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Heatstroke prevention with multi-device terminals via sensing of older adults living alone

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KEY WORDS

device, heatstroke, older adults, robot, sensing

Introduction

Heatstroke is a life threatening health problem. The mortality by heatstroke was 1,077, and 77.3% of them were older adults in 2013, Japan [1)]. Older adults and those with chronic illness are most prone to become heatstroke caused by excessive heat exposure [2)]. Older adults are deteriorating on their physiological functions related to heatstroke, resulting in decreasing water volume in the body. Decrease in sensory sensitivity of dipsia among older adults is associated with reduction of amount of fluid intake, and reduction of muscle mass where fluids are maintained causes quantity of water possession in the body, which eventually cause dehydration [3)]. Unfortunately, dehydration caused by heat is one of factors of ischemic heart disease [4)]; death by cardiovascular diseases with hyperthermia occurred 56.6% [5)]. It is necessary to intervene their lives as soon.

In the data, 41.9% of heatstroke among older adults occurred indoor [1)]. Living alone is the strongest risk factor for heat-related death [6)]. Heatstroke, involving abnormal central nervous system, such as ataxia and coma that might result in death, occurs unless appropriate measurements are taken from earlier. Older adults living alone have to take measures to meet the dangerous conditions in their home by themselves before being heatstroke, since they impair consciousness progressively.

Since sensing can work for 24-hours, we considered that sensing would be one of the effective preventive methods for heatstroke. Remote sensing method was employed to detect heat on the ground [7)]. However, this method cannot be utilized for indoor, even though 40% of heatstroke occurred indoor among older people [1)]. Moreover, Nguyen suggested the use of mobile communications, such as mobile phones for safe in their house; however, 55.6% of older adults preferred face-to-face learning, indicating perception of difficulty in acquisition of use of the device [8)].

No one prevents or gives alarms and teaches or operate devices, such as tablets, to older adults living alone. Risk of heatstroke was identified at the rate from 15.4 to 19.1 % during activity and sleeping time indoor [9)]. Even though they are not able to recognize developing heatstroke in the body, sensing is capably of identifying the risks. Development of a communication system that did not require operation was needed, for sensing temperature and humidity so as to detect risks of heat exhaustion and heatstroke indoor 24-hours.

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We examined responses of older adults living alone about alarms of the risks through multi-device terminals from sensing without any operation by themselves on living environments to prevent heat exhaustion and heatstroke.

Participants

Eligible participants were selected from candidates belonging to three Comprehensive Support Centers where residents of older adults could utilize services from one district area in Kanazawa city, located in the middle west in Japan. The criterion for participants were: age ≥ 65 years who were living alone, being intact cognition and able to walk, and having no animals since they might influence sensing data. Fifteen older adults were employed as participants.

Methods and Materials

Study design was a post-test only. Summer period in Japan is from July to September and therefore the three-month period from July 13st to October 12th, 2017 was selected as an observation period.

We sat up human detection sensors (NEC Solution Innovator Co.) on the walls in two rooms. The sensor detected temperature and humidity as well as detected whether the person staying in or out from the room. Sensing was implemented 24 hours. The temperature detection range of the device was -40 to 125 ℃, and that for humidity was 0-100 %.

We utilized the Wet-Bulb Globe Temperature (WBGT) index, which is widely used in the world and measures heat stress, so that appropriate exposure levels can be grasped [10]. WBGT is associated with temperature, humidity, wind speed, sun angle and solar radiation [11]. WBGT is calculated for indoors, indicating in the shade by 0.7 × the wet-bulb temperature + 0.3 × the globe temperature [11]. In the case that the criterion based-on the WBGT reached the lowest caution level, above 21 ℃ namely, alarm was automatically provided to participants through a small robot (RoBoHoN, Sharp Co.) and a tablet as multi-device terminals.

The robot verbally warned the participant automatically when the room condition matched the criteria, while the sensor was identifying the participant being in the either room, whereas the tablet showed the warning details by operating the icons by themselves. The basic approach of WBGT is "to seek to limit the combined metabolic and environmental heat load to what can be dissipated by the evaporation of sweat in the prevailing environment" [11]. Moreover, high environmental temperature interferes thermal transfer from the inside to the outside of the body. The verbal alarm then provided messages such as "(the robot talk automatically) I'm very hot. Cool me down by using the air conditioner." "I feel thirsty. Shall we have cold tea?" for lowering room temperature, and also prevention of dehydration. The alarm details were developed based on the "Guidelines related to daily life" [12-13]. We developed both contents and the alarm system.

In the case that the participant was judged not to do anything for the prevention identified by the sensing after fifteen minutes from the warning, the robot continuously warned them verbally. Although we were not able to identify what preventive measurement(s) the participants took, we grasped that the level of WBGT was declined in the room, and they probably used an air conditioner, or evacuated from the house to cooler place, such as shopping center and the support center.

Demographic variables were collected: sex, age, the number of diagnosed diseases, and cognitive level. Mini-mental state examination – Japanese (MMSE-J) was used to examine cognition state: sensitivity 0.86, specificity 0.89, test-retest reliability 0.81 [14]. Participants were asked time of get out from the bed and get in the bed.

Analysis

Continuous data are expressed as mean ± standard deviation. The number of times of the robot's utterance were collected as an outcome, and descriptive statistics were examined to its total number, regarding the level of WBGT and time. The level of WBGT is classified four categories: caution (21≤ WBGT <25 ℃), alert (25 ≤ WBGT <28 ℃), warning (28 ≤ WBGT < 31℃), and danger (31 ℃ ≤ WBGT) [13]. The time was determined based on the median time that the participants get out from the bed and get in the bed.

Ethics

This study was approved by the Kanazawa University Medical Ethics Committee (754-2). The informed consent was provided to primary family caregivers as well as older adults. The contents were study aim, methods, measurements, potential risks and its prevention methods, ethical considerations, publication, etc. Participants were allowed to withdraw from this study anytime without any disadvantage. Agreements from both of them were required to become participants.

Results

Demographic characteristics were shown in Table 1. The average age of the participants was 77.9±6.6 years, and the average scores of MMSE-J was 29.6±0.8. The number of diagnosed diseases was 2.8 ± 1.5.

The time was classified two groups: daytime (6am-10pm) and night time (10pm-6am), since the median of wake-up time was 6 am (range: 5-8am), whereas that of bedtime was 22 (range: 21pm-1am).

The number of times of the robot's utterance is shown in Table 2. The total number of times of utterance were 3,844; 3,455 (89.9%) for 6am-10pm, and 389 (10.1%) for 10pm-6am. The rate of participants who did not take actions to prevent heat at the caution level from 6am to 10pm was 52.1%; 2.2% for 10pm-6am at the caution level; 13.5% for 6am-10pm at the alert level. All participants acted at the alert level from 10pm-6am and at the level more than warning all day long. No one became heatstroke.

Table 1. Demographic characteristics of participants

N=15

Variables		Destribution
Sex n(%)		
	Men	4(26.7)
	Women	11(73.3)
Age (years) n(%)		
	65-74	5(33.3)
	75-84	8(53.3)
	≥85	2(13.3)
Body mass index	mean ± standard deviation	24.4 ± 3.6
	median (minimum - max)	25(17.1-31.2)
Number of diagnosed diseases		
	mean ± standard deviation	2.8 ± 1.5
	median (minimum - max)	2(2-7)
Score of Mini-mental state examination		
	mean ± standard deviation	29.6 ± 0.8
	median (minimum - max)	30(27-30)
Score of Geriatric depression scale		
	mean ± standard deviation	3.9 ± 1.9
	median (minimum - max)	3(2-8)

Table 2. Participants' behaviors regarding utterance times from the robot on the levels of WBGT

Behaviors		Utterance times of the robot					
		All day long		6am-10pm		10pm-6am	
		n	%	n	%	n	%
Caution-danger	Total	3844	100	3455	89.88	389	10.12
Caution	Total	2879	74.90	2698	78.09	181	46.53
Take no action		1410	48.98	1406	52.11	4	2.21
Take action		1469	51.02	1292	47.89	177	97.79
	Did something	1061	72.23	885	68.50	176	99.44
	Left the room	408	27.77	407	45.99	1	0.56
Alert	Total	643	16.73	461	13.34	182	46.8
Take no action		62	9.60	62	13.45	0	0
Take action		581	90.40	399	86.55	182	100
	Did something	573	98.60	391	97.99	182	100
	Left the room	8	1.40	8	2.01	0	0
Warning	Total	321	8.35	295	8.54	26	6.68
Take no action		0	0	0	0	0	0
Take action		321	100	295	100	26	100
	Did something	321	100	295	100	26	100
	Left the room	0	0	0	0	0	0
Danger	Total	1	0.03	1	0.03	0	0
Take no action		0	0	0	0	0	0
Take action		1	100	1	100	0	0
	Did something	1	100	1	100	0	0
	Left the room	0	0	0	0	0	0
More than warning	Total	322	8.38	296	8.57	26	6.68
Take no action		0	0	0	0	0	0
Take action		322	100	296	100	26	100
	Did something	322	100	296	100	26	100
	Left the room	0	0	0	0	0	0

WBGT: Wet-Bulb Globe Temperature
More than warning: warning and danger

Discussion

It was considered that the automatic and continuous alarms of robot could be effective to prevent heatstroke at the levels more than alert for older adults living alone, especially during night time. Older adults had difficulty in accessing mobile communications [8]. Verbal alarms were given to participants automatically via a robot although participants were also handed a tablet. We confirmed that convenience was a basic way so that older people adhere to heat prevention.

However, 50% of them during day time and 2% during night time at the caution level, and 13.5% at the alert level during daytime did not take preventive action. Although those rates were low, we need to consider it seriously, since it is continuous life threatening condition, especially for older adults. Older adults tend to become dehydrated. First, when air temperature is rising, water loss in the body accelerates via lots of sweating with insensible water loss in the body of older adults whose water volume in the body is decreased by aging. Second, older adults tend to have chronic disease(s), such as cardiovascular disease (CVD); diuretics medication prescribed to patients with CVD is prone to dehydration, resulting in ischemia [3]. Third, they tend to limit the intake of fluid after dinner time, since they are concerned about night voiding to avoid disturbance of sleeping, resulting in tending to become dehydration during night, in addition to nighttime sweeting among older adults [15]. In fact, those participants were multiply diagnosed. Therefore, we considered that some modification in the verbal contents from robots is necessary. Also, the number of danger levels was extremely small in this study, which did not allow us confirm if this alarm would be effective or not. It is needed to examine them furthermore to confirm their effectiveness.

The number of participants were small with a limited region; therefore, generalization of this study findings were limited.

Conclusion

The results showed that 50% of verbal alarms at 6 am-10pm at the caution level and 10% of those at 10pm-6 am at the alert level were ignored; however, no actions were taken at the levels that were over the warning level, suggesting that older adults living alone were careful toward higher levels of heat exhaustion. We presume that the automatically and continuous alarms of robot could be effective to prevent heatstroke at the levels more than alert for older adults living alone, especially during night time.

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