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Normal body temperature and the effects of age, sex, ambient temperature and body mass index on normal oral temperature: A prospective, comparative study

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ABSTRACT

Background: Body temperature is an indicator of health status. However, thermoregulatory function is thought to decline with aging.
Objectives: To determine normal body temperature and the effects of age, sex, ambient temperature (AT), and body mass index (BMI) on normal oral temperatures (OTs).
Design: A prospective four group comparative descriptive design was used to compare four cohorts: young adults in summer, older adults in summer, young adults in winter, and older adults in winter.
Methods: The OT of 519 community dwelling older adults ages 65–95 and 540 younger adults ages 20–64 was compared. The OT was taken with an electronic thermometer between 8 a.m. and 10 a.m. during summer and winter in 2007 in Taipei, Taiwan.
Results: There was no difference in mean OT between the <65 and ≥65 groups measured during winter. However, the mean OT of the <65 group was 0.11 °C lower than the ≥65 group measured in the summer. Subjects (≥85 years) had a higher correlation coefficient ($r = 0.48$) between OT and AT than those in the 65–74 year older group ($r = 0.31$) and 75–84 year older group ($r = 0.23$). Moreover this study found that the mean OT of older females was higher than that of older males in both winter and summer cohorts. Finally, multiple regression analysis results indicated AT and sex were predictors of OT while age and BMI were not a significant predictor of OT. These four factors together accounted for 9.4% of the variance in the overall sample (age 20–95), 12.8%, in those 65–95 and 28.2% for those, ≥85 years old.
Conclusions: These findings help to clarify discrepancies in the literature. The OT of those over age 65 and those 20–64 was lower than the accepted 37 °C norm. However, "older is colder" does not apply to all older adults. Our findings indicate AT and sex rather than age alone account for temperature variation in older adults with normal baseline temperature. Further investigation is needed to identify potential risk factors of impaired thermoregulation in older adults.

What is already known about the topic?

- Age is believed to affect homeostatic thermoregulatory mechanisms.
- Previous studies suggest that the normal baseline temperature of adults is 37 °C and older adults have lower body temperature than that of younger adults.

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- There is disagreement about the extent to which ambient temperature, sex influence baseline body temperature.

What this paper adds

- The oral temperature of healthy younger and older adults is usually lower than 37 °C.
- The aging process alone may not result in lower baseline body temperature.
- Healthy younger and older adults do not differ in baseline body temperature in moderate environmental temperature.
- The present research contradicts the belief that the elderly have a lower temperature than younger adults.
- Ambient temperature most strongly influenced the oldest (≥85) adults which may indicate a sign of thermoregulatory decline. This finding raises consideration for protecting this oldest adults group from temperature extremes.

1. Introduction

An elevated body temperature is a vital indicator of illness and infection. However, there is a commonly held assumption that this immune response is diminished in older patients (Castle et al., 2007; Tal et al., 2002). This is commonly attributed to a decline in the ability to regulate core body temperature. This is allegedly due to the aging process (Castle et al., 1993; Collins and Exton-Smith, 1983; Downton et al., 1987) and declines in temperature perception and thermoregulatory response with advancing age (Pocock and Richards, 2006).

The commonly accepted baseline temperature is 98.6 °F or 37 °C. Previous studies have reported normal adult body temperature is actually lower than 37 °C (Mackowiak et al., 1992). Some researchers suggest that the normal body temperature of older adults is lower than the expected 37 °C of younger adults (Gomolin et al., 2005, 2007; Higgins, 1983). However, rigorous human experimental study is lacking to confirm these assumptions. There is also no evidence that a lower baseline temperature would limit the upper ranges of a febrile response; in fact one study of experimentally induced fever found older adults more likely to be hyperresponsive to a pyrogen (Krabbe et al., 2001). In order to gain a better perspective on surveillance for infection, more evidence is needed to determine if baseline body temperatures are actually lower than 37 °C and older adults have lower temperature than younger adults. A fever is typically defined as 1.0 °C over baseline. Clinicians cannot adequately assess fever without first establishing what is "normal" for different age groups. Therefore, the purposes of this study were to (1) compare baseline body temperatures of adults ages 20–64 with those 65 and older. (2) Determine the association between age and baseline body temperature. (3) Determine the effect of ambient temperatures (AT) on baseline body temperature values. (4) Determine sex differences between baseline temperatures in adults ages 20–64 and those 65 and older. (5) Determine the effect of body mass index (BMI) on baseline body temperature values.

2. Background and significance

Normal has been defined as "conforming to or constituting an accepted standard, model, or pattern; usual; standard; typical."(p. 689) (Halsey, 1986). Knowledge of both normal and abnormal values serves as an initial screen and abnormal value can trigger further screening measures and interventions. The concept of 37 °C as the value for normal body temperature was established by Wunderlich and Reeve (1869) and continues to be the standard found in dictionaries and text books (Anderson, 2002; Dinarello and Porat, 2008; Witzmann, 2009).

Since ancient times, scholars have alluded to elderly people having lower body temperatures than the general adult population. Hippocrates noted in his Aphorisms that "the fevers of old men are less acute than others, for the body is cold." (Berman and Fox, 1985). Wunderlich and Reeve (1869) also reported a 0.5 °C lower reading in older adults compared to those of younger adults.

Textbooks also suggest that older people have lower baseline temperatures (Collins, 2000; Herbert and Rowswell, 2006; Sanko, 1999) because age is believed to affect homeostatic thermoregulatory mechanisms. Age-associated changes in vasomotor and sweating function, skeletal muscle function, temperature perception, and physical behaviors influence the ability to maintain optimum temperature. These capacities appear to decline with advancing age (Collins, 2000; Herbert and Rowswell, 2006; Sanko, 1999) making basal body temperature in the older lower (Campbell and Travis, 1997; Castle et al., 1991; Worfolk, 1997). However, some studies found no significant relationship between age and body temperature (Howell, 1975; Keilson et al., 1985; Marion et al., 1991). The findings of studies that relate to body temperature to age are not conclusive.

Research findings also suggest that AT may affect body temperature in older adult (Kenney, 1997; Nakamura et al., 1997; Thatcher, 1983). This may be related to measurement error that can occur when colder temperatures decrease blood flow to the measurement site, including the ear canal and tympanic membrane (Doyle et al., 1992; Zehner and Terndrup, 1991). Another factor may be age-associated changes in physiological and behavioral thermoregulation that influences the ability to maintain temperature (Collins and Exton-Smith, 1983; Taffett, 2003).

There is considerable evidence that sex influences thermoregulatory responses, particularly related to sweat responses (Bar-Or, 1998; Hazelhurst and Claassen, 2006), hormonal changes (Kelly, 2006) and body fat distribution (Kaciuba-Uscilko and Grucza, 2001). There is disagreement on whether females and males differ on baseline body temperature. McGann et al. (1993) found no gender difference. Sund-Levander et al. (2002) found woman have lower mean OT compared with man. Mackowiak et al. (1992) found women had higher baseline temperatures than men.

Other factors found to influence baseline temperatures include BMI (Adam, 1989; Eriksson et al., 1985; Sund-Levander and Wahren, 2002). Little is known about how

BMI affect older persons or whether it is related to baseline thermoregulatory responses. Therefore, this factor was also included to examine its effect on normal body temperature.

An accurate body temperature depends upon three factors: an accurate thermometer; a valid measurement site; and, the skills of the individual measuring the temperature. A measurement site that is supplied with the same blood supply as the hypothalamus is more likely to reflect core body temperature (Erickson and Yount, 1991; Smith, 2004; Varney et al., 2002). The oral cavity is a good site for temperature measurement because the thermometer probe is placed in a sublingual pocket near deep tongue arteries that share the same carotid artery blood supply as the hypothalamus (Fulbrook, 1993). Erickson (1980) found a temperature difference of 1.7 °C among different sites within the oral cavity; therefore, the skills of the individual measuring the temperature is very important. However, compared to other non-invasive measurement route, the oral temperature is easy to control the confounding factors in healthy community dwelling adults. For this reason this study chose to take temperature from sublingual route.

In addition, the ideal measurement device which reflects core temperature change accurately, safely, quickly and with easy access continues (Erickson and Yount, 1991; Varney et al., 2002). Each of the measurement devices available today has strengths and limitations. Due to concerns about mercury poisoning and environmental protection, mercury-in-glass thermometers have almost disappeared from clinical practice. The electronic thermometer has instead of mercury-in-glass thermometers. Moreover, some studies were found no significant difference in the average accuracy of between electronic thermometer and mercury-in-glass thermometer (Modell et al., 1998; Pugh-Davies, 1986). Hence the current study used electronic thermometer as measurement device.

3. Methods

3.1. Design, subjects, and setting

A prospective four group comparative descriptive design was used to determine normal body temperature during two different seasons for a population of adults ages 65 and over. The sample included: (1) a first older group (age 65 and older) and (2) one younger group (age 20–64) were studied in summer and (3) a second older group and (4) younger group were studied in winter. The total sample of 1059 included 540 subjects ages 20–64 and 519 subjects ages 65 and older. The study design controlled for the variables of sex, BMI and AT. The sample consisted of a similar number of males and females.

Two cohorts (one in summer and one in winter) of younger subjects were recruited from 15 general community recreational centers and libraries in Taipei City.

The subjects ages 65 and older were two cohorts of senior citizens from 17 community senior leisure centers in Taipei City.

All were free from active infection or acute illness. Subjects were excluded if they had oral temperatures above 38 °C at any measurement. Those with mucosal ulcers, hypothyroidism, or those on anti-pyretic NSAIDS were excluded along with those who had been inoculated for influenza or received another vaccine within 1 week. A power analysis indicated a minimum sample of 250 subjects would be required for each sub-group to obtain a power of 0.80 with the level of significance set at 0.05, and a small effect size of 0.25. The study was carried out from November 2006 to March 2007 (winter period) and April 2007 to July 2007 (summer period) in order to study effects of seasonal changes in AT on body temperature.

According to the records about Taipei City from Taiwan Central Weather Bureau (2008) over the last decade, the temperature ranged between 8.2 and 30.8 °C, and the relative humidity ranged from 74 to 79% in the winter time; the temperature ranged between 14.0 and 38.6 °C, and the relative humidity ranged from 69 to 80% during the summer time.

3.2. Variables and instruments

The study instruments were (1) a demographic data collection sheet and (2) a Welch Allyn Sure Temp 679 electronic digital oral thermometer with a thermistor probe. The temperature value was displayed within 4–6 s after activation. The accuracy of the device was ±0.1 °C, over the range 26.7–43.3 °C (Amesdata Technology Co., TW). Thermometers were calibrated for accuracy, according to manufacturer's standard, before and after the study and were used only for this research study. Ambient temperatures were measured by a digital thermo-hygrometer (Yeong–Shin Co., TW) with range of −20 to 70 °C (±0.1 °C). Body weight (BW) was measured using a digital battery-powered floor scale (SAMPO Co., TW). Weight was used along with self-reported height to calculate the BMI by the formula BMI = BW (kg)/height (m^2).

3.3. Data collection procedure

The study was approved by the Research Ethics Committee of National Taiwan University Hospital and informed consent was obtained from each subject. Temperatures were all taken between 8 a.m. and 10 a.m. Subjects were instructed not to eat, drink, or smoke for 30 min and to rest for at least 15 min prior to temperature measurement. To avoid inconsistency, data collection and temperature measurement were carried out by one research assistant trained in correct probe placement. Her technique was periodically reviewed to maintain fidelity of the data collection. In addition AT and BW was noted at the time of measurement.

3.4. Data analysis

Data were analyzed using the statistical package SPSS 12.0 descriptive statistics; independent samples *t*-test, ANOVA, Pearson—product moment correlation, partial correlation, curve estimation, and multiple regression analysis procedures were conducted.

Table 1
Demographic data and health status of subjects.

	Older adult, $n = 519$			Younger adult, $n = 540$		
	n	%	Mean ± S.D. (range)	n	%	Mean ± S.D. (range)
Cohorts						
Winter	262	50.5		275	50.9	
Summer	257	49.5		265	49.1	
Sex						
Male	271	52.2		277	51.3	
Female	248	47.8		263	48.7	
Age						
65–74	246	47.4	75.52 ± 6.98 (65–95)			40.31 ± 13.15 (20–64)
75–84	212	40.8				
≥85	61	11.8				
Number of chronic diseases	0	17.0	1.8 ± 1.35 (0–6)			
	1–3	71.3				
	4–6	11.8				
Number of routinely taken medications	0	27.7	1.47 ± 1.39 (0–10)			
	1–5	68.5				
	6–10	3.9				

4. Results

Tables 1 and 2 show the demographic and health profile of subjects as well as main research variables with means and ranges. The mean OT for those over age 65 in the summer cohort was 0.11 °C higher than in the winter cohort ($t = -6.113$, $p < 0.001$). In addition, when older subjects were further grouped into the following age groups: 65–74, 75–84, and ≥85 years of age, an analysis of variance (ANOVA) showed no difference in temperature in winter ($F = 1.608$, $p = 0.202$) or summer ($F = 1.753$, $p = 0.175$). OT did not decline with age in any age group (see Table 3). There was no significant difference in mean OT between summer and winter cohorts of all subjects ages 20–64 ($t = 0.622$, $p = 0.534$) nor in mean OT between those young adults, ages 20–64, and older adults, ages 65 and older, during the winter. However, the mean OT of the age 65 and older group was significantly higher (0.11 °C) than the 20–64 age group during the summer ($t = 6.512$, $p < 0.001$).

The mean OT of older females was higher than that of older males in both winter and summer (winter: 36.79 ± 0.17 °C vs. 36.70 ± 0.18 °C, $t = -4.125$, $p = 0.001$; summer: 36.88 ± 0.21 °C vs. 36.82 ± 0.22 °C, $t = -2.182$, $p = 0.034$). Furthermore, the mean OT of younger females were slightly higher than the males in either age group in both winter and summer, but this difference was not statistically significant (winter: 36.75 ± 0.18 °C vs. 36.73 ± 0.17 °C, $t = -0.932$, $p = 0.352$; summer: 36.77 ± 0.18 °C vs. 36.73 ± 0.17 °C, $t = -1.821$, $p = 0.07$).

A weak relationship between age and OT was seen in the total study sample ($r = 0.161$, $p < 0.001$). However, body temperature is a complex and non-linear variable (Kelly, 2006). Such as the infancy's thermoregulation function may be not yet mature and the older adult's thermoregulatory function may be declined (Boron and Boulpaep, 2003). Therefore, we postulate the relationship between age and OT to be curvilinear (lower in infancy and old age, but higher in middle adulthood), a curve estimation was done. There was a small ($R^2 = 0.013$) but

Table 2
Main research variables with means and ranges.

Cohorts	Group	n	Age	AT[a]	OT[b]	BMI[c]
Winter	Older adult	262	74.5 ± 6.3 (65–93)	23.4 ± 2.1 (19–27.4)	36.74 ± 0.18 (36.3–37.4)	24.5 ± 3.3 (17.4–35.1)
Winter	Young adult	265	40.3 ± 13.8 (20–64)	28.5 ± 2.5 (22–34.6)	36.85 ± 0.22 (36.4–37.5)	Not measured
Summer	Older adult	257	76.6 ± 7.5 (65–95)	28.5 ± 2.5 (22–34.6)	36.85 ± 0.22 (36.4–37.5)	24.5 ± 3.6 (15.6–36.7)
Summer	Young adult	265	40.3 ± 12.4 (22–64)	25.6 ± 2.2 (22–32.7)	36.74 ± 0.18 (36.3–37.4)	Not measured

[a] Ambient temperature.
[b] Oral temperature.
[c] Body mass index.

Table 3
Comparison of mean oral temperature between the 65–74, 75–84, ≥85 and older groups during the two Cohorts.

Cohorts	OT[a]	65–74	75–84	≥85	F (p-value)
Winter	Mean ± S.D. (range)	36.74 ± 0.18 (36.30–37.30)	36.75 ± 0.19 (36.30–37.40)	36.67 ± 0.16 (36.30–36.90)	1.608 (0.202)
Summer	Mean ± S.D. (range)	36.87 ± 0.21 (36.40–37.40)	36.82 ± 0.21 (36.40–37.50)	36.87 ± 0.22 (36.40–37.50)	1.753 (0.175)

[a] Oral temperature.

Table 4
Multiple regression analysis descriptive factors influencing body temperature.

Variable	Model 1 Total subjects (age 20–95) $n = 1059$			Model 2 Elderly group (age 65–95) $n = 519$			Model 3 ≥85 years old, $n = 61$		
	B	S.E.	β	B	S.E.	β	B	S.E.	β
Age	0.001	0.000	0.087*	−0.001	0.001	−0.039	−0.002	0.011	−0.020
AT[a]	0.016	0.002	0.243***	0.019	0.003	0.311***	0.032	0.010	0.413***
Sex	−0.054	0.012	−0.137***	−0.081	0.018	0.191***	−0.111	0.056	0.241*
BMI[b]				−0.001	0.003	0.028	0.003	0.007	0.058
Constant	36.363			36.437			36.153		
R^2			0.094			0.128			0.282
Adj. R^2			0.092			0.121			0.229
F			36.619**			18.678***			7.090***

B = unstandard coefficient, S.E. = standard error, β = standard coefficient.
[a] Ambient temperature.
[b] Body mass index.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

significant ($p = 0.009$) curvilinear relationship between age and baseline body temperature in the winter cohort, but no such relationship was found in the summer cohort.

There was also a weak relationship between AT and OT ($r = 0.258$, $p < 0.001$) among all subjects in summer and winter. When the older subjects were subdivided into the three ordinal age categories the association between OT and AT on those ages ≥85 years ($r = 0.475$, $p < 0.001$) was higher than that found in both the other age groups: ages 65–74 ($r = 0.313$, $p < 0.001$) and ages 75–84 ($r = 0.230$, $p < 0.001$).

In order to clarify the correlation between age and OT and exclude the effect of AT, a partial correlation was conducted. After controlling for AT no significant relationship was found between OT and age in the age 65 and older group ($r = -0.052$, $p = 0.239$), however, a mild correlation was found between OT and age in the age 20–64 group ($r = -0.137$, $p < 0.001$).

For males age 65 and older, BMI and OT were weakly correlated ($r = 0.207$, $p = 0.014$) in the winter cohort. However, in the summer cohort, there was no correlation between BMI and temperature in either sex. Finally, multiple regression analyses were performed with OT as the dependent variable and age, AT, sex, and BMI as independent variables to determine the effect of these variables on body temperature. See Table 4, models 1, 2 and 3 for findings for overall sample (age 20–95), those 65–84 years old, and those ≥85 years old, respectively. Age, AT, sex and BMI together accounted for 9.4% of the variance in the overall sample (age 20–95); 12.8% in those 65–84 and 28.2% for those ≥85 years old. The results indicated AT and sex were predictors of OT but age and BMI were not.

5. Discussion

Findings of this study revealed that regardless of AT or age, the average OT of both older and younger adults is approximately 0.2–0.25 °C below the generally accepted normal value of 37 °C. These findings are consistent with those from a study of 148 young adults by Mackowiak et al. (1992) that reported the baseline body temperature was 36.7 °C, not the traditionally accepted 37 °C established in 1869 when Wunderlich and Reeve used a mercury thermometer to measure auxiliary temperatures of 25,000 persons and define normal body temperature as 37 °C. The axillary site is now considered unreliable. Mackowiak and Worden (1994) also found that older thermometers of the type used by Wunderlich overestimate temperature values by 1.4–2.2 °C.

Our study found that older adults' body temperature in summer averages 0.11 °C (0.2 °F) higher than those of younger adults. This is not consistent with two studies that suggest that older adults have lower body temperatures (Gomolin et al., 2007; Keilson et al., 1985). Keilson et al. (1985) showed on average, the youngers' mean temperature was 0.2 °C higher, but not statistically different, than that of older. Gomolin et al. (2007) in a comparison of teenagers and older adults in nursing homes found temperatures to be higher in teenagers, but again these findings were not statistically significant. Neither of these studies took AT into account and the older group in the Gomolin's study consisted of nursing home residents with unreported health status. The current study used rigorous inclusion criterions to recruit healthy community dwelling adults; therefore, the subjects were a representative sample of community dwelling older adults.

Previous studies suggested normal physiologic changes associated with the aging process may result in a lower body temperature which coupled with less temperature variability may result in a blunted fever response. Blunting of the febrile response may cause delay in diagnosis and treatment of infection and result in higher mortality among the elderly (Downton et al., 1987; Tal et al., 2002). Castle et al. (1991) suggested that the temperature criterion for fever in the elderly should be less than 38 °C (Castle et al., 1991), otherwise health care providers might miss to notice some fever episodes in the elderly.

This study found that the average OT is about 36.75–36.8 °C with a range of 36.3–37.5 °C. The inter-individual difference of baseline body temperature can be over than 1 °C. This can have clinical significance. If we define the fever as the 1.0 °C over baseline temperature, it is crucial to establish the baseline data of body temperature of our general population. The lower body temperature in the elderly found in some situations may not necessarily be due to aging, maybe result from non-age-related factors such as co-morbidity, malnutrition, activity and cognitive impairment must be considered (Cooper, 1998; Kelly, 2007). Therefore, future studies are needed to investigate these factors.

It is not entirely clear why the OT of the age 65 and older cohort were higher in summer. It might be because summer AT in Taiwan sometimes reaches 38 °C. Even in an air conditioned environment, indoor temperature may be ≥30 °C, causing compensatory vasodilatation and sweating (Holtzclaw, 2002). In older adults, vasomotor and sweat gland activity are known to decrease (Thompson-Torgerson et al., 2008). This increases the sweating threshold for older adults, making them less able to lose heat by evaporative heat loss (Kenney and Munce, 2003; Vassallo et al., 1995).

The moderate influence of AT on OT is consistent with findings of previous studies (Nakamura et al., 1997; Salvosa et al., 1971; Thatcher, 1983). The strongest influence of AT on OT readings seen with each consecutively the oldest group suggests that advancing age puts people at greater risk from exposure to extreme temperatures. The sub-group of older adults, those 85 years and older, showed the greatest influence of AT on OT. This supports earlier findings of Howell (1975), but not of Fox et al. (1973) who found OT and AT were correlated, but not affected by advancing age.

The finding that women in the over 65 age group have significantly higher OT than men in that group, regardless of season, is consistent with the notion that variations in ovarian function associated with the menopause can produce small elevations in core body temperatures (Freedman and Krell, 1999). Higher mean temperatures in older women compared to men have been attributed to sex differences in thermoregulatory mechanisms such as sweating and could possibly make older women more vulnerable than men to high AT (Bar-Or, 1998; Hazelhurst and Claassen, 2006; Robbins, 1989). In contrast to our findings, McGann et al. (1993) found no significant difference in mean OT between older men and women.

The lack of influence provided by BMI on body temperature is seen in this study with weak (in men) or absent (in women) correlation between OT and BMI. These findings were consistent with those of Eriksson et al. (1985) and Sund-Levander and Wahren (2002). However, in Adam's (1989) study with a more diverse age group, an inverse relationship was found between mean daytime OT and BMI and reflected circadian variation as well as hormonal influences of a younger sample.

The current study overcomes many of the limitations of previous studies by providing greater control over confounding variables such as heath status, medication taking, time of temperature measurement, and inter-rater reliability. In addition, it included a comparison group of adults ages 20–64 and was adequately powered to detect differences where they existed. These findings establish baseline temperature ranges for healthy adults over age 65 and dispel the notion that older is colder. Our findings may not be generalizable to more extreme climates because winter temperatures in Taiwan are relatively mild compared to those reported from colder climates.

6. Limitations

Although our study design overcomes some shortcomings of previous studies, it is not without limitations. Body temperature is a variable influenced by circadian rhythm (Kelly, 2006); therefore, a longitudinal design of diurnal temperature variations would be more appropriate for studying this dynamic (Burns and Grove, 2005). However, a longitudinal design was not feasible in the current study of community dwelling adults recruited from community recreational/leisure centers and libraries where attendance may be sporadic. In an ideal study, the ambient temperature would be constant. Although we recorded the ambient indoor temperature at the time of temperature measurement, we were not able to control the ambient indoor temperature in the public locations where the study took place. Finally, in this study the sample was divided into groups based on chronological age; however, chronological age may differ from physiologic age. In addition, arbitrary divisions may not capture incremental changes in thermoregulatory function.

7. Conclusion and suggestions for future research

The research result shows the baseline body temperature of both younger and older is lower than the generally accepted 37 °C norm so this standard should be questioned. In addition, in our samples of healthy older community dwelling adults in moderate AT, their baseline body temperature was not lower than those of younger adult's but at time it was even higher. This confirms that the aging process alone may not result in lower baseline body temperature. "Older is colder" does not apply to all older people.

While the implications of these findings have been mainly directed at finding baseline temperature levels that might help put fever or hyperthermia into proper perspective, these findings have implications for assessing temperature alterations in older persons as well. Older adults are at higher risk than younger adults for mortality in conditions of heat stress or hypothermia (Kare and Shneiderman, 2001; Robbins, 1989). The evidence that the temperature of the older adult varies with the environment raises significant and unsolved questions that warrant continued research.

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