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Chronoecological health watch of arterial stiffness and neuro-cardio-pulmonary function in elderly community at high altitude (3524 m), compared with Japanese town

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Abstract

Effects of high altitude on arterial stiffness and neuro-cardio-pulmonary function were studied. Blood pressure (BP) and heart rate (HR) were measured in a sitting position on resting Ladakhis, living at an altitude of 3250–4647 m (Phey village, 3250 m: 17 men and 55 women; Chumathang village, 4193 m: 29 men and 47 women; Sumdo village, 4540 m: 38 men and 57 women; and Korzok village, 4647 m: 84 men and 70 women). The neuro-cardio-pulmonary function, including the Kohs block design test, the Up and Go, the Functional Reach and the Button tests, was examined in 40 elderly subjects (19 men and 21 women, mean age: 74.7 ± 3.3 years) in Leh, Ladakh (altitude: 3524 m), for comparison with 324 elderly citizens (97 men and 227 women, mean age: 80.7 ± 4.7 years) of Tosa, Japan (altitude: 250 m). Cardio-Ankle Vascular Index (CAVI) was measured as the heart-ankle pulse wave velocity (PWV) in these subjects using a VaSera CAVI instrument (Fukuda Denshi, Tokyo).

SpO₂ decreased while Hb and diastolic BP increased with increasing altitude. At higher altitude, residents were younger and leaner. Women in Leh vs. Tosa had a poorer cognitive function, estimated by the Kohs block design test (3.7 ± 3.6 vs. 16.4 ± 9.6 points, $P < 0.0001$) and poorer ADL functions

(Functional Reach: 13.7 ± 7.0 cm vs. 25.3 ± 8.7 cm, $P < 0.0001$; Button test: 22.5 ± 4.8 vs. 14.8 ± 5.7 s, $P < 0.0001$). Time estimation was shorter at high altitude (60-s estimation with counting: 41.1% shorter in men and 23.0% shorter in women).

A higher voltage of the QRS complex was observed in the ECG of Leh residents, but two times measurement of CAVI showed no statistically significant differences between Leh and Tosa (two times of CAVI measures; 9.49 vs. 10.01 m/s and 9.41 vs. 10.05 m/s, respectively), suggesting that most residents succeed to adapt sufficiently to the high-altitude environment. However, correlation of CAVI with age shows several cases who show an extreme increase in CAVI. Thus, for the prevention of stroke and other adverse cardiovascular outcomes, including dementia, CAVI may be very useful, especially at high altitude.

In conclusion, elderly people living at high altitude have a higher risk of cardiovascular disease than low-latitude peers. To determine how these indices are associated with maintained cognitive function deserves further study by the longitudinal follow-up of these communities in terms of longevity and aging in relation to their neuro-cardio-pulmonary function.

Keywords

High-altitude; Arterial stiffness; Cardio-ankle vascular index; Cognitive function; ADL function; Time estimation; Gender difference; Elderly community-dwelling people

1. Introduction

Leh, Ladakh is a strongly Buddhist district of east Kashmir, adjacent to Tibet and lying at 3524 m above sea level between the Karakoram range and the Himalayas. It was virtually unknown to the West until the 1970s and it still has limited contacts with the outside world today. The economy is based on subsistence farmers who grow mainly barley but also legumes. Whereas physiological adaptation to high altitude has been studied in resident populations of the Andes, Tibet, Nepal, North America and Europe, much less is known about high altitude natives in India. This study investigates arterial stiffness and cardiopulmonary functions in Ladakhis living at different altitudes, and compares neurocardiovascular functions of Ladakhi people with Japanese living at low altitude, with the aim of preventing strokes and the decline in cognitive function of the elderly.

2. Subjects and methods

We studied Ladakhi residents to determine any effects of high-altitude on the cardiopulmonary function. Physical examinations, including the measurement of pulse oximetry, hemoglobin concentration (Hb), blood pressure (BP), heart rate (HR), respiration rate (RR) and body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters) were conducted on resting Ladakhi subjects living at different altitudes (Phey village, 3250m: 17 men and 55 women; Chumathang village, 4193 m: 29 men and 47 women; Sumdo village, 4540 m: 38 men and 57 women; and Korzok village, 4647 m: 84 men and 70 women). BP and HR were measured in a sitting position after a 2-min rest, using a semi-automated BP device (UA-767PC, A&D Co, Ltd, Tokyo, Japan).

In addition, 334 subjects aged from 13 to 81 years (mean $\pm$ S.D.: 50.0 ± 14.8 years) living in Leh, Ladakh (altitude: 3524 m) visited and utilized our free health screening programme and our field medical service consultation. We assessed the neurocardiovascular function of 40 residents older than 70 years (19 men and 21 women, mean age: 74.7 ± 3.3 years). For comparison, we studied 324 elderly citizens (97 men and 227 women, mean age: 80.7 ± 4.7 years) living in Tosa town, Kochi, Japan (altitude: 250 m). Oxygen saturation (SpO_2),

respiration rate at rest and several cardiovascular variables, including BP, HR, conventional 12-lead ECG, and the heart-ankle pulse wave velocity (haPWV) were measured. BP was measured six times (twice in a sitting, twice in a supine and twice in a standing position).

The Kohs block design test and time estimation test were used to assess the overall cognitive function. Time estimation was performed in a supine position, 10- and 60-s being estimated with and without counting. The Up and Go test measured, in seconds, the time it took the subject to stand up from a chair, walk a distance of 3 m, turn, walk back to the chair, and sit down again. This test is a simple measure of physical mobility and demonstrates the subject's balance, gait speed, and functional ability. A lower time score indicates a better physical mobility. Functional Reach, used to evaluate balance, represents the maximal distance a subject can reach forward beyond arm's length while maintaining a fixed base of support in the standing position. A higher score indicates a better balance. Manual dexterity was assessed using a panel with combinations of 10 hooks, 10 big buttons, and five small buttons. Three discrete measurements of time were recorded for each participant (10 "hook-on"s, 10 big "button-on-and-off"s, and five small "button-on-and-off"s). The total manual dexterity time in seconds, defined as the button score (Button), was calculated by adding the average times for one hook-on and one big or small button-on-and-off. A lower button score indicates a better manual dexterity.

3. The haPWV assessed by CAVI

PWV was measured between the right arm and ankle in a supine position, using a VaSera CAVI instrument (Fukuda Denshi Co., Ltd., Tokyo, Japan). Aortic PWV was defined as a value obtained by dividing the distance from the aortic valve to the femoral artery by the sum of a transmission time difference between the carotid artery and the femoral artery and a time difference between the second sound of phonocardiogram (PCG II) and the notch of carotid pulse wave. Recently, devices which calculate PWV through measurement of brachial and ankle BPs and pulse waves (PWs) were developed (Colin in 1999 and Fukuda Denshi in 2002). With these devices, PWs are detected with the cuffs inflated to lower than the diastolic pressure and the PWV is measured based on the time difference between brachial and ankle PWs and the difference between the length of the artery from the aortic valve to the ankle and that from the aortic valve to the brachium. Simplicity of the measurement has spread the method, making many institutions accumulate clinical data. However, this method involves the following problems. Measurement regions cannot be specified, since the difference in distance the two PWs go in different directions (aortic valve to ankle and aortic valve to brachium) is divided by the difference in time these PWs reach the respective regions; (2) BP dependency; (3) measurement is affected by the stress due to pressurization of four limbs with cuffs, since the regions include muscular blood vessels of upper and lower limbs.

With the problems of these past methods in mind, a new method may be desired to satisfy the following requirements: (1) clarify measurement regions; (2) indicate BP-independent characteristic function of the blood vessel; (3) minimize effects on circulatory dynamics in the whole body; and (4) simplicity and good reproducibility. The Cardio-Ankle Vascular Index (CAVI) is a new index representing an elastic property of the artery in a wide area (from the aortic valve to the ankle). In practical measurement for this study, PWV was calculated by dividing the distance from the aortic valve to the ankle artery by the sum of the difference between the time the PW was transmitted to the brachium and the time the same wave was transmitted to the ankle, and the time difference between PCG II and the notch of brachial PW. Systolic and diastolic BPs and pulse pressure were obtained by measuring the BP at the right brachial artery. To minimize cuff inflation effects on blood flow dynamics, PWs were measured with cuffs inflated to lower than the diastolic pressure (30–50 mmHg), and then the BP was measured.

4. Statistical analysis

All data were analyzed with the Statistical Software for Windows (StatFlex Ver.5.0, Artec, Osaka, <http://www.statflex.net>). Student's *t*-tests and one-way analyses of variance (ANOVA) served for the comparison of two or more groups. A *P*-value below 0.05 was considered to indicate statistical significance.

5. Results

First, we compared the cardiopulmonary functions among the five villages, including Leh at 3524 m, Table 1. The average age of residents of both genders decreased with altitude. SpO₂ decreased from 91.7% and 90.7% at 3250 m to 83.7% and 85.4% at 4647 m in men and women, respectively ($P < 0.0001$), whereas diastolic BP and Hb increased with altitude. By contrast, systolic BP did not correlate with altitude. Pulse pressure (PP) and HR decreased only in men and RR increased only in women as a function of altitude. Height, weight and BMI decreased with altitude in both genders.

In Leh at 3524 m, elderly residents had a lower SpO₂ and a higher respiration rate than elderly Japanese residents in Tosa (SpO₂: $88.0 \pm 4.3\%$ vs. $96.6 \pm 1.2\%$, $P < 0.0001$; RR: 21.1 ± 4.2 vs. 17.8 ± 4.2 , $P < 0.0001$), Table 2. All six measurements of diastolic BP and 5 of the 6 h measurements were statistically significantly higher in Leh than in Tosa. Changes in HR from the supine to the standing position were larger in Leh than in Tosa (13.8 ± 8.1 bpm vs. 9.9 ± 6.7 bpm, $P < 0.001$). A higher voltage of the QRS complex (SV1 + RV5) was observed in the ECG of Leh's residents, but PWV and ABI measures showed no statistically significant difference between the two populations (CAVI-1 and two measures in Leh and Tosa; 9.49 vs. 10.01 m/s and 9.41 vs. 10.05 m/s, respectively).

Table 2 also shows the comparison of scores of cognitive and neurobehavioral function tests and of ADL scores between the two populations. Results from the Kohs block design test were lower in Leh than in Tosa (9.0 ± 8.8 vs. 16.4 ± 10.0 , $P < 0.0001$). Time estimation of 10 s, and even more so of 60 s, was lower in Leh than in Tosa (10-s without counting, TE10-1: 8.5 ± 2.7 s vs. 11.5 ± 5.8 s; 10-s with counting, TE10-2: 7.9 ± 2.4 s vs. 10.0 ± 4.3 s; 60-s without counting, TE60-1: 42.7 ± 16.8 s vs. 57.1 ± 23.0 s; 60-s with counting, TE60-2: 38.3 ± 10.2 s vs. 55.4 ± 20.8 s, $P < 0.01$). ADL scores of the Functional Reach test were also statistically significantly lower in Leh than in Tosa.

These endpoints were also compared between the two populations separately for men and women, Table 3 and Table 4. SpO₂ was lower whereas diastolic BP and RR were higher in Leh than in Tosa in both men and women. The higher QRS complex in the ECG of Leh's residents reached statistical significance only in men. On the other hand, CAVI measures were significantly lower in women only the second time measurement (the first and second measures of CAVI in women; 9.34 vs. 10.09 m/s, N.S. and 9.20 vs. 10.19 m/s, $P < 0.05$, respectively).

The lower cognitive function estimated by the Kohs block design test in Leh was statistically significant only in women (3.7 ± 3.6 vs. 16.4 ± 9.6 , $P < 0.0001$). Unskillful ADL scores in Leh of both the Functional Reach and the Button tests were observed in women (FR: 13.7 ± 7.0 vs. 25.3 ± 8.7 s, $P < 0.0001$; BT: 22.5 ± 4.8 vs. 14.8 ± 5.7 s, $P < 0.0001$) but not in men. The shorter time estimation in Leh vs. Tosa was particularly pronounced in men and reached statistical significance in women only for TE60-2 (60-s time estimation with counting; men: 35.3 ± 9.3 s vs. 59.9 ± 19.6 s, $P < 0.0001$; women: 41.2 ± 10.4 vs. 53.5 ± 21.1 s, $P < 0.05$).

6. Discussion

Altitude was found to affect neuro-cardio-pulmonary functions in Ladakh, India. At high altitude, SpO₂ decreased, whereas Hb and diastolic BP increased with altitude. Residents of both genders were younger and leaner at higher altitude. At high altitude, optimal improvement of pulmonary mechanics may be an important adaptation to indoor and outdoor dust exposure [1]. Our study also suggests that there may be a limitation to such a physiological adaptation, which is gender-dependent: in women, respiration rate increases with altitude, with no decrease in HR.

Adaptation to high altitude was confirmed in the thorough investigation in Leh. At 3524 m, SpO₂ was lower and respiration rate was higher than at the low altitude of Tosa, Japan. Diastolic, but not systolic, BP was higher, and the increase in HR with postural change from the supine to the standing position was higher in Leh than in Tosa. In terms of target organ damage, Ladakhis showed a higher voltage of the QRS complex (SV1 + RV5) than Japanese, the difference being statistically significant only in men, with no difference in PWV.

The present study also showed that the cognitive function (estimated by the Kohs block design test) and ADL functions (scored by the Functional Reach and Button tests) were worse at high than at low altitude, the difference being statistically significant only in women. Time estimation also differed between the two populations, being shorter in Leh than in Tosa, a finding seen primarily in men.

Gender differences in neuro-cardio-pulmonary functions observed herein may be accounted for by the following factors. First, improved lung mechanics may be an important adaptation to indoor biomass and outdoor dust exposure in high-altitude populations [1]. Norboo et al. [2] reported that the prevalence of chronic cough was greater among women than among men. The percentage of villagers over 50 years of age with a forced expiratory volume in 1 s/forced vital capacity ratio (FEV_{1.0}/FVC) of less than 65% was 24% in men and 32% in women. Older people exposed to environmental dust may develop advanced cardiopulmonary dysfunction. In Ladakh, women are more heavily exposed to dust with the use of chimneys in the kitchen, and to dust storms in the course of their work, and appear to be more commonly affected than men [3]. Second, it has been reported that the urinary sodium/potassium ratio is larger in women than in men in Ladakh [4]. Urinary potassium (nmol/24-h) is lower in women (37.4 ± 13.2) than in men (56.7 ± 23.8). The urinary sodium/potassium ratio is higher in women (5.52 ± 2.03) than in men (4.24 ± 1.99), which itself is higher than in Japanese (Osaka) women (3.90 ± 1.14). Nutritional imbalances may be associated with unfavorable neuro-cardio-pulmonary functions in women, a question being pursued in our ongoing study of how nutrition may affect physiological adaptation to a high-altitude environment. Third, medical services are now developing in Ladakh and citizens, especially poor women have not received sufficiently high quality care. Lastly, Leh, the present capital of Ladakh, was once the central meeting-point for trade caravans from Central Asia and the plains of India. Their religion is Tibetan Buddhism and many monks practice it in its original form. From a cultural anthropology standpoint, such original lifestyles, including the educational system, may contribute to the gender difference seen in Ladakh.

Atherosclerosis is an important cause of morbidity and mortality in the elderly, and arterial stiffness may predict cardiovascular events [5]. Arterial stiffness can be assessed non-invasively by measuring pulse wave velocity (PWV), which is a simple and reproducible endpoint [6]. Traditionally, carotid-femoral PWV is an established method for measuring PWV. Contrary to this traditional PWV, baPWV includes peripheral components of the arterial tree. We need to consider the role of this arterial tree because the influence of age changes in different parts of the arterial tree. In this investigation, we excluded an influence of peripheral

components of the arterial tree, using an instrument of VaSera (Fukuda Denshi Co., Ltd., Tokyo). We measured CAVI, a revised value of haPWV. Although high-altitude residents had a lower SpO₂, a higher respiration rate, an increased diastolic BP and a larger increase in HR with postural change from the supine to the standing position, there was no difference in PWV. These results suggest that most residents succeed to adapt sufficiently to the high-altitude environment. A correlation of haPWV (CAVI) with age, however, shows that several subjects have very high CAVI values, Fig. 1. There are several cases who show an extreme increase in CAVI. For the prevention of stroke and other adverse cardiovascular outcomes, including dementia, CAVI may be very useful, especially at high altitude.

Our study shows that elderly people at high-altitude are at high risk of cardiovascular disease. It has not yet been shown, however, how these indices are associated with maintained cognitive function. A longitudinal follow-up of these populations in terms of longevity and aging is needed to better understand any changes in neurocardiological function. Our goal is the prevention of stroke and the decline in cognitive function of the elderly, especially in high-altitude communities such as those of Ladakh.

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Fig. 1. Correlation between PWV, gauged by CAVI, and age in high-altitude residents of Leh, Ladakh

CAVI increases linearly with age. Several citizens show very high values of CAVI, however. For the prevention of adverse cardiovascular outcomes, including myocardial infarction, stroke and dementia, this measure of PWV could be very useful, especially in high-altitude populations.

Table 1

Comparison of cardiopulmonary functions among five villages in Ladakh

Females					Males				
Age	n	Mean	S.D.		Age	n	Mean	S.D.	
Phey	55	42.7	18.3		Phey	17	58.0	17.3	
Leh	197	48.4	15.2		Leh	137	52.4	14.0	
Chuma	47	41.8	17.2		Chuma	29	51.4	18.6	
Sumdo	57	40.6	19.0		Sumdo	38	45.3	14.7	
Korzok	70	38.9	15.9		Korzok	84	39.5	14.1	
									$P < 0.0005$
SpO ₂	n	Mean	S.D.		SpO ₂	n	Mean	S.D.	
Phey	55	91.7	2.7		Phey	17	90.7	3.0	
Leh	178	88.7	4.3		Leh	121	88.6	4.7	
Chuma	47	88.7	3.3		Chuma	29	87.2	4.6	
Sumdo	57	84.0	4.1		Sumdo	38	83.4	4.8	
Korzok	70	83.7	4.9		Korzok	84	85.4	4.3	
									<0.0001
HR	n	Mean	S.D.		HR	n	Mean	S.D.	
Phey	55	84.5	11.7		Phey	17	85.2	14.0	
Leh	195	79.8	13.7		Leh	137	76.2	14.2	
Chuma	47	81.1	15.5		Chuma	29	76.5	8.5	
Sumdo	57	84.3	13.1		Sumdo	37	79.4	10.7	
Korzok	70	80.0	14.4		Korzok	84	73.3	12.7	
									<0.01
Hb	n	Mean	S.D.		Hb	n	Mean	S.D.	
Phey	55	14.0	1.3		Phey	17	16.3	1.7	
Chuma	47	13.1	2.6		Chuma	29	16.9	1.9	
Sumdo	57	15.8	2.3		Sumdo	38	17.9	2.4	
Korzok	69	15.1	2.1		Korzok	84	17.9	2.2	

Females		Males			
		<0.0001		<0.05	
Syst BP		Syst BP		Syst BP	
n	Mean	n	Mean	n	Mean
55	121.1	16	128.1	16	128.1
195	127.5	136	137.4	136	137.4
47	127.2	29	127.1	29	127.1
57	123.1	34	131.1	34	131.1
68	128.9	84	133.8	84	133.8
N.S.		N.S.		N.S.	
Diast BP		Diast BP		Diast BP	
n	Mean	n	Mean	n	Mean
55	78.7	16	79.0	16	79.0
195	83.2	136	88.2	136	88.2
47	79.4	29	84.7	29	84.7
57	82.4	32	88.6	32	88.6
68	84.9	84	91.5	84	91.5
P < 0.05		P < 0.005		P < 0.005	
PP		PP		PP	
n	Mean	n	Mean	n	Mean
55	42.4	17	46.2	17	46.2
195	44.3	136	49.2	136	49.2
47	47.8	29	42.4	29	42.4
57	40.7	32	43.0	32	43.0
68	44.0	84	42.3	84	42.3
N.S.		N.S.		N.S.	
Resp rate		Resp rate		Resp rate	
n	Mean	n	Mean	n	Mean
54	20.5	17	22.6	17	22.6
177	20.1	121	20.8	121	20.8
47	21.9	29	20.9	29	20.9
57	22.6	38	22.6	38	22.6
70	21.4	83	21.2	83	21.2
N.S.		N.S.		N.S.	

Females		Males				N.S.	
		<0.0005					
Height	n	Mean	S.D.	Height	n	Mean	S.D.
Phey	55	152.8	6.0	Phey	17	161.9	7.7
Leh	197	151.9	6.0	Leh	137	164.2	7.2
Chuma	47	151.2	5.2	Chuma	29	162.0	6.1
Sumdo	57	149.8	5.7	Sumdo	38	162.2	6.6
Korzok	70	149.2	4.0	Korzok	84	159.1	6.3
			<0.0005				<0.0001
Weight	n	Mean	S.D.	Weight	n	Mean	S.D.
Phey	55	48.9	7.3	Phey	17	59.0	12.7
Leh	197	53.7	8.9	Leh	137	64.2	10.6
Chuma	47	46.9	7.2	Chuma	29	52.9	5.2
Sumdo	57	49.2	8.6	Sumdo	37	55.2	9.6
Korzok	70	45.8	6.0	Korzok	84	51.8	9.0
			<0.0001				<0.0001
BMI	n	Mean	S.D.	BMI	n	Mean	S.D.
Phey	55	20.9	2.8	Phey	17	22.4	3.6
Leh	197	23.3	3.6	Leh	137	23.9	4.0
Chuma	47	20.4	2.7	Chuma	29	20.2	2.0
Sumdo	57	21.9	3.3	Sumdo	37	20.9	3.5
Korzok	70	20.6	2.5	Korzok	84	20.4	2.9
			<0.0001				<0.0001

Table 2
Cognitive, neurobehavioral and ADL scores, and cardiovascular variables at high and low altitude

Ladakh			Tosa town			Student's <i>t</i> -test		
	n	Mean	S.D.	n	Mean	S.D.	<i>t</i> -value	<i>P</i> -value
Age	40	74.7	3.3	324	80.7	4.7	-7.89	<0.0001
BW	40	57.2	11.3	322	50.3	8.9	4.44	<0.0001
Height	40	155.0	8.7	322	147.6	8.2	5.35	<0.0001
BMI	40	23.8	4.2	321	24.4	16.2	-0.24	N.S.
SBP S1	39	155.7	24.4	324	153.4	22.0	0.63	N.S.
DBP S1	40	91.0	13.7	324	87.3	10.9	1.86	0.05
Pulse S1	40	76.4	14.8	323	70.4	11.6	3.01	<0.005
SBP S2	40	151.2	23.5	324	153.4	22.1	-0.60	N.S.
DBP S2	40	90.2	15.2	324	85.2	10.6	2.66	<0.01
Pulse S2	40	75.1	14.5	323	69.2	11.4	2.95	<0.005
SBP L1	40	142.1	20.8	324	144.2	19.9	-0.63	N.S.
DBP L1	40	86.7	15.3	324	78.9	9.5	4.54	<0.0001
Pulse L1	40	72.5	12.9	323	66.6	10.5	3.23	<0.005
SBP L2	40	143.8	20.7	324	146.5	19.8	-0.80	N.S.
DBP L2	40	82.8	13.3	324	79.0	9.1	2.30	<0.05
Pulse L3	40	71.4	14.5	323	65.7	10.7	3.00	<0.005
SBP U1	40	142.1	26.0	322	143.8	24.1	-0.40	N.S.
DBP U1	40	88.0	14.1	322	83.5	11.6	2.24	<0.05
Pulse U1	40	85.2	16.1	321	75.6	12.4	4.43	<0.0001
SBP U2	40	150.0	21.5	322	149.5	24.3	0.10	N.S.
DBP U2	40	91.6	14.8	322	85.7	11.1	3.06	<0.005
Pulse U2	40	79.7	15.4	321	75.5	12.3	1.95	N.S.
Delta SBP	40	-1.7	17.1	322	-2.9	16.1	0.43	N.S.
Delta DBP	40	5.2	8.8	322	4.4	9.4	0.52	N.S.
Delta Pulse	40	13.8	8.1	321	9.9	6.7	3.47	<0.001
Up & Go	36	15.0	4.3	322	17.6	8.5	-1.79	N.S.
FR	34	18.1	8.2	323	25.7	8.8	-4.79	<0.0001

Ladakh			Tosa town			Student's <i>t</i> -test		
	n	Mean	S.D.	n	Mean	S.D.	<i>t</i> -value	<i>P</i> -value
Button	39	18.8	6.0	321	16.6	9.3	1.44	N.S.
Kohs	39	9.0	8.8	323	16.4	10.0	-4.44	<0.0001
TEI0-1	35	8.5	2.7	324	11.5	5.8	-2.97	<0.005
TEI0-2	35	7.9	2.4	324	10.0	4.3	-2.78	<0.01
TE60-1	34	42.7	16.8	323	57.1	23.0	-3.55	<0.0005
TE60-2	35	38.3	10.2	324	55.4	20.8	-4.81	<0.0001
SpO ₂	35	88.0	4.3	305	96.6	1.2	-27.23	<0.0001
Respiration	38	21.1	4.2	324	17.8	4.2	4.49	<0.0001
Heart rate	40	70.2	11.7	311	68.7	12.0	0.72	N.S.
SV1	40	10.5	7.0	304	8.3	5.0	2.52	<0.05
RV5	40	18.5	10.4	317	16.4	7.4	1.57	N.S.
SV1 + RV5	40	29.0	14.5	305	24.7	9.6	2.46	<0.05
haPWV (CAVD)-1	39	9.49	1.53	323	10.01	1.97	-1.60	N.S.
haPWV (CAVD)-2	39	9.41	1.63	321	10.05	2.07	-1.86	N.S.
ABI-1	39	1.08	0.14	323	1.11	0.11	-1.46	N.S.
ABI-2	38	1.09	0.14	321	1.10	0.11	-0.56	N.S.
SBP	39	145.3	19.3	322	141.5	20.5	1.12	N.S.
DBP	39	88.6	12.7	322	80.2	9.6	4.98	<0.0001
HR	37	70.5	14.5	322	66.5	12.3	1.81	N.S.

Table 3
Comparison of neurocardiovascular and chronobiological functions of elderly men of Leh, Ladakh, and Tosa, Kochi prefecture

Ladakh				Tosa town			Student' s t-test		
	n	Mean	S.D.	n	Mean	S.D.	t-value	P-value	
Age	19	74.4	3.4	97	81.3	4.6	-6.22	<0.0001	
BW	19	63.7	10.8	97	55.8	8.9	3.46	<0.001	
Height	19	161.7	7.2	97	155.8	7.2	3.29	<0.005	
BMI	19	24.5	4.2	96	25.0	20.8	-0.12	N.S.	
SBP S1	18	162.1	23.9	97	146.4	19.7	2.99	<0.005	
DBP S1	19	93.0	14.2	97	84.6	10.0	3.13	<0.005	
Pulse S1	19	73.4	17.3	97	67.5	11.8	1.83	N.S.	
SBP S2	19	157.4	23.6	97	148.0	19.5	1.85	N.S.	
DBP S2	19	93.6	16.5	97	83.9	10.6	3.30	<0.005	
Pulse S2	19	71.8	16.5	97	66.7	11.4	1.66	N.S.	
SBP L1	19	146.0	23.2	97	140.6	18.1	1.12	N.S.	
DBP L1	19	89.0	17.0	97	77.6	8.7	4.33	<0.0001	
Pulse L1	19	71.0	15.2	97	64.4	11.0	2.24	<0.05	
SBP L2	19	146.8	21.5	97	143.7	17.6	0.67	N.S.	
DBP L2	19	84.6	14.5	97	78.5	8.7	2.45	<0.05	
Pulse L2	19	68.9	16.9	97	63.3	11.2	1.83	N.S.	
SBP U1	19	145.5	30.9	97	139.7	22.1	0.98	N.S.	
DBP U1	19	89.2	16.3	97	80.2	11.0	3.00	<0.005	
Pulse U1	19	80.7	17.7	97	71.5	11.5	2.89	<0.005	
SBP U2	19	152.0	25.8	97	142.3	19.9	1.84	N.S.	
DBP U2	19	92.4	16.4	97	82.1	10.2	3.59	<0.0005	
Pulse U2	19	76.6	17.5	97	71.9	11.8	1.46	N.S.	
Up & Go	17	13.1	1.9	96	17.5	9.7	-1.86	N.S.	
F R	16	23.1	6.5	97	26.5	8.8	-1.46	N.S.	
Button	19	15.0	4.7	97	20.8	9.3	-1.83	N.S.	
Kohs	19	14.6	9.1	97	16.4	11.0	-0.69	N.S.	
TE10-1	17	7.6	1.6	97	11.2	4.3	-3.36	<0.005	

Ladakh			Tosa town			Student' s <i>t</i> -test		
	n	Mean	S.D.	n	Mean	S.D.	<i>t</i> -value	<i>P</i> -value
TE10-2	17	7.2	2.0	97	10.4	4.6	-2.80	<0.01
TE60-1	16	37.7	10.5	97	60.6	19.5	-4.58	<0.0001
TE60-2	17	35.3	9.3	97	59.9	19.6	-5.06	<0.0001
SpO ₂	17	89.1	4.4	96	96.6	1.3	-13.93	<0.0001
Respiration	19	21.5	5.0	97	17.5	3.8	3.97	<0.0005
Heart Rate	19	68.4	13.7	92	66.9	13.1	0.46	N.S.
SV1	19	12.0	7.9	89	9.2	5.8	1.76	N.S.
RV5	19	20.1	13.2	94	16.6	8.3	1.48	N.S.
SV1+RV5	19	32.1	16.7	90	25.6	11.3	2.06	<0.05
haPWV (CAVI)-1	19	9.65	1.84	97	9.81	2.03	-0.33	N.S.
haPWV (CAVI)-2	19	9.63	2.00	97	9.72	2.01	-0.18	N.S.
ABI-1	19	1.09	0.16	97	1.11	0.13	-0.59	N.S.
ABI-2	18	1.13	0.12	97	1.10	0.12	0.99	N.S.
SBP	19	147.3	20.7	97	141.3	23.4	1.03	N.S.
DBP	19	90.0	12.0	97	79.9	9.9	3.92	<0.0005
HR	19	70.0	17.1	97	65.4	11.0	1.51	N.S.

Table 4
Comparison of neurocardiovascular and chronobiological functions of elderly women of Leh, Ladakh, and Tosa, Kochi prefecture

Ladakh			Tosa town			Student's <i>t</i> -test		
<i>n</i>	Mean	S.D.	<i>n</i>	Mean	S.D.	<i>t</i> -value	<i>P</i> -value	
Age	18	71.0	11.5	225	67.0	12.8	<0.0001	
BW	21	51.2	8.2	225	48.0	7.8	N.S.	
Height	21	149.0	4.7	225	144.1	5.8	<0.0005	
BMI	21	23.1	4.1	225	24.1	13.8	N.S.	
SBP S1	21	150.3	24.0	227	156.3	22.3	N.S.	
DBP S1	21	89.1	13.3	227	88.4	11.1	N.S.	
Pulse S1	21	79.0	11.8	226	71.5	11.3	<0.005	
SBP S2	21	145.5	22.5	227	155.7	22.8	N.S.	
DBP S2	21	87.2	13.7	227	85.8	10.5	N.S.	
Pulse S2	21	78.0	12.1	226	70.3	11.3	<0.005	
SBP L1	21	138.6	18.2	227	145.7	20.5	N.S.	
DBP L1	21	84.7	13.6	227	79.5	9.8	<0.05	
Pulse L1	21	73.8	10.6	226	67.5	10.2	<0.01	
SBP L2	21	141.1	20.2	227	147.6	20.5	N.S.	
DBP L2	21	81.1	12.3	227	79.3	9.3	N.S.	
Pulse L2	21	73.6	11.8	226	66.8	10.3	<0.005	
SBP U1	21	139.0	21.0	225	145.5	24.8	N.S.	
DBP U1	21	86.9	12.1	225	84.9	11.6	N.S.	
Pulse U1	21	89.2	13.8	224	77.4	12.4	<0.0001	
SBP U2	21	148.1	17.2	225	152.6	25.4	N.S.	
DBP U2	21	90.9	13.6	225	87.2	11.1	N.S.	
Pulse U2	21	82.4	13.1	224	77.1	12.2	N.S.	
Up and Go	19	16.8	5.1	226	17.7	8.0	N.S.	
F R	18	13.7	7.0	226	25.3	8.7	<0.0001	
Button	20	22.5	4.8	224	14.8	5.7	<0.0001	
Kohs	20	3.7	3.6	226	16.4	9.6	<0.0001	
TE10-1	18	9.4	3.2	227	11.6	6.3	N.S.	

Ladakh			Tosa town			Student's <i>t</i> -test		
	<i>n</i>	Mean	S.D.	<i>n</i>	Mean	S.D.	<i>t</i> -value	<i>P</i> -value
TE10-2	18	8.6	2.5	227	9.8	4.2	-1.20	N.S
TE60-1	18	47.2	20.1	226	55.6	24.2	-1.42	N.S.
TE60-2	18	41.2	10.4	227	53.5	21.1	-2.47	<0.05
SpO ₂	18	87.0	4.0	209	96.6	1.2	-24.95	<0.0001
Respiration	19	20.6	3.3	227	18.0	4.4	2.60	<0.01
Heart rate	21	71.8	9.7	219	69.5	11.5	0.88	N.S.
SV1	21	9.2	6.0	215	7.9	4.7	1.20	N.S
RV5	21	17.1	7.1	223	16.4	7.0	0.43	N.S
SV1 + RV5	21	26.2	11.8	215	24.3	8.9	0.92	N.S.
haPWV (CAVD)-1	20	9.34	1.20	226	10.09	1~95	-1.71	N.S.
haPWV (CAVD)-2	20	9.20	1.21	224	10.19	2.09	-2.09	<0.05
ABI-1	20	1.07	0.12	226	1.11	0.11	-1.61	N.S
ABI-2	20	1.06	0.16	224	1.10	0.11	-1.80	N.S
SBP	20	143.5	18.3	225	141.5	19.1	0.45	N.S.
DBP	20	87.4	13.5	225	80.3	9.6	3.05	<0.005
HR	18	71.0	11.5	225	67.0	12.8	1.27	N.S