Original Article

Orthostatic hypotension before and after meal intake in diabetic patients and healthy elderly people

Tarig A. Abdel-Rahman

Physiology Department, College of Medicine, King Saud University, Riyadh, Saudi Arabia

Address for correspondence: Prof. Tarig Ahmed Abdel-Rahman, Physiology Department, College of Medicine, King Saud University, P.O. Box 2925, Riyadh 11461, Saudi Arabia. E-mail: tatarig36@gmail.com

ABSTRACT

Objectives: The symptoms of orthostatic hypotension may be ignored or go unnoticed and may predispose some diabetic or elderly people to repeated falls and trauma, leading to immobility and prolongation of rehabilitation. The present investigation is concerned mainly with testing the reaction of the cardiovascular system in response to physiological stimuli, such as, standing upright from a supine position before and after meal intake in diabetic patients and the healthy Saudi population. **Materials and Methods:** Seventy-five healthy and 49 diabetic patients were selected for this study. Parameters of heart rate, systolic and diastolic blood pressures, and electrocardiograms (ECG) were obtained for each subject by Dinamap (an automatic recorder), after 10 minutes of rest in the supine position and then after one and two minutes of standing. All parameters were taken before and after an intake of a standard meal. The results were compared between the diabetic and non-diabetic groups, and between the elderly diabetic and the healthy elderly ≥ 65 year olds, and between the young adults ≤ 40 year olds and the elderly ≥ 65 year olds. **Results:** The postural changes of blood pressure and heart rate between the diabetic and non-diabetic groups, and between the elderly diabetic and the healthy elderly groups, were not significant. However, a highly significant postural drop in blood pressure, and an increase in the resting heart rate were recorded before and after a meal intake in the elderly compared to the young adults. **Conclusion:** The highly significant postural drop in blood pressure and increase in the resting heart rate in the elderly diabetic and healthy elderly people can be attributed to a defect in the arterial baroreceptors control of blood pressure and parasympathetic control of heart rate in this population.

Key words: Blood pressure, diabetic, elderly, heart rate, orthostatic hypotension

INTRODUCTION

The autonomic nervous system regulates vital body functions, and it is an essential system for the maintenance of normal homeostasis. Autonomic dysfunctions involving different systems in the body are more common and well-recognized features in the elderly. Cardiovascular reflexes are seen to change with aging, including respiratory sinus arrhythmia,[1] vagal baroreflex responses, cardiopulmonary reflexes, facial cooling, bradycardia, and cold pressor reflexes.[2-4] Progressive autonomic dysfunctions with aging are recognized features, and they can occur in diabetic patients.[5,6]

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In animal studies, arterial baroreflex control of the heart rate, renal sympathetic activity, and arterial blood pressure were all significantly diminished in older animals, and this was shown to represent a defect in control of both parasympathetic and sympathetic supply of the baroreflex.[6]

Reactions of the cardiovascular system to physiological stimuli such as taking a meal or standing upright differ in the elderly compared to the young people, partly because age modifies the balance between the parasympathetic and sympathetic control systems.[7] Impairment of thermoregulation in the human elderly was demonstrated by decreased sweat output, reduced size of the glandular acini, and reduced density of the periacinar sympathetic nerves.[8] Similar changes were found in the eccrine sweat glands of the rat foot pad.[9]

Orthostatic and postprandial hypotension is a physical finding, not a disease, which may be symptomatic or asymptomatic. It can occur in all age groups, but is more frequent in the elderly than in the young or middle-aged groups.[10] It is defined as a decrease in systolic blood pressure of at least 20 mmHg, or a decrease in diastolic blood pressure of at least 10 mmHg, within three minutes of standing.[11] Autonomic control of cardiovascular responses to postural changes in older individuals is of considerable importance in helping to assess the cardiovascular potential in the elderly. Diseases that may decrease cerebral blood flow, like hypertension, diabetes mellitus, heart disease, and hyperlipidemia are more frequent in the elderly, which make them more vulnerable to cerebral ischemia and syncope if their blood pressure decreases. The symptoms of hypotension may go unnoticed or ignored and they may lead to repeated falls and trauma, in addition it may lead to psychological loss of confidence causing immobility and prolongation of rehabilitation and sometimes to depression. Little is known about the incidence of orthostatic hypotension in the Saudi Arabia population. The present investigation is concerned mainly with establishing and confirming this problem as one of an important autonomic cardiovascular reflex in the elderly and diabetic Saudi population.

MATERIALS AND METHODS

Dinamap (an Automatic blood pressure and heart rate recorder), which can also monitor subcutaneous oxygen tension (SPO_2), the respiratory rate, and record an ECG rhythm, and not a full 12 lead ECG, was used in this study. This machine resolved many of the problems of blood pressure recording, including observer bias.

We excluded from our study the elderly individuals of more than 70 years, and those subjects with a history of cardiovascular disease, like supine hypertension or heart failure or those with other major illness, or those using vasodilator drugs. We included in our study all those volunteers, who were reasonably healthy, or those who were only suffering from diabetes. The research was approved by the Department Research Committee, and by the College Ethical Committee. The nature of the test was explained to all the subjects after their consent was obtained and before their participation in the study.

Forty-eight diabetic patients were selected from the Outpatient Clinic of the King Khalid University Hospital, 24 were elderly diabetic patients ≥ 65 years old, and 24 were young diabetic adults ≤ 40 years old. Both groups were attending the Outpatient Clinic regularly for at least two years. Seventy-five healthy elderly and young adults from King Saud University employees volunteered for this study. Each subject attended the laboratory, three hours after a light breakfast. Subjects rested supine for at least 10 minutes. Then parameters of heart rate, systolic, diastolic, and mean blood pressure, and ECG, were recorded by the Dinamap. Those readings were taken after resting for 10 minutes in the supine position, and then after one and two minutes of standing upright from the supine position. Subsequently, a standard meal was provided to each subject, and after 45 minutes all parameters were recorded by the Dinamap, after 10 minutes in the supine position, and then after one and two minutes of standing in the upright position. All the subjects were able to perform the standing test without much difficulty.

Statistical methods

The subjects were divided into two age groups. Elderly subjects ≥ 65 years old, and young adults ≤ 40 years old. Comparative studies were made between three different groups: The diabetic and healthy group, the elderly diabetic and healthy elderly group, and between the elderly and young adults.

We used the student t-test for matched pairs to compare each variable in the supine position with the standing position in the two groups.

We also used the student t-test for independent groups, to compare each variable between the diabetic group (n = 48) and healthy group (n =75), between elderly diabetic (n = 24) and healthy elderly (n = 30), and between the elderly (n = 54) and young adults (n = 69), in the supine and standing positions, before and after meals.

We also studied the changes in systolic and diastolic blood pressures from the supine position to the standing position before and after meals, and we compared the changes between the elderly and young adults.

We used the SPSS statistical package version 10.01 for data analysis. The results were expressed as mean values ± standard deviation.

RESULTS

The physical characteristics of the diabetic and healthy groups are shown in Table 1. The mean heart rate, systolic and diastolic blood pressures in the supine and standing positions were comparable between the diabetic and healthy groups, with no significant differences between all variables [Table 2]. When comparing the elderly diabetic with the healthy elderly ≥ 65 year olds also, there were no significant differences between all variables before and after a meal [Table 3].

Table 1: Physical characteristics of the diabetic and healthy groups, Mean + SD

Variables	Diabetic group n = 48	Healthy group n = 75	*P* value
Age (Years)	54.6 + 14.7	45.1 + 19.1	< 0.004
Weight (Kgs.)	82.2 + 14.7	77.8 + 13.2	N S
Height (cm)	161.5 + 8.3	163.9 + 8.4	N S

Table 2: Systolic, diastolic blood pressures, and heart rate in the supine (SP) and standing (ST) positions before and after meal in the diabetic and healthy groups, Mean + SD

Variables	Before meal			After meal		
	Diabetic group N = 48	Healthy group N = 75	*P* value	Diabetic group N = 48	Healthy group N = 75	*P* value
Heart rate (SP)	82.4 + 10.6	79.8 + 11.8	NS	82.5 + 9.5	80.4 + 10.3	NS
Heart rate (ST)	85.8 + 9.1	83.1 + 10.7	NS	86 + 8.6	83.8 + 9.5	NS
Systolic BP (SP)	146.7 + 25.7	141.5 + 23.2	NS	143.9 + 21.7	140.7 + 20.2	NS
Systolic BP (ST)	131.2 + 19.2	129 + 15.0	NS	129.4 + 16.3	129.2 + 12.8	NS
Diastolic BP (SP)	78.7 + 8.3	76.9 + 7.9	NS	78.3 + 8.2	76.2 + 7.4	NS
Diastolic BP (ST)	75.6 + 9.2	74.5 + 7.9	NS	75.2 +7.2	74.3 + 6.4	NS

Table 3: Systolic, diastolic blood pressure and heart rate in the supine (SP) and standing (ST) positions before and after a meal in the elderly diabetic and the healthy elderly groups (≥ 65-years old), Mean + SD

Variables	Before meal			After meal		
	Elderly diabetic group N = 24	Healthy elderly group N = 30	*P* value	Elderly diabetic group N = 24	Healthy elderly group N = 30	*P* value
Heart rate (SP)	89.5 + 8.2	92.4 + 6.7	NS	88.1 + 9.1	91.4 + 7.1	NS
Heart rate (ST)	91.7 + 7.4	94.4 + 6	NS	91 + 7.8	93.6 + 5.7	NS
Systolic BP (SP) mmHg	160.7 + 25.8	162.1 + 23.8	NS	153.9 + 23.6	156.8 + 21.9	NS
Systolic BP (ST) mmHg	134.9 + 20.5	132 + 18.9	NS	131 + 19.2	128.8 + 18	NS
Diastolic BP (SP) mmHg	80.6 + 8.3	80.9 + 7.8	NS	80.5 + 8.5	80.2 + 8.2	NS
Diastolic BP (ST) mmHg	75.8 + 10.2	74.0 + 10.0	NS	75.8 + 7.8	76.3 + 7.6	NS

Table 4: Physical characteristics of young adults and elderly group, Mean + SD

Variables	Young adults < 40 years old n = 69	Elderly group > 65 years old n = 54	*P* value
Age (Years)	28.6 + 7.6	67.9 + 2.4	< 0.0001
Weight (Kgs)	75.7 + 12.9	81.6 + 15.5	N S
Height (cm)	166.6 + 7.3	161.5 + 9.0	< 0.0003

The physical characteristics of the elderly group ≥ 65 years old (n = 54), and the young adults ≤ 40 years old (n = 69) are shown in Table 4.

When comparing the elderly group ≥ 65 years old (n = 54), with the young adults ≤ 40 years old (n = 69), the mean resting heart rate was significantly high (P < 0.0005) in the elderly group, compared to the young adults, in the standing or supine positions, both in the pre-meal and postprandial periods [Table 5]. The mean systolic and diastolic blood pressures were significantly high in the elderly (n = 54), compared to the young adults (n = 69), in the supine position, both in the pre-meal and post-prandial periods ($P < 0.0006$), [Table 5].

Comparisons between the mean postural changes in systolic and diastolic blood pressures from the supine position to the standing position in the elderly group compared to the young adults were highly significant ($P < 0.0004$), both in the pre-meal and postprandial periods [Table 6].

DISCUSSION

The mean heart rate and systolic and diastolic blood pressures were comparable and they showed no significant differences between the diabetic (n = 48) and the healthy (n = 75) groups, and also between the elderly diabetic

Table 5: Systolic, diastolic blood pressures, and heart rate in the supine (SP) and standing (ST) positions before and after a meal in the young adults ≤ 40 years old and the elderly group ≥ 65 years old, Mean + SD

Variables	Before meal			After meal		
	Young adults N = 69	Elderly group N = 54	*P* value	Young adults N = 69	Elderly group N = 54	*P* value
Heart rate (SP)	72.3 ± 6.1	91 ± 7.5	*P* < 0.0004	74.6 ± 6.1	89.6 ± 8.2	*P* < 0.0004
Heart rate (ST)	76.8 ± 5.8	93.1 ± 6.8	*P* < 0.0005	78.5 ± 5.8	92.3 ± 6.9	*P* < 0.0005
Systolic BP (SP) mmHg	129.2 ± 9.4	161.4 ± 24.5	*P* < 0.0006	130.4 ± 9.4	155.4 ± 22.6	*P* < 0.0006
Systolic BP (ST) mmHg	126.6 ± 9.4	133.4 ± 19.5	NS	129 ± 9.4	129.9 ± 18.4	NS
Diastolic BP (SP) mmHg	74.2 ± 6.1	80.8 ± 8.0	*P* < 0.0008	73.8 ± 6.1	80.3 ± 8.3	*P* < 0.0008
Diastolic BP (ST) mmHg	75.0 ± 5.8	75.3 ± 10.0	NS	74.0 ± 5.8	76.3 ± 7.6	NS

Table 6: Mean postural changes in systolic and diastolic blood pressures before and after meal in the young adults < 40 year olds (n=69), and the elderly group > 65 year olds (n=54), Mean + SD

Variables	Groups	Mean changes + SD	*P* value
Systolic BP before meal (mmHg)	Young	2.6 + 0.8	< 0.0004
	Elderly	28 + 1.7	
Systolic BP after meal (mmHg)	Young	1.4 + 0.8	< 0.0004
	Elderly	25.5 + 1.4	
Diastolic BP before meal (mmHg)	Young	- 0.7 + 0.5	< 0.0004
	Elderly	5.5 + 0.7	
Diastolic BP after meal (mmHg)	Young	- 0.29 + 0.6	< 0.0004
	Elderly	4.3 + 0.8	

(n = 24) and the healthy elderly (n = 30) groups, before and after meal intake. However, both elderly groups showed a drop in mean systolic blood pressure on standing, of more than 20 mmHg, which confirmed the conclusions of other studies.[12,13] The reported drop of more than 20 mmHg in the mean systolic blood pressure on standing observed in the two elderly groups in our study did not correlate well with diabetes mellitus, which is a known risk factor of orthostatic hypotension,[5,14-16] but it did correlate well with aging, as it is noted in [Tables 3,5, and 6]. In our study, we were not able to demonstrate any significant postural hypotension in the diabetic patients, when comparing them with the healthy subjects [Table 3]. This may be attributed to a better control of diabetes in our patients, who were regularly attending the Outpatient Clinic. They were University employees, expected to be more oriented in their health problems, and for that reason diabetes was not complicated by autonomic neuropathy. However, that finding may not represent the postural changes of diabetes in the general population.

To show further, the effects of aging in our study, we compared the mean supine and standing heart rate and systolic and diastolic blood pressures between the young adults ≤ 40 years old (n = 69), and the elderly group ≥ 65 years old (n = 54), before and after a meal. The results showed a highly significant postural drop in the mean systolic blood pressure of the elderly subjects, compared to a very small and insignificant drop in that of the young adults, as shown in Tables 5 and 6, ($P < 0.0004$). The drop in systolic blood pressure in the elderly group confirmed the conclusions of several other studies.[10,17-19] Up to about 30% of the elderly subjects were reported to experience a significant drop in systolic blood pressure on standing.[12]

The mean postural drop in systolic blood pressure in the elderly group in our study ranged between 25 and 28 mmHg. [Table 6], which was greater than those changes reported in the literature.[20,21] That difference may be attributed to variations in standardization of procedures, and may also be due to the higher environmental temperature in our area, compared to those areas where previous studies in the literature were conducted. The increased activity of the sweat glands at higher environmental temperatures may contribute to greater postural changes in blood pressure.

The reported increase in heart rate on standing was less and insignificant in our elderly group compared to the young adults. The increase of heart rate on standing was related to changes in the plasma norepinephrine level,[22] and that increase was not found in some patients with orthostatic hypotension.[23] Our study also demonstrated a higher resting heart rate in the elderly group ≥ 65 years old, compared to the young adults ≤ 40 years old, both in the supine and standing positions, as shown in Table 5. It was reported that heart rate variability diminished with

advancing age, by using Power Spectral Analysis.[24] The decreased compliance of the baroreceptors, which were responsible for correction of rapid changes in BP, were impaired.[2,3] That impairment was mainly explained by arteriosclerosis, leading to loss of elasticity in the arterial walls with aging, and the loss of baroreflex sensitivity could be explained by changes in the arterial distensibility.

Our investigation demonstrated a defect in the reaction of the cardiovascular system in response to physiological stimuli, such as, standing upright or taking a meal, in the elderly group compared to the young adults. That defect was shown by a significant drop in the mean systolic blood pressure on standing, and by the relatively high mean resting heart rate in the elderly group. These findings were consistent with several previous studies on changes in cardiovascular reflexes with aging.[1,3,12,13] The significant drop in systolic blood pressure observed in our elderly subjects was generally asymptomatic, however, that did not exclude the symptoms that occurred in the same individual at different times of the day. It was reported that a decrease in blood pressure following an upright tilt was a useful predictor of falls in older people.[25]

Autonomic cardiovascular dysfunctions, particularly orthostatic hypotension should be considered seriously in all elderly people, particularly those at risk, for example, those with supine hypertension or those using vasodilator drugs. Elderly people should be advised to exercise caution and slow the process of changing positions from lying to sitting to standing. They should also be advised to take small frequent meals to reduce postprandial hypotension. The floors and stairs of the house should not be slippery, and loose rugs should not be used in the house, and light should be sufficient to reduce the possibility of fall, and they should not use inappropriate footwear. Blood pressure should be measured routinely in the supine and standing positions for all elderly people, to check for possibility of postural hypotension. These preventive measures may reduce the risk of the clinical outcome of postural hypotension, like dizziness or falls and fractures, which may lead to prolonged rehabilitation, and increase morbidity and mortality in the elderly.[26]

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