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ORIGINAL ARTICLE

Blood pressure changes at the Dead Sea (a low altitude area)

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The Dead Sea (barometric pressure: 800 mm Hg) is an important balneotherapeutic centre for chronic dermatologic and arthritic diseases. In the past, hypertensive patients have complained sporadically of weakness and dizziness during a stay in the Dead Sea. It was therefore recommended that hypertensives do not stay at these health centres. The aim of our study was to investigate the changes in blood pressure (BP) parameters of 72 hypertensive and normotensive osteoarthritic and rheumatoid arthritic elderly patients during a 2-week stay in the Dead Sea, and to further evaluate the effect of different balneotherapeutic means on these BP changes. Following a primary BP assessment at the out-patient clinic (Beer Sheva barometric pressure: 745 mm Hg), the patients were divided into four groups: (1) thermomineral pool; (2) Dead Sea water baths; (3) combination of the aforementioned treatments; and (4) controls (no balneotherapy). We demonstrated that the systolic BP (SBP) of hypertensives and normotensives decreased by an average of 17 mm Hg and that diastolic BP (DBP) decreased by an average of 8 mm Hg from their basic clinic-measured values. These favourable results were sustained during the first 10 days duration, and by the end of their stay they had diminished slightly. Thermomineral water had an additional lowering effect on the BP of the normotensives, but the SBP of hypertensives increased. Immediately following Dead Sea bath immersion, we noted a temporary increase of SBP in normotensives only. No patient, hypertensive or normotensive, complained of dizziness, malaise, or any other complaint. In our experience, patients feel well at low altitudes, and there is no justification in upholding hypertension as a contraindication to balneotherapy in the Dead Sea.

Keywords: BP changes; Dead Sea; balneotherapy; mineral water immersion

Introduction

The public's awareness of health and medical issues has an impact on decisions concerning travel destinations. Consequently, patients diagnosed with hypertension or coronary disease are often wary of travelling to destinations which entail a significant change in altitude. For example, it is common knowledge that the low pO2 in high altitudes causes headache and muscle fatigue in non-acclimatised individuals. The physiological explanation for 'altitude sickness' is the increased sympathetic nervous activity due to the hypoxic stimulus, which is manifested by increased heart rate, blood pressure (BP), cardiac output, and systemic vascular resistance.[1,2] Coronary patients travelling to high altitudes are at a particular risk for effort angina and dysrhythmia.

Whereas this information concerning precautions for high altitude is easily available, there is a dearth of information about the effect of low altitude, and hyperbaric conditions where pO2 is higher than normal. The conclusions of the studies that did test the effect of hyperbaric oxygen on rats and humans respectively, stated that exposure to hyperbaric O2 normalised parameters of central haemodynamics and improved myocardial status.[3–5]

In Israel, the balneotherapeutic resorts of the Dead Sea (barometric pressure: 800 mm Hg) comprise a major tourist attraction. The resorts offer a spectrum of activities and therapies including bathing in the Dead Sea waters or in the thermal springs around it, mud packs, and various massages. The area is also favoured for its high temperatures, low relative humidity, and absence of city noise and pollution. Following balneotherapy, significant if transient improvement has been reported in diseases such as psoriasis, psoriatic arthritis, rheumatoid arthritis and osteoarthritis.[6–10]

Until recently, this relatively hyperbaric environmental impact on haemodynamic parameters has not been investigated, and this led to a certain fear of travelling to the Dead Sea among coronary and hypertensive patients. Specifically, the possible contribution of high barometric pressure and increased pO2 to the health or general well-being of these patients or others receiving balneotherapy, is just starting to undergo investigation. There is a need for reliable data in this field in order to give these patients accurate and complete information, and to dispel biased preconceived notions.

Our aim was to measure BP and heart rate in elderly hypertensive and normotensive patients in a controlled prospective trial. The effect of a 2-week

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stay in the Dead Sea area as well as the effect of balneotherapy in the Dead Sea and in thermomineral springs in a Dead Sea resort was sustained. With this new information, elderly arthritic patients will be able to make a more informed decision concerning therapy options in this unique environment.

Subjects and methods

Subjects

The study included 36 rheumatoid arthritic and 36 osteoarthritic patients. The study was performed in two separate rounds; each round lasted 12 days during which the patients received daily therapy in the hot springs of Ein-Gedi resorts by the Dead Sea. The patients were randomly assigned to one of four groups: a control group and three study groups:

(1) treated with thermomineral (sulphur) pools (35°C) ($n = 18$);
(2) treated with Dead Sea waters only ($n = 16$);
(3) combined treatment group: Dead Sea waters and thermomineral baths ($n = 19$);
(4) control group (none of the above-mentioned treatments) ($n = 19$).

All patients continued their antirheumatic and antihypertensive medications regularly throughout the study.

Procedures

The patients' BP was measured on the first, 8th and 12th day of their stay at the Dead Sea. On day 1, BP measurement was taken in the morning in Beer Sheva prior to the descent to the Dead Sea, and at noon in the Dead Sea area. On day 8, BP measurement was taken in the morning in the resort before the start of any balneotherapy.

On day 12, BP was measured at noon in the Dead Sea area before leaving the area. Additional BP measurements were taken on the 8th day of treatment inside the thermomineral spring from the sulphur spring treatment group and from the combined treatment group. BP was measured in the Dead Sea waters treatment group and in the combined treatment group immediately after exiting the water.

BP measurement

All measurements were performed using the same automatic-digital device: 8100 Dinamap™ Vital Signs Monitor produced by Critikon. All the measurements were performed on the right arm; the sleeve fitted the examinee's arm. Three automatic measurements were performed every 2 min where the first measurement was not considered in the statistical analysis, but the average of the second and third measurements was used.

The changes in systolic and diastolic BPs (SBP/DBP) and heart rate (HR) in five time-points were tested by repeated measurement analysis of variance and paired *t*-test. A significance level of 0.05 was used.

Results

The mean age of the patients was 63 years (range: 54–75). Of the 72 patients tested, 36 were osteoarthritic and 36 were rheumatoid-arthritic. Twenty-four patients were hypertensive and 48 patients were normotensive. All patients received pharmacological treatment for the rheumatic disease (NSAID's). Out of the 24 hypertensive patients, all received dietary treatment and 20 received antihypertensive pharmacological treatment which was mainly diuretics and calcium antagonists. None of the patients had any other significant disease nor received other medical treatment.

Effect of a 2-week stay on SBP and DBP

SBP of normotensives decreased from 143 mm Hg measured in Beer Sheva to 133 mm Hg ($P < 0.05$) measured on the 8th day near the Dead Sea and to 136 mm Hg ($P < 0.05$) on day 12 before leaving the area. DBP decreased from 78 mm Hg to 69 mm Hg ($P < 0.05$) and to 72 mm Hg ($P < 0.05$), respectively. No significant changes of HR were observed although there was a tendency of an elevation in HR by the Dead Sea.

SBP of hypertensives decreased from 173 mm Hg measured in Beer Sheva to 151 mm Hg ($P < 0.05$) measured on the 8th day near the Dead Sea and 151 mm Hg ($P < 0.05$) on day 12 before leaving the area. DBP decreased from 92 mm Hg ($P < 0.05$) to 82 mm Hg ($P < 0.05$) and to 80 mm Hg ($P < 0.05$), respectively.

As shown in Table 1, SBP before descent to the Dead Sea, compared to day 8 decreased significantly in the normotensive control group (143 to 131 mm Hg), in the thermal pool treatment group (147 to 133 mm Hg), and the combined treatment group (143 to 131 mm Hg) ($P < 0.05$). In the sea water treatment group there was a significant decrease of SBP (143 to 132 mm Hg), compared to the values before the descent to the Dead Sea on the 12th day of stay. There was a tendency of elevation in SBP from the 8th day levels towards day 12, although none of the changes were significant. SBP of the hypertensive group changed similarly, and even more notably: in the control group from 167 mm Hg before descent to the Dead Sea to 148 mm Hg on the 8th day of stay, in the sea group from 172 to 156 mm Hg, in the thermal pool group 177 to 148 mm Hg, and in the combined group from 163 to 146 mm Hg ($P < 0.05$), accordingly.

The DBP changes in normotensives and hypertensives followed the same pattern, maximal reduction on day 8 and a slight elevation towards day 12, but most of the results did not reach statistical significance due to a larger statistical variation and the small size of the groups (Table 2).

Effect of balneotherapy on SBP, DBP and HR

The mean SBP of normotensives who bathed in the Dead Sea was 134 mm Hg on day 8 of their stay before entering the sea, and 143 mm Hg after exiting the sea—a significant rise ($P < 0.05$). Hypertensives

Table 1 Mean SBP (mm Hg) of normotensive and hypertensive patients by treatment group

Normotensive (n = 48)	*Control group*		*Sea group*		*Pool group*		*Combined group*	
	n = 11	*std*	*n = 8*	*std*	*n = 13*	*std*	*n = 16*	*std*
Beer Sheva	143	26	143	36	147	20	143	15
Dead Sea								
day 1	134	21	141	28	138	17	145	15
day 8	131	20	136	28	133	16	131	17
day 12	138	18	132	15	137	16	140	14
Hypertensive (n = 24)	*n = 8*		*n = 8*		*n = 5*		*n = 3*	
Beer Sheva	167	12	172	18	177	19	163	13
Dead Sea								
day 1	164	20	151	17	162	20	154	18
day 8	148	8	156	17	148	21	146	20
day 12	154	18	152	15	146	22	151	17

Table 2 Mean DBP (mm Hg) of normotensive and hypertensive patients by treatment group

Normotensive (n = 48)	*Control group*		*Sea group*		*Pool group*		*Combined group*	
	n = 11	*std*	*n = 8*	*std*	*n = 13*	*std*	*n = 16*	*std*
Beer Sheva	81	15	76	18	76	10	78	9
Dead Sea								
day 1	70	16	80	21	76	16	75	11
day 8	68	12	75	16	66	10	66	10
day 12	71	12	73	15	73	8	71	12
Hypertensive (n = 24)	*n = 8*		*n = 8*		*n = 5*		*n = 3*	
Beer Sheva	91	9	87	14	98	23	86	10
Dead Sea								
day 1	94	17	79	20	89	12	88	20
day 8	80	10	74	14	93	20	78	18
day 12	76	17	80	13	82	14	82	29

did not demonstrate a significant change in SBP before and after bathing in the sea water.

The mean SBP of normotensives who bathed in the thermomineral pool was 135 mm Hg before entering and 130 mm Hg in the thermomineral pool—a nonsignificant decrease. The hypertensives' mean SBP was 148 mm Hg before entering the thermomineral pool and 164.4 mm Hg in the thermomineral pool—a significant increase ($P < 0.01$) as shown in Figure 1.

No significant changes were found in the DBP of either hypertensives or normotensives as a result of bathing in the thermomineral pool. No significant changes in HR were found.

Discussion

In our study of 72 elderly patients suffering from rheumatoid arthritis and osteoarthritis, both hypertensive and normotensive patients demonstrated a decrease in BP during their stay in the Dead Sea area. This decrease was most apparent on the 8th day of stay, and was moderated towards the 12th day of stay. No significant variation in pulse rate was observed during the patients' stay. The changes in BP were well handled by the patients and were symptomless. None of the patients exhibited any side effects related to BP changes. Balneotherapy in thermomineral pools significantly reduced SBP and DBP in normotensives, and increased these parameters in hypertensives. Dead Sea bathing caused a significant, though small increase of SBP in normotensives only.

The BP change in normotensives following balneotherapy received attention by Kruse *et al*[11] in a paper on water immersion in healthy individuals. They noted suppressed plasma renin activity (PRA) and aldosterone following immersion due to augmentation of diuresis and natriuresis. In Kruse's report however, BP remained unchanged.

Most of the visitors in the Dead Sea area and the thermomineral pools are elderly people who suffer from various chronic diseases such as hypertension and rheumatic diseases.

The importance of our study is in its attempt to dispel preconceived notions about any potential hazard the Dead Sea might pose for elderly hypertensive patients, and to enable them to feel confident

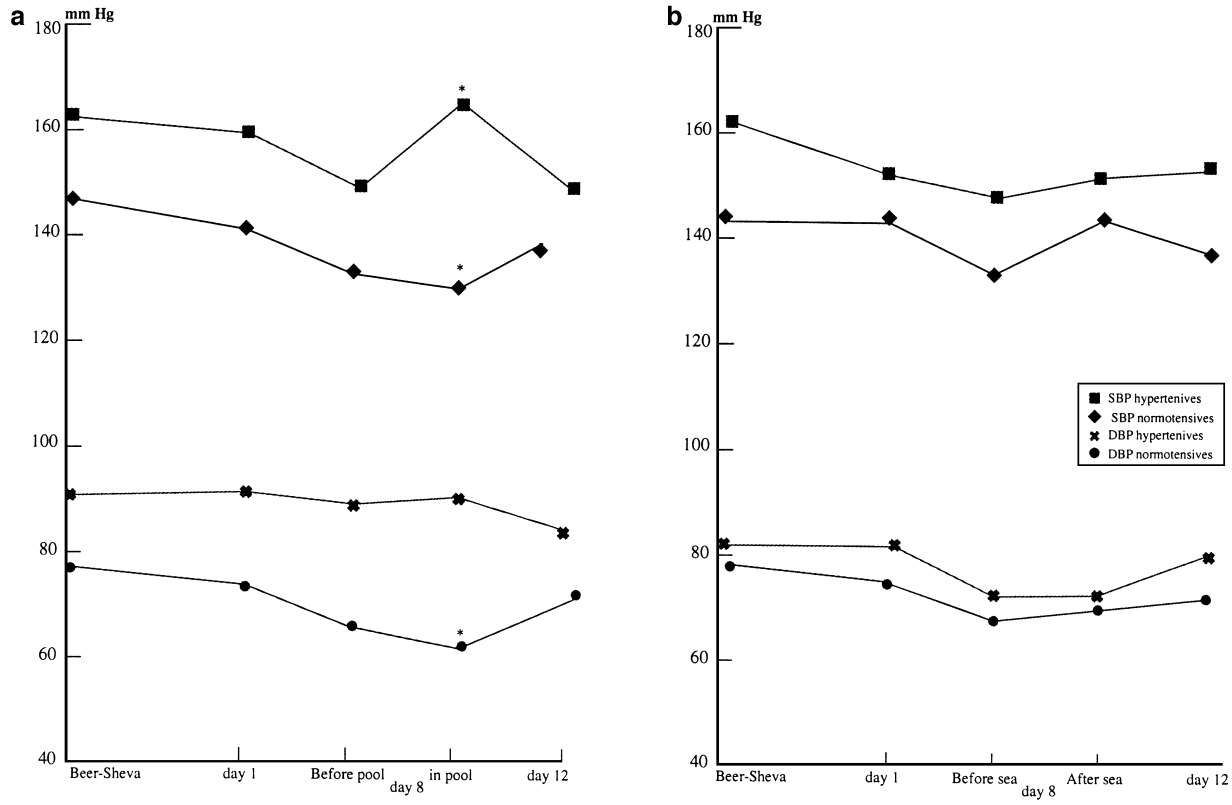

Figure 1 Effect of (**a**) sulphur spring pool therapy and (**b**) Dead Sea water therapy on the mean SBP and DBP of hypertensive and normotensive patients.

about choosing the Dead Sea area and balneotherapy as treatment of their rheumatic disease.

Our results are supported by Shani's findings on psoriatic patients (all ages) which show a significant decrease in SBP from the 2nd day of stay in the Dead Sea and onward.[12] Shani did not observe any variation in HR or body weight during the 21-day stay. When testing for the effect of age in hypertensive psoriatic patients undergoing climatotherapy in the Dead Sea, Kushlevsky noted a less abrupt drop in SBP in the older (>65 years) than in the younger (<40 years) patients, concluding that high BP is not a contraindication for climatotherapy in psoriatic patients in the Dead Sea.[13]

Could the observed drop in BP just be a result of a non-representative first measurement due to the excitement of travel?[12] We believe this is not very likely since Bernheim's 1984 results demonstrate a significant drop in BP in 19 healthy male hotel workers each time they commuted from Arad to the Dead Sea (a drop of 1035 m).[14] We also concluded that the drop in BP is apparently unrelated to balneotherapy since the control group also showed a BP decrease, and since the hypertensive patients had an increase in BP following balneotherapy in the thermomineral springs. High temperatures were also discarded as the cause of BP depression since measurements in Shani's study[12] were made in the spring when the average temperature was 25–28°C, and Bernheim's study[14] was performed on hotel workers who were not exposed to the sun. This means that the cardiovascular improvement reflected by the lowered BP was not due to a heat-induced dilatation of blood vessels.

The oxygen concentration 400 m below sea level is approximately 10% higher than that of Beer Sheva as a result of increased atmospheric pressure in the Dead Sea. However, it is believed that this effect on the circulatory system is marginal as the blood is normally saturated with oxygen, and according to Stuhr's experiment[5] using hyperbaric oxygen on anesthetised and conscious rats, all BP parameters increased significantly rather than decreased at 1 bar oxygen. Interestingly, Kramer and Godfrey[15] found the oxygen enrichment to be beneficial to patients with obstructive lung disease, especially when their place of residence is in a relatively high altitude.

It has been suggested that the hazy atmosphere of the Dead Sea, rich in bromides and magnesium which have sedative and vasodilatory properties respectively, play a role in BP reduction.[12] Clearly, further investigation is needed in order to clarify the specific factors that play a role in BP changes at the Dead Sea. Finally, a well-supported explanation is needed for the increase of BP in the hypertensive patients following balneotherapy in thermomineral springs. Rovensky *et al*[16] observed certain temporary increases in the serum levels of GH and cortisol after water immersion of 39°C for 30 min but the relationship of these changes to BP has not been specifically investigated.[17] On the basis of these studies we conclude that balneotherapy in the Dead Sea waters is relatively safe irrespective of age, while bathing in the thermomineral springs of the area might bring about a temporary rise in BP in hypertensives. The mechanism of this rise is worth exploring in order to ensure the maximum well-being of those seeking therapy at the Dead Sea.

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