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Research Article

Circulatory Hyperactivity and Risk of Heart Attack in Elderly Persons During High Land Physical Activity: Concomitant Risk for Rescuers Who May Work on Cardiopulmonary Resuscitation

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ABSTRACT

Objective: Wide blood pressure fluctuations among elderly persons can be a cause of cardiovascular events. Physicians working in suburban hospitals adjacent to highland resorts often see cases hospitalized following some weekend activities, mostly with cardiovascular events. Authors examined hemodynamic and muscle power parameters of the weekend trekkers, on site, and reviewed risks of high land trekkers and rescuers who may work on cardiopulmonary resuscitation (CPR).

Materials and methods: To know the circulatory and muscular conditions of people visiting a suburban resort by themselves, a health check-up was organized in a ropeway station. Blood pressure, heart rate, arterial oxygen saturation, and hand and back muscle powers were measured before and after a physical activity, outdoor trekking. Also, authors' previous reports regarding cardiopulmonary resuscitation at high altitudes were reviewed.

Results: Significantly higher blood pressure was observed in elderly persons than in other age groups ($p<0.05$). 13 out of 31 in only elderly persons (male 9/18 and female 4/13) had blood pressure higher than 160 mmHg. A decrease in blood pressure after trekking was apparent among elderly visitors ($p<0.05$). There was no difference between male and female visitors. A limited number of visitors had interest in muscle power measurements.

Conclusions: Many elderly persons have risk factors for cardiovascular accidents. Leisure activity-related accidents caused by heart attacks or strokes tend to be more common in this population. Suburban medical staff should be well prepared for this, and elderly persons should be made aware of their fluctuating circulatory parameters and their increased risk of emergency diseases and injuries, especially in remote settings. Furthermore, applying CPR places major demands on the body of rescuers at high altitude.

Keywords: Pre-work high blood pressure; Highland accident; Trekking; Elderly persons; Muscle power

INTRODUCTION

It is well known that blood pressure fluctuates widely when elderly persons are exposed to some stress, such as physical exercise, and it can be a cause of unexpected cardiovascular events or out-of-hospital emergencies. Emergency Department (ED) and intensive care unit (ICU) physicians in suburban hospitals adjacent to highland resorts often see emergency cases mostly having cardiovascular events, especially on weekends before noon [1]. The authors often treat cases having coronary events and arrhythmias on weekend mornings, some of which are fatal, while others recover.

As many middle-aged to elderly people enjoy a quiet environment and moderate exercise, non-challenging mid-altitude trekking has become increasingly popular in Japan [2]. "Green exercise", meaning physical activity in plant-rich outdoor environments, such as forests and relatively lower-altitude mountains, is widely recommended to maintain physical performance and to prevent lifestyle-related diseases to middle-aged and elderly persons [3]. This population prefers nearby areas to distant areas, but such popularity has had a significant impact on the trends in alpine accidents and weekend ED/ICU functions [2,4].

The Japanese National Police Agency released data regarding highland accidents and announced that the number of outdoor

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accidents has increased markedly over the past 5 years [5]. The records for 2017 showed that the total number of highland accidents was 2583 cases (3111 persons). Injuries provoked by stumbling, slipping, and falling accounted for 32%, diseases and fatigue accounted for 13% of these, and 78% of casualties were older than 40 years, with 51% being older than 60 years. Some of them were apparently suffering a stroke or heart attack while trekking in highland resorts. Furthermore, it is suspected that many other accidents, such as those involving slipping, falling, or disorientation, originate from some form of pre-existing physical problem.

Another concern is that rescuing such victims at high lands places serious workloads on rescuers. We previously showed that applying CPR places major demands on the body at high altitude [6,7]. Our results indicated that CPR in a hypoxic environment significantly impacts the physiological parameters, such as arterial oxygen saturation and rate pressure products of providers. Recently, we also reported that compression-only CPR seems likely to further deteriorate oxygenation among rescuers [8,9].

Considering this social environment, warning the public of the physical effects of "green exercise" seems indispensable. In addition, such knowledge should be used to set up a well-organized emergency rescue system.

In the present survey, basic circulatory parameters, such as blood pressure, heart rate, and arterial oxygen saturation, as well as hand and back muscle powers, were assessed pre- and post-"green exercise" in a popular suburban resort. According to our preliminary survey, this report is the first one which assessed hemodynamic parameters of the weekend trekkers, on site at a super aged developed country suburb.

MATERIALS AND METHODS

A health check-up post was set in a ropeway station located in a suburban resort in collaboration with the local government and regional rescue committee. Approval was obtained from the human ethics committee of our institute (Gunma University Faculty of Medicine, epidemiological study 20-20). We retrospectively analyzed the data obtained at this health check-up post.

A total of 120 participants stopped at the check-up post and had all or some of the parameters measured. To increase the number of participants, their exact age was not asked, and the age-range was indicated voluntarily. Body size was neither measured nor asked to increase the number of participants who were reluctant to take off their shoes and backpacks, and who were hesitant to admit their exact body size.

Measured parameters and devices were as follows: arm blood pressure monitor, Omron HEM-1010 (Omron Healthcare Inc., Kyoto, Japan); pulse oximeter, OhmedaTuffSat LR46381 (GE Healthcare Inc., Helsinki, Finland); hand grip power meter, Hand Grip Meter 6103 (Tanita Inc., Tokyo, Japan); and back power meter, Back-A (Takei Scientific Instrument Co. Ltd., Niigata, Japan).

The location of the health check-up post was in a corridor connecting a ropeway ticket booth and the boarding gate at 745 m above sea level (Mt. Tanigawa Tenjindaira ropeway in Minakami, operated by Tobu Railway Corporation, Tokyo), and all of the highland visitors aiming at a high viewpoint (Mt. Tanigawa has an altitude of 1963 m) using the ropeway went past the front of the gate. The most common trekking route from the ropeway station was 2.5-km-long, with a difference in altitude of 650 m, with an average trek time of 2-4 hours.

At the post, the passers-by were asked several basic questions, and pre-exercise health check-ups including blood pressure (BP), heart rate, arterial oxygen saturation, and hand and back muscle power measurements were recommended. Since the survey was for the general population, the visitors were not strongly encouraged to complete all of the measurements possible.

Statistics

All data are expressed as means ± SD, unless otherwise specified. Data analysis was conducted using Sigma Plot 12 statistical software (Systat Software, San Jose, CA). Comparisons between age-sex groups at pre-or post-exercise were tested using one-way analysis of variance (ANOVA) followed by the Holm-Sidak method or by Kruskal-Wallis one-way ANOVA on Ranks followed by Dunn's method. Changes within groups pre- and post-exercise were assessed by the t-test. Values of $p<0.05$ were considered significant.

RESULTS

Demographic characteristics of the participants, such as age-range and sex, are listed in Table 1. The number of pre-exercise participants was larger than that of post-exercise participants. Eight participants had the same circulatory parameters measured both pre-exercise and post-exercise.

Table 1: Number of participants in each group.

Category	Age	Gender	Pre-exercise	Post-exercise
Elderly	> 60 y	Male	18	8
		Female	13	6
Middle-aged	31-60 y	Male	22	8
		Female	14	4
Young	< 31 y	Male	12	2
		Female	16	5

Circulatory parameters were compared between age-ranges, sexes, and pre-and post-exercise (Table 2). Significantly higher blood pressure was observed in elderly persons than in the those in other age groups ($p<0.05$). In particular, significant differences in pre-exercise systolic blood pressure between groups were: elderly-male 158.8 ± 16.1 mmHg vs young-male 125.7 ± 9.0 mmHg, young-female 116.3 ± 11.2 mmHg, middle-aged male 136.1 ± 17.7 mmHg, and middle-aged female 119.9 ± 11.4 mmHg; and also, elderly female 155.5 ± 12.5 mmHg vs young-male, young-female, and middle-aged female. 13 out of 31 in only elderly persons (male 9/18 and female 4/13) not in the other groups had blood pressure higher than 160 mmHg. A decrease in systolic blood pressure after trekking was apparent in elderly visitors ($p<0.05$). Systolic blood pressure of male participants changed from 158.8

± 16.1 mmHg pre-trekking to 144.9 ± 15.5 mmHg post-trekking, and that of female participants changed from 155.5 ± 12.5 mmHg to 132.2 ± 13.7 mmHg. There was no difference between male and female participants.

Muscle power is also shown in Table 2. Because of the limited number of muscle power measurements, no comparisons were made between age-ranges, sexes, and pre-and post-exercise. Muscle power of female participants had a tendency to be weaker than that of male participants.

Eight participants had blood pressure and heart rate measurements both at pre-and post- exercise (Figure 1). Elderly participants showed a decreased blood pressure and increased heart rate after exercise.

Since the health check-up post was set at 745 m above sea level, the atmospheric pressure was not actually low in this survey. Thus, it was not possible to identify significant differences in arterial oxygen saturation between age groups and between male and female participants. All of the participants had arterial oxygen saturations greater than 94%, mostly greater than 96%. One middle-aged participant had saturation of 94%, and two had saturations of 95%.

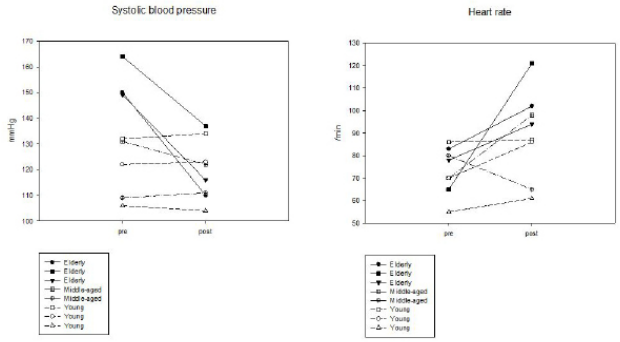

Figure 1: Sequential trends of systolic blood pressure and heart rate of participants whose parameters were measured before and after trekking.

DISCUSSION

Population of visitors

In the present survey, the health check-up posts were available from 7:00 a.m. to 3:00 p.m. Since the ropeway service was operated from 7:00 a.m. to 4:00 p.m., most visitors who used the ropeway had an opportunity to visit the check-up post. Since the ropeway usually transports 600 people in a day, it was roughly estimated that almost 20% of the visitors used the post in the day.

Table 2: Physiological parameters and comparisons between groups (This table has a supporting information table, Table S1. The results of statistical comparison are listed in Table S1).

	Elderly (age>60 y)		Middle-aged (31 ≤ age ≤ 60 y)		Young (age<31y)	
	Male	Female	Male	Female	Male	Female
<Circulation parameters>						
Systolic BP(mmHg, means ± SD)						
pre	158.8 ± 16.1	155.5 ± 12.5	136.1 ± 17.7	119.9 ± 11.4	125.7 ± 9.0	116.3 ± 11.2
post	144.9 ± 15.5	132.2 ± 13.7	121.3 ± 13.5	115.5 ± 8.4	118.0 ± 22.6	107.6 ± 13.0
diastolic BP (mmHg)						
Pre	83.3 ± 14.4	82.1 ± 12.3	77.5 ± 13.7	68.5 ± 10.0	75.5 ± 7.3	67.3 ± 13.4
Post	84.9 ± 9.0	73.5 ± 12.3	72.9 ± 10.0	68.3 ± 7.8	73.0 ± 12.7	61.8 ± 6.9
HR (min-1)						
Pre	81.4 ± 16.3	74.5 ± 12.3	81.4 ± 12.3	73.1 ± 10.1	78.2 ± 10.3	73.0 ± 11.3
Post	83.6 ± 18.3	75.5 ± 12.2	84.4 ± 17.7	76.0 ± 7.6	92.0 ± 7.1	77.4 ± 12.5
SpO2 (%)						
Pre	97.8 ± 1.1	97.4 ± 1.1	96.8 ± 1.4	97.7 ± 1.2	96.6 ± 0.8	97.7 ± 1.0
Post	97.1 ± 1.6	97.6 ± 1.3	97.3 ± 1.5	97.8 ± 1.7	98.0 ± 0.0	97.0 ± 1.2
<Muscle power parameters>						
Grip (Kg)						
Pre	38.7 ± 14.8	25.5 ± 7.0	39.0 ± 9.4	26.8 ± 4.9	39.7 ± 6.5	26.9 ± 6.9
Post	36.6 ± 14.5	29.3 ± 6.3	41.1 ± 9.8	19.1 ± 7.9	37.9 ± 1.6	26.9 ± 3.4
Back (Kg)						
Pre	114.1 ± 63.0	63.6 ± 19.5	115.9 ± 38.4	69.8 ± 10.3	115.1 ± 28.0	65.6 ± 13.3
Post	98.3 ± 41.7	65.0 ± 17.4	113.7 ± 37.5	61.0 ± 26.9	119.0 ± 1.4	66.0 ± 0.0

In the present survey, only a very limited number of visitors visited the post on their way back. Since the trekkers are most anxious about their physical condition immediately before the physical load, the great difference between the number of visitors prior to trekking and that after the trekking seems reasonable. Trekkers who had completed their schedule successfully seemed to have very limited interest in their health condition, and they were probably thinking of their hearty dinner after the exercise. The muscle power measurements attracted limited attention from the visitors. Most of them may have thought that muscle power was relatively stable in a day, and that there was no reason to care about hand and back muscle power during trekking, which did not require special upper body muscle power.

Public health issues: Hypertension, cardiovascular events

Statistical data of blood pressure reported by the national government is shown in Table 3 [10]. Although the general trends regarding the age-dependent increase were similar to the current data, increased systolic blood pressure in the elderly group was more apparent in the present survey, which measured blood pressure immediately before the physical activity. These populations apparently have a higher risk of cardiovascular events during physical workloads.

Table 3: Statistical data of blood pressure reported by the national (Japan) government (mmHg , mean SD) .

Age(y)	Gender	Subject number	Systolic BP	Diastolic BP
30-39	Male	319	124.5 ± 13.6	78.7 ± 10.7
	Female	544	114.5 ± 14.5	71.7 ± 10.8
40-49	Male	376	131.2 ± 16.6	84.2 ± 11.8
	Female	616	124.5 ± 17.7	77.2 ± 11.5
50-59	Male	531	138.4 ± 20.1	85.7 ± 12.3
	Female	813	133.4 ± 20.1	81.7 ± 12.2
60-69	Male	622	143.1 ± 18.4	84.4 ± 11.2
	Female	703	141.3 ± 20.5	82.1 ± 12.0
70-	Male	457	147.0 ± 19.5	80.4 ± 11.8
	Female	637	146.2 ± 19.7	79.0 ± 11.9

Blood pressure data analysis and suggestions

In this survey, the measurement done before the ropeway ride was not necessarily pre-exercise, because the participants apparently walked to the site on foot from the bus station or parking lot. Minor physical work had been performed prior to the measurement. For this reason, the measurement timing could be considered the very early phase of exercise.

Blood pressure is high during the early phase of exercise. Otsuki reported that blood pressure was higher at the 1-km mark than both the 2 and 3-km marks in outdoor walking [11]. Exaggerated elevation of systolic blood pressure during exercise is a risk factor for future cardiovascular disease [12]. Therefore, elderly visitors who showed high blood pressure in the health checkup post were considered to have a higher risk of cardiovascular (CV) events during exercise. With advancing age and disease, the compliance of the large central arteries (namely the aorta and carotid arteries) declines. Aortic pulse wave velocity and central pulse pressure (PP; as a surrogate of large artery stiffness in older people) were recently found to be associated with submaximal exercise systolic BP [13].

Hypertension during exercise was classified as systolic BP ≥ 210 mmHg in men or ≥ 190 mmHg in women, or diastolic BP ≥ 110 mmHg in men or women. This phenomenon can be a manifestation of multiple factors, including large artery stiffness, increased peripheral resistance, neural circulatory control, and metabolic irregularities [14]. It can be 'masked' hypertension, associated with the future incidence of hypertension and adverse left ventricular structure. It predicts future CV events and/or mortality. Exercise-related hypertension at a low-to-moderate exercise workload is strongly associated with an increased likelihood of adverse CV outcomes [15]. The visitors who had high blood pressure pre- or during exercise might be better to be advised to care for their circulatory complications.

Blood pressure decrease after exercise in elderly persons

In the present survey, systolic blood pressure among elderly visitors was lower after trekking than the pre-exercise value. The data obtained from trekkers who underwent both pre- and post-exercise measurements showed a decrease after exercise. This phenomenon can be explained by the reduction of sympathetic activity following exercise completion and by possible dehydration after exercise. Mental stress seems to be lower after exercise, and trekkers often have dehydration after outdoor activity, where water loss through respiration and perspiration is inevitable, and the liquid supply is limited. Salt is also excreted with sweat, which decreases blood pressure, especially in salt-sensitive hypertension. It is widely noted that a bout of vigorous exercise in the morning increases the relative risk of primary cardiac events even in apparently healthy individuals [16]. However, although the risk of cardiovascular events induced by sympathetic hyperactivity is lower in the afternoon and after physical activity, trekkers should be wary of hypotension and thrombosis, which can be provoked by dehydration.

Muscle power data analysis and suggestions

In the present survey, a limited number of visitors underwent hand and back muscle power measurements at pre- and post- exercise; therefore, no statistical analysis was performed. The observed data in the present survey were comparable to the government data [17]. It is considered that the present participants were not special athletes, and their physical performance was within standard levels.

Recommended outdoor exercise for seniors: Not hard, slow adaptation

The synergistic combination of exercise and exposure to nature, called "green exercise", has been recommended to prevent both physical inactivity and non-communicable diseases. Moderate physical exercise in the natural environment has been reported to stabilize heart rate, blood pressure, autonomic nervous system balance, and the endocrine system [3]. Although outdoor activity can be risky for elderly persons, especially in the early phase and in the morning, participation in regular physical activity is a well-

established therapeutic modality to lower the risk related to both CV disease and high blood pressure [18,19]. Aerobic, moderate, long-lasting exercise is beneficial to reduce blood pressure. Care for dehydration is important for elderly persons. Considering the age-dependent decline in physical performance, elderly trekkers are advised to be more cautious when preparing for sports activities. Although there are exceptionally unprepared elderly trekkers, many elderly trekkers comply with such precautions and perform preliminary exercises before starting their activities. Proper education programs regarding physical performance for elderly persons and about the risks of outdoor exercise may be effective to prevent highland accidents.

Preventing high land accidents is beneficial not only for trekkers, but also for local medical and paramedical staffs. Applying CPR has both physiological and mental effects, including feelings of fatigue. Scores on the exhaustion scale were high at 3,700 m, where SpO2 decreases and HR increases [6,7]. The latest guidelines recommend switching personnel who apply chest-compressing every 2 min based on findings of fatigue and an accompanying loss of CPR quality [7]. In particular, rescuers should switch every minute to maintain the quality of chest compression during compression-only CPR [8,9]. In remote, high-altitude, out-of-hospital environments, few passers-by or colleagues might be able to apply CPR. Therefore, CPR is unlikely to be applied according to recommendations in such environments. High land trekkers themselves should endure such rescue workload in a physically demanding environment.

CONCLUSION

Many people in Japan try to participate in non-challenging highland activities. Because a significant percentage of these elderly persons have circulatory system disorders, weekend accidents caused by these health problems tend to be more common in this population. Medical staff should be well prepared for this, and elderly persons should be made aware of their increased risk of cardiovascular emergencies in outdoor settings.

AUTHOR'S CONTRIBUTION

All authors substantially contributed to the acquisition, analysis and interpretation of data for the work. RM was responsible for the work, analyzed and interpreted the data and drafted the manuscript (55%). SS supervised the field methods and provided critical revision (20%). YM, MK and MT (5% each) obtained the data and provided critical revision. HK assisted with data analysis (10%).

CONFLICT OF INTEREST

The authors declare there are no competing interests.

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