Indian J Physiol Pharmacol 2004; 48 (1) : 106–110

EFFECT OF AGE AND NUTRITIONAL STATUS ON HEART RATE RESPONSES TO COUGH AND MAXIMUM HANDGRIP

S. SUCHARITA, A. V. BHARATHI AND MARIO VAZ*

Division of Nutrition, Department of Physiology,
St. John's Medical College,
Bangalore – 560 034

(Received on April 30, 2003)

Abstract : Autonomic nerve activity can be assessed using simple bed side tests such as cough and maximum hand grip (MHG). The alterations in these tests are, however, poorly documented in physiological states. The present study aimed to uncover the effect of nutritional status and age on these tests. 93 male adults were divided into normal body mass index (BMI) (BMI; 18.5 to 25 kg/m^2; young 18–30 yrs, n=28; old >60 yrs, n=25) and low BMI (BMI; <18.5 kg/m^2; young 18–30 yrs, n=19; old >60 yrs, n=14) groups. The younger subjects showed a significantly higher heart rate response to cough and MHG in both normal and low BMI groups as compared to the older subjects (P<0.01). However, there were no significant differences for the heart rate responses to cough and MHG between the low and normal BMI groups either in the young or in the elderly. The data suggest that while the heart rate response to cough and MHG are useful tests of vagal activity to the heart when expected differences are large, they may be of limited use in uncovering more subtle changes.

Key words : cough maximum handgrip BMI age heart rate

INTRODUCTION

Cardiac parasympathetic nervous system activity (PNS) is assessed using heart rate responses to conventional tests such as Valsalva manoeuvre, postural stress and timed deep breathing (1). Less often used, are simple bedside tests like the heart rate response to cough and maximum hand grip (MHG) (2, 3). The initial chronotropic response to these tests has been shown to be vagally mediated (3, 4). While the heart rate response to cough and MHG show linear associations with conventional tests of parasympathetic nerve activity (5, 6), the magnitude of the vagal withdrawal is less compared to other tests (5). Nonetheless, the fact that these tests involve less demanding manoeuvres and can be performed in people who are bed ridden or infirm, makes them especially important to evaluate physiologically.

While the heart rate response to cough and MHG are clearly decreased in frank autonomic failure (4, 7), variations in

*Corresponding Author

physiological states are poorly documented. In this study we describe the alterations in the heart rate response to cough and MHG in two situations; the first is ageing in which cardiac PNS activity has been shown to be lowered using a variety of tests (1, 8, 9). The second is that of a lower body mass index, where there is limited data to show alterations in vagal activity (10, 11), although the direction of change has not been consistently demonstrated. The more recent data from our laboratory indicates that heart rate variability in the high frequency spectrum is lowered in chronically undernourished adults of low body mass index in whom physical activity was controlled for as a confounder. This was accompanied with a reduction in baroreflex sensitivity (11).

METHODS

Ninety three male adults were divided into normal body mass index (BMI; 18.5 to 25 kg/m^2; young 22±4 yrs, n=28; old 65±7 yrs, n=25) and low body mass index (BMI; <18.5 kg/m^2; young 22±4 yrs n=19; old 65±7 yrs, n=14) groups. Subjects who had a history of asthma, diabetes, hypertension and other cardiovascular disease and those on chronic medication were excluded from the study. All subjects were weight stable; those with a history of noticeable weight gain or weight loss over the preceding 3 months were excluded from the study. None of the subjects were current smokers and all had alcohol consumptions of less than two standard drinks per day. All subjects were studied in the fasted state, in the morning. Subjects were instructed to have their last meal prior to 9 pm on the night before experimentation and to avoid heavy physical activity the evening prior to experimentation. They were also instructed to avoid smoking and all caffeinated beverages for 12 hrs prior to the experiment. Details of the experimental procedures were outlined to all the participants, and written consent was obtained. The Ethics Review Committee of the medical college approved the study.

Heart rate responses to cough and MHG were measured after a mandatory 30 minutes rest period. ECG (Lead II, Nihon Kohden RM–6000 Polygraph system, Japan) was recorded continuously, immediately following each manoeuvre and subsequently until heart rate had returned to normal. Baseline heart rate for each manoeuvre was calculated using 10 consecutive RR intervals immediately prior to manoeuvre, while the maximal heart rate was determined by scanning the shortest RR intervals following each manoeuvre. The subsequent test was performed only after the heart rate returned to the baseline. Details of the tests are given below:-

Cough: Subjects were asked to cough maximally once. This was repeated a second time after the heart rate had returned to baseline. The increment in heart rate (maximal heart rate following cough-baseline heart rate) was used in the analysis as an index of vagally mediated withdrawal to the heart. Highest increment in heart rate was considered for analysis.

Maximum hand grip (MHG): Subjects were instructed to perform a single unsustained maximal hand grip for a brief period of 3 seconds, the immediate heart rate response to which is mediated by the parasympathetic nervous system (Smedley's Dynamometer, TTM, Tokyo). The test was performed twice. The increment in heart rate (maximal heart rate following MHG - baseline heart rate) was considered. The amount of force applied during each MHG i.e., maximum handgrip was also recorded simultaneously. Highest value between the two occasions was considered for analysis.

Statistical analysis

Data were analysed using SPSS for Windows, version 10.1. All data are expressed as mean ± standard deviation (SD). Between-group comparisons were done using a one-way ANOVA with least significant difference (LSD) as the post hoc test to determine differences between the four study groups. Since age (12) and nutritional status (13) are determinants of maximal handgrip, increments in heart rate during MHG were adjusted for the actual force applied using an ANCOVA. The Null hypothesis was rejected at $P<0.05$.

RESULTS

Table I summarises the characteristics of the study subjects. The mean height of all the four groups was comparable. Weight, midarm circumference, percentage fat and fat mass significantly higher in normal BMI group as compared to the low BMI group in both young and old subjects ($P<0.01$).

The younger age group showed a significantly higher heart rate response to cough and MHG in both normal and low BMI group compared to the corresponding old age groups ($P<0.01$). This difference persisted in case of MHG even after adjusting for amount of handgrip strength using an ANCOVA. There were, however, no significant differences for the heart rate responses to cough and MHG between the low and normal BMI groups either in the young or in the elderly. Maximal handgrip was significantly higher in the young compared to the older subjects in both normal and low BMI groups ($P<0.01$). There

TABLE I: Anthropometric characteristics of the four study groups.

	Young Normal BMI	*Young Low BMI*	*Old Normal BMI*	*Old Low BMI*
Sample size	28	25	19	14
Height (cm)	169.3±7.0	166.5±7.0	164.3±7.7	163.8±6.8
Weight (kg)	61.3±6.7	46.9±4.6*	58.7±8.2	46.2±4.5†
(BMI) (kg/m^2)	21.3±1.4	16.9±0.8*	22.1±2.7	17.2±0.7†
Body fat (%)	18.8±4.4	12.3±3.2*	27.0±5.0	16.6±4.7†
Fat free mass (kg)	49.7±5.6	41.2±4.3*	41.3±6.0	38.0±3.9
Fat mass (kg)	11.6±5.8	5.8±1.6*	16.0±4.5	7.6±2.4†
Midarm Circumference (cm)	25.9±1.8	22.4±1.7*	25.1±2.1	21.3±1.3†

Data represented as Mean ± SD, BMI = body mass index.
*$P<0.01$, young normal BMI vs young low BMI.
†$P<0.01$, old normal BMI vs old low BMI.

TABLE II : Heart rate responses to cough and maximum hand grip in the four study groups.

	Young *Normal BMI*	*Young* *Low BMI*	*Old* *Normal BMI*	*Old* *Low BMI*
Maximal increment in heart rate to cough (bpm)	24.9±9.6	25.3±7.4	11.0±4.9*	15.3±7.8†
Maximal increment in heart rate to MHG (bpm)	23.0±7.0	21.8±6.8	14.7±7.2*	15.9±7.9†
Maximal hand grip (kg)	37.1±6.5	35.0±5.8	27.3±7.5*	27.9±4.5†

Data represented as Mean ± SD, bpm = beats per minute.
*P<0.01, young normal BMI vs old normal BMI.
†P<0.01, young low BMI vs old low BMI.

were, however, no differences in the handgrip between low and normal BMI grouped at each age range.

DISCUSSION

Heart rate responses to cough and MHG are simple tests measuring cardiac vagal tone, and are particularly useful in patients who cannot perform strenous manoeuvers, as for instance the elderly (8). The mechanisms attributed to the cardioacceleration with coughing include baroreceptor (4) as well as independent pulmonary receptor-mediated effects (6). Decreased baroreceptor sensitivity with advancing age (14) may thus explain, in part, the diminished heart rate response to cough that we observed in the elderly. There were no significant differences in the heart rate responses to cough between the low and normal BMI groups either in the young or in the elderly.

Maximum handgrip is accompanied by a significant cardiac acceleration which depends on the strength of the muscle (15). Parasympathetic withdrawal is the efferent mechanism responsible for the immediate rise in heart rate that occurs in response to unsustained MHG (16, 17, 18), and possibly involves mechanoreceptor inputs from muscles that inhibit cardiac vagal activity (19). The younger age group irrespective of BMI showed a significantly higher heart rate response to MHG compared to the old age group. In the present study we noticed that a higher force was applied in the young age group. This is in keeping with data we have published earlier (12). However, differences persisted between young and older subjects even after handgrip strength was adjusted for using an ANCOVA. There were no differences in the heart rate response to MHG in low and normal BMI groups in both the young and the elderly.

Thus, while clear difference in these tests emerged with age, there were no differences with BMI. The inability of these tests to uncover differences in the BMI groups demonstrated earlier (10, 11) can be attributed to atleast two reasons. First, the extent of vagal withdrawal with these two tests of parasympathetic nervous system activity to the heart is lower than with other conventional tests (5). Subtle physiological differences may thus be more difficult to demonstrate with these tests. Second, while all cardiac parasympathetic nervous system tests involve a common efferent pathway (i.e., vagal withdrawal), the afferent pathways are varied and correlations between tests are low (5).

In conclusion, our data suggests that while the heart rate response to cough and MHG are useful tests of vagal activity, these tests did not uncover any differences between the parasympathetic control of HR in either young or elderly subjects with normal and low BMI group. Further, studies are needed to characterise the physiological variations in these tests across age ranges, gender, obesity and menstrual cycle, among others. This will allow for a clearer understanding of the utility of these simple bedside tests.

ACKNOWLEDGEMENTS

This study was funded by the Nestle Foundation, Switzerland. The authors would like to acknowledge discussions on the project that were held with the late Dr. Beat Schurch.

REFERENCES

1. O'Brien IAD, O'Hare P, Corrall RJM. Heart rate variability in healthy subjects: effect of age and denervation of normal ranges for tests of autonomic function. *Br Heart J* 1986; 55: 348–354.
2. Wei JY, Rowe JW, Kestenbaum AD, Benhaim S. Post cough heart rate response: influence of age, sex and basal blood pressure. *Am J Physiol* 1983; 245: R18–R24.
3. al-Ani M, Robins K, al-Khalidi AH, Vaile J, Townend J, Coote JH, Isometric contraction of arm flexor muscles as a method of evaluating cardiac vagal tone in man. *Clin Sci* 1997; 92: 175–180.
4. Cardone C, Bellavere F, Ferri M, Fedle D. Autonomic mechanism in heart rate response to coughing. *Clin Sci* 1987; 72: 55–60.
5. Sucharita S, Bharathi AV, Kurpad AV, Vaz M. A comparative study of tests of cardiac parasympathetic nervous activity in healthy human subjects. *Physiol Meas* 2002; 23: 347–354.
6. Leishout VE J, Leishout VJJ, Harker TAD, Wieling W. Cardiovascular response to coughing: its values in the assessment of autonomic nervous control. *Clin Sci* 1989; 77: 305–310.
7. Marin-Neto JA, Maciel BC, Gallor LJR, Junqueira JRLF, Amorim DS. Effect of parasympathetic impairment on the haemodynamic response to handgrip in chaga's disease. *Br Heart J* 1986; 55: 204–210.
8. Piha SJ. Age related diminution of the cardiovascular autonomic responses: diagnostic problems in the elderly. *Clin Physiol* 1993; 5: 507–517.
9. Srinivasan K, Sucharita S, Vaz M. Effect of standing on short term heart rate variability across age. *Clin Physiol & Func Im* 2002; 22: 404–408.
10. Vaz M, Jayarajn MP, Kulkarni RN, Balasubramanyam A, Shetty PS. Parasympathetic tone in chronic energy deficient human subjects. *Nutr Res* 1992; 12: 613–620.
11. Vaz M, Bharathi AV, Sucharita S, Nazareth D. Heart rate variability and baroreflex sensitivity are reduced in chronically undernourished, but otherwise healthy, human subjects. *Clin Sci* 2003; 104: 295–302.
12. Vaz M, Hunsberger S, Diffey B. Prediction equations for handgrip strength in healthy Indian male and female subjects encompassing a wide age range. *Ann Hum Biol* 2002; 29: 131–141.
13. Vaz M, Thangam S, Prabhu A, Shetty PS. Maximal voluntary contraction as a functional indicator of adult chronic undernutrition. *Br J Nutr* 1996; 76: 9–15.
14. Gerristen J, Tenvoorde BJ, Dekker JM, Kostense PJ, Bouter LM, Heethaar RM. Baroreflex sensitivity in the elderly: influence of age, Breathing and spectral methods. *Clin Sci* 2000; 99: 371–381.
15. Galvez JM, Alonso JP, Sangrador LA, Navarro G. Effect of muscle mass and intensity of isometric contraction on heart rate. *J Appl Physiol* 2000; 88: 487–492.
16. Martin CE, Shaver JA, Leon DF, Thompson ME, Reddy PS, Leonard JJ. Autonomic mechanisms in hemodynamic responses to isometeric exercise. *J Clin Inves* 1974; 54: 104–115.
17. Ludrock J. Reflex control of blood pressure during exercise. *Annu Rev Physiol* 1983; 45: 155–168.
18. Mitchell JH, Wildenthal K. Static (isometeric) exercise and the heart: physiological and clinical considerations. *Annu Rev Med* 1974; 25: 369–381.
19. Gladwell VF, Coote JH. Heart rate at the onset of muscle contraction and during passive muscle stretch in humans: a role for mechanoreceptors. *J Physiol* 2002; 540: 1095–1102.