Influence of profuse sweating on systolic time intervals

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SUMMARY The influence of profuse sweating on systolic time intervals was investigated. Systolic time intervals were recorded in 21 healthy men before and after sauna bathing. After sauna bathing the ejection time was significantly shortened and the pre-ejection time and ratio of pre-ejection time to ejection time (PEP:ET) were significantly increased. The upper limit of the PEP:ET ratio is generally believed to be 0.42 and this ratio increases when left ventricular performance is impaired. Before sauna bathing the PEP:ET ratio was <0.42 in all 21 men, but after sauna bathing it was >0.43 in six (28.5%) of them. Systolic time intervals measured after profuse sweating can give a false impression of cardiac function.

Systolic time intervals obtained from simultaneous recordings of electrocardiograms, carotid pulse tracings, and phonocardiograms have been widely used to assess left ventricular function in various clinical settings.¹⁻⁶ The relation of these intervals to heart rate, cardiac output, and stroke volume⁷ and their alterations during heart failure¹ and in response to autonomic drugs⁸ have been examined in detail. We noticed that systolic time intervals were sometimes abnormal in healthy subjects who had been sweating profusely, and this prompted us to investigate the effect of sweating on systolic time intervals in a group of healthy men.

Patients and methods

We studied 21 healthy men (age range 22-40 years; mean 26.5 years) who used a Finnish sauna with an air temperature of 80-90°C and relative humidity of 30-40%. The amount of fluid lost was estimated from the decrease in body weight and ranged from 1.5 kg to 3.0 kg (mean 2.2 kg). We measured blood pressure, heart rate, haematocrit, and serum electrolyte concentrations, and we recorded systolic time intervals in all the men before they entered the sauna and an hour after bathing.

Carotid pulse tracings, phonocardiograms, and

electrocardiograms were recorded simultaneously on a Fukuda model 100 A, six channel oscillographic recorder at a paper speed of 100 mm/s. We used the electrocardiographic lead that most clearly demonstrated the onset of ventricular depolarisation (usually lead II or a precordial lead). A contact microphone (Fukuda MA 250) was placed over the upper part of the precordium in the best position for recording the initial high frequency vibration of the first and second heart sounds. The carotid arterial pulse was recorded from a pick up with a time constant of 2.0 s (Fukuda TY 303).

The following phases of the cardiac cycle were measured directly: (a) the total electromechanical systolic interval (Q-II) estimated from the onset of the QRS complex to the first frequency vibrations of the aortic component of the second heart sound (II); (b) the left ventricular ejection time (ET) measured from the beginning upstroke to the trough of the incisura of the carotid pulse tracing; (c) the interval between the first heart sound and the second heart sounds (I-II) measured from the onset of the first heart sound to the second heart sound; (d) the pre-ejection period (PEP) calculated by subtracting ET from Q-II; (e) PEP:ET obtained by dividing PEP by ET; and (f) Q-SI derived by subtracting I-II from Q-II. Results for Q-II, ET, and PEP were corrected ((Q-II)_c, ET_c, and PEP_c) for heart rate by means of Weissler's equation.¹

The systolic time intervals were calculated as means from 10 consecutive complexes. To avoid interobserver variations⁹ systolic time intervals were all measured by one experienced physician.

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ble Systolic time intervals in 21 healthy men before and after sauna bathing

e	Age	Ht (%)		(Q-II)c (ms)		I-II (ms)		ETc (ms)		PEPc (ms)		Q-I (ms)		PEP:ET		HR (bpm)		BW (kg)	
		B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
	30	42.4	45.5	541.3	550.5	370	350	410.1	418.5	131.2	122.0	60	85	0.34	0.31	53	55	76.5	73.5
	28	44.0	42.4	515.5	534.7	340	340	420.5	381.9	117.0	152.8	60	75	0.32	0.46	55	57	62.0	60.0
	23	41.9	43.0	542.0	553.5	340	310	424.0	399.5	118.0	154.0	55	65	0.30	0.47	70	85	64.2	62.5
	23	42.5	43.8	549.2	553.1	375	360	413.4	403.7	135.8	149.4	65	65	0.35	0.42	52	61	56.5	55.0
	24	40.0	42.0	523.9	531.8	335	355	395.3	398.6	128.6	133.2	65	55	0.36	0.37	59	58	55.0	52.5
	24	45.5	48.5	530.2	528.1	350	330	420.4	398.7	109.8	129.4	50	70	0.27	0.36	62	61	68.0	65.0
	25	42.0	45.0	549.7	550.2	375	350	416.9	415.4	132.8	134.8	55	70	0.34	0.35	57	62	63.0	61.1
	30	44.0	44.5	558.3	542.8	340	320	409.1	400.6	149.2	142.2	65	80	0.42	0.40	73	68	55.1	53.4
	32	48.0	51.5	549.2	548.6	375	340	413.4	407.2	135.8	141.4	65	70	0.35	0.39	52	66	54.7	52.0
	40	42.0	44.5	521.2	547.0	310	320	412.4	399.0	108.8	148.8	60	80	0.28	0.43	72	70	75.0	72.6
	30	43.8	46.3	534.3	535.3	305	280	416.1	398.1	118.2	137.2	55	60	0.31	0.47	83	93	66.5	64.0
	22	46.3	49.0	522.9	514.5	350	350	428.3	401.5	94.6	113.0	70	70	0.22	0.29	49	45	80.0	77.0
	23	43.9	45.1	526.6	526.3	360	360	408.2	400.1	118.6	126.2	70	55	0.30	0.34	46	53	66.5	64.5
	24	46.3	47.7	516.5	523.9	320	340	415.5	410.3	101.0	113.6	60	60	0.25	0.29	65	59	59.0	57.5
	23	49.6	50.5	544.4	542.3	355	350	408.8	427.1	135.6	115.2	55	60	0.37	0.28	64	63	77.0	74.5
	27	43.2	46.0	560.1	540.2	340	350	442.1	405.4	117.4	134.8	50	60	0.28	0.37	81	62	52.5	49.0
	29	52.9	53.3	560.2	628.5	360	325	440.4	419.5	119.8	159.0	70	75	0.28	0.45	62	85	92.5	90.0
	28	45.5	46.8	518.6	543.0	330	325	392.2	396.0	126.4	147.0	50	50	0.36	0.44	66	80	47.0	45.5
	22	42.3	45.2	547.0	508.6	330	315	419.0	392.2	128.0	116.4	70	55	0.33	0.32	70	66	67.7	66.2
	25	52.5	55.9	511.8	513.3	345	300	403.6	399.1	108.2	144.2	45	60	0.28	0.42	58	73	71.0	68.5
	25	45.3	47.9	543.9	533.9	355	350	410.3	400.3	133.6	133.6	65	60	0.35	0.37	59	59	61.0	58.0
in	26.5	44.9	46.9	536.5	540.5	345.7	334.3	415.2	403.5	117.2	130.9	60.0	65.7	0.31	0.38	62.3	65.8	65.2	63.0
luc	4.3	3.4	3.6	15.6	24.1	20.1	21.2	12.1	10.1	13.3	14.1	7.6	9.5	0.047	0.059	10.0	11.8	10.7	10.6
		p < 0.001		NS		p < 0.01		p < 0.01		p < 0.001		p < 0.05		p < 0.001		NS		p < 0.001	

haematocrit; (Q-II)c, corrected total electromechanical systolic interval; I-II, interval between the first and second heart sounds; ETc, corrected ventricular ejection time; PEPc, corrected pre-ejection period; Q-I, interval between onset of ventricular depolarisation and the first heart sound; heart rate; BW, body weight; bpm, beats per minute; SD, standard deviation; NS, not significant; B, before sauna bathing; A, after sauna bathing.

Fig. 1 After sauna bathing (Q-II)c was not significantly altered, PEPc was significantly increased, and ETc was significantly shortened. PEP:ET was significantly increased after sauna bathing.

Fig. 2 (Q-II)c, PEPc, and PEP:ET were increased and ETc was decreased after sauna bathing.

Results

The Table summarises all the data obtained before and after sauna bathing. This Table and Fig. 1 show significant increases in PEPc, Q-I, and PEP:ET; a significant decrease in ETc; and no change in (Q-II)c after sauna bathing. Before sauna bathing

PEP:ET was <0.42 in all the men, whereas after sauna bathing it had increased to >0.43 in six (28.5%) men.

The mean haematocrit increased slightly from 44.9% before sauna bathing to 46.9% after sauna bathing. Heart rate, blood pressure, and serum electrolytes (such as potassium, calcium, and magnesium) were not significantly changed after sauna bathing. Fig. 2 shows data for a representative case in which (Q-II)c, PEPc, and PEP:ET increased and ETc decreased after sauna bathing.

Discussion

Systolic time intervals can be measured at the bedside and they give useful information on cardiac function. They are cheap, carry no risks, and give immediate results, and so they can be performed repeatedly. Because systolic time intervals may be considerably influenced by extracardiac factors, they can give a misleading assessment of cardiovascular function. Beat to beat variations¹⁰ and observer variations⁹ may lead to their misinterpretation. We have occasionally seen abnormal systolic time intervals in apparently healthy subjects who have been sweating profusely. These findings prompted us to examine the effect of sweating on systolic time intervals. Sweating induced by sauna bathing is considered to resemble physiological sweating more closely than does sweating induced by exercise or drugs.

In an attempt to exclude the direct influences of sauna bathing and to ensure stable cardiac status, we recorded systolic time intervals an hour after sauna bathing. Heart rate and blood pressure were unchanged after sauna bathing, but there were significant increases in PEPc, (Q-I) time, and PEP:ET, and a significant decrease in (I-II) time and ETc. There was no essential change in total electromechanical systole (Q-II)c.

ETc, PEPc, and PEP:ET are more commonly used in daily clinical practice than the other variables that are derived from systolic time intervals. Generally speaking, ETc is shortened by a decrease in stroke volume,¹ by an increase in left ventricular ejection velocity (as seen in hyperthyroidism¹¹ or anaemia¹²), and by inotropic agents such as digitalis¹³ or isoproterenol.¹⁴ The ETc shortening observed in this study was probably due to a decrease in stroke volume. PEPc is prolonged by a decrease in stroke volume or myocardial contractility¹ and by negative inotropic agents such as beta blockers.¹⁴ A decrease in stroke volume was considered to be responsible for the prolongation of PEPc observed in the present study.

In the present study the PEP:ET ratio increased because PEP was increased and ET was shortened. This ratio is widely used to assess ventricular function. The upper limit of normal is believed to be

0.42, and the ratio is increased when function is impaired. We found that after sauna bathing the ratio increased to >0.43 in six (28.5%) of 21 men. This result indicates that systolic time intervals measured after profuse sweating can give a false impression of cardiac function. This should be borne in mind when systolic time intervals are measured at high temperature and high humidity, in febrile patients, and in subjects who have been exercising vigorously.

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