

CARDIOVASCULAR RESPONSES OF PARAPLEGIC BEDRIDDEN AND NORMAL SUBJECTS TO HEAD-UP TILTING

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ABSTRACT

This study compared the cardiovascular parameters of paraplegic, bedridden and normal subjects aged 23-55 years during head-up tilting at 0, 10, 20, 30, 40, 50, and 60 degrees. There were 45 subjects in three groups. All subjects were placed on a manually operated tilt table and their heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) measured. The data were analyzed using descriptive statistics of mean and standard deviation as well as inferential statistics of ANOVA. Post-hoc analysis was done with the Duncan multiple range test. Results showed that the cardiovascular responses of the three groups were not significantly different at 0 and 10 degrees of head-up tilt. However, at 20, 30, 40, 50 and 60 degrees of tilt, there were significant differences in the responses of the three groups. At these angles, the mean HR for the high lesion paraplegics was significantly higher than that of the bedridden and normal subjects, while their DBP and SBP were lower. Also at these angles, the mean HR of the bedridden patients was significantly higher than that of the normal subjects while the mean diastolic and systolic blood pressures were significantly lower. It was concluded that paraplegic and bedridden patients should be gradually returned to the upright posture in order to avoid adverse cardiovascular reactions in these groups of patients.

Key words: head up tilting, cardiovascular response, paraplegic, heart rate, systolic blood pressure and diastolic blood pressure

INTRODUCTION

The efficient functioning of the cardiovascular system requires regulation through the neural and hormonal control systems working in conjunction with the local metabolic control of vascular resistance.¹ Injuries to the spinal cord, whether traumatic or non-traumatic, may cause a complete or incomplete transection of the spinal cord, resulting in tetraplegia or paraplegia depending on the level of the injury. Inability to tolerate the upright posture and orthostatic hypotension are two important complications of spinal cord injury, while the accompanying clinical features include loss of vasomotor control, paraesthesia, loss of temperature control, abnormal reflex response, sensory loss, urine or fecal incontinence and risk of pressure sores.²

Bedridden patients have similarly been observed to undergo a number of cardiovascular, respiratory, musculoskeletal and neurophysiological changes. Taylor et al.³ showed that prolonged bed rest produced a marked deterioration in the cardiovascular response to posture as measured by pulse rate and blood pressure changes produced by a 68° head tilt. Also, Convertino et al.⁴ reported that

confinement to bed produces dramatic reductions in maximal stroke volume, cardiac output and oxygen uptake. Consequently, an integral part of the rehabilitation programme for this group of patients is postural tilting prior to standing. Postural (head-up) tilting helps to gradually re-orientate the patient to the upright postures, enables early wheelchair mobility, decreases lower extremity spasticity, improves bladder and bowel functions, prevents osteoporosis in the lower extremity bones and provides pressure relief from long periods of sitting.⁵

In a study of the haemodynamic responses of healthy elderly and young subjects to head-up tilt, Lye and Walley⁶ observed that elderly subjects maintained a higher blood pressure throughout the tilt. A literature search has, however, not revealed any recent work on the cardiovascular responses of paraplegic and bedridden patients to head-up tilting. In view of the importance of head-up tilting in the rehabilitation of bedridden and/or neurological patients, the present study was designed to compare the cardiovascular responses of paraplegic, bedridden and normal subjects to head-up tilting.

MATERIALS

Subjects: Forty-five subjects aged 23-55 years participated in the study. They were divided into three groups.

Group A: Consisted of 15 subjects who have had high level paraplegia for three to six months and have been referred for physiotherapy at the ward unit, Physiotherapy Department, University College Hospital Ibadan (UCH).

Group B: Consisted of 15 subjects who had been on admission in the orthopaedic ward of UCH for three to six months at the time of the study.

Group C: Consisted of 15 apparently healthy subjects who were either workers in UCH, Ibadan or students of the College of Medicine, University of Ibadan. Those subjects who were certified not to have evidence of hyper or hypotension were involved in the study.

Instrumentation

- An aneroid sphygmomanometer was used to measure the blood pressure of the subjects.
- A stethoscope (Surgifriends Medicals, Middlesex, England) and a digital stop watch

(Saxon chronograph) were used to monitor the heart rate.

A manual tilt table (Midland USA) graduated from 0 to 80 degrees was used to tilt subjects to the various angles required.

METHOD

Two of the researchers had training sessions to ensure a high level of reliability in measuring heart rate and blood pressure, which were to be measured simultaneously during tilting.

Procedure

The approval of the UI/UCH Joint Ethical Committee was sought and obtained before the commencement of data collection. The rationale and procedure for the study were explained to the subjects and their informed consent sought and obtained.

Each subject rested in a horizontal position on the tilt table for thirty minutes to ensure a steady HR and BP. The resting HR and BP of the subjects were then measured in the last 30 seconds of the first, third and fifth minutes in the supine position using standard procedures. The HR and BP were taken simultaneously by two of the researchers. The average of the measurements were used for data analysis. Next, the subjects was strapped to the tilt table by three safety belts attached across the upper abdomen, the pelvis and the knees. The belt at the upper abdomen was adjusted so as not to impair respiratory movements. Subjects were then tilted gradually to angles of 10, 20, 30, 40, 50 and 60 degrees for 5 minutes each with the HR and BP (systolic and diastolic) being measured during the last 30 seconds of the first, third and fifth minutes. During tilting, patients were closely monitored for any signs of cardio-respiratory distress as an indication for immediate termination of the procedure. However, there was no such occurrence during the study.

Data Analysis

Descriptive statistics of mean and standard deviation were used to summarize the demographic and physiological characteristics of the subjects. A one-way analysis of variance (ANOVA) was used to compare the cardiovascular responses of subjects in the three groups at each level of table tilting. Where significant differences existed, Duncan's multiple range test was used for the post-hoc analysis.

RESULTS

Characteristics of Subjects

The subjects in this study consisted of high lesion paraplegics, bedridden patients and normal subjects (control group). The subjects were aged 23-55 years, and in three groups. The mean age of the paraplegics was 40.44 years \pm 9.99 years with a mean duration of paraplegia of 4.20 \pm 5.60 months. The mean age of the bedridden patients was 39.91 \pm 10.22 years and they had been bedridden for 4.10 \pm 6.60 months. The normal subjects had a mean age of 40.20 \pm 10.08 years. One-way ANOVA did not reveal any significant difference between the ages of subjects in the three groups (F=0.01, p>0.05). Also, the t-test did not reveal any significant difference between the period since onset of paraplegia and the duration of bed rest (t=0.018, p>0.05).

Heart Rate (HR)

The HR responses are presented in table 1. ANOVA did not reveal any significant difference in the HR response of the paraplegic, bedridden and normal subjects at rest (supine) and at 10 degrees of head-up tilt (p>0.05). The paraplegics had the highest mean HR response at all angles of tilt, while the normal subjects had the lowest. Post-hoc analysis revealed that the HR response of the paraplegics was significantly higher than that of the bedridden and normal subjects at 20, 30, 40, 50 and 60 degrees of head-up tilt. Similarly, the HR response of the bedridden subjects was significantly greater than that

of normal subjects at 20, 30, 40, 50 and 60 degrees head-up tilt.

Blood Pressure

Systolic Blood Pressure (SBP)

Table 2 shows the SBP responses of the three groups at the different angles of head-up tilt. The SBP values were highest for the normal subjects and lowest for the paraplegics. Further, ANOVA revealed significant differences in the SBP of the three groups except at rest and 10° head-up tilt positions. The Duncan multiple range test showed that the SBP responses of the paraplegic patients were significantly lower than those of the bedridden patients and normal subjects at 20, 30, 40, 50 and 60 degrees of head-up tilt.

Diastolic Blood Pressure (DBP)

The DBP responses of the subjects presented in table 3 show that DBP at all angles of tilt was least for the paraplegic patients and highest for the normal subjects. ANOVA showed significant differences between the DBP responses of the three groups of subjects except at 0 and 10 degrees of tilt. The Duncan multiple range test revealed that the DBP responses of the paraplegic patients were significantly lower than those of the bedridden and normal subjects at 20, 30, 40, 50 and 60 degrees head-up tilt. Similarly, the DBP responses of the bedridden patients were significantly lower than those of the normal subjects at 20, 30, 40, 50 and 60 degrees of head-up tilt.

Table 1. Heart Rate Responses to Different Degrees of Table Tilting

	HR (beats/min)			F-value	P-value
	Group A (Paraplegia)	Group B (Bedridden)	Group C (Normal)		
Resting	68.60 \pm 3.41	67.13 \pm 3.67	65.07 \pm 4.82	2.50	> 0.05
10° Tilt	71.36 \pm 5.32	70.44 \pm 4.16	69.44 \pm 4.31	2.56	> 0.05
20° Tilt	74.54 \pm 6.92	72.82 \pm 4.34	70.58 \pm 3.58	4.93*	< 0.05
30° Tilt	78.37 \pm 7.19	75.24 \pm 3.96	72.16 \pm 3.76	9.18*	< 0.05
40° Tilt	83.02 \pm 4.56	79.31 \pm 8.00	74.07 \pm 5.55	23.30*	< 0.05
50° Tilt	89.11 \pm 6.72	82.49 \pm 7.77	77.11 \pm 8.95	26.01*	< 0.05
60° Tilt	92.42 \pm 6.52	84.47 \pm 8.32	78.76 \pm 8.87	35.22*	< 0.05

* Indicates significant across group difference
Horizontal lines join groups with significantly different means

Table 2. Systolic Blood Pressure Responses to Different Degrees of Table Tilting

	SBP (beats/min)			F-value	P-value
	Group A (Paraplegia)	Group B (Bedridden)	Group C (Normal)		
Resting	133.87±18.63	134.31±20.36	135.87±12.63	1.12	>0.05
10° Tilt	133.47±19.91	134.64±10.84	135.00±6.16	0.52	>0.05
20° Tilt	128.16±10.40	132.40±20.20	134.60±19.36	3.00*	<0.05
30° Tilt	125.62±10.45	130.13±20.36	134.00±19.60	3.42*	<0.05
40° Tilt	123.71±12.79	128.27±19.49	133.58±18.95	6.60*	<0.05
50° Tilt	118.33±13.47	126.18±19.29	133.30±19.79	8.90*	<0.05
60° Tilt	114.76±14.35	124.67±19.01	133.00±19.20	12.61*	<0.05

* Indicates significant across group difference
Horizontal lines join groups with significantly different means

Table 3. Diastolic Blood Pressure Responses to Different Degrees of Table Tilting

	DBP (beats/min)			F-value	P-value
	Group A (Paraplegia)	Group B (Bedridden)	Group C (Normal)		
Resting	85.31±19.77	86.22±7.69	87.07±5.67	2.10	>0.05
10° Tilt	83.96±19.30	84.93±10.49	86.36±6.30	2.19	>0.05
20° Tilt	78.71±10.42	80.33±7.40	81.22±6.66	3.20*	<0.05
30° Tilt	73.91±9.07	77.78±5.51	83.53±10.44	69.94*	<0.05
40° Tilt	70.47±2.78	75.64±9.93	85.44±9.40	15.96*	<0.05
50° Tilt	67.60±1.42	73.20±9.95	86.62±8.33	20.46*	<0.05
60° Tilt	63.71±6.79	71.16±9.73	87.44±7.44	27.00*	<0.05

* Indicates significant across group difference
Horizontal lines join groups with significantly different means

DISCUSSION

Cardiovascular Response of Subjects

The results of the present study show that there were significant differences in the mean resting heart rate (HR) values of high lesion paraplegics, bedridden patients and normal subjects. This is, however, contrary to the findings of Pledger et al.⁷ who found that high lesion paraplegic patients have statistically lower resting HR values than normal subjects. The

observed disparity between the findings of the studies may be attributed to the fact that the high lesion paraplegic patients in this study were wheelchair-ambulant prior to tilting while those in the study by Pledger et al.⁷ were not. In line with the explanation of Guttman et al.^{8,9} the stability in the mean resting HR of high lesion paraplegic patients months after their injury as in normal control subjects is due to their ability to change posture

which might produce an increase in the circulating blood volume and subsequent return of vascular tone. Likewise Sharpey-Shafer¹⁰ stated that such patients as reported by Guttman et al.^{8,9} may recover venous tone even though reflex venous activity does not return. Another possibility as explained by Folkov¹¹ is that chronically enervated vessels may develop increased activity in response to stretch.

In the present study, with head-up tilt from 20 degrees upwards, the high lesion paraplegic patients showed significantly higher mean HR values than normal subjects and bedridden patients. According to Wicks et al.,¹² this may be explained by the loss of central control of sympathetic outflow to blood vessels, and the increased HR which occurs in the spinal cord-injured person probably represents an attempt to compensate for a smaller stroke volume through increased cardiac frequency.¹³ Furthermore, in bedridden patients, it was observed that the HR significantly increased from 20° head-up tilt and above. The observed mean HR value, though higher than that of normal subjects, was lower for the high lesion paraplegic group. Unlike in the latter group of patients, HR response was not due to the loss of sympathetic outflow, but to an impairment of the cardiovascular function due to inactivity⁴ with consequent diminished stroke volume and cardiac output. The heart responds in a compensatory manner by increasing the HR. This higher mean HR value compared to normal subjects has also been attributed to reconditioning after prolonged bed rest.¹⁴ The mean HR response of normal subjects to tilting was considerably lower than that of the high lesion paraplegic and bedridden subjects. This may be due to the fact that the normal subjects have an intact reflex circulatory adjustment unlike the paraplegic subjects¹⁵.

In consonance with the findings of Guttman et al.,^{8,9} there was no significant difference between the mean SBP of high lesion paraplegics, bedridden and normal subjects at 0° of head-up tilt. However, in contrast to the HR responses, the SBP responses from 20° head-up tilt were highest for the normal subjects and lowest for the high lesion paraplegic patients. This is in line with the observation of Sharpey-Schaefer¹⁰ that the mean SBP dropped significantly in high lesion paraplegics due to inadequate venous and arteriolar vasoconstriction.

For the bedridden patients, the mean drop in SBP per degree of tilt was less pronounced than in high lesion paraplegics. This may not be unconnec-

ted with the fact that the bedridden patients had an intact sympathetic outflow; the impaired cardiovascular function (decreased stroke volume, cardiac output and blood pressure) being due to reduced physical work capacity.⁴ This is contrary to what obtains in high lesion paraplegic patients where the sympathetic outflow from the central control has been disrupted. In normal subjects, however, the SBP maintained an approximately constant mean value per degree of tilt. This may not be unconnected with a generalized arteriolar and venous vasoconstriction in an attempt to compensate for the effect of gravity on circulation.¹⁰

At 0° of head-up tilt, there was no significant difference in the DBP responses of the three groups of subjects. This was probably because the paraplegic patients have been wheelchair-ambulant with consequent better cardio-vascular conditioning. However, at 20° head-up tilt position and above, there were statistically significant differences between the three groups of subjects with the mean diastolic pressure value of high lesion paraplegics being lowest and that of normal subjects being highest.

In bedridden patients, the cardiovascular reconditioning could have been associated with reduced physical work capacity following prolonged bed rest. The average drop in diastolic blood pressure per degree of tilt was more pronounced among the high lesion paraplegic patients than in the bedridden subjects. This may be explained by the report of Ibrahim et al.¹⁶ that the failure of the neurogenic and other cardiovascular adjustments to raise the systemic peripheral resistance results in a lesser distension of the heart during diastole with the resultant effect of a decrease in stroke volume, cardiac output and arterial pressure.

CLINICAL IMPLICATIONS

Passive head-up tilting produced significant differences in the cardiovascular responses of high lesion paraplegic, bedridden and normal subjects. Consequently, physiotherapists should take cognizance of the beneficial therapeutic results of passive head-up tilting on the cardiovascular system and incorporate this when designing rehabilitation programmes for high lesion paraplegics and bedridden patients. Patients should thus be allowed to adapt to gravitational forces at each angle of head-up tilt before proceeding to subsequent head-up tilt position.

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