Open Access

SCHOLARENA

SAJ Biotechnology

RESEARCH ARTICLE

ISSN: 2375-6713

Comparison of Body Temperature in Adult Hospitalized Patients Using Axillary and Tympanic Measurement Methods

Demirci S[1], Kartal ED[2] and Özcan L[3*]

[1]*Center for Medical and Surgical Research of Eskişehir Osmangazi University, Eskişehir, Turkey*
[2]*Department of Infectious Disease, Medical School of Eskişehir Osmangazi University, Eskişehir, Turkey*
[3]*Biomedical Engineering Department, Afyon Kocatepe University, Afyonkarahisar, Turkey*

[*]**Corresponding author:** Özcan L, Biomedical Engineering Department, Afyon Kocatepe University, Afyonkarahisar, Turkey, E-mail: leventozcan@aku.edu.tr

Citation: Demirci S, Kartal ED, Özcan L (2019) Comparison of Body Temperature in Adult Hospitalized Patients Using Axillary and Tympanic Measurement Methods. SAJ Biotechnol 6: 101

Abstract

The measurement of body temperature in humans should be safer, easily applicable, non-invasive, and affordable method providing the most accurate measurement of the internal body temperature, and yielding to results in a short time. In addition, it should be unaffected by the peripheral conditions and facilitate measurement procedure for physicians and nurses. Results of the measurements should be reliable and not altered with the person performing the measurement. In the present study, we aimed to establish potential correlations through comparing body temperature measurements obtained with axillary contact digital thermometer (ACDT) and tympanic non-contact infrared thermometer (TNCIT). For the present study, body temperature of 111 adult female/male patients at age of 18 or older was obtained concurrently. A total of 1889 times of measurements were obtained noninvasively from 111 patients with an average of 17.02 times of measurements for per patient. The measurements obtained using TNCIT were 0.3 to 0.5 °C higher than the measurement average values acquired using ACDT. The results showed that there was a significant difference between the measurements of the TNCIT and the ACDT ($p < 0.001$). If any doubt exits about the values of the body temperature measurement, the body temperature should be confirmed with other methods.

Keywords: Internal Body Temperature; Axillary; Tympanic; Thermometer; Noninvasive

Introduction

Thermoregulation is a vital body function that provides physiological hemostasis in individuals. Therefore, accurate measurement of body temperature is an important intervention, indicating level of physiological hemostasis [1]. Fever is defined as the increase of body temperature resulting from physiological response of the organism as an action-reaction response created against the inflammatory immune (defense) system of body temperature. Normal values of body temperature relative to measurement zones are considered as rectal 38 °C, oral 37.8 °C, and axillary 37.2 °C. The body temperature values above these values are called fever [2]. It is generally accepted that the normal measurement of the body temperature is between 36 °C and 38 °C. Body temperature below 36 °C is called hypothermia and above 38 °C is called hyperthermia (Fever) [3].

Different methods are used for body temperature measurement in compliance with technological and scientific devices. The approaches for body temperature measurement are either invasive or non-invasive [4]. The measurements for the body temperature can be obtained using glass- mercury, electromagnetic, digital, and trans-tympanic, single-use thermometers or thermal cameras [5]. The sites that are commonly used to obtain body temperature include oral cavity, armpit, tympanic, intrathoracic, inguinal region, and pulmonary artery. Although the use of pulmonary artery is considered to be the gold standard method for the body temperature measurement, it is not feasible and easily applicable in many patients since it is invasive [6,7].

While contact measurement method is used in the axillar region, rather noncontact measurement method is preferred in the tympanic region during routine health care services in hospitals. Although tympanic measurement method has its own advantages and disadvantages, it is still the ideal approach for obtaining body temperature both in children and adults since tympanic membrane is anatomically closer to the heat regulation center of the hypothalamus [8]. Tympanic measurement method is advantageous since it allows rapid measurement of body temperature with low risk of contamination. However, it has also certain disadvantageous due to the fact that the patient must have rested in sitting position during the measurement, the thermometer might irritate ear canal

and harm tympanic membrane. Moreover, ear canal infection or presence of dirt in it may hinder precise measurement of body temperature, and previous training of the health personnel is required to obtain correct measurements. At the same time the cause of pain in the middle ear infection occurred [9].

Likewise, the axillary measurement method also possesses its own advantages and disadvantages. It is advantageous since the axillary (armpit) measurement is reliable, easy to apply and use, does not require any previous training for the user in addition it is .On the other hand, the axillary measurement method has also some disadvantages since keeping thermometer still in armpit is difficult, application time is longer, the measurement values might be significantly lower than they are owing to vasoconstriction and sweating in the skin due to fever [10,11].

Similarly, in a recent study, Devrim, *et a*l. demonstrated that obtained body temperatures using the axillary thermometer was 0.75 °C lower than the measurement values obtained using the tympanic thermometers [12]. In another study, Çoban and Dolgun observed significant differences between body temperature measurements obtained in tympanic and axillary regions [13]. In a study, İlçe and Karabay noted a 0.26 °C difference in average body temperature measurements obtained using TNCIT and ACDT in tympanic and axillary regions, a study similar to and further supporting our present measurements revealing a 0.22 °C difference in average body temperature measurements obtained using TNCIT and ACDT [14].

Measurement and follow of body temperature is critical for diagnosis, and treatment of infectious diseases. Precise and quick obtainment of body temperatures in adults hospitalized in the infection service is accomplished through comparing of the measurements taken using TNCIT and ACDT.

Materials and Method

In the present study, the body temperatures of the adult patients hospitalized between March and June 2017 at the Clinic of Infectious Diseases, Hospital of Medical School of Eskişehir Osmangazi University (Turkey) were obtained and recorded. A separate sheet was prepared for each patient included in the present study. The sheet contained information pertaining to the name, surname, age, gender, arrival time to infection service and hospitalization time and body temperatures obtained using both thermometers that were all recorded daily. A total of 111 adult patients were studied. The distributions of gender and age ranges of the studied patients were presented in Figure 1. During the first physical examination of the patients their body temperatures were measured with infrared non-contact and digital contact thermometers on axillary and tympanic regions. Their body temperatures were simultaneously obtained from the tympanic membrane of the right ear and the right axilla (the armpit), which was cleaned with sponge and dried prior to the measurement. The measurements were carried out by experienced medical staff. For the measurements, the TNCIT (Infrared Covidien Brand) and ACDT (Digital Micro Life TM3001 brand) were used. Both methods are non-invasive, and the working principle of thermometers is as follows: The wavelength of infrared radiation is between 750 nanometers and 1 micrometer. The human body at normal temperature radiates around 10 micrometers. Working principle TNCIT is based on measuring infrared radiation emitted from the tympanic membrane. Digital contact thermometers, on the other hand, are based on the fact that electrical conductors change their resistance to electrical currents as their temperature changes. The thermometers used were calibrated in biomedical engineering, and the reliability of measurement was recorded by testing the validation of the thermometers in the medical biochemistry laboratory (with 10 day intervals). We assessed and compared measurement times and reliability of TNCIT and ACDT, and their usefulness and comfort for health staff and patients. We assessed diurnal body temperature difference, which is the difference in body temperature measurements between the day and night. Limits for normal body temperatures, hypothermia and hyperthermia were also determined. Relative measurement values of body temperatures obtained using the thermometers are present in Table 1.

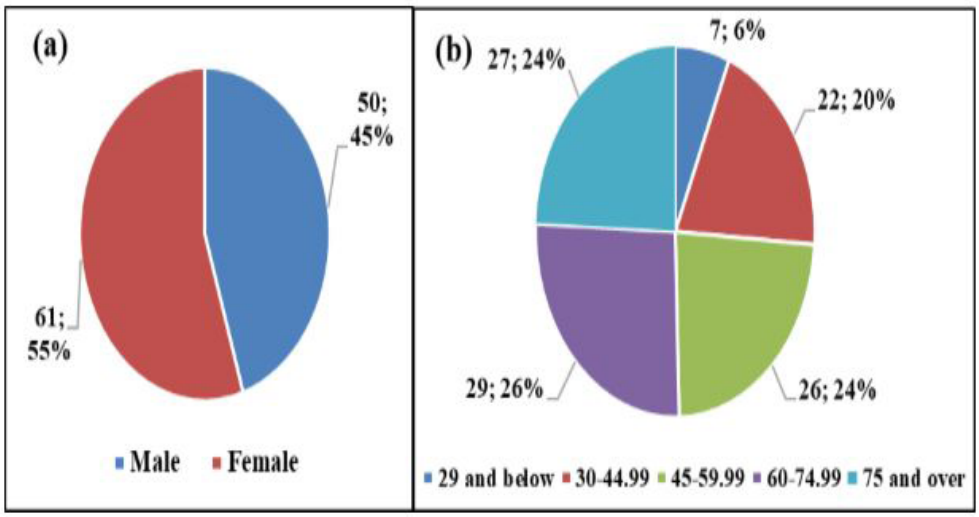


Figure 1: The distributions of gender (a) and age ranges (b) of the studied patients in this study

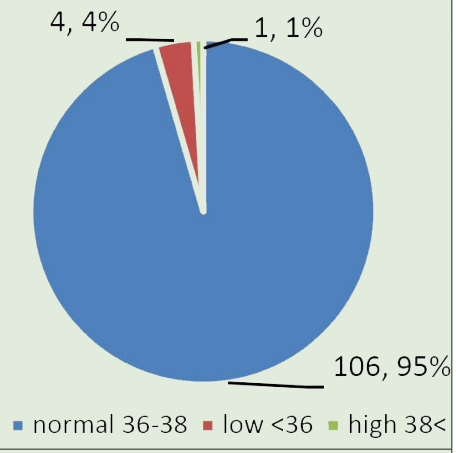
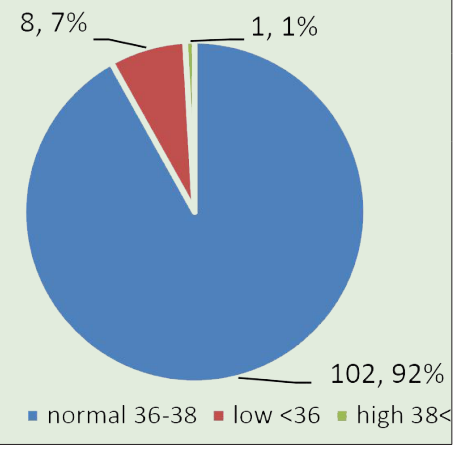
Type of thermometers	Heat exchange	N (Number of Persons)	%	Graphical representation
Infrared non-contact thermometer	Normal temperature 36 – 38 °C	106	95.5	
	Low temperature < 36 °C (Hypothermia)	4	3.6	
	High temperature 38 °C < (Hyperthermia)	1	0.9	
Digital contact thermometer	Normal temperature 36 – 38 °C	102	91.9	
	Low temperature < 36 °C (Hypothermia)	8	7.2	
	High temperature 38 °C < (Hyperthermia)	1	0.9	

Table 1: Distribution of relative body temperatures (normal, hypothermia, hyperthermia)

Statistical Analysis

While continuous quantitative data (n) were expressed as mean and standard deviation, qualitative data (n) were illustrated as median value, 25th and 75th percentage values. Continuous variables, consisting of independent measurements and showing normal distribution, were analyzed using One Way Analysis of Variance and Independent Samples T-Test. On the other hand, the variables consisting of dependent groups were analyzed with Paired Samples T-Test. In order to show the relationship between the variables, the Pearson Correlation test was applied to the variables that showed normal distribution according to the results of normality tests. Whereas, the categorical data sets were evaluated using Chi-square tests. A $p<0.05$ value was considered to be statistically significant. All the data analyses were done with SPSS 21.0 packaged software.

Results

A total of 111 adult patients were included in the current study and sums of 1889 measurements (repeated at least 1 up to 45 times) were obtained from the patients with a mean of 17.02 times measurements for per patient.

As a result of the measurements, the tympanic measurement was found to be shorter in time and closer to the average body temperature value. The measurement comfort is better for the patient/nurse. There was a 0.3 - 0.5 °C difference between the measurement values of the tympanic thermometer and the axillary thermometer.

Body temperatures of the patients were obtained during their clinical examination's rom axillary/tympanic regions using TNCIT and ACDT. While average body measurement obtained using infrared thermometer was 36.44 °C, it was 36.22 °C with digital thermometer. The difference between the measurements of two different types of the thermometers used to obtain body temperatures in axillary and tympanic regions was 0.22 °C, which was statistically significant ($p<0.001$) (Table 2).

Type of thermometers	N (Number of Patients)	Average	Std. deviation	P
Infrared non-contact thermometer	111	36.44 °C	0.39 °C	<0.001
Digital contact thermometer	111	36.22 °C	0.60 °C	<0.001

Independent Samples T-Test (Mean± Std. Deviation)

Table 2: Mean body temperatures of the patients obtained during their clinical examinations

Table 3 reports the comparison of average body temperatures of the male and female patients. There is no difference between TNCIT and ACDT measurements by gender (p>0.05). Comparison of the average of body temperature measurement by age groups with thermometers are also presented in Table 4. There is no difference between TNCIT and ACDT measurements by age group (p>0.05).

Type of thermometers	Gender	N	Average	Std. deviation	p
Infrared non-contact thermometer	Male	50	36,41	0,44	0,387
	Female	61	36,47	0,35	
Digital contact thermometer	Male	50	36,13	0,67	0,166
	Female	61	36,29	0,53	

Independent Samples T Test (Mean± Std. Deviation)
Table 3: Comparison of thermometer mean values by gender

Type of thermometers	Age groups	N	Average	Std. deviation	p
Infrared non-contact thermometer	29 and below	7	36,43	0,58	0,988
	30-44.99	22	36,45	0,52	
	45-59.99	26	36,47	0,36	
	60-74.99	29	36,41	0,34	
	75 and over	27	36,44	0,31	
Digital contact thermometer	29 and below	7	36,37	0,42	0,461
	30-44.99	22	36,01	0,75	
	45-59.99	26	36,25	0,65	
	60-74.99	29	36,23	0,53	
	75 and over	27	36,30	0,50	

One Way Analysis of Variance (Mean±Std. Deviation)
Table 4: Comparison of the average of body temperature measurement by age groups with thermometers

Average body temperature during the day (between 6 am and 6 pm) for the patients hospitalized in Infection Service was determined to be 36.39 °C and 36.16 °C using TNCIT and ACDT, respectively . The difference between the average day time measurements was 0.23 °C. On the other hand, average body temperature during the night (between 6 pm and 6 am) was found to be 36.56 °C and 36.38 °C using TNCIT and ACDT, respectively. The difference between the average day time measurements was 0.18 °C. The difference between the day and night average body temperature measurements was statistically significant (p<0.001) (Table 5).

Type of thermometers	Day and night measurements	N	Average	Std. Deviation	P
Infrared non-contact thermometer	(6am-6pm)	111	36.39 °C	0.38	0.001
Digital contact thermometer	(6am-6pm)	111	36.16 °C	0.60	
Infrared non-contact thermometer	(6pm-6am)	105	36.56 °C	0.48	0.001
Digital contact Thermometer	(6pm-6am)	105	36.38 °C	0.72	

Paired Samples T Test (Mean± SD)
Table 5: Comparison of day and night measurements of the thermometers

Furthermore, the sensitivity of both thermometers to capture diurnal difference was investigated as well. Mean body temperature obtained in the tympanic region using TNCIT was determined to be 36.39 °C during the day (between 6am and 6pm) and 36.16 °C during the night (between 6 pm and 6 am); daily difference (circadian) in the measurements of the TNCIT itself was noted to be 0.17 °C. On the other hand, mean body temperature obtained in the axillary region using ACDT was established to be 36.18 °C during the day (between 6 am and 6 pm) and 36.38 °C during the night (between 6pm and 6am); daily difference (circadian) in the measurements of the ACDT itself was noted to be 0.20 °C.

The present results indicated that TNCIT and ACDT are reliable devices in terms of detecting diurnal difference in body temperatures obtained in tympanic and axillary regions (p<0.001). Our current observations are consistent with previous studies and support them further (Table 6). Besides, we noticed statistically no significant difference between the body temperatures of men and woman using TNCIT and ACDT even though mean body temperature in women was slightly higher compared to men, which was thought to be owing to changes in female physiology activity and hormonal parameters (p> 0.05).

Type of thermometers	Day and night measurements	N	Average	Std. Deviation	P
Infrared non-contact thermometer	(6am-6pm)	105	36.39 °C	0.38	**<0.001**
Digital contact thermometer	(6am-6pm)	105	36.56 °C	0.48	
Infrared non-contact thermometer	(6pm-6am)	105	36.18 °C	0.59	**<0.001**
Digital contact Thermometer	(6pm-6am)	105	36.38 °C	0.72	

Table 6: Comparisons of the thermometers for detecting ratios of diurnal differences

Discussion

In the present study, we assessed body temperature measurements using TNCIT, which is routinely used in hospital and other healthcare services, and ACDT, although whose use has been decreased in hospital and other healthcare services, it is still preferred since it allows more reliable body temperature measurements. We assessed and compared measurement times and reliability of TNCIT and ACDT, and their usefulness and comfort for health staff and patients.

Body temperature measurement with TNCIT is preferred to body temperature measurement with ACDT because measurement with TNCIT takes less time and easier to use; whereas, use of ACDT takes longer time and not practical to use for health workers. On the other hand, studies trying to obtain body temperature closest to the real body temperature accept the rectal measurement value as gold standard. Since body temperature values obtained with ACDT is closer to the real body temperature than TNCIT, ACDT is stated to be more reliable. The difference between the average day time measurements was 0.23 °C in our study. Even though this difference was statistically important for both measurement methods, both methods were correlated each other, indicating that both methods can be used reliably for obtaining body temperature.

Nevertheless, the use of the tympanic thermometers is more comfortable for both health-givers and patients, and generates more comfortable measurements. In these cases, measurement with axillary digital thermometer seems to be more convenient, at the same time; usage of the tympanic thermometer for nurses and patients is more comfortable. The precise value of the body temperature is more accurate. On the other hand, the use of the axillary digital thermometer is not comfortable for both nurses and patients since its use necessitates axillary cleaning, holding the thermometer properly still for a while in the armpit. At the same time, it is difficult for the patient to keep it still in the axillary region. Since the waiting period is high for the nurses (3-5minutes), comfort of use is lower. Overall, the present results indicated that not only the time required for body temperature measurements was shorter but also measurement results were closer to average temperature values obtained using the tympanic thermometers than axillary digital thermometer. The tympanic thermometers provide better comfort both patients and nurses; however, use of the tympanic thermometers has also some drawbacks since it might yield to some measurement errors in certain circumstances. For instance, if patient in lying position, the patient should rest in the sitting or standing position for 11-12min. prior to measurement so that the tympanic thermometers can work properly. Temperature measurement with TNCIT might yield to mistakes in measurements, especially in paralyzed patients. However, in daily practice the measurement is usually made when the patient is in the supine position regardless of his/her position prior to measurement. This is an obstacle to the reliability of the results. On the other hand, although the difference in measurement values is statistically significant, it is difficult to fully evaluate the response during clinical follow-up. It is clear that a comparative study involving more patients is needed.

There is no significant difference in male / female body temperatures in terms of gender. But, women have a slightly higher body temperature than men in both thermometers. This is thought to be caused by differences in physiological / hormonal parameters of women.

Conclusion

The present results indicate that body temperature measurement with TNCIT on tympanic membrane is easier, quicker and more comfortable than ACDT. The measurements obtained using TNCIT were 0.3 to 0.5 °C higher than the measurement average values acquired using ACDT. The results showed that there was a significant difference between the measurements of the TNCIT and the ACDT ($p < 0.001$). Nevertheless, the measurement results obtained with TNCIT and the ACDT were correlated each other. If any doubt exits about the values of the body temperature measurement, the body temperature should be confirmed with other methods.

Acknowledgements

We would like to express our special thanks to the doctors and nurses of Infectious Diseases Clinics for their cooperation during the current study.

References

1. Browne S, Coleman H, Geary E (2000) Accurate measurement of body temperature in the neaonate: A comparative study. J Neonat Nurs 6: 165-8.

2. Kara B (2003) Review of information about fever in childhood (Çocuklukta ateşle ilgili bilgilerin gözden geçirilmesi). TTD J Continuing Med Educ (STED) 12: 10-4.

3. Baykal Y Body temperature regulation (Fever Hyperthermia Hypothermia) (Vücut ısısının düzenlenmesi (Ateş Hipertermi Hipotermi)).

4. Askar Pour H, Yavuz M (2010) Effect of elevated body temperature (fever) on hemodynamic parameters (Vücut sıcaklığındaki yükselmenin (ateşin) hemodinamik parametrelere etkisi). Maltepe Univ J Nurs Sci Art 3: 73-9.

5. Barton SJ, Gaffney R, Chase T, Rayens MK, Piyabanditkul L (2003) Pediatric temperature measurement and child/parent/nurse preference using three instrument. J Pediatr Nurs 18: 314-320.

6. El Radhi AS, Patel S (2006) An evaluation of tympanic thermometry in a pediatric emergence department. Emerg Med J 23: 40-41.

7. Van Vliet M, Donnely JP, Potting CM, Blijlevens NM (2010) Continuous Non-invasive monitoring of the skin temperature of HSCT recipients. Support Care Cancer 18: 37-42.

8. Neyzi O, Ertuğrul T, Demirkol M (2002) History and physical examination. O. Niyazi, T. Ertuğrul Editors Pediatrics İstanbul Medical Bookstore. (Öykü ve fiziki muayene. O. Niyazi, T. Ertuğrul Editörler Pediatri İstanbul Tıp Kitapevi).

9. El-Radhi AS, Barry W (2006) Thermometry in pediatric practice. Arc Dis Child 91: 351-6.

10. Kara A, Devrim I, Cengiz AB, Celik F, Tezer H, et al. (2009) Is the axilla the right site for temperature measurement in children by chemical thermometer. Turk J Pediatr 51: 325-7.

11. Karel A, Kristina C, Llse Van G, Guz B (2014) Tympanic, infrared skin and temporal artery scan thermometers compared with rectal measurement in children: A real-life assessment. Curr Ther Res Clin Exp 76: 34-8.

12. Devrim I, Kara A, Ceyhan M, Tezer H, Uysal AK, et al. (2007) Measurement accuracy of fever by tympanic and axillary thermometry. Pediatr Emerg Care 23: 16-9.

13. Çoban B, Dolgun A (2016) Comparision of axillary with infrared tympanic and non-contact infrared thermometry. J Pediatr Inf 10: 82-5.

14. İlçe A, Karabay O (2009) Comparison of four different body regions in fever measurement and examination of patient preference (Ateş ölçümünde dört farklı vücut bölgesinin karşılaştırılması ve hasta tercihinin incelenmesi) Düzce Univ Faculty Med J 11: 5-10.