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Time Dependent Mathematical Model of Thermoregulation in Human Dermal Parts During Sarcopenia

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Abstract: *Sarcopenia is an illness characterized by the loss of skeletal muscle mass, and its strength occurs in aging after 50 years. Muscle mass plays a vital role in body weight and metabolism. The loses in body weight impact reducing the basal metabolic rate (BMR). The BMR affects the human body temperature due to lower metabolic heat production during sarcopenia. The present study deals with time dependent temperature variation in human dermal parts during sarcopenia. The finite element method is used to solve a one-dimensional bioheat equation. In this model, the thickness of the epidermis, dermis layers, and the BMR of different aging, are estimated. The results show the nodal temperature of the epidermis and dermis layers increases due to reducing the thickness. Further, the subcutaneous nodal temperature slightly decreases due to the cause of BMR.*

Keywords: Muscle strength, Basal metabolic rate, Skin thickness, Physical activity, Thermoregulation

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1 Introduction

Sarcopenia is an age-related reduction in skeletal muscle mass and its strength. It appears in an older person after the age of 50 years. It concerns physical disability and reducing the spirit of life. The loss of muscle mass is responsible for reducing muscle strength. It associates with increasing body fat so that despite weight causes the weakness of the body in aging people. The impact of sarcopenia is a far-reaching substantial phenomenon that occurs in terms of morbidity, disability, and high cost of health care. The loss of muscle mass and muscle strength are the key factors to determine sarcopenia. Physical activities are helpful to reduce the level of sarcopenia. The change in skin is a universal biological phenomenon that occurs the loss of muscle mass due to intrinsic and extrinsic aging. Intrinsic aging is an inevitable change attributing to the passage of time and display primarily by physiologic alternation. Extrinsic aging is caused by the environment, ultra-violet light, pollution, and smoking. The skin thickness declines cause an increase in the risk of infection and decrease immunity power. It also reduces the repair rate in wound healing process.

In aging, skin metabolism mainly affects by low physical activity, and decrease nutrient intake help on increasing the level of sarcopenia. The thyroid gland plays a principal role in the metabolic process. It brings on the growth and development of cells of the human body. It helps to regulate body functions by constantly releasing a steady amount of thyroid hormones. But in aging, thyroid glands cannot regulate hormones regularly into the bloodstream.

The loss of muscle mass plays an important etiologic role in the frailty process. Muscle mass increases at the childhood stage of life and decreases approximately 8% per decade after 50 years of age due to reduces intake nutrient consumption [5]. The basal metabolic rate decreases due to the slow metabolic process during aging. The preservation of muscle mass prevents the BMR, helps in the reduction of sarcopenia. The basal metabolic rate(BMR) decreases and affects the body's core temperature and feels cold by the aging people.

The pH value of blood in a healthy human body ranges from 7.35 to 8.35, but it changes in aging due to loss of muscle mass. If the pH value changes either below from 6.8 or above from 8.8, it may danger and the result may be death. So the blood maintains or controls the pH value by the buffering process. The buffering capacity may reduce in aging due to reducing the blood flow rate.

Muscle mass plays a crucial role in body weight and metabolism. The body weight reduces due to decreasing the fat-free mass, change in hormones, deficiency in protein consumption rate, and increases fat mass. The excess fat causes the risk of coronary artery diseases, hypertension, and hyperlipidemia [4]. The lean muscle mass burns more energy than fat muscle mass, and energy expenditure decreases with increasing age. Decrease energy expenditure also associates with losing body weight. In aging (50-60), the average energy expenditure is 1679.44 kcal/day having its body weight is 77.85 kg. The aging (80-90) has an average body weight of 77.49 kg and expends 1407.15 kcal/day of energy. The average energy expenditure and body weight are estimated by the aging 50 to 90 are presented in Table **1.**

Age (years)	Body weight (kg)	Average energy expenditure (kcal/day)
50-60	77.85	1679.44
60-70	77.49	1599.23
70-80	73.83	1485.42
80-90	74.42	1407.15

Table 1: Estimation of average energy expenditure and body weight of different ages [17, 23].

Metabolism plays a vital role in the temperature distribution of the human body. It concerns calories consume by the metabolic process. BMR is the number of calories consuming to sustains the body functions at rest in thermoneutral conditions. The decrease in BMR with aging appears in a change in reducing energy expenditure. Generally, BMR depends on body composition expressed by fat-free mass, gender, age, physical activity, and nutrient status. The change in body weight and metabolic rate of tissue and organs bring on the changes in the BMR of the body. The body weight associates with calculating the BMR of the body [17]. Skeletal muscle accounts for (35-40)% of body weight contributes to (18-24)% BMR of the body. The principal organs as the heart, kidneys, brain, liver, and gut, make about 7% of the body weight contributes 60% BMR of the entire body. This data shows these organs contribute a large amount of BMR in the metabolic process[18]. But in aging, due to reducing body weight, the BMR decreases.

Skin is the largest sensory organ generally divided into the epidermis, dermis, and subcutaneous tissue. It serves as a barrier between the internal and external environment and protects from diverse critical factors, and maintains homeostasis. The heat exchanging process depends upon the thickness, thermal conductivity, location, and heat transfer coefficient of the skin layers. It also depends on the environment, age, and several active sweat glands occurring in the dermal layer [1]. Skin thickness rises over the first 20 years while the epidermis and dermis thickness reduces after aging 50 years even the number of cells remains constant [9].

The dermal region temperature changes towards the outer skin surface from the body core with a change in environmental temperature. The body core temperature reduces due to decreasing the BMR and keeps the body in thermoregulation by the body mechanism [2].

Exercise is the primary treatment source that prevents sarcopenia by reducing the loss of muscle mass. Resistance exercise can improve physical performance and muscular capacity in aging. During exercise, the movement speed of muscle cells increases. These help to increase the heat transfer rate through conduction and increases the body temperature.

Pennes' developed the oldest and the most studied mathematical model based on temperature profiles in human forearms. The temperature varies as a function of physiological, physical, and many transient parameters. Pennes' model described the effect of diffusion, blood perfusion, and a uniform distribution of the metabolic heat generation within the tissue on the energy balance equation given by [21]

$$\rho c \frac{\partial T}{\partial t} = \nabla.(K \nabla T) + \rho_b c_b w_b (T_A - T) + E_m(t)$$

Where,

ρ : Tissue density (kg/m^3),
c : Tissue specific heat capacity (J/kg°C),
K : Tissue thermal conductivity (w/m.°C),
T : Tissue temperature (°C),
ρ_b : Blood density (kg/m^3),
c_b : Blood specific heat capacity (J/kg^{0}C),
w_b : Blood perfusion rate (/s.),
T_A : Artery temperature (°C) and
$E_m(t)$: Metabolic heat generation rate (w/m^3).

Balmain et al. [3] discussed the thermoregulatory control mechanism and the factors that may increase the risk of heat-related illness in older aging. Coscarelli et al. [6] described the tissue temperature due to the effect of blood flow. They suggested that the change in arterial blood flow does not affect the tissue temperature distribution in aging. Waalen and Buxbaum [25] compared the temperatures between the male and female. They have investigated that females appear to have a slightly higher body core temperature than males and mean temperature decreases by $0.17°C$ in the ages (70 - 80). Henry [13] developed the relationship between the basal metabolic rate, age, and the bodyweight of the human body. He also provided the approximation basal metabolic rate of major organs. Kenney and Munce [16] investigated the body core temperature between young and older adults under resting thermoneutral conditions. They reported that the body core temperature decreases with advancing age and has more variability in older populations. Thomas et al. [24] explained that the body core temperature and sweating were improved in aging by aerobic and resistance exercise training due to increased blood flow rate. They also suggested that exercise training may have improved thermoregulatory control by augmenting heat-induced skin blood flow and sweating responses. Keil et al. [15] provided the relationship between body core temperature and the aging life of the human body. They noticed that women appear to have a slightly higher body temperature and yet live longer than men.

Previously, researchers have only explained the temperature distribution in dermal parts of the adult human body. The model has estimated the basal metabolic rate and thickness of epidermis, dermis, and subcutaneous tissue in aging. The model has also investigated the nodal temperature of these layers in aging. The finite element method technique is using to get the sensible temperature profiles by discretizing the domain of the skin layers.

2 Discretization

Skin is an important organ of the body and has numerous functions. It forms a physical barrier to the environment to helps on regulating and maintaining the body temperature. The thickness of the skin layer is important for maintaining body temperature normal. In this paper, each layer distance is measured perpendicularly from the outer skin surface towards the body core. Let L_1, L_2, and L_3 are the distance of epidermis, dermis, and subcutaneous tissue respectively measure from the outer surface of the skin. This provides the thickness of the epidermis is $L_1 - 0$, the dermis is L_2-L_1, and subcutaneous tissue is L_3-L_2. The schematic diagram of the skin layers thickness of the human body is presented in Figure **1**.
Let T_0, T_1 and T_2 are the nodal temperatures at a distance of $x = 0$, $x = L_1$, $x = L_2$ respectively. T_3 is the body core temperature at a distance of $x = L_3$. Let $T^{(0)}$, $T^{(1)}$ and $T^{(2)}$ is the temperature functions of epidermis, dermis and subcutaneous tissue respectively.

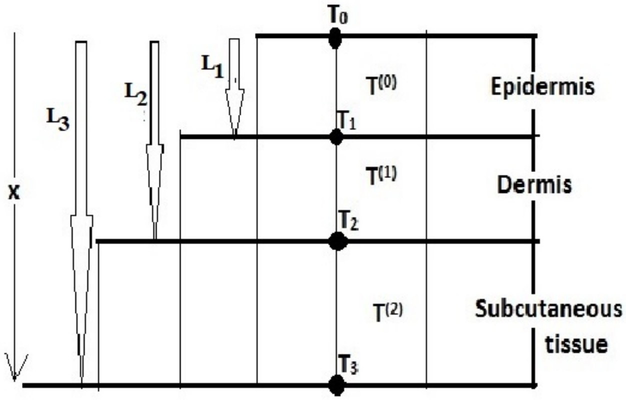

Figure 1: Schematic diagram of three skin layers.

3 Estimation and Simulation of Basal Metabolic Rate and Skin Layers Thickness in Aging

3.1 Basal metabolic rate

The BMR value is increasing at the beginning of age and has a maximum value at the age of three months [13]. After it, the basal metabolic rate falls with age. The average BMR of a healthy adult is 1114 w/m^3, and its value depends on body size, hormones, gender, age, and body weight [22]. Due to loss of muscle mass, the BMR reduces after the age of 50 years and behaves as a logistic phenomenon. The average BMR of aging (50-60) is approximately 1022.8 w/m^3 and aging (80-90) is approximately 895.58 w/m^3. The behavior of BMR equation $E_m(t)$ in aging is considered as [22]

$$E_m(t) = S_B + \frac{M_A - S_B}{1 + e^{-\gamma(t-t_m)}} \tag{1}$$

Where,

S_B : Basal metabolic rate in normal human body,
t : Age in years,
M_A : BMR of aging,
γ : BMR controlled parameter,
t_m : Sigmoid's midpoint of the curve.

Figure (**2**) shows the unsteady behavior of basal metabolic rates of different aging group from 50 to 90 at $\gamma = 0.22/years$, and $t_m = 65$ years with BMR of adult $=1114$ w/m^3.

3.2 Skin layers thickness

In a healthy adult, the epidermis, dermis, and subcutaneous tissue thickness are taken as 0.001m, 0.003m, and 0.005m, respectively [12]. On increasing the age after 50 years, the epidermis layer thickness reduces by 6.4% per decade while the dermis layer thickness decreases by 2% per year[9]. The subcutaneous tissue loses fatty cushion while the basement membrane thickness increases and the total thickness of tissue almost constant with age [9]. The approximate thickness of the epidermis and dermis layer in the age of (50-60) becomes 9.36×10^{-4} m and 24.51×10^{-4} m, and in the age of (80-90), its approximate thickness reduces

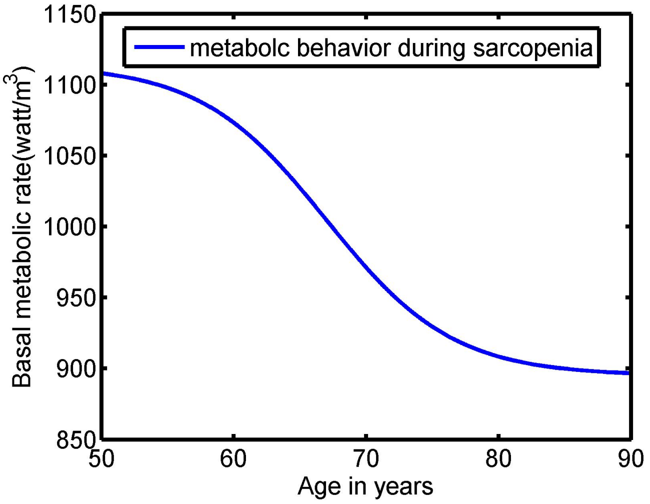

Figure 2: Behavior of basal metabolic rate during different aging.

to 7.68×10^{-4} m and 13.38×10^{-4} m respectively. The reduction of epidermis and dermis layers thickness are graphically shown in Figure **3**. The estimation of BMR values and skin layers thickness of aging 50-90 is presented in the Table **2**.

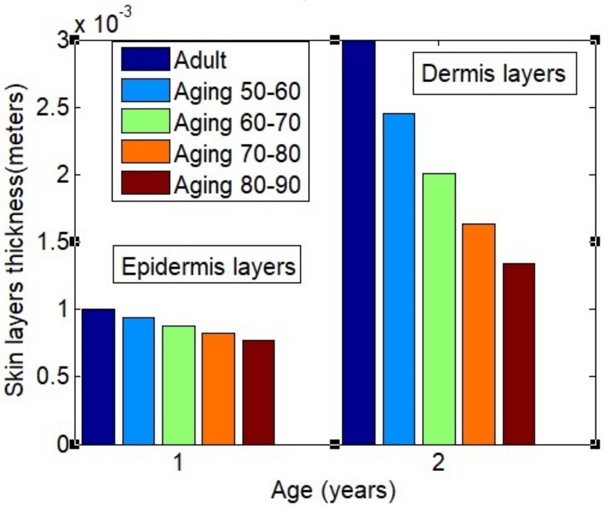

Figure 3: Variation of epidermis and dermis layers thickness during adult and aging.

4 Mathematical Model and Boundary Conditions

4.1 Mathematical model

After 50 years, the basal metabolic rate decreases. It happens due to the reduction of the body weight affected by the loss of muscle mass. The behavior of basal metabolic rate in different aging are showing in Figure **2** and, its estimated numerical values are presenting in Table **2**. In aging, heat regulation in in-vivo tissue of human skin layers, is given by the Pennes' bioheat equation for 1D which can be written as;

Age (years)	BMR (w/m^3)	Thickness of epidermis layer ((L_1) meters)	Thickness of dermis layer (($L_2 - L_1$)meters)	Thickness of subcutaneous tissue (($L_3 - L_2$) meters)
50-60	1022.8	9.36×10^{-4}	24.51×10^{-4}	50.00×10^{-4}
60-70	978.45	8.76×10^{-4}	20.03×10^{-4}	50.00×10^{-4}
70-80	948.83	8.20×10^{-4}	16.37×10^{-4}	50.00×10^{-4}
80-90	895.56	7.68×10^{-4}	13.38×10^{-4}	50.00×10^{-4}

Table 2: Estimation of basal metabolic rate and skin layers thickness during aging [9,17]

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$$\rho c\frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\big(k\frac{\partial T}{\partial x}\big) + M(T_A - T) + \left(S_B + \frac{M_A - S_B}{1 + e^{-\gamma(t-t_m)}}\right) \tag{2}$$

Where, $M = \rho_b c_b w_b$ $(J/m^3 s°C)$.

4.2 Boundary conditions

(a) Boundary condition at $x = 0$ (skin surface)

Since heat flux is taken at the outer skin surface $x = 0$, the skin exposes to the environment. The outer skin surface loses the heat energy to the atmosphere by the process of convection, radiation, and evaporation. The net heat flux obtained by mixed boundary condition change to

$$K\frac{\partial T}{\partial x}\bigg|_{x=0} = H_A(T - T_\infty) + L_A E_A \tag{3}$$

where,

$\frac{\partial T}{\partial x}$: Temperature derivative along outward normal to the boundary surface,
T_∞ : Ambient temperature,
L_A : Latent heat capacity in aging,
E_A : Sweat evaporation rate in aging and,
H_A : Combined heat transfer coefficient due to convection and radiation.

(b) Boundary condition at $x = L_3$(body core)

The metabolic energy produces in aging is insufficient due to the slow movement of muscle mass. So all the metabolic energy dissipate instantaneously during aging and the body core temperature maintains to $37°C$ by the body mechanism. So, the Dirichlet's inner boundary condition is taken as

$$T(L_3) = T_b = 37°C$$

where, T_b is body core temperature and L_3 is the total thickness of the skin layer.

5 Solution of the Model

Finite element method is used for solving the equation (2) by using the boundary and initial conditions. The variational integral form of equation for unsteady state temperature is given by

$$\begin{aligned} I[T(x,t)] =& \frac{1}{2}\int_\Omega \left[K\left(\frac{dT}{dx}\right)^2 + M(T_A - T)^2 - 2\left(S_B + \frac{M_A - S_B}{1 + e^{-\gamma(t-t_m)}}\right)T + \rho c\frac{dT^2}{dt}\right]dx \\ &+ \frac{1}{2}H_A(T_0 - T_\infty)^2 + L_A E_A T_0 \end{aligned} \tag{4}$$

Where,

Ω : Domain of skin layers,
T_0 : Temperature of skin outer surface.

The use of physical and physiological parameters of the epidermis, dermis, and subcutaneous tissue in the model depending on environmental conditions are given in Table **3**.

Physical and physiological parameters	Epidermis layer $0 \leq x \leq L_1$	Dermis layer $L_1 \leq x \leq L_2$	Subcutaneous tissue $L_2 \leq x \leq L_3$
K	K_1	K_2	K_3
M	$M_1 = 0$	M_2	M_3
T_A	$T_A^{(1)} = 0$	$T_A^{(2)} = T_b$	$T_A^{(3)} = T_b$
$E_m(t)$	$E_{m1}(t) = 0$	$E_{m2}(t) = S_B + \frac{M_A - S_B}{1+e^{-\gamma(t-t_m)}}$	$E_{m3}(t) = 2[S_B + \frac{M_A - S_B}{1+e^{-\gamma(t-t_m)}}]$
$T^{(k)}$	$T^{(1)} = T_0 + (\frac{T_1 - T_0}{L_1})x$	$T^{(2)} = \frac{L_2T_1 - L_1T_2}{L_2 - L_1} + (\frac{T_2 - T_1}{L_2 - L_1})x$	$T^{(3)} = \frac{L_3T_2 - L_2T_3}{L_3 - L_2} + (\frac{T_3 - T_2}{L_3 - L_2})x$

Table 3: Parameters used in the model.

Let, I_1, I_2 and I_3, are the integral solutions of three layers epidermis, dermis and subcutaneous tissue, respectively with $I = \sum_{z=1}^{3} I_z$. On Solving the integrals I_1, I_2 and I_3, we obtain as,

$$I_1 = A_1 + B_1T_0 + D_1T_0^2 + E_1T_1^2 + F_1T_0T_1 \tag{5}$$

$$I_2 = A_2 + B_2T_1 + C_2T_2 + D_2T_1^2 + E_2T_2^2 + F_2T_1T_2 \tag{6}$$

$$I_3 = A_3 + B_3T_2 + C_3T_3 + D_3T_2^2 + E_3T_3^2 + F_3T_2T_3 \tag{7}$$

where A_j, B_j, D_j, E_j, F_j and C_k are all constants with $1 \leq j \leq 3$ and $2 \leq k \leq 3$. To optimize the value of I, we differentiate the system of equations (5), (6) and (7) with respect to the nodal temperatures T_0, T_1 and T_2.
On simplification after setting $\frac{dI}{dT_z} = 0$, for $z = 0, 1, 2$. Then we obtain the system of equation in matrix form as,

$$AT + B\dot{T} = C \tag{8}$$

where,

$$A = \begin{pmatrix} 2D_1 & F_1 & 0 \\ F_1 & 2(D_2 + E_1) & F_2 \\ 0 & F_2 & 2(D_3 + E_2) \end{pmatrix}, \quad B = \begin{pmatrix} 2\alpha_1 & \alpha_1 & 0 \\ \alpha_1 & 2(\alpha_1 + \alpha_2) & \alpha_2 \\ 0 & \alpha_2 & 2(\alpha_2 + \alpha_3) \end{pmatrix}$$

$$T = \begin{pmatrix} T_0 \\ T_1 \\ T_2 \end{pmatrix}, \quad \dot{T} = \begin{pmatrix} \frac{dT_0}{dt} \\ \frac{dT_1}{dt} \\ \frac{dT_2}{dt} \end{pmatrix}, \quad C = \begin{pmatrix} -B_1 \\ -B_2 \\ -C_2 - B_3 - F_3T_3 \end{pmatrix}$$

6 Numerical Results and Discussion

The basal metabolic rate decreases by increasing the age during sarcopenia. The Table **2** has illustrated the BMR in aging 50-60, 60-70, 70-80, and 80-90 are 1022.8 w/m^3, 978.45 w/m^3, 948.83 w/m^3 and 895.56 w/m^3 respectively. The physical and physiological parameter's values used in the model for numerical simulation is presented in Table **4**.

Parameter	L_A	K_1	K_2	K_3	h_A	$M_2 = M_3$	$\rho_1 = \rho_2 = \rho_3$	$c_1 = c_2 = c_3$
Value	2.42×10^6	0.209	0.314	0.418	6.27	1254	1050	3469.4
Unit	J/kg	$w/m°C$	$w/m°C$	$w/m°C$	$w/m^{2o}C$	w/m^{3o}C	kg/m^3	$J/kg°C$

Table 4: Parameter values used in model [12, 22].

In this model, the initial skin temperature is considered $24.30°C$ for calculation of skin layers temperature by iteration process. So the tissue temperature increases from the skin surface towards the body core temperature. So we consider the tissue temperature T(x,0) in linear order given by the equation

$$T(x,0) = T_0 + \nu x \tag{9}$$

The use of ν in equation (9) is constant, whose numerical value is determined by taking the core temperature $(T_3) = T_b = 37°C$ at $x = L_3$. We use the Crank -Nicolson method to solve the equation (8). The Crank -Nicolson method has given,

$$\left(B + \frac{\triangle t}{2}A\right) T^{(i+1)} = \left(B - \frac{\triangle t}{2}A\right) T^{(i)} + \triangle t\ C \tag{10}$$

Here, $\triangle t$ is the time interval, and $T^{(0)}$ is the initial nodal temperature in 3×1 matrix form.

Temperature Results

The unsteady temperatures T_i, (i= 0, 1, 2) for sets of four aging groups 50-60, 60-70, 70-80 and 80-90 are presented in Figures **4** to **9** and Table **5** at ambient temperatures $15°C$ and $25°C$. The obtaining results also compared with the temperature of adults.

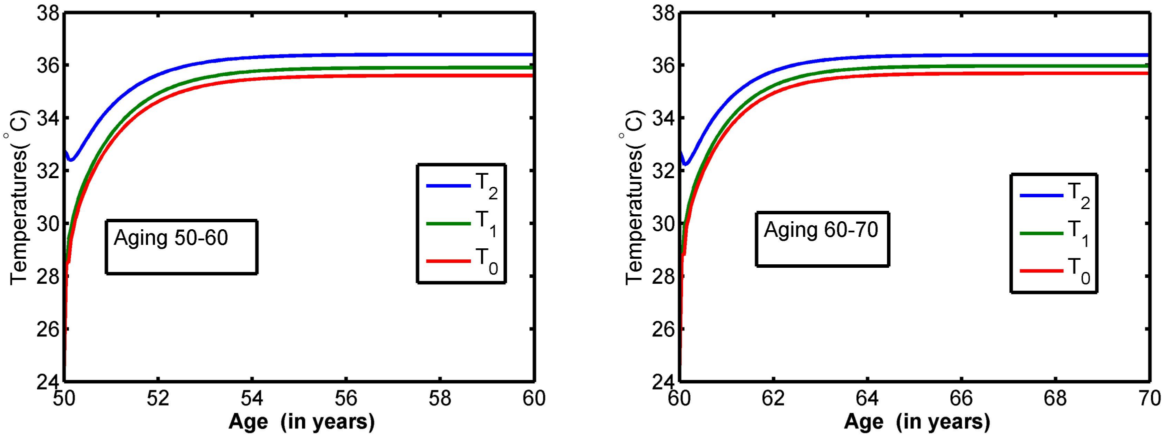

Figure 4: Observation of unsteady temperatures T_0, T_1, and T_2 during aging 50-60 and 60-70 at $E = 0$ $kg/m^2.s$ and $T_\infty = 25°C$.

Figure **4** reveals the unsteady temperatures T_i, at T_∞= $25°C$ without evaporation rate during aging 50-60 and 60-70. These results exhibit that the temperatures T_0, T_1, and T_2 respectively reached steady at $35.61°C$, $35.91°C$, and $36.41°C$ during ages 50-60 and reached steady at $35.69°C$, $35.97°C$, $36.38°C$ during aging 60-70. These results also show the temperatures T_0 and T_1 have slightly more during aging 60-70 than during aging 50-60 due to the cause of variation of skin thickness. But the temperature T_2 is more during aging 50-60 than during aging 60-70 due to the effects of BMR.

Figure **5** indicates the unsteady temperatures T_i at T_∞ = $25°C$ and $E_A = 0$ $kg/m^2.s$ during aging 70-80

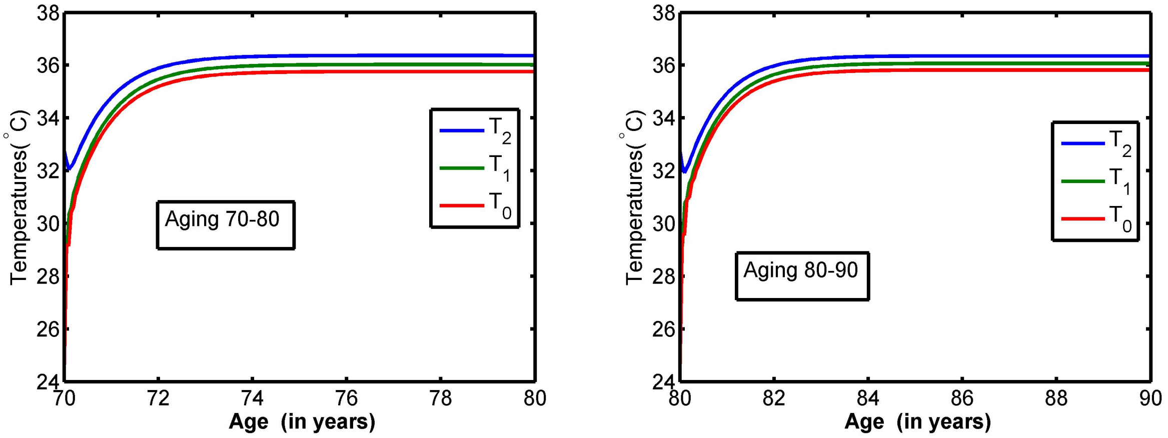

Figure 5: Observation of T_0, T_1, and T_2 temperatures during aging 70-80 and 80-90 at $E_A = 0\ kg/m^2.s$ and $T_\infty = 25°C$.

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and 80-90. The results reveal that the temperature T_0 is more by $0.07°C$ and T_1 is more by $0.06°C$ during aging 80-90 than the temperature during aging 70-80. But the temperature T_2 is decreased by $0.02°C$ during aging 80-90 than aging 70-80. These are due to the epidermis and dermis layers thickness decrease during aging 80-90 and has no effects of BMR in epidermis layers.

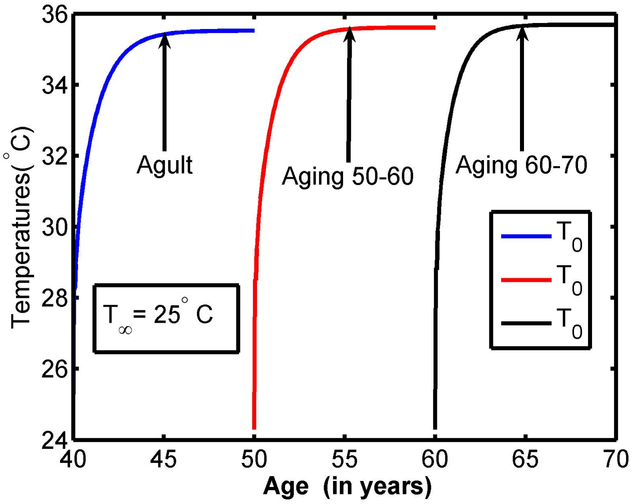

Figure 6: Comparison of unsteady temperatures T_0 during adult, aging 50-60 and 60-70 at $T_\infty = 25°C$ and $E_A = 0\ kg/m^2.s$

Figure **6** delineates the unsteady temperature T_0 during adult, aging 50 - 60, and 60 - 70. The results exhibit that the temperatures T_0 and T_1 during aging 50 - 60 have more than the temperature during adult at $T_\infty = 25°C$ without evaporating heat energy. These are due to no significant effects of BMR and cause the different thickness of epidermis layers during adult and different aging.

Figure **7** presents the unsteady temperature T_1 during aging 50-60, 60-70 and, adult at $T_\infty = 25°C$ without evaporation rate. These results exhibit that T_1 has the greatest during aging 60-70 among the three age groups. These are due to more conduction of heat energy in a thinner layer than a thicker layer and occurs no more effects of BMR in the dermis layer during aging.

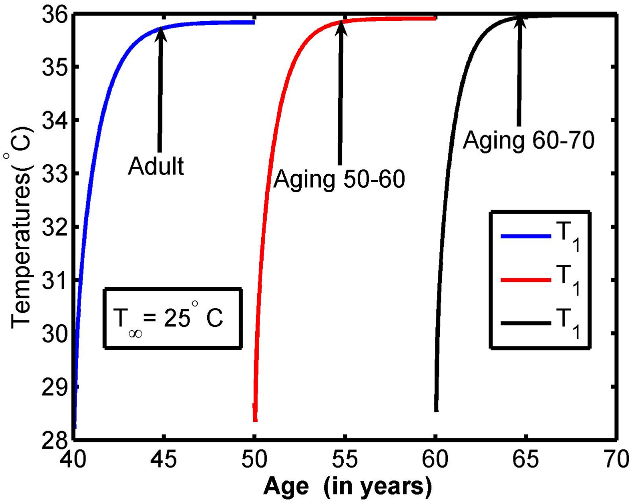

Figure 7: Comparison of unsteady temperature T_1 during adult, aging 50-60 and 60-70 at $T_\infty = 25°C$ and $E_A = 0\ kg/m^2.s$.

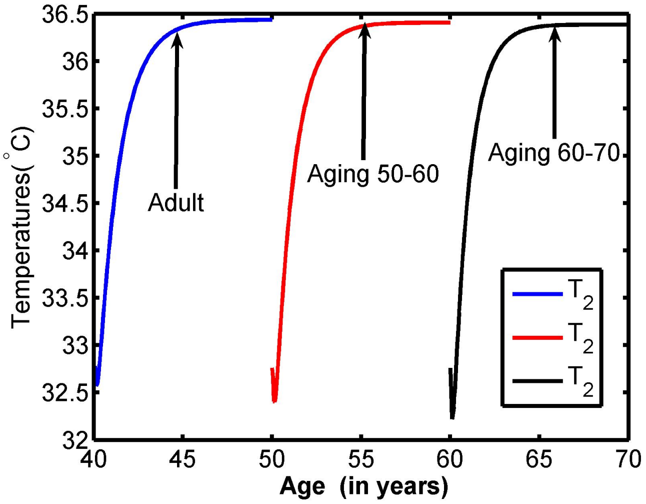

Figure 8: Comparison of unsteady temperatures T_2 during adult, aging 50 - 60, and aging 60 - 70 at $T_\infty = 25°C$ with $E_A = 0\ kg/m^2.s$.

On comparing the unsteady temperatures T_2 among adults, during aging 50- 60 and 60-70 as presented in Figure **8**. The figure delineates that T_2 has least during aging 60-70 and has greatest during adult. These are due to the effects of BMR in subcutaneous tissue.

Figure **9** provides the unsteady temperatures T_0, T_1, and T_2 during aging 50-60, 60-70, 70-80 at T_∞ =15°C and 25°C without evaporation. The comparing results indicate, T_2 has least during aging 70-80, and greatest during aging 50-60 among the three groups of aging in both ambient temperatures 15°C and 25°C. These are because the skin layers thickness decrease on increasing the ages and happens the metabolic effect in subcutaneous tissue.

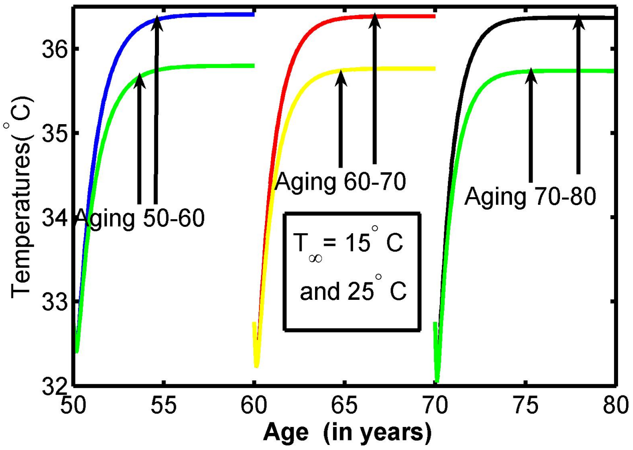

Figure 9: Comparison of unsteady temperatures T_2 during aging 50-60, 60-70 and 70-80 at $T_\infty = 15°C$ and $25°C$ with $E_A = 0\ kg/m^2.s$.

Age (years)	Skin nodal temperatures at T_∞= $15°C$			Skin nodal temperatures at T_∞= $25°C$		
	T_0	T_1	T_2	T_0	T_1	T_2
Adult	34.17	34.74	35.84	35.52	35.84	36.44
$50-60$	34.34	34.88	35.80	35.61	35.91	36.41
$60-70$	34.49	35.00	35.76	35.69	35.97	36.38
$70-80$	34.62	35.10	35.73	35.75	36.02	36.36
$80-90$	34.74	35.19	35.71	35.82	36.07	36.35

Table 5: Estimation of steady nodal temperatures T_0, T_1, and T_2 at different ambient temperatures in adult and aging.

7 Conclusion

Natural aging process causes sarcopenia which is the loss of muscle mass and it's strength. The intake of nutrient food decreases during aging, so the release rate of heat energy reduces due to decreases in the BMR. It shows the weak significant effects on the steady temperature of the subcutaneous tissues during aging as compared to the adult. Furthermore, the skin thickness of aging people has thinner than healthy adults. Due to this effect, the interface temperature of the epidermis and dermis layers increases in increasing age. These results execute that the variation of thickness of skin layers during aging plays a crucial role to maintains body temperature.

Previously, researchers have experimentally studied sarcopenia due to the cause of reducing the BMR affected by the loss of muscle mass and its strength. They suggested its treatment by the process of resistance exercise and clinical method. But they haven't prepared the model on temperature distribution in the human dermal parts due to the effect of BMR and the skin layers thickness in sarcopenia. So this model is developed for the realistic temperature distribution in the human body due to reducing the thickness of skin layers and the effect of BMR in aging. This paper will be helpful to maintain the physiological parameters for aging people from sarcopenia. It also helps to develop the models for the realistic temperature distribution in different age levels of people.

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