Gender and age differences in cardiovascular reflexes in response to upright tilting

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Summary:

Background: *the integrity of cardiovascular reflexes & autonomic activities can be assessed by different tests and different techniques. However most of these studies carried out on male subject & usually on young group only .very little researches available concerning the differences in cardiovascular reflexes between male & female in different age group.*

Aim of study: *is to investigate the differences in cardiovascular reflexes in young , old male & female in response to go head up tilting using totally non- invasive system .*

Sub. & Methods: *this study was carried out in AL-Najaf teaching hospital on 85 normal sub. , 41 males & 44 females they were divided into two age groups (20-40 years) & (41-60 years) for both sex. The blood pressure was measured by sphygmomanometer (BP) cardiac out put (Co) measured by Echocardiography technique, heart rate by ECG & the peripheral vascular resistance was measured by dividing the (BP) over (Co) according to Ohm's law . All these measurements were first made in supine position at a study state & then all the measurements were repeated on 60' head up tilting.*

Results: *the results indicate that there was a significant difference between the two sexes in both age groups by using this totally non – invasive system to measure all the above mention homodynamic variables.*

Conclusion: *this study provided great advantages for the investigation of abnormal cardiovascular reflexes in patients with orthostatic postural hypotension on the detection of some autonomic dysfunction or in case of prolonged bed rest after post operative surgery.*

Introduction

The integrity of cardiovascular reflexes and autonomic activities can be assess by different tests and different techniques such as changing of posture from the supine to the standing position(1), using tilting table(2,3), lower body negative pressure (LBNP)(4,5), immersion in water(6,52), exercise by treadmill or bicycle ergometer(7,8,58), or study the carotid baroreflex by neck suction(9,10), or by injection of vasoactive drugs(53) or by electrical stimulation of the carotid sinus nerve(54) combination of LBNP and neck suction(11,25,57), combination of upright tilting and neck suction(12) or using various tests for the investigation of autonomic dysfunction and abnormal cardiovascular reflexes such as valsalva maneuver(13,14,55), or using other tests like cold pressor, stressful mental arithmetic, reflex sweat test and hyperventilation.(25,55)

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However most of these studies carried out on male subjects and usually on young group only moreover a very little researches available concerning the differences in cardiovascular reflexes between male and female in different age groups and since the changing of body posture provide a very sensitive orthostatic test for vasomotor function.(1) Therefore the aim of this study is to investigate the differences in cardiovascular reflexes in young, old male and female in response to 60° head up tilting using totally non-invasive system.

Material and Method:

The study was carried out in Al-Najaf teaching hospital, involve (85) subjects, (41 male and 44 females), they are divided into two age groups, young age group (20-40 years) and old age group (41-60 years) for both sex.

Each subject was placed on tilting table provide with foot plat for weight supports for 5-10 minutes steady state, (steady state: mean the HR in consecutive minutes changing by less than three beat/mintus)(15), the blood pressure measured by sphygmomanometer hold with stand move up and down according to level of subject as recommended by British hypertension society (BHS) was taken, the systematic and random errors of this device was previously evaluated.(16) The mean blood pressure (BP) is calculated as diastolic pressure + 1/3 of plus pressure (difference between systolic and diastolic pressures).(17) The cardiac output (CO) was calculated by M-mode echocardiography which was evaluated by many investigators.(15,18) The peripheral vascular resistance (PVR) calculated as mean BP divided by cardiac out put (CO).(19) heart rate (HR) was calculated from ECG. The subject then passively manually tilted by 60° head up tilt and the same procedure repeated after 5-10 minutes of steady state.(15)

Stastical analysis: the difference between supine and tilting position will compared for both sex by using paired techniques test and the difference between two different groups of supine and upright tilting was compared by using non-paired techniques test the differences were considered significant if P<0.05. Also the significance level were determined between young male & female and also old male & female in both the supine position (control) and in the responses to upright tilting.

The anthropometric data of subjects including body surface area (BSA) and body mass index (BMI) are presented in table (1.a ,1.b).

BSA: was calculated according to formula of Dubois(20) and BMI: was calculated by dividing the weight (Kg) by the square height (M2).(21,22)

Table (1.a): Anthropometric data for young male and female.
value is a mean ± SD

Anthropometric data	Young male N= 24(28.2%)	Young female N= 24(28.2%)
Age range (years)	20 - 40 years	20-40 years
Mean age ± SD (years)	30.08 ± 6.22	32.79 ± 6.74
Mean weight ± SD (Kg)	75.29 ± 11.53	69.83 ± 13.84
Mean height ± SD (cm)	172.87 ± 9.14	161.87 ± 7.04
Body surface area (BSA)±SD(m^2)	1.871 ± 0.157	1.708 ± 0.172
Body mass index (BMI) ±SD (kg/m^2)	26.02 ± 4.63	26.74 ± 5.79

Table (1.b): Anthropometric data for old male and female
value is a mean ± SD

Anthropometric data	Old male N= 17(20 %)	Old female N= 20(23.5 %)
Age range (years)	41 - 60 years	41 - 60 years
Mean age ± SD (years)	49.7 ± 5.7	49.85 ± 6.16
Mean weight ± SD (Kg)	73.8 ± 15.08	76.25 ± 10.17
Mean height ± SD (cm)	171.17 ± 8.57	160.25 ± 7.34
Body surface area (BSA)±SD(m^2)	1.81 ± 0.20	1.82 ± 0.19
Body mass index (BMI) ±SD (kg/m^2)	25.18 ± 4.9	29.02 ± 3.1

Rersult:

Differences in the Control (Supine) values of haemodynamic variables and the responses to 60° head-up tilting in young male and young female age groups:

On comparison between young male and young female age group concerning the control (supine) values of haemodynamic variable the result indicates that there are significant decrease in diastolic, mean BP and cardiac output with a significant increase in heart rate and peripheral vascular resistance in the young female comparing to that of the young male.

However, no significant difference have been found in the control systolic BP value as shown in table (2.a) and figures.(1,3,4,5)

On comparison of the cardiovascular responses between the young male and young female age groups, indicate that there are significant decrease in the responses of diastolic and mean BP with a significant increase in responses of heart rate, cardiac output and peripheral vascular resistance in the young female than that of the young male age groups.

Whereas there is no significant difference in the responses of systolic BP between the two age groups as shown in table (2.b) and figures.(2,3,4,5)

Table (2.a): Differences in the control (supine) haemodynamic variables and the responses to young male and young female groups.
Value is mean ± SD

Haemodynamic variable	Young male N= 24(28.2%)	Young female N= 24(28.2%)	P values
SBP (mmHg)	120.4 ± 10.6	117.0 ± 5.0	P>0.5
DBP (mmHg)	75.2 ± 5.9	71.2 ± 4.7	P>0.02
MBP (mmHg)	90.2 ± 6.9	86.4 ± 4.1	P>0.05
HR (b/min)	75.4 ± 4.3	78.0 ± 5.8	P>0.05
CO (L/min)	5.5 ± 0.5	5.0 ± 0.7	P>0.001
PVR (unit)	16.2 ± 1.8	26.74 ± 5.79	P>0.05

Table (2.b): Anthropometric data for old male and female.
Value is a mean ± SD

Haemodynamic variable	Young male (Difference)	Young female (Difference)	P values
SBP (mmHg)	3.3 ± 7.7	3.5 ± 6.8	P>0.5
DBP (mmHg)	8.3 ± 2.4	6.4 ± 2.7	P>0.02
MBP (mmHg)	4.8 ± 3.0	3.3 ± 2.3	P>0.05
HR (b/min)	9.1 ± 2.0	10.7 ± 2.2	P>0.05
CO (L/min)	1.0 ± 0.2	1.2 ± 0.4	P>0.001
PVR (unit)	5.2 ± 1.7	6.9 ± 2.7	P>0.05

Figure 1: Control values of blood pressure (systolic, diastolic and mean pressure) of young male and young female.
****p<002 *p<0.05.**

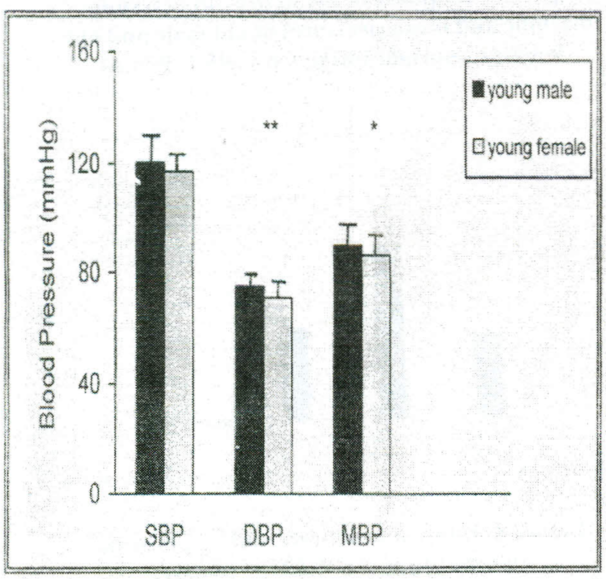


Figure 2: Response of blood pressure (systolic, diastolic and mean pressure) of young male and young female to upright tilting * p<0.01.

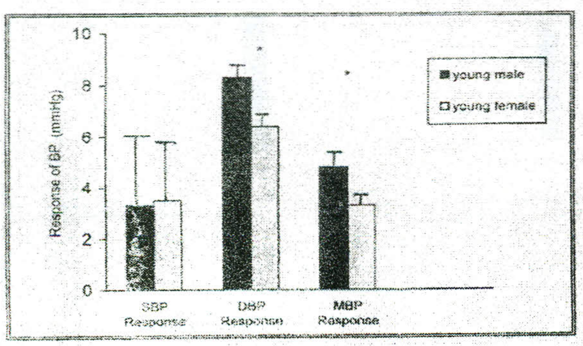


Figure 3: Control heart rate and response of young male and young female to upright tilting. *P<0.05, **P<0.01.

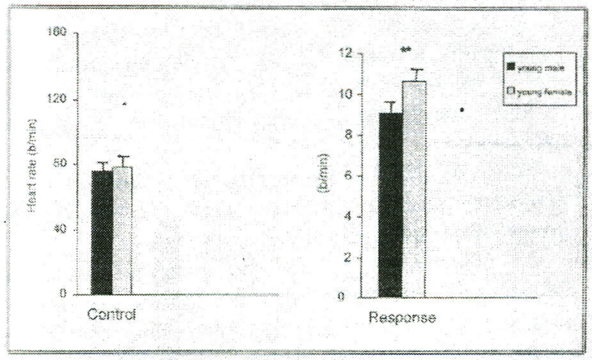


Figure 4: Control cardiac output and response of young male and young female to upright tilting *p<0.05, ** p<0.01.

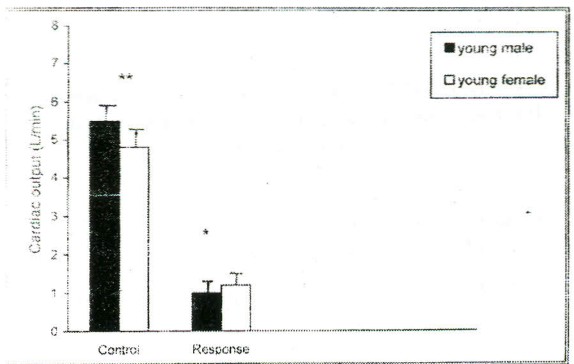
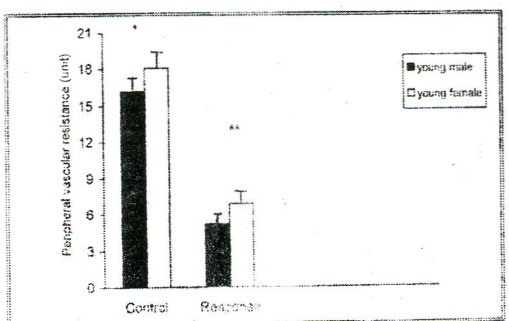


Figure 5: Control Peripheral vascular resistance and response of Peripheral vascular resistance of young male and young female to upright tilting. * p<o.05 *P<o.o1



Differences in the control (supine) values of haemodynamic variables and the responses to 60° head-up tilting in old male and old female age groups:

On Comparison between old male and old female age groups concerning the control (supine) values of haemodynamic variables indicate that the systolic, diastolic, mean BP and cardiac output are significantly lower in the old female age group than that of the old male, but there is significant increase in heart rate in the old female than that of old male age group.

However, there is no significant difference in the peripheral vascular resistance between the two age groups as shown in table (3.a), figures.(6,8,9,10)

On Comparison of the cardiovascular responses between the old male and old female age groups indicate that, there are a significant increase in the responses of heart rate cardiac output and peripheral vascular resistance in old female when compared with that of the old male age groups.

Whereas there are no significant differences in the responses of the systolic, diastolic and mean BP between the two age groups as shown in table (3.b) and figures.(7,8,9,10)

Table (3.a): Differences in the control values of haemodynamic variables in old male and old female groups.
Value is mean ± SD

Haemodynamic variable	Old male 17(20%)	Old female 20(23.5%)	P values
SBP (mmHg)	128.2 ± 9.0	123.2 ± 4.0	P>0.5
DBP (mmHg)	80.8+5.0	76.5±6.9	P<0.05
MBP (mmHg)	96.6±4.7	90.7±6.1	P<0.001
HR (b/min)	[illegible].3±5.2	[illegible]9±4.2	P<0.02
CO (L/min)	4.5±0.6	4.2±0.4	P<0.001
PVR (unit)	[illegible]	21.2±2.1	P>0.5

Table (3.b): Differences in haemodynamic responses in old male and old female group.
Value is mean± SD

Haemodynamic variable	Old male (Difference)	Old female (Difference)	P values
SBP (mmHg)	3.2 ± 6.1	4.5 ± 8.7	P>0.5
DBP (mmHg)	6.7 ± 6.6	7.2 ± 4.4	P<0.5
MBP (mmHg)	3.4±5.1	4.1±4.1	P>0.5
HR (b/min)	6.9±3.3	8.3±2.1	P<0.01
CO (L/min)	0.51 ± 0.13	0.74 ± 0.24	P<0.001
PVR (unit)	3.8±1.6	5.6±2.3	P<0.001

Figure 6: Control values of blood pressure (systolic, diastolic and mean pressure) of old male and old female
***p<0.05, ** p<0.01.**

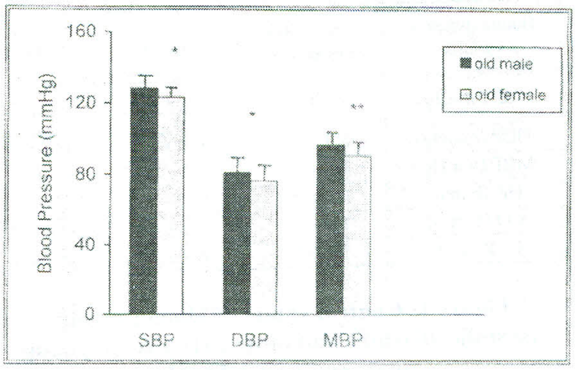


Figure 7: Response of blood pressure (systolic, diastolic and mean pressure) of old male and old female to upright tilting.* p<o.05 **P<o.o1

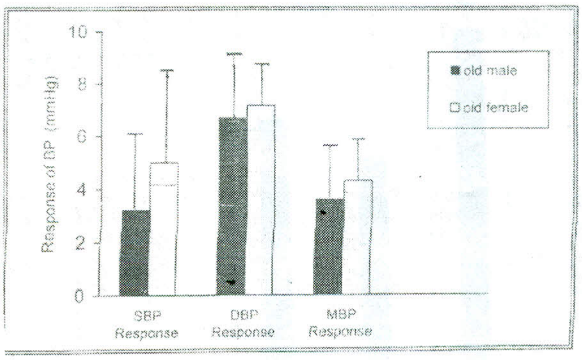
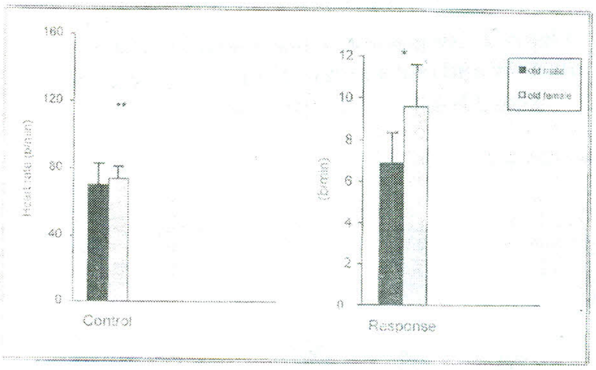


Figure 8: Control heart rate and response to upright tilting. *p<0.02, ** p<0.01.



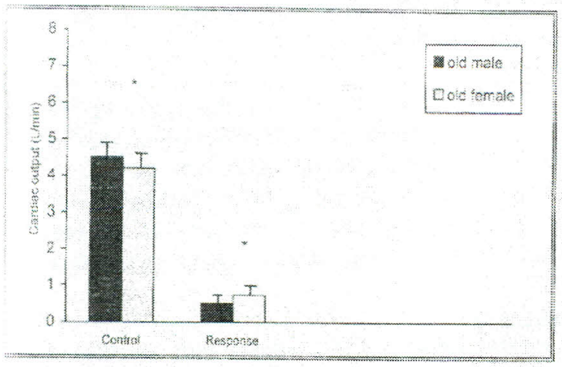


Figure 9: Control cardiac output and response of old male and old female to upright tilting *P<0.001.

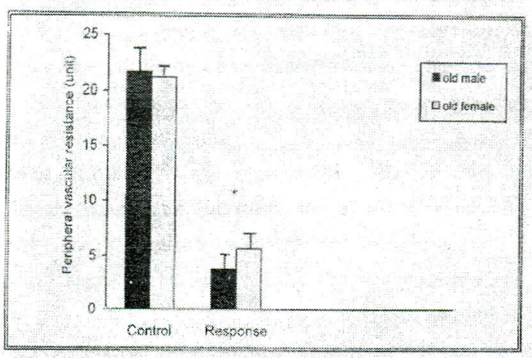


Figure 10: Control and response of Peripheral vascular resistances of old male and old female to upright tilting. *P<0.001.

Discussion:

The integrity of the cardiovascular reflexes can be investigated by dfferent stressful test and the most important sensitive test is to use the tilt table(2,3) which is considered to be the most important orthostatic stress test to assess vasomotor function and even to assess the autonomic dysfunction(13,14,51,55) in this study upright tilting by 60° is preferable test for cardiovascular reflexes to active standing because standing involves muscular activity of variable degree moreover using 60° angle of tilt because the vertical displacement by a 60° tilt proportional to sin 60 is approximately 90% of maximum displacement on fully upright tilting(2,23,25) in addition passive upright tilting or free standing unlike active standing there is no significant increase in oxygen consumption in relation to supine position(24,25) for these reasons upright tilting is a more stressful test than the active standing(25) in this study a totally non-invasive techniques are used for the assessment of blood pressure (BP), cardiac output (CO), heart rete (HR) and peripheral vascular resistance (PVR) because using a non-invasive technique in such study will avoid syncopal attack which may take place in invasive technique due to complicated instrumentation and catheterization which are often used for continuous blood sampling e.g. for estimation of cardiae output or intra-arterial catheterization for measurement of direct blood pressure, farther more usually the invasive technique is un acceptable for normal or patients individuals(26), in addition it may cause different psychological and physiological disturbances which might interfere with such stressful test(25).

The anthropometric data of the subject groups in this study table (1.a,b) a relationship have been made between cardiac index and the age of all the groups (male and female) the result shows a positive relationship as it was reported previously.(50)

However, in this study a negative relationship have been reported between cardiac output and body mass index and also a negative relationship reported between cardiac output and body surface area although other study have reported a positive relationship between the cardiac output and Body mass index and between the cardiac output and body surface areas.(44)

Haemodynamic reflex response in young and old male or female age groups to upright tilting:

The cardiovascular reflexes in response to upright tilting in this study as shown in figs.(1-5) for young age groups and figs. (6-10) for old age groups indicate that there are significant increases in diastolic blood pressure (DBP), mean blood pressure (MBP), heart rate (HR) and peripheral vascular resistance (PVR) which are in agreement with other Investigators.(5,25,27,28,29,30) The most likely reason of the changes in these haemodynamic variables in responses to upright tilting is that mainly due to increase sympathetic outflow by the effect of baroreflex activation due to pooling and redistribution of blood from the upper to the lower part of the body (central hypovolemia) resulted in a reflex tachycardia and vasoconstriction in order to maintain a normal blood pressure(23,31,32,33)

The systolic blood pressure (SBP) is significantly decreased in upright tilting in all age groups, this result is in agreement with another previous study(30,34) while others(27,28) found little decrease in SBP in upright tilting, other investigators(35) found that the SBP was the same as in supine and upright posture. However, the decrease in SBP may be due to decrease CO since the BP is the product of CO and PVR.(36,37)

However despite reflex tachycardia and vasoconstriction the value of CO was found to be lower in the upright position than the supine position due to the fact that some of the pooled blood will be accommodated in the lower extremities in upright position resulting in a decrease in venous return, decrease stroke volume and decrease CO(25,38,39)

Differences in the control haemodynamic variables and the responses to 60° head-up tilting in young male and young female groups, tables (2.a,b),figs (1-5):

Blood Pressure:

The result indicates that the control values of DBP and MBP were significantly lower in young female with no significant difference in SBP, the same changes were found with responses to upright tilting which may be due to less physical effort, less dynamic exercises, less body fluid and electrolyte and less autonomic activity in female.(36,40)

Heart Rate:

The control value of HR is significantly higher in young female than young male also there is a significant increase in the responses of HR to upright tilting, this finding is similar to other observation.(23,41) The cause of increase in HR in young female than young male may be due to greater decrease in thoracic blood volume in female than male and therefore greater activation of sympathetic system.(38)

Cardiac Output:

The control value of CO is significantly lower in young female than young male which is most likely due to less body surface area (male is heavier and taller than female), less metabolic rate in the female.(42,43,44)

The responses of CO is significantly higher in young female than young male due to greater decrease in venous return and left ventricular end diastolic volume because of higher pooling of blood due to greater thoracic blood shifting to lower extremities in female.(38)

Peripheral Vascular Resistance:

The control value of PVR and responses to upright tilting is significantly higher in young female than young male because of lower value of CO in female since PVR equal to BP/CO, therefore PVR is higher in the female.(38) However, other investigator(45) reported greater increase in PVR in men than the women. While other(38) found greater increase of PVR in elderly than young and more in women than the men this may be due to greater activation of sympathetic system and greater vasoconstrictions which take place later on.

Differences in the control haemodynamic variables and the responses to 60° head up tilting in old male and old female age groups. Tables (3. a,b) and figs. (6-10):

Blood Pressure:

The control values of systolic, diastolic and mean BP are significantly lower in old female which may be due to less physical activity and effort, less dynamic exercises, less body fluid and electrolyte in female.(36,40) But there are no significant differences in the responses of SBP, DBP and MBP to upright tilting which may be due to attenuated autonomic nervous system in elderly age.(46,47)

Heart Rate:

The control value of HR and the responses to upright tilting was found to be significantly higher in old female than the old male which may be due to greater decrease in thoracic blood volume with upright position in female resulted in higher sympathetic activity and greater vagal withdrawal effect.(38)

Cardiac Output:

The control value of CO is significantly smaller in old female than old male similar to that in the young female and young male.(42,44) Also, there is a significant increase in responses of CO to upright tilting in old female than old male which may be due to greater blood pooling in female due to greater thoracic blood volume shifted to lower extremities in female.(38)

Peripheral Vascular Resistance:

The control value of PVR showing no significant difference between old male and old female, but there is significant increase in response of PVR to upright tilting in old female, this may due to greater sympathetic activity and more vasoconstriction due to greater pooling of blood in female.(38)

This study provide a great advantages for the investigation of abnormal cardiovascular reflexes in patients with orthostatic postural hypotension or the detection of some autonomic dysfunction specially patients with history of syncopal attack as in late complication of diabetic patients(13,14) or in case of prolonged bedrest after post operative surgery(56) in which the process of baroreceptor resetting to the normal baroreflex function after prolonged inactivation of autonomic nervous system.(48,49)

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