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Original Article

Comparing the alarm detectability of electronic axillary thermometer in older adults aged 70 years or more: buzzer alarm, vibration alarm, or buzzer/vibration alarm

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Abstract

This study aimed to compare the detectability of four alarms among two kinds of axillary thermometers in adults aged ≥70 years. In this randomized crossover study, the detectability of four alarms was assessed using within-subject differences between a reference (A) and a new thermometer with lower frequency and higher volume (B1), vibration (B2), and both functions (B3). The seconds was calculated by subtracting the time buzzer or vibration going off, from the time participant detected it. Positive detectability was defined as below 5 seconds. Complete data of 47 participants (mean age, 79.7 years) were collected. The numbers (proportions) of participants able to detect the alarm of A, B1, B2, and B3 was 19 (40.4%), 31 (65.9%), 46 (97.8%), and 46 (97.8%), respectively. A generalized linear mixed-effects model analysis, alarm detection was positively associated with alarm type, and age, but not between Mini-Mental State Examination. The odds ratios (95% confidence interval, *P* value) of B1, B2, B3, and age were 4.98 (1.15 to 21.51, $P = 0.031$), 688.92 (23.36 to 20316.95, $P < 0.001$), 688.92 (23.36 to 20316.95, $P < 0.001$), and 0.81(0.67 to 0.99; $P = 0.042$), respectively. Vibration was the most important variable that allowed for easier detection of alarms in this group, with or without cognitive impairment.

Key words: aging, cognitive impairment, hearing loss

Introduction

Accurate measurement of body temperature among older adult patients with comorbid disorders has been reported to be necessary for detecting infection, monitoring inflammatory processes, and evaluating progress of disease and treatment[1)2)].

Owing to the coronavirus disease pandemic, the use of non-contact forehead thermometers outside hospitals for infection screening has increased. However, Nia et al. showed that forehead thermometer readings had low agreement with the tympanic temperature[3)]. Other studies have indicated that infrared tympanic thermometers may be inaccurate because of the effects of ambient or environmental temperatures in older adults[4)5)]. In older adults, using these devices as routine screening tools for fever may also be difficult because of decreased finger dexterity resulting from symptoms caused by senescence. In addition, an electronic axillary thermometer with a beep alarm has been shown to be a highly reliable and valid alternative to traditional gallium-in-glass thermometers in older adults[6)]. Therefore, an axillary electronic thermometer may be considered the best way to measure fever in older adults because of its ease of use, and high reliability.

The prevalence of hearing loss increases with age[7)8)]. European studies have also shown a steady decline in

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hearing from the sixth to the ninth decades[9)10)], which is the same in Japan. The 10-year incidence rates of hearing impairment in the 60-64- and 70-74-year-old age groups were 32.5% and 62.5% (age at baseline), respectively[11)]. Although the electronic axillary thermometer, which is easy to use and reliable, is commonly used in Japanese older adults, their reduced ability to hear alarm sounds may also increase with age. We identified that the prevalence of a reduced ability to hear a beeping alarm signal of 50 dB at frequencies from 2700 to 4000 Hz was approximately 70% in older adults aged ≥ 65 years (N = 107)[12)]. To support appropriate usage of the electronic axillary thermometer in individuals with reduced ability to hear the alarm sound, it is also significant to identify the factors associated with reduced ability to hear the alarm sound among the known factors for hearing loss. Age was identified to be the most independent factor, and the age cut-off point for inability to hear the alarm sound was set to 70 years in this study. It was also observed that six participants aged 70 years older with reduced ability to hear buzzer alarm, without cognitive impairment (5.6%), removed the thermometer before buzzer occurrence[12)]. In these six participants, the body temperature could not be measured because of errors. This is because older individuals with a reduced ability to hear alarm beeping could not be identified when the measurement was complete. Therefore, it is possible that older adults aged ≥70 years may not be able to accurately measure their own body temperature using electronic axillary thermometer owing to reduced ability to hear the alarm sound. For this patient population, electronic axillary thermometer with detectable new alarm function is of great importance to measure their own body temperature.

The largest variation in hearing loss was found at high frequencies and in older ages[13)]. Overall, hearing thresholds increase by 1 dB per year on average in individuals aged >60 years, depending on age, sex, and initial thresholds[14)]. Therefore, higher volume and lower frequency or devising a new alarm type with vibration (no buzzer), may improve the ability to detect thermometer alarm among older adults aged ≥70 years. A new electronic axillary thermometer, with three alarm types, has been already developed for older adults. The alarm types included vibration only, higher volume, lower frequency, and a combination of all three features. However, whether this new thermometer with multiple alarm types could improve the detectability of alarm beeping among adults aged ≥70 years has yet to be determined.

This study aimed to compare the detectability of four alarm signals among two kinds of axillary thermometers: alarm with high frequency, alarm with higher volume and lower frequency, that with vibration, and a mixed alarm with all three features in older adults aged ≥70 years.

Methods

1. Study design and participants

This randomized crossover trial was conducted in a gastroenterology inpatient unit in a university hospital in Tokyo, Japan, between January and March 2021. The thermometers used were as follows (**Figure 1**): a Terumo Electronic Thermometer-C205 for reference (A) and a Citizen Systems Electronic Thermometer-CTEBV720VA with three types of signals: beeping (B1), vibration (B2), and both beeping and vibration (B3). The efficacies of A, B1, B2, and B3 were assessed for the within-subject differences between the two types of electronic axillary thermometers with four different alarms.

The gastroenterology inpatient unit was selected for this study. Patients in this unit are older every year, with advances in gastroenterology treatment (mean patient age in this unit in 2020 was 69 years). The fact that the unit had a good turnover rate of hospitalized patients made it well suited for the intervention study. The treatments provided in this unit were as follows: endoscopic resection of the stomach, colon, and esophageal cancer (endoscopic submucosal dissection); radiofrequency ablation of liver cancer; stenting plus anticancer chemotherapy for pancreatic and biliary cancer; endoscopic treatment for biliary and pancreatic stones; and clinical trials for new drugs for liver cancer, pancreatic cancer, colon cancer, biliary tract cancer, and hepatitis B and C.

Participants were recruited from new inpatients in this ward by a primary researcher during the day. The participants were adults aged ≥70 years. Patients who could read and understand Japanese, even if they had cognitive impairment, history of a noisy job, hearing impairment due to disease, or accidents in childhood or adulthood, were included in this study if

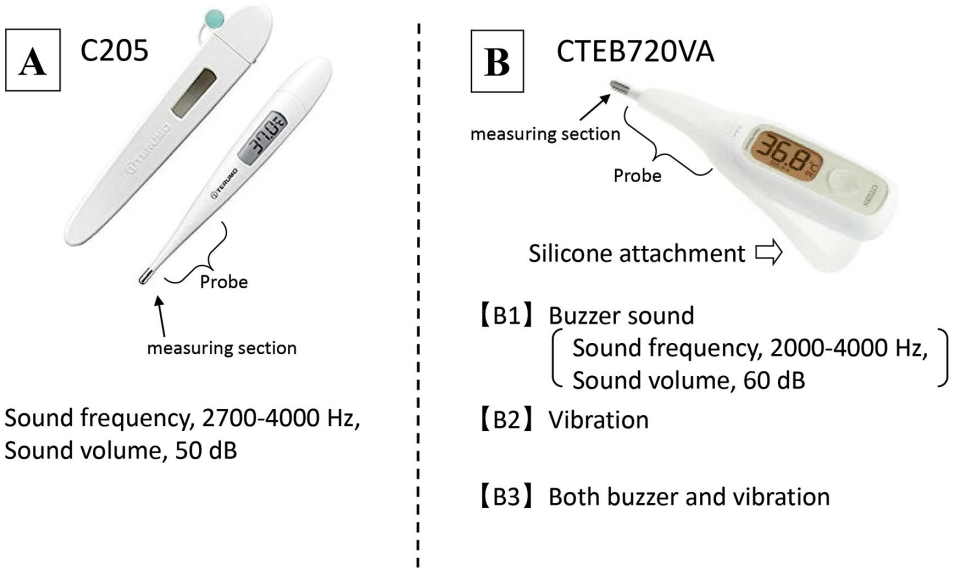

Figure 1 Samples of electronic axillary thermometer available in this study
(A) C205 with a buzzer of 50 dB with dual frequency band at 2700 and 4000 Hz (Terumo Corporation, Tokyo, Japan).
(B) CTEB720VA with three types of alarms (Citizen Systems Japan Co., Ltd., Tokyo, Japan): buzzer signal of 60 dB with dual frequency band at 2000 and 4000 Hz frequencies (B1), vibration (B2), and mixed version with all three features (B3). The CTEB720VA with a new silicone attachment supports the maintenance of the correct position for older adults with age-related sarcopenia.

they provided written informed consent. Additionally, eligible participants were required to place the thermometer tip at the axilla by themselves and report their body temperature to a nurse after it was beeped. Patients were excluded if they (i) had a depressed level of consciousness due to hepatic coma, pain, difficulty breathing, or were under sedation; (ii) manifested acute febrile illness or a body temperature ≥38.0℃ at the axilla; or (iii) could not keep the thermometer at the axilla until it beeped due to delirium.

2. Calculation of power and sample size

The difference in the proportion of patients who were able to detect these alarms for axillary temperature was assumed to be 40%, derived from our preliminary study of alarms A and alarm B2. The sample size that would provide 80% power with a two-tailed type I error rate of 0.05, was calculated to ensure the detection of an absolute difference of 40% between alarms A and alarm B2. The estimated sample size was 42; therefore, 46 patients were enrolled, assuming a loss to follow-up of 10%.

3. Data collection

Two types of axillary electronic thermometers were used. The first was C205, which was used as the reference (Terumo Corporation, Tokyo, Japan). C205 was used in our previous study[12] and is often used in participating hospitals. The other was the CTEB720VA, which was used as the intervention (Citizen Systems Japan Co., Ltd., Tokyo, Japan). These devices were lightweight and portable. These compact electronic thermometers measure the body temperature both actually and predictively. A predictive measurement, which is generally used in clinical settings, can measure body temperature in approximately 20–35 seconds. A predictive measurement would require less work by each participant compared with actual measurements lasting for 10 min or more. Therefore, we used predictive measurements. The thermometers were calibrated for accuracy according to the manufacturer's standards before measuring body temperature. All temperatures were recorded at ℃. The room temperature ranged from 20℃ to 26℃.

C205 (A) weighed approximately 13 grams, was 129 mm long and 17.6 mm wide, and had a depth of 12.6 mm. The temperature value is displayed digitally during temperature taking, with an accuracy of ±0.1℃, ranging from 26.7℃ to 43.3℃. A buzzer of 50 dB with dual frequency band at 2700 and 4000 Hz are

set to sound alternately when performing predictive measurement using C205. Different tone generated by each frequency was produced.

The CTEB720VA (B) targets older people, specifically those experiencing physical changes due to age-related sarcopenia, hearing loss at high frequencies, and visual degradation. Thermometer misplacement at the axilla due to reduced muscle mass or skin folds could frequently lead to significant errors without a nurse's assistance. To address this problem, a new silicone attachment to the CTEB720VA was developed. The CTEB720VA with the new silicone attachment was maintained in the correct position when used by skinny older individuals. This device has three alarm types and a wide display for ease of viewing. One alarm can be selected based on the user preference: buzzer for 4 s (B1), vibration for 8 s (B2), or buzzer and vibration for 4 s (B3). Citizen Systems succeeded in bringing lower frequency (2000 Hz) to buzzer specifications. Buzzer signal for B1 and B3 was equipped with 60 dB, and dual frequency bands at 2000 Hz and 4000 Hz. Different tones were generated similar to those by the C205. A vibration noise approximately of 39 dB was generated as a sound upon rotation of a micro vibration motor within the thermometer. Numbers of seconds of each alarm type was different. B1 and B3 were set to 4 s in terms of battery life. Vibration period (B2) was set to 8 s. Since the whole external surface of the CTEB720VA was covered by a silicone attachment, which was a soft and flexible material, vibration insulation was generated. That way the silicone attachment could damp the vibration by thermometer. Therefore, more time was needed to detect vibration at the axilla. A small hole was made at the back side of thermometer and silicone attachment, all sounds coming from there. CTEB720VA weighs approximately 25. 5 grams (approximately 35 grams with a silicone attachment) and was 126.5 mm long and 31.5 mm wide, with a depth of 15 mm deep. In this study, the CTEB720VA had no functional customization, by which this instrument on board was unchangeable. The temperature value is displayed digitally during temperature taking and ranges from 32.0℃ to 42.0℃, with an accuracy of ±0.1℃.

4. Procedure with randomization and blinding

Although age-related hearing loss was considered being a gradual deterioration equally occurring on both sides[8], there would have been a unilateral hearing loss in the participants. The measurement position of the axilla (left or right) may have an impact on alarm detectability. Therefore, the participants' measurement positions were assigned randomly using a random number table. All the participants recorded their body temperature with each alarm for a total of four measurements per participant. There were 24 combinations of measurement orders of the axillary electronic thermometers with four different alarms. After informed consent was obtained, the participants randomly selected only one combination of the measuring order by drawing a lot. A long washout phase was not required to diminish the carryover effect in this study because hearing or alarm detection could not be affected by the previous session. We determined the measurement interval between the devices to be approximately 30 s.

For each participant, body temperature and information on known correlations with hearing sensitivity were recorded by the primary researcher. As vibration alarm (B2), the primary researcher was able to detect a rotational noise of vibration with 39 dB at 30 cm from participant's axilla. This sound pressure was enough to hear in silent position, like a patient room or library. Therefore, every recording was set to keep an appropriate distance (approximately 30 cm) between the primary researcher and the participant's axilla. If participant wore thick clothing, like a sweater, this sound was not clear. Therefore, they were only in their underclothes and wearing hospital pyjamas, no sweater or layers of clothing. To ensure accurate results, the participants were instructed to dry their axillary region using a towel, turn off the television, and remove their hearing aids before temperature measurement. With the participants sitting on their beds, an electronic thermometer was placed at the center of the axilla (left or right). The instructions given by the primary researcher to each participant were as follows: after thermometer tip placement (starting body temperature measurement), please tell me when you hear a beeping sound or feel a vibration. If you do not hear a buzzer sound or feel vibration, please hold the thermometer in the axilla until the primary researcher gives you further instructions. Blinding was only possible for the participants with thermometers B1, B2, and B3 because the thermometers were exactly the same

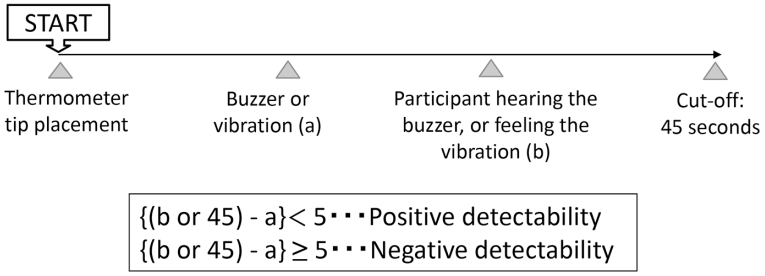

Figure 2 The time of the buzzer or vibration (a), the time of the participant's detection of the buzzer or vibration (b), and the cut-off point (45 s). Positive and negative detectability were defined as (b or 45) - a <5, and (b or 45) - a ≥5, respectively.

product; therefore, they were identical in shape and color. However, blinding was not possible for the researcher who measured the period from the thermometer tip placement to the participants' self-reports of alarm detection using a stopwatch.

5. Evaluation of the alarm detectability (hearing the beeping signal or feeling the vibration)

The period from the thermometer tip placement (starting body temperature measurement) to the alarm signal (buzzer and vibration) differed between the two devices, from 30 to 38 s and from 20 to 35 s for C205 and CTEB720VA, respectively. Forty-five seconds was the cutoff point if a participant did not notice the ringing alarm due to impaired hearing. The primary researcher measured the period from the thermometer tip placement to participants' self-report "I hear a buzzer sound, or feel a vibration." The time measured was as follows (**Figure 2**): the time of the buzzer or vibration going off (a), the time the participant heard the buzzer or felt the vibration (b), and the cutoff point was 45 s. By subtracting (a) from (b) or 45, the detectability in this study was defined as follows: <5 s, participants were determined to be able to detect the alarm (positive detectability), and ≥5 s, the alarm was considered to have not been properly detected (negative detectability). If participants could detect the vibration over 5 s after vibration alarm starting, it denoted negative detectability.

6. Statistical analysis

Descriptive data are expressed as mean ± standard deviation (SD) for continuous variables or as n (%) for categorical variables. The proportion of alarm detection for each alarm version was calculated as follows: (number of participants detecting an alarm/all participants) ×100. All statistical analyses were performed using the IBM SPSS Statistics version 24 (IBM Corporation, Armonk, NY, USA). The statistical significance level was set at $P<.05$.

A generalized linear mixed-effects model was used to identify the factors associated with alarm detectability, including the association among alarm type, age, and cognitive impairment. Age and cognitive impairment, which was shown to be associated with hearing loss[15)16)]. Cognitive impairment was defined as a Mini-Mental State Examination (MMSE) score <23[17)18)]. Regarding to alarm type, alarm A was used as reference for B1, B2, and B3. Patient ID was used as the random effect. The odds ratios and 95% confidence intervals (95% CIs) of these variables were estimated using the model. In the case of odds ratio greater than 1, alarm detectability of B1, B2, B3, or age, was higher rather than reference, and was higher with advancing age, respectively.

7. Ethical considerations

This study protocol was approved by the Ethical Committee of the Graduate School of Medicine, The University of Tokyo, Tokyo, Japan (study number 2020107N1). Written informed consent to participate in the study was obtained from all participants. The study was conducted in accordance with the STROBE statement and ethical guidelines of the Declaration of Helsinki.

Results

During the 3-month study period, 182 patients aged ≥70 years were hospitalized in a gastroenterology inpatient unit. Approximately 84 patients left the hospital before enrolling as participants. Of 98 patients, sixty patients agreed to participate in the study. We excluded 13 patients due to insufficient

Table 1 Characteristics of participants

Characteristic	N=47
Age (years)	79.72 (5.26)
Sex (male)	31 (66.0)
Body mass index	23.04 (3.87)
Scores < 18.5	4 (8.5)
Mini-Mental State Examination	24.04 (4.13)
Scores > 24	24 (58.5)
Scores < 23 (cognitive impairment)	17 (41.5)
History of smoking	25 (53.2)
Barthel index	18.93 (3.39)
Number of pharmacies	5.93 (3.32)
Diabetes mellitus	19 (40.4)
Hypertension	25 (53.2)
Measurement position at axilla	
Right	24
Left	23
Information related to hearing loss	
Hearing impairment	10 (21.3)
History of noisy job	6 (12.8)
Subjective hard of hearing	18 (38.3)
Right	9
Left	9
Use of hearing aid	3 (6.4)
Platinum antitumor agent	1 (2.1)

Values are mean (standard deviation) or number of participants (%).

data (n = 2), withdrawal before performing statistical analysis (n = 2), and catching infections, including coronavirus or deterioration in condition before starting the research (n = 9). Therefore, complete data were obtained from 47 participants (31 male, 16 female) with a mean ± SD age of 79.7 ± 5.26 years. The type of patient room was divided into three types, single room (n = 6), a room for two patients (n = 15), and a room for four patients (n = 36). The clinical characteristics of the 47 participants were as follows: esophageal cancer (n = 4, 8.5%), stomach cancer (n = 4, 8.5%), pancreatic cancer (n = 6, 12.8%), liver cancer (n = 9, 19.1%), biliary tract cancer (n = 2, 4.3%), colorectal cancer, and lateral spreading tumor (n = 13, 27.7%), cholangitis (n = 5, 10.6%), and others (n = 4, 8.5%). **Table 1** presents the demographic data of the participants. The number of patients with hearing impairment due to disease or accident was 10 (21.3%), history of a noisy job was six (12.8%), subjective hard of hearing was 18 (38.3%), and use of hearing aids was three (6.4%). The average value and SD for the MMSE were 24.04 (4.13), and the number of participants with MMSE scores >24 and <23 was 24 (58.5%) and 17 (41.5%), respectively. Six participants refused to complete the MMSE.

The average value and SD in measurements subtracted a from b of the four alarms were 6 ± 4.03 (A), 5.42 ± 6.83 (B1), 1.29 ± 1.44 (B2), and 1.10 ± 2.39 (B3), respectively. Plots of the participants with and without the ability to detect each alarm as an outcome are shown in **Figure 3**. Each number of participants, and proportion below the dotted line (5 seconds), which was being able to detect the alarm, was 19 (A: 40.4%), 31 (B1: 65.9%), 46 (B2: 97.8%), and 46 (B3: 97.8%), respectively. Regarding the participants with cognitive impairment (MMSE scores <23, n=17), the number of participants and proportion, being able to detect the alarm, was 3 (A: 17.6%), 10 (B1: 58.8%), 17 (B2: 100%), and 16 (B3: 94%), respectively. The mean body temperature was 36.3℃ (SD 0.37) for B1, 36.41℃ (SD 0.44) for B2, and 36.39℃ (SD 0.37) for B3.

As shown in **Table 2**, generalized linear mixed-effects model analysis using the adjusted model, alarm detection was positively associated with alarm type, and age (odds ratios 0.81, 95% confidence interval 0.67 to 0.99; $P = 0.042$), but not between MMSE (odds ratios 0.2, 95% confidence interval 0.02 to 1.49; $P = 0.118$). The odds ratios (95% confidence interval, P value) of B1, B2, and B3 in the adjusted model were 4.98 (1.15 to 21.51, $P = 0.031$), 688.92 (23.36 to 20316.95, $P < 0.001$), and 688.92 (23.36 to 20316.95, $P < 0.001$), respectively.

Discussion

This clinical study represents the first effort to identify the type of electronic axillary thermometer alarm (higher volume and lower frequency, vibration, or all three features) that can be an independent factor for detecting the thermometer's alarm signal in patients aged ≥70 years, regardless of cognitive impairment. **Figure 3** shows that almost all participants using alarm B2 and B3 were below the dotted line (5 seconds), which indicated positive detectability. Although one participant could not detect the vibration or another patient could not detect the signal when all three features were used, this was well within tolerance. For verifying associations between alarm detectability and alarm types in a generalized

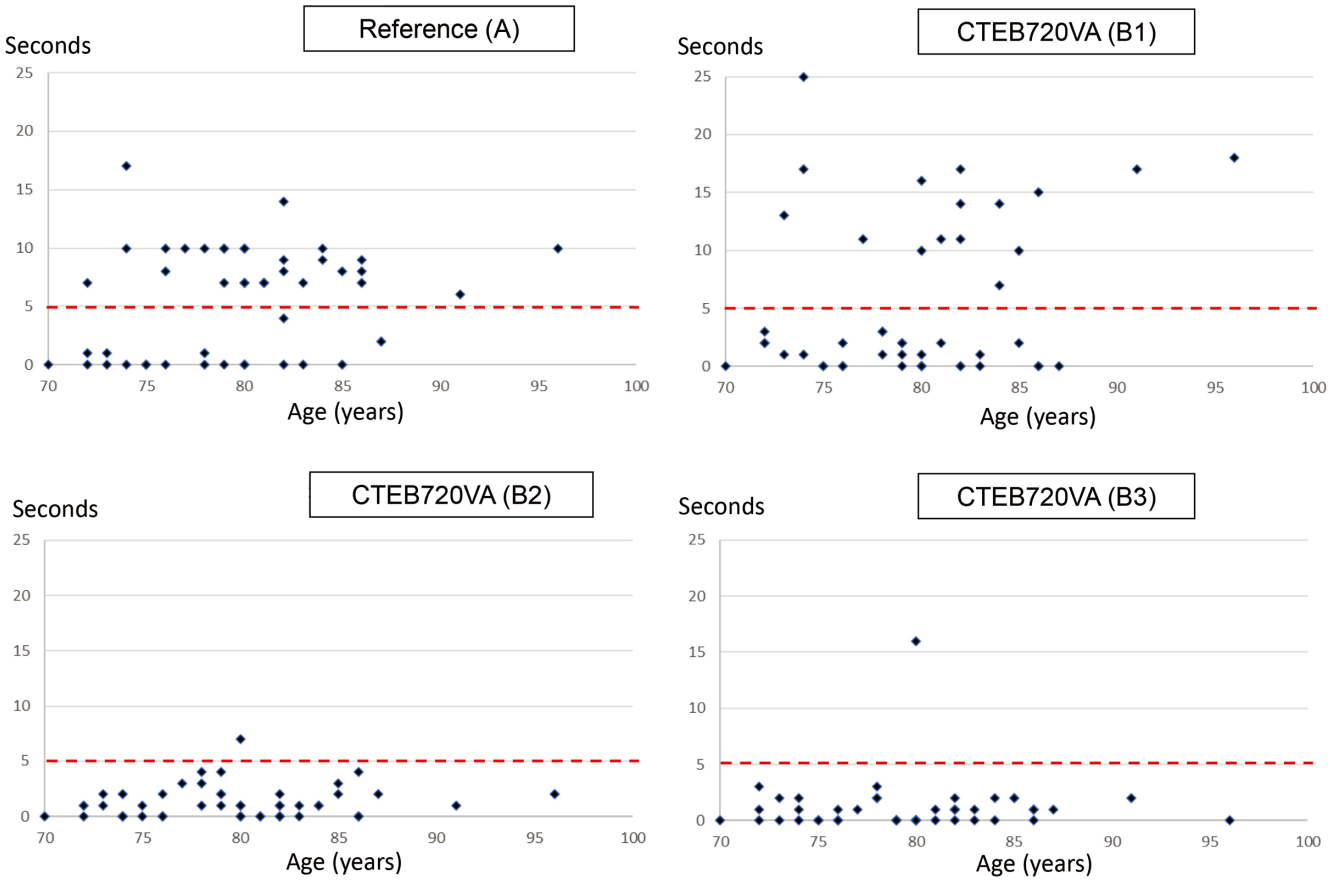

Figure 3 Age-categorized distribution data of participants' ability to detect the alarm
X-axis indicates age, and *Y*-axis indicates the values after a is subtracted from b. Participants below the dotted line (< 5 s) were determined to be able to detect the alarm, as positive detectability. Participants over the dotted line (≥ 5 s) were determined to not have detected the alarm, as negative detectability. The number of participants (proportion) below the dotted line was 19 for A (40.4%), 31 for B1 (65.9%), 46 for B2 (97.8%), and 46 for B3 (97.8%).

linear mixed-effects model, alarm types had significant association with alarm detectability. The odds ratios of alarm detectability B2, and B3 were highest. According to these results, it is thought that alarm detectability of B2, and B3 was higher rather than A, and B1 in older adults aged ≥70 years. Thereby, the best alarm types of axillary thermometer for in older adults aged ≥70 years with or without cognitive impairment were vibration and the mixed version.

The proportion of participants aged ≥70 years who could detect the buzzer alarm with high frequency (A) and those with higher volume and lower frequency (B1) was only 40.4% and 65.9%, respectively. We did not determine which function, bigger volume or lower frequency, did contribute to good alarm detectability of B1, as separate verification of each function has not been conducted. However, the odds ratio of B1 (4.98) was higher than C205 in **Table 2**, this suggests the possibility that the change in frequency and volume contributed to an increasing number of participants being able to detect the buzzer alarm. To date, no research has compared the alarm detectability of axillary thermometers with different alarm types. Owing to the lack of published research regarding the detectability of alarm beeping, there is a paucity of data against which to benchmark the findings of this study. Referring to the ISO 7029 standards in men and women[19], older adults aged ≥70 years could hear a sound of 60 dB at frequencies from 2000 to 4000 Hz. The average pure-tone audiogram in different age groups in Japanese (ranging from 20 to 84 years with an increment of 5 years) showed that the average hearing threshold in both men and women aged 70–74 years was 40 dB at 4000 Hz[20]. However, even if frequency and volume were improved in this age group, approximately 35% of the participants had no

Table 2 Generalized linear mixed-effects model for the factors associated with detecting the alarm

	Crude model			Adjusted model		
Variables	OR	(95% CI)	*p-value*	OR	(95% CI)	*p-value*
Alarm B-1	7.18	(1.73-29.78)	0.007	4.98	(1.15-21.51)	0.031
Alarm B-2	811.78	(30.43-21655.50)	< 0.001	688.92	(23.36-20316.95)	< 0.001
Alarm B-3	811.78	(30.43-21655.50)	< 0.001	688.92	(23.36-20316.95)	< 0.001
Age	0.92	(0.86-0.98)	0.015	0.81	(0.67-0.99)	0.042
MMSE	0.46	(0.21-1.03)	0.062	0.2	(0.02-1.49)	0.118

CI, confidence interval, OR, odds ratio
MMSE, Mini-Mental State Examination

ability to detect the buzzer signal (B1). Alarm detectability was less affected by the laterality of the measurement position when the measurement position at the axilla was randomly assigned for equality on the left or right. The number of participants with subjective hearing difficulties was the same for the right and left sides. Therefore, the negative factor of buzzer detectability was not due to the laterality of the measurement position (right or left), but the closed environment within the axilla.

Aging has long been associated with a decline in sensory function, which is a critical component of the health and quality of life of older adults[21]. Individual sensory impairments are common. The prevalence of hearing loss (33%) and vision impairment (18%) is high among older adults aged ≥70 years[22][23]. Impairment of the sense of touch has been found in adults as young as 55 years[24]. However, in our study, almost all older adults could detect the vibration at the axilla due to effects of the silicone attachment. Thermometer misplacement at the axilla due to reduced muscle mass or skin folds associated with age-related sarcopenia did not enable these patients to measure their body temperature, as the thermometer tip and probe could be in less contact with the skin at the axilla. Thus, a new silicone attachment to the CTEB 720VA was developed to enable contact with the skin. On the other hand, a silicone attachment with viscoelasticity also had a negative side regarding vibration absorption of alarm signal. However, almost all older adults could detect the vibration alarm at the axilla for a few seconds (average, 1.29). There is a possibility that the surface area of the thermometer probe would be created more than expected due to silicone attachment, and larger propagation of vibration contributed to enable good detection of vibration alarm.

Age was also positively associated with alarm detection, and the odds ratio (0.81) was less than 1. This indicates that alarm detectability was lower with advancing age. As the prevalence of hearing loss in older adults increases with age[7][8], it is quite possible that older adults, whose alarm detectability is negative, increase with aging. However, almost all participants using alarm B2 and B3 were positive detectability, regardless of age. As shown to **Figure 3**, possible causes include that the numbers of participants, who were able to detect alarm A and B1, decrease with aging.

Vibration is an important feature of thermometer alarms that allows for easier detection of alarm signals in adults aged ≥70 years with or without cognitive impairment. All participants with cognitive impairment had detected vibration alarms, and the odds ratios of vibration and mixed-version alarms were highest in adults aged ≥70 years in this study, regardless of cognitive impairment. The proportion of participants who could detect the buzzer alarm with higher volume and lower frequency (B1), or mixed version (B3) was 65.9%, and 98%, respectively. Just including vibration in buzzer alarm, the proportion of participants who could detect the alarm increased over thirty percent. Using the vibration alarms of the CTEB720VA, older adults with cognitive impairment were able to measure their own body temperature if they received assistance in maintaining the temperature probe in an accurate position. In addition, we recommend using different positions for each alarm. The CTEB720VA was used for additional resounding and vibrations. Clinical nurses also could hear the vibration alarm, even if they were close to patient during body temperature measurement by the

CTEB720VA. However, the clinical nurse often missed hearing vibration alarm due to loud environment in patient room or having conversation with patients. The use of a mixed thermometer may be optimal for healthcare professionals. In addition, the use of a thermometer with vibrations may be optimal for self-management in community-dwelling older adults.

One important limitation of this study is that community-dwelling older adults who most likely required temperature measurements were not included. This study was conducted in the inpatient unit of a university hospital. Older adults with fever or acute illnesses were excluded from this study. Therefore, the results may not have been generalizable to all older adults, particularly those who most likely need temperature measurement, such as those living in the community and those with persistent high fever >38.0℃. In addition, we could not show a relationship between an environmental noise of patient room, and alarm detectability. The primary researcher subjectively confirmed that noise level of each patient room has not been changed when participants measured their body temperatures for four times by two electronic axillary thermometers.

Conclusions

The present randomized crossover study using two electronic axillary thermometers and four types of alarms in 47 patients aged ≥70 years obtained the following findings:

1. Even when the frequency and volume of the buzzer alarm was improved, 35% of the participants had no ability to hear the buzzer.
2. Vibration is an important feature of thermometer alarms that allows for easier detection of alarm signals in adults aged ≥70 years with or without cognitive impairment.
3. A thermometer alarm with vibration or a mixed version is optimal for community-dwelling older adults for self-management and for clinical nurses working with these patients.

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Conflict of Interest

All authors and persons involved in the project group confirm that they have no financial or other interests concerning the manufacturers or vendors.

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原　著

70歳以上高齢者における腋窩電子体温計のアラーム検知の比較：ブザーアラーム，振動アラーム，ブザー／振動アラーム

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要　旨

目的は70歳以上の高齢者を対象に腋窩体温計2種に備わった4つのアラームの検知結果を比較することである．デザインはランダム化クロスオーバー試験で全参加者が4アラームで体温を測定した（高音域ブザーAはリファレンス，音量大で低音域ブザーB1，振動B2，振動とブザーB3）．参加者がアラームを検知した秒数からアラームが鳴った秒数を差し引き，アラーム検知可を5秒未満と定義した．参加者47名の平均年齢は79.7歳，アラームを検知できた人数（%）はAが19人（40.4），B1が31人（65.9），B2が46人（97.8），B3は46人（97.8）であった．アラームタイプと年齢がアラームの検知に有意に関連しており，ミニメンタルステート検査に関連はなかった．各オッズ比はB1が4.98，B2が688.92，B3が688.92，年齢が0.81であった．振動は認知機能低下にかかわらず70歳以上のアラームの検知に重要であることが分かった．

キーワード：加齢，認知機能低下，難聴

キーメッセージ

1．今回の研究は看護・介護のどのような問題をテーマにしているのか？研究を行うきっかけとなったことはどのようなことか？

・高齢者にとって腋窩体温計のブザーアラームのように高音域の電子機器音は聞き取りづらい．
・ブザーアラーム聞き取り調査を実施すると（対象者107人の平均年齢：70.9歳），対象者58人（54.2%）がアラームを聞き取れていなかった．
・今回は70歳以上の高齢者を対象に，振動・低音域ブザーといった新しいアラームを有する腋窩体温計を用いて，どのアラームが最も聞き取れるか評価した．

2．この研究成果が看護・介護にどのように貢献できるのか？あるいは，将来的に貢献できることは何か？

70歳以上の高齢者は振動アラーム付き腋窩体温計を使用すれば振動を検知できるため，病院または自宅でサポートがなくても正確に体温管理ができる可能性がある．

3．今後どのような技術が必要になるのか？

非接触型体温計は数秒で体温測定ができるためコロナ禍で市場が拡大した．腋窩体温計（測定に30〜35秒を要する）の汎用性を維持するためには，測定時間の短縮化が課題である．