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Effect of Gender on Cardiovascular Response at 12.5% of Maximum Voluntary Contractions of Dynamometer

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Abstract

Introduction: Handgrip device held at 30% of maximum voluntary contractions (MVC) is one among the batteries of test to assess the sympathetic autonomic nervous system (ANS). Subjects at our set-up failed to continue contracting the hand for the recommended 4 min. Therefore we tried to find the minimum percentage of MVC that could affect the sympathetic ANS and we also tried to explore the effect of gender on the acute physical stress. **Materials:** Subjects recruited were healthy health science students. Male (n=30) were of age 21.03 ± 1.73 yrs (mean ± S.D.) and female (n=30) were 19.93 ± 0.91 yrs. The study was conducted at Neurophysiology and Neurocardiology Lab in the Department of Basic and Clinical Physiology, BPKIHS. Acute minimal physical stress was 12.5% of MVC held for 5 min. Blood pressure (BP) was measured at the end of 2 and 4 min. **Results:** The given physical stress significantly raised the diastolic BP (DBP)in both the gender from the baseline (rest vs. at 4 min of physical stress: 76.33 ± 7.60 vs. 100.60 ±7.61 mmHg, p=0.001 in male; 71.53 ± 4.75 vs. 91.07 ± 9.82 mmHg, p= 0.001 in female). However the rise in DBP was not significantly different between the gender (male vs. female: 100.60 ± 7.61 vs. 91.07 ± 9.82 mmHg, p= NS). **Conclusion:** The selected stress,12.5% of MVC, elicited cardiovascular response and thus could be used to determine the adequacy of sympathetic response of cardiac function. Post ovulatory female demonstrated comparable DBP rise as male subjects on exposure to 12.5% of MVC handgrip as acute stress.

Keywords: handgrip, gender, sympathetic response.

Introduction

Autonomic Nervous System (ANS) enables our body to handle stress. It has two components: Sympathetic and Parasympathetic (Malik, 1998). Both components act simultaneously and balance each other dynamically in normal conditions. When a stress is exposed, the sympathetic arm gets more activated (Van Houdenhove & Luyten 2006; Carter & Ray 2009; Emilie Pérusse et al, 2012; Mezzacappa et al. 2001). It causes secretion of Epinephrine and Norepinephrine, which increase the heart rate, blood pressure (BP) and breathing rate (Forsman L 1983; Kirschbaum et al. 1993; Akerstedt et al. 1983). On the other hand, when stress is removed, the parasympathetic or vagal system takes over and returns the cardio respiratory variables to baseline (Herd 1991; Krantz et al. 2004).

The intactness of the ANS, especially, the one supplying the cardiovascular region is assessed using five batteries of cardiovascular autonomic reactivity tests *viz*; Deep breathing test, Valsalva maneuver, Cold pressure test, Handgrip test, Lying to standing or head up tilt test (Malik 1998).

The isometric contraction of the flexor muscles of hand by using the dynamometer, also known as handgrip, at 30% maximum voluntary contraction (MVC) held for 4 min is one of the tools to assess the sympathetic division of ANS. Here the subject first generates a maximum handgrip. Thereafter a percentage of this maximum, often 30%, is sustained for a period of time. It causes an afferent signal to the brain that is independent of baroreflex. The signal takes its origin from central command-a signal from higher neurological center that initiates and sustains exercise. Mechano and metaboreflexes from contracting muscles are mainly responsible (Malik 1998; McArdle et al. 2006).

Isometric exercise raises BP more than any other exercises as it causes compression of blood vessels in the contracting muscles and thus resists blood flow. The Total Peripheral Resistance (TPR) is increased, but the increase in heart rate and cardiac output are less compared to rise in systolic, diastolic and mean arterial pressure (Hall JE, 2011).

Subjects at our population are unable to continue pressing the handle of the device at 30% of their MVC for the prescribed length of time and thus made the test impossible to assess. Hence it was proposed to determine the minimum amount of physical stress that a subject could tolerate for the prescribed length of time and which will still show sympathetic response.

Materials and Methods

The study was carried out at the Neurophysiology and Neurocardiology Lab, Department of Basic and Clinical Physiology of BPKIHS.

All procedures and experimental protocols were approved by the Institute's Ethical Review Board (BPKIHS, Dharan, Nepal).Informed written consent was obtained from all the participants. The subjects (30 male and 30 female) were healthy young adult medical and paramedical students. Male were 21.03 ± 1.73 yrs (mean ± S.D.) and female were 19.93 ± 0.91 yrs.

Body mass index of study participants were under 25kg/m^2. Study subjects were not under any regular prescription medication. Neither did they have a history of drug/alcohol abuse.

Parameters of female participants were recorded 2-4 days before the expected menstruation so as to harmonize them in regard to ovulatory phase.

Regarding CVS variables pulse rate (PR), systolic blood pressure (SBP) and diastolic BP (DBP) were measured in the non-dominant hand in sitting position at rest.

At first, a pilot study was done in 10 healthy males to find out the changes in CVS response to minimal isometric handgrip test. The handgrip exercise was conducted at 10%, 15% and 20% of MVC. Cardiovascular changes were not significantly altered at 10% of MVC whereas it was significant at 15 and 20% of MVC. Then handgrip at 12.5% of MVC was conducted and it yielded significant CVS response. Thus, 12.5% of MVC was selected as the physical stress for this study.

The subjects were then asked to maintain sustained grip on the dynamometer till 5 min. The CVS variables were taken at end of 2 and 4 min of the stress period.

Statistical analyses

Statistical software SPSS ver.17 (SPSS INC., Chicago, ILL, USA) was used for statistical analysis. Parametric unpaired t-test was applied to compare anthropometric and CVS variables between the sexes. Repeated measures of ANOVA followed by Bonferroni test for normally distributed data were done for within group comparison. The data are expressed as mean ± SD for normally distributed. The P<0.05 was considered as statistically significant.

Results

All subjects enrolled in the study had comparable anthropometric variables. The baseline SBP and PR were comparable between the sexes. However, males were found to be significantly older and had more DBP than the females (Table 1).

Table 1: Anthropometric and cardiovascular variables at rest

Variables	Group mean ± SD		p value
	Male	Female	
Age (yrs)	21.03 ± 1.73	19.93 ± 0.91	**0.002**
BMI (kg/m^2)	20.83 ± 2.07	20.70 ± 2.49	NS
SBP mm Hg	112.73 ±6.74	103.93 ±7.75	NS
DBP mm Hg	76.33 ± 7.59	71.53 ± 4.75	**0.007**
PR (bpm)	76.33 ± 7.59	79.67 ± 11.36	NS
RR (cycles per min)	16.43 ± 2.89	14.70 ± 2.41	NS

BMI= body mass index, SBP= systolic blood pressure, DBP= diastolic blood pressure, PR= pulse rate, RR= respiratory rate, $p<0.05$= statistically significant.

Acute physical stress significantly increased the CVS variables at the end of 2 and 4 min in both the sexes (table 2 and 3) and the variables were comparable between the sexes (table 4).

Table: 2 Cardiorespiratory variables in Males at Rest, during Physical stress (handgrip)

Variable	Rest	Physical stress (handgrip)		p1	p2	p3
		2 min	4 min			
SBP	112.73 ± 6.74	123.87±6.88	131.6 ± 7.82	0.001	0.001	0.001
DBP	76.33 ± 7.60	91.27 ± 8.83	100.60 ±7.61	0.001	0.001	0.001
PR	67.20 ± 9.17	72.8 ± 9.42	78.13 ± 0.10	0.010	0.001	0.04
RR	16.43 ± 2.90	16.77 ± 2.94		NS		NS

SBP=systolic blood pressure (mm Hg), DBP=diastolic blood pressure (mm Hg), PR=pulse rate (bpm), RR=respiratory rate (per min), p1=between rest and 2 min of Physical stress (handgrip),p2= between rest and 4 min of Physical stress (handgrip), p3=between 2 min of Physical stress (handgrip)and 4 min of Physical stress (handgrip), The $p<0.05$ was considered statistically significant, NS=statistically non-significant.

Table: 3 Cardiorespiratory variables in Females at Rest, during Physical stress (handgrip)

Variable	Rest	Physical stress (handgrip)		p1	p2	p3
		2 min	4 min			
SBP	103.93±7.75	112.80±9.09	116.87 ± 8.32	0.001	0.001	0.001
DBP	71.53 ± 4.75	83.93 ± 9.01	91.07 ± 9.82	0.001	0.001	0.001
PR	79.67±11.37	84.70±10.73	88.80 ± 11.40	0.045	0.001	NS
RR	14.70 ± 2.41	16.70 ± 2.1		0.03		NS

SBP=systolic blood pressure (mm Hg), DBP=diastolic blood pressure (mm Hg), PR=pulse rate (bpm), RR=respiratory rate (per min), p1=between rest and 2 min of Physical stress (handgrip),p2= between rest and 4 min of Physical stress (handgrip), p3=between 2 min of Physical stress (handgrip)and 4 min of Physical stress (handgrip), The $p<0.05$ was considered statistically significant, NS=statistically non-significant.

Table 4: Comparison of Cardiorespiratory Variables of Male and Female Students in Response to Physical Stress (Handgrip)

Variables	Groups		p value
	Male (n=30) (mean ± SD)	Female (n=30) (mean ± SD)	
RR (cycles per min)	16.77 ± 2.94	16.70 ± 2.99	NS
At the end of 2 min of Physical Stress			
SBP (mm Hg)	123.87 ± 6.89	112.80 ± 9.09	NS
ΔSBP (mm Hg)	11.13 ± 5.81	8.87 ± 7.23	NS
DBP (mm Hg)	91.27 ± 8.83	83.93 ± 9.01	NS
ΔDBP (mm Hg)	14.93± 7.06	12.40 ± 7.29	NS
PR (bpm)	72.80 ± 9.42	84.70 ± 10.73	NS
At the end of 4 min of Physical Stress			
SBP (mm Hg)	131.60 ± 7.82	116.87 ± 8.32	NS
ΔSBP (mm Hg)	18.87 ± 5.93	12.93 ± 7.27	NS
DBP(mm Hg)	100.60 ± 7.61	91.07 ± 9.82	NS
ΔDBP (mm Hg)	24.27 ± 7.39	19.53 ± 8.38	NS
PR (bpm)	78.13 ± 10.99	88.80 ± 11.40	NS

SBP=systolic blood pressure, ΔSBP=Change in SBP (systolic blood pressure during physical stress-systolic blood pressure at rest), DBP=diastolic blood pressure, ΔDBP=Change in DBP (diastolic blood pressure during physical stress - diastolic blood pressure at rest), PR=pulse rate, bpm=beats per min, RR=respiratory rate. The $p<0.05$ was considered statistically significant, NS=statistically non-significant

Discussion

Increase in DBP by ≥ 15 mmHg at the end of 4 min of isometric contraction of handgrip at 30% of MVC is considered to show adequate sympathetic response (Malik 1998). In our study, the handgrip at 12.5% of MVC produced response similar to 30% of MVC. Thus, the lower stress (12.5% of MVC) could produce the exercise pressure reflex since it increased both HR and BP significantly (Malik 1998).

In the present study, age and DBP of the females were lower than males. A multivariate regression analysis with age adjustment was performed. It showed that age did not contribute to DBP difference. The lower DBP in female is probably due to effect of estrogen. Xue et al, reviewed the central regulatory actions of estrogen on brain nuclei involved in BP. They concluded that estrogen plays an important protective role against HTN by affecting the Renin-Angiotensin-Aldosterone system (RAAS) in the CNS (Xue B et al. 2013).

Sex is known to influence CVS response in several situations. Isometric and aerobic exercise and postural changes are no exceptions (Saeki et al. 1997; Sanchez et al. 1980; Mier et al. 1996; Antelmi et al. 2004). It is now appreciated that estrogen and testosterone receptors are present in the heart and these modulate the ion channel currents. Sex genotypes also provide different phenotypic internal environment in women and men. These differences are manifested in gender related differences in function as well (Huikuri et al. 1996; Kuo et al. 1999). But in our study gender difference to this stress response is not seen (Table 4). This could be due to enrolling female in post ovulatory phase (2-4 days before menstruation) when female hormone levels are considered supposedly minimal (Hall JE, 2011).

Conclusion

The selected stress, 12.5% of MVC, elicited significant change in DBP. Therefore, it has a potential to be the minimum stress to test the cardiovascular response in handgrip test. At the given physical stress, post-ovulatory females showed change in DBP similar to males.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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