.78 with a P value of 0.0009 which is very highly significant. Deep breathing ratio in males is found to be 0.99±0.79 while in females is 0.93±0.7 with a P value of 0.05. Systolic BP change (from lying to standing) in males is found to be 1.31±0.3 while in females is found to be 5.86±0.5 with a P value of 0.033. Diastolic BP change (from lying down to standing) in males is found to be 5.2±0.22 while in females is 1.2±0.4 with a P value of 0.007 which is very significant. Diastolic BP change during handgrip test in males is 25.72±0.25 while in females is 19.33±0.4 with a P value of 0.01.

Table 1: Comparison of different parameters among males and females

	Males (Avg+SD)	Females (Avg+SD)	P value
Resting Heart Rate	75.2 ± 4	80.2 ± 2	0.045
Resting BP (Systolic)	124.5 ± 3	113 ± 2	0.23
Resting BP (Diastolic)	79 ± 3	76 ± 2	0.181
Valsalva Ratio	11.13 ± 1.12	0.94 ± 0.78	0.0009
Deep Breathing Ratio	0.99 ± 0.79	0.93 ± 0.7	0.05
HR Ratio	1.01 ± 0.17	1.04 ± 0.2	0.87
Systolic BP change (lying to standing)	1.31 ± 0.3	5.86 ± 0.5	0.033
Diastolic BP change (lying to standing)	5.2 ± 0.22	1.2 ± 0.4	0.007
Systolic BP change (Handgrip Test)	20.63 ± 1.08	17.34 ± 2.84	0.131
Diastolic BP change (Handgrip Test)	25.72 ± 0.25	19.33 ± 0.4	0.01

When compared with the weight groups of 44-54Kg, 55-64 kg and 65 Kg onwards in males, the following results were observed. The resting HR was found to be 77±4, 73±4 and 75±2. Resting BP (Systolic) was found to be 120±3, 128±3 and 127±2. Resting BP (Diastolic) was found to be 77±3, 78±2.5 and 83±2 respectively. Valsalva ratio was found to be 1.1±0.2, 1.15±0.1 and 1.08±0.86 respectively. Deep breathing was found to be 0.93±0.1, 1.07±0.16 and 1±0.68 respectively. Similarly, HR ratio was found to be 0.99±0.66, 1.02±0.2 and 1.04±0.2 respectively. Table 2 shows the HR and BP changes in different weight groups in the studied males.

Table 2: HR and BP changes in different weight groups in the studied males

	44-54kg (Avg ± SD)	55-64kg (Avg ± SD)	≥65kg (Avg ± SD)
Resting HR	77 ± 4	73 ± 4	75 ± 2
Resting BP (Systolic)	120 ± 3	128 ± 3	127 ± 2
Resting BP (Diastolic)	77 ± 3	78 ± 2.5	83 ± 2
Valsalva Ratio	1.1 ± 0.2	1.15 ± 0.1	1.08 ± 0.86
Deep Breathing (Exp/Insp)	0.93 ± 0.1	1.07 ± 0.16	1 ± 0.68
HR Ratio (Standing/Supine)	0.99 ± 0.66	1.02 ± 0.2	1.04 ± 0.2
SBP change to posture	1.08 ± 0.67	1.5 ± 0.05	1.4 ± 0.61
DBP change to posture	6.9 ± 1.88	3.3 ± 0.75	5.2 ± 2.12
SBP change to Handgrip	20 ± 3.97	22.3 ± 0.57	19.4 ± 1.58
DBP change to Handgrip	28.9 ± 3.78	24.16 ± 0.97	23.4 ± 1.43

When compared in the weight groups of 36-45Kg and >45Kg in females, the following results were found. The resting HR was found to be 80±6.5 and 80±6.3. Resting BP(systolic) was found to be 112±2 and 116±3 while resting BP(diastolic) was found to be 76±3 and 75±4. Valsalva ratio was found to be 1.09±0.7 and 1±0.1. Deep breathing ratio was found to be 0.93±0.6 and 0.92±0.6. HR ratio was found to be 1.08±0.3 and 0.96±0.5. SBP change to posture was found to be 5±0.7 and 9±2 while DBP change to posture was found to be 1±0.2 and 2±0.3. SBP change to handgrip was found to be 18±2.8 and 16±3.8 while DBP change to handgrip was found to be 21±4.3 and 16±2.8.

Table 3: Changes in HR and BP in different weight groups in the studied females

	36-45 kg (Avg ± SD)	46 kg upwards (Avg ± SD)
Resting Heart Rate	80 ± 6.5	80 ± 6.3
Resting BP (Systolic)	112 ± 2	116 ± 3
Resting BP (Diastolic)	76 ± 3	75 ± 4
Valsalva Ratio	1.09 ± 0.7	1 ± 0.1
Deep Breathing Ratio	0.93 ± 0.6	0.92 ± 0.6
HR Ratio	1.08 ± 0.3	0.96 ± 0.5
SBP change to posture	5 ± 0.7	9 ± 2
DBP change to posture	1 ± 0.2	2 ± 0.3
SBP change to Handgrip	18 ± 2.8	16 ± 3.8
DBP change to Handgrip	21 ± 4.3	16 ± 2.8

Discussion

From the various above calculations, the following inferences have been worked out. DBP change to posture was found to be more in males than in females (P=0.007). This is a very significant change indicating dominant sympathetic activity among males. DBP change to handgrip was also found to be more in males than in females (P=0.01). This is a significant change again indicating predominant sympathetic activity among males. When resting DBP was observed, it was found that it gradually increased along with increase in weight among the studied males. HR change to posture gradually increased with increase in weight among males indicating increasing sympathetic activity with increase in weight. When DBP change to handgrip was observed, it was found that it gradually increased with increase in weight among males again indicating increasing sympathetic activity along with increasing weight. Among the females, it was observed that both resting SBP as well as DBP gradually increased along with increase in weight. In another observation, it was seen that SBP change to posture is more in females than in the males (P=0.033). But this value was not found to be significant as the P value was more than 0.01.

Comparing standing and supine postures, cardiac autonomic nervous activity was so variable among participants that not much significant differences could be detected. However, heart rate and arterial systolic and diastolic blood pressures all were significantly greater in the supine position than standing, indicating sympathetic dominance during supine position and BP was also higher in supine posture. Again, comparing males and females, heart rate variability parameters indicate sympathetic dominance among males. With increasing weight, heart rate variability parameters are found to be not significantly changed.

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