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Obesity and the Activity of the Autonomic Nervous System

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Abstract: This study was conducted to examine the autonomic nervous system functions of obese people. The study group consisted of 30 healthy obese people (20 female, 10 male, age range 18-58, median 37.6±9.7 years of age) and the control group consisted of 30 healthy nonobese people (18 female, 12 male, age range 17-56, median 34.4±7.5 years). Each function was tested by non-invasive applications (orthostatic test, isometric exercise test, Valsalva ratio test, 30/15 ratio test, heart rate change test by deep respiration). The results of the orthostatic test and isometric-exercise test yielded a statistically significant difference between the study and control groups. The Valsalva ratio, 30/15 ratio, and heart rate change with deep respiration tests also demonstrated significant differences in the study and in the control group.

The results indicate characteristic hypofunctional sympathetic autonomic nervous system dysfunction in obese subjects.

Key Words: Obesity, Autonomic Nervous System.

Introduction

Despite wide fluctuations in physical activity and caloric intake, body weight remains remarkably stable over time in animals and humans, which suggests that integrative control mechanisms couple energy expenditure and food intake. A regulatory system that maintains constant energy storage is likely to involve complex interactions among humoral, neural, metabolic, and psychological factors, and it has been suggested that the Autonomic Nervous System (ANS) may be central in the co-ordination of this system (1, 2). Many experimental observations support this point of view. For example, experimentally induced ventromedial hypothalamic lesions have been found to produce a combination of decreased sympathetic activity, increased parasympathetic activity and obesity (3). In several animal models of spontaneous obesity, decreased sympathetic activity has been noted (4). Parasympathetic blockade by pharmacological means has been shown to influence thermogenesis induced by food intake, and a relation has been found between parasympathetic activity and total energy storage in humans exogenously administered sympathetic agonist has been shown to increase caloric expenditure (1).

Since the ANS is involved in energy metabolism and the regulation of the cardiovascular system (5-7), it is conceivable that one or more subgroups of persons with idiopathic obesity have an alteration in their autonomic nervous systems that may promote obesity, account for several clinical consequences of obesity or protect against certain health problems, such as sudden death or hypertension. Therefore, ANS will be taken into consideration more in the future in studies of the causes and the results of human obesity. We studied the relationship between ANS and obesity.

Materials and Methods

The study group consisted of 30 healthy obese people, 20 female and 10 male. The mean age of the subjects was 37.6±9.7 years (18-58 yrs).

Patients with the following histories were excluded from the study: alcohol use, diabetes mellitus, cardiac failure, cardiac arrhythmias, chronic obstructive lung disease, psyhiatric disorders and head trauma with concussion. In addition, patients with abnormal laboratory test results (routine blood and urine analysis) were also excluded from the study.

Thirty nonobese healthy individuals similar to the patients with regard to age and sex were selected for the control group.

Written permission was obtained from every subject before the study. Non invasive tests were conducted both in the study and control groups, in order to evaluate ANS functions in every subject.

In both groups, the orthostatic, Valsalva ratio, heart rate change with deep respiration, 30/15 ratio and isometric exercise tests were performed sequentially (7-10) in the same room with a constant temperature of 25 °C. Before the tests, all subjects rested in supine position for a minimum of 15 minutes. ECG was recorded in standard D_2 derivations. Subjects rested for a minimum of 2 minutes between tests. Blood pressure measures were taken with standard sphygmomanometer.

To detect heart rate change with deep respiration (HRCDR), heart rate was recorded first during normal respiration (at rest), and then during deep respiration (6/min). ECG 3rd and 6th respiration, minimum R-R intervals and corresponding heart rate were calculated. Maximum R-R intervals in normal respiration, and corresponding heart rate were then calculated, and the difference between both values was obtained.

Valsalva ratio: (PV/V) this is a test showing heart rate change during the Valsalva Manoeuvre (forced expiration when the glottis is closed) and gives valuable information about autonomic control of heart rate. ECG records of subjects were obtained over at least 20 sec in forced expiration with an expiration pressure of 40 mmHg after that test 20 sec normal expiration. During the test, minimal R-R intervals were measured, and after the test, maximal R-R intervals were measured. The ratio of post-test R-R interval to test R-R interval was calculated as post-Valsalva over Valsalva (PV/V).

30/15 ratio: after the subjects rose to erect posture from supine position, the 30th and 15th heart beat R-R interval was measured as corresponding heart rate ratio.

Orthostatic test: first, after the blood pressure of the subjects in supine position was measured, they suddenly rose to erect position. Starting from zero in the 1st and 2nd minutes, blood pressure was measured. Supine blood pressure levels and the lowest erect blood pressure levels were recorded (both systolic and diastolic), and differences in systolic blood pressure (SBP) levels and diastolic blood pressure (DBP) levels were calculated and the obtained values were documented in mmHg.

Isometric exercise tests: subjects performed hand grip at 30% of maximal effort capacity, for 5 minutes. Before and after the exercise blood pressures were measured, and the difference between both values was calculated.

All ECG recordings were performed by cardiofax (Nihon Kohden corporation Tokyo-Japan).

Results of the study were expressed as "mean±standard deviation" Statistical analysis was performed by Student's t-test.

Results

Some clinical characteristics of the study and of the control group are shown in Table 1.

The weight of the study group was 92.17±13.29 kg, and that of the control group was 59.70±9.06 kg. The statistically significant difference between the groups was (p<0.0001).

	Study group (n=30)	Control group (n=30)	p
Age (year)	37.6±9.7	34.4±7.5	>0.05
Weight (kg)	92.17±13.29	59.70±9.06	<0.0001
Body mass index (kg/m^2)	38.5±5.9	21.8±1.1	<0.0001
Valsalva ratio	1.39±0.33	1.18±0.25	>0.05
HRCDR	11.66±7.41	13.08±10.68	>0.05
30:15 ratio	1.04±0.72	1.08±0.26	>0.05
Orthostatic test (SBD)	16.00±6.99	2.25±4.99	<0.0001
Orthostatic test (DBD)	8.42±2.91	2.36±3.86	<0.0001
Isometric exercise test (SBD)	10.61±4.55	16.39±4.17	<0.05

Table 1. Some clinical parameters in the study and control groups.

HRCDR: Heart rate change with deep respiration, SBD: Systolic Blood Pressure differences (mmHg), DBD: Diastolic Blood Pressure differences (mmHg).

The body mass index (BMI) of the study group was 38.5±5.9 kg/m^2, and that of the control group was 21.8±1.1 kg/m^2. The statistically significant difference between the groups was (p<0.0001).

Orthostatic test: the mean SBP of the study group in supine position was 149.75±10.81 mmHg (130–170 mmHg), and that in erect position was 133.75±13.36 mmHg (105-150 mmHg). The difference between the two values was calculated as 16.00±6.99 mmHg. The mean DBE in supine position was 78.00±7.84 mmHg (70–100 mmHg), and that in erect position was 69.50±7.23 mmHg (60-90 mmHg). The difference between the two values was calculated as 8.42±2.91 mmHg.

The mean SBP of the control group in supine position was 114.25±11.84 mmHg, and that in erect position was 111.50±11.25 mmHg (80–130 mmHg). The difference between the two values was 2.25±4.99 mmHg. The mean DBP of the control group in supine position was 71.25±9.01 mmHg (50-80 mmHg), and that in erect position was 69.00±10.20 mmHg (50-80 mmHg). The diffference between the two values was 2.36±3.86 mmHg.

In erect position and supine position, the difference in SBP in the study group (16.00±6.99 mmHg) was higher than in the control group (2.25±4.99 mmHg). The difference between two groups was statistically significant (p<0.001).

In erect position and supine position, the difference in DBP in the study group (8.42±2.91 mmHg) was higher than in the control group (2.36±3.86 mmHg). The difference was statistically significant (p<0.0001).

The valsalva ratio was somewhat higher in the study group (1.39±0.33) than in the control group (1.18±0.25), although the difference was not significant (p>0.05).

The 30:15 ratio was 1.04±0.72 in the study group and 1.08±0.26 in the control group. The difference was not significant (p>0.05).

Heart rate change with deep respiration was 11.66±7.41 in the study group, and 13.08±10.68 in the control group. The difference was not significant (p>0.05).

The SBP change with isometric exercise was 10.61±4.50 mmHg in the study group, and 16.39±4.17 mmHg in the control group. The difference was statistically significant (p<0.05).

The DBP change with isometric exercise was 7.31±6.50 mmHg in the study group, 6.92±4.43 mmHg in the control group. And the difference between the values was not significant (p>0.05).

Discussion

Obesity, a common and significant health hazard, is associated with an increased incidence of hypertension, congestive heart failure, and unexplained sudden death, as well as an overall increase in mortality rate (11, 12). In the studies about the relationship between total mortality and the obesity, it is clearly seen that when the body mass index reaches 30 kg/m^2, mortality incidence increases dramatically (13). Nevertheless, the causes of most cases of human obesity are still unknown (14). Body weight and the level of stored calories in humans and animals remain constant over long periods of time, suggesting that integrative control mechanisms couple energy expenditure and food intake. A regulatory system that maintains constant energy storage is likely to involve complex interactions among humoral, neural, metabolic, and psychological factors, and it has been suggested that the ANS may be central in the coordinatiton of this system (1, 2, 15).

Orthostatic and isometric exercise tests were used in the study are for the evaluation of the sympathetic nervous system functions. Both tests showed a decrease in the hypofunctional sympathetic system. There were no statistically significant differences between the control and study groups in the results of Valsalva ratio, HRCDR and 30/16 ratio, which evaluate parasympathetic nervous system activity.

Our findings revealed hypofonctional sympathetic ANS dysfunction in the study group. In the literature, some studies have shown increased caloric expenditure by exogenously sympathetic agonist administration, parasympathetic blockade by pharmacological means has been shown to influence thermogenesis induced by food intake, and a relation has been found between parasympathetic activity and total energy storage in humans (1), and a decrease in the sympathetic activity with an increase in body fat percentage (7). With a reduction of caloric intake there can be a prompt and major decline in sympathetic activity, although an increase in sympathoadrenal activity has also been documented (16, 17). In several animal models of spontaneous obesity, decreased sympathetic activity has been noted (4). Experimentally induced ventromedial hypothalamic

lesions have produced a combination of decreased sympathetic activity, increased parasympathetic activity and obesity (3). In obese animals, the decrease in sympathetic activity may lead to an increase in hypogenesis, and a decrease in lypolisis, as well as excessive energy storage (16).

The findings of our study are similar to some human studies and obese animal models in respect to sympathetic activity decrease (1, 3, 4, 7, 16).

Sympathetic acitvity decrease may be the primary reason for excessive energy storage, or it may be the reflection of any other unknown factor of factors.

In obese persons, serious health problems may be seen if current ANS stress increases. This may not be compensated (7).

In conclusion, obesity, a risk factor for health, and its complications can be coped with by diagnosing and treting ANS dysfunction.

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