https://doi.org/10.26682/ajuod.2023.26.1.28
Journal of University of Duhok., Vol. 26, No.1 (Agri. and Vet. Sciences), Pp 270-278, 2023

THE RELATIONSHIPS AMONG PHENOTYPIC BODY INDICES OF LOCAL GOAT

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(Received: May 29, 2023; Accepted for Publication: July 18, 2023)

ABSTRACT

The relationship between some body indices are significant tools to evaluate the final yield in animals. The present research was carried out in a private farm at Sumeal area, Duhok province, Kurdistan Region, Iraq. The present trial aimed to illustrate the relationships between/among some body indices, in addition to try finding a prediction equation for some complicated body indices. One-way ANOVA, correlation and regression coefficients were analyzed. The results revealed that most body indices differed significantly ($p \leq 0.05$) among the studied ages; and the correlation coefficients between of them were also significant ($p \leq 0.05$). The stepwise analysis within regression revealed that it may predict with Body ratio (BR) from body (IB) and from weight 3 (Heart girth related), with high significant effect ($p \leq 0.01$), but having relatively low coefficient of variation (R^2).

KEY WORDS: Local goat, Body indices, Animal age, Prediction equation.

INTRODUCTION

To preserve the integrity and genetic variation of local goats and to use their crosses commercially, it is crucial to preserve their populations. Chacon et al., (2011) studied a few morphological measurements with several body indices in Cuban Creole goats, and they showed low variation in the majority of the analyzed measurements and indices indicating homogeneity among goats. More over, the native goat of Iraq with its population of about 1.3 million in 1999 (FAO, 2000) is raised primarily for meat and milk. Yet, unlike in sheep, very limited work has been attempted to investigate the various performance and economic trait of the locale goat in Iraq (Alkass and Juma, 2005). They further mentioned that many functional indices were linked to the milk biotype supporting the breed's (Canary Islands breed) conceivable origin. Goats are preferred by farmers with little resources since they are cheaper to buy, easier to manage, more productive, mature earlier, and more tolerant of severe environmental conditions (Kumar et al., 2010; Sousa et al., 2011). During the selection of goats, paying close attention is important to properties such as the age of goats, its growth rate, live body weight (LBW), heart girth (HG), body length (BL), and wither heights (WH). According to Janssens and Vandepitte (2004), Yilmaz et al. (2013), and Iqbal et al. (2013), the prediction of body weight (BW) and its correlations to other morphological parameters provides useful information for breeding examination with reference to the amount of meat produced per animal. According to Miserani et al. (2002), performance and conformation features are heritable, in addition to influence by a variety of environmental circumstances. The aim of evaluating body conformation from the standpoint of type is frequently achieved by the derivation of such indices from the phenotypic measurements (Mwacharo et al., 2006).

Researchers throughout the world have conducted studies on the use of body indices to forecast goat's body weight. It has been reported in previous research that there is a correlation based on age and gender between a goat's body weight and its measurements. The effects of age and gender on the regression model have not been thoroughly studied. The purpose of such studies often carried out to determine the most accurate slope model for estimating live weight based on some body measurements, and to examine the relationships between live weight and a different body measurement (length of body, height of shoulder and heart girth) in the goats of various old and sexes. (Dakhlan et al., 2021).

Although there are different perceptions about what creates ideal conformation between breeds, the overall result is proportionate to its size (Martin et al., 1978). One of the hardest animals that man has ever domesticated are goats, which are an important cause of income and employment for sizable communities. Due to its small size, simple housing requirements, higher resilience to illness, and simplicity of product disposal, it uses low-quality roughages (Bhondve et al., 2018). To accomplish this aim, accurate measurements of this feature are necessary, which is frequently challenging in rural areas without weighing scales. Therefore, there is a requirement for estimating the trait from straightforward and best accessible variables, like linear body measures. Studies involving the linear body measurements of goats for determining the animals' body weights have been conducted in other parts of the world (Islam et al. 1991; Slippers et al. 2000; Singh and Mishra 2004;).

The aims of the current study are to derive and build different indices with predication equations for body weight of local goats from different body measures, to be standard body confirmation of local goats as possible.

MATERIAL AND METHOD

The present study was conducted at a private farm of goat in summel area, Duhok, Kurdistan Region-Iraq. A total of 75 local goats that were distributed randomly according to their age, for measuring all external body measurements (Figure1). Adult goats were classified into three classes, firstly 1-2 years; secondly 2.5-3.5 years and thirdly 4-6 years. The average of ambient temperature for the studied period was ranged from (37.4-38.4 ºc).

Measuring different body measurement as follow

The following body measures were taken using length scale by centimeters (cm).

1. Height of Withers (WH)
2. Height of Rump (HR)
3. Length of Body (BL)
4. Height of Sternum (SH)
5. Depth of Body (RD)
6. Diameter of Bicoastal (BD)
7. Length of Ear (EL)
8. Width of Rump (RW)
9. Width of Head (HW)
10. Length of Rump (RL)
11. Length of Head (HL)
12. Heart girth (HG)
13. Cannon Circumference of bone (CC)
14. Diameter of Muzzle (DH)

However, the deriving or calculating indices, was according to Salako, (2006)

Moreover, the studied indices were computed as follow:

1. (Head width × 100) / Head length = Cephalic (IC);
2. (Body length × 100) / Heart girth = Body (IB): If IB > 0.90, the animal is longiline; from 0.86 to 0.88 is medigline and < 0.85, it is brevigline;
3. (Shoulder height × 100) / Body length = Proportionality (IPr);
4. (Rump width × 100) / Rump length = Pelvic (IP);
5. [Body length × body depth × (hip width + chest width)/2] /1050 = Weight 1;
6. (0.5 × HG) – 14.87 = Weight 3, according to (Mohammed and Amin, 1997);
7. (0.63 × HG) – 19.5 = Weight 4, according to (Singh and Mishra, 2004);
8. Rump width / chest width = Width slope (WS);
9. (Rump width × 100) / rump height = Transverse pelvic (IPT);
10. (Rump length × 100) / rump height = Longitudinal pelvic (IPL);

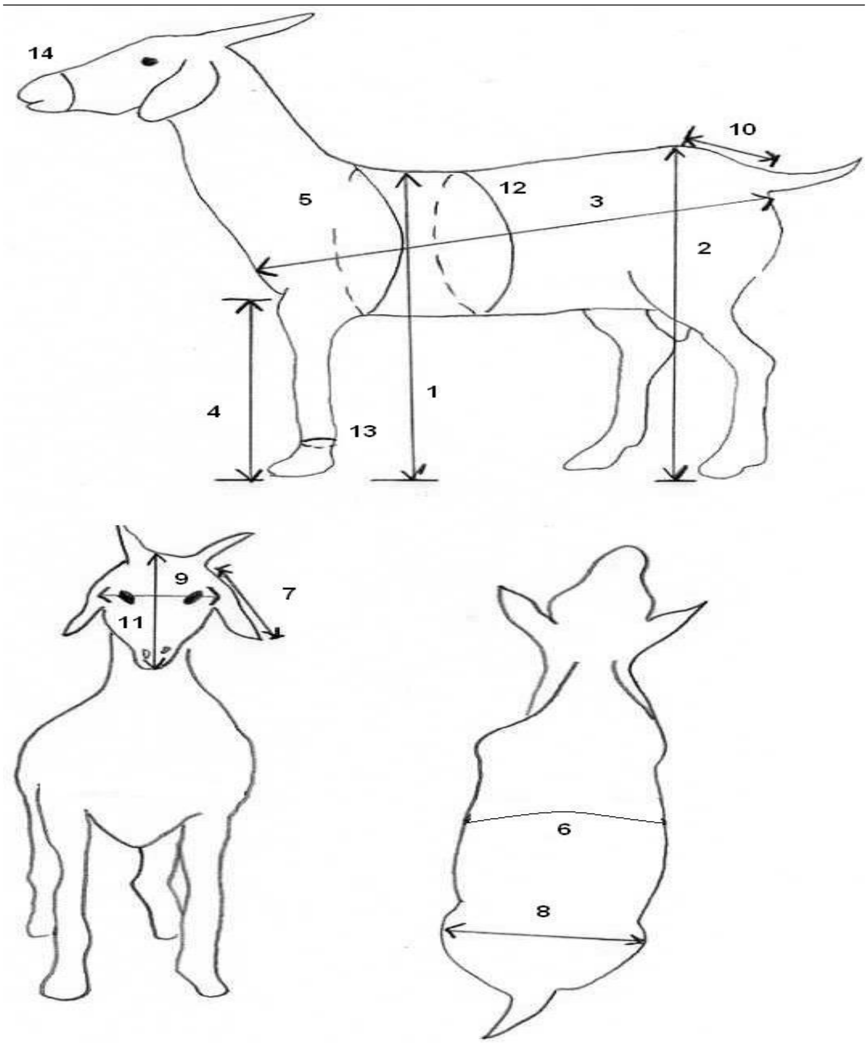

Fig. (1): The measurement taken on studied local goat.

11. (BL × 100) / wither height = Relative body index (RBI), this also called length index;
12. CC / HG = Dactyl thorax index (DTI), this index should not be higher than 10.5 in light animals, up to 10.8 in intermediary; up to 11.0 in light meat and up to 11.5 in heavy meat type.
13. (HS + HR) /2) / SH = Pectoral Index (PI), When the height of back is smaller than the sternum height, the animal is referred as “far from ground”;
14. HG / HS = Thoracic development (TD), its value above 1.2 indicating as good animals;
15. HS / HR = Body ratio (BR), if its value is lower than the rump, then the animal is low in front and vice versa.
16. HG2 / HS = Baron and Crevat (BC), the greater the index, the more robust the animal, also called Conformation Index;
17. (W / HS) /100 = Compact index 1 (CI1), its value indicates how compact the animal is. Meat type animal has value above 3.15, value close to 2.75 indicates dual purpose and close to 2.60 indicates animal more suitable for milk yield;
18. [W / (HS-1)] / 100 = Compact index 2 (CI2), such index indicates the animal’s aptitude, value above 9.5 indicates meat type, range from 8.0 to 9.5 indicating animal suitable for dual purpose and from 6.0 to 7.75 indicating milk type animal (Salako, 2006).

Statistical analysis

The collected data were analyzed using SAS software (SAS, 2016), some descriptive statistics, one-way ANOVA, correlation coefficients and regression analysis were applied to illustrate the relationships, and also, to build a prediction equation/s for the future complicated indices of such breeds, from some easier body indices.

However, ANOVA proc., had the following model (Model I):

$$Y_{ij} = \mu + A_i + e_{ij}$$

Where: Y_{ij} = the observations of an index; μ = overall mean; A_i = Age of the animals (fixed factor); e_{ij} = random error.

The means differences of indices were separated using Duncan multiple range test (Duncan, 1955).

Moreover, the stepwise regression analysis was performed according to the following model (model II)

$$Y_{ijkl} = a_i + b_1 x_j + b_2 x_k + e_{ijkl}$$

Where: Y_{ijkl} = the predicted variable (Body ratio); a= Intercept (constant); b_1 & b_2 = partial regression coefficients; x_1 & x_2 are the predictors (Body and Weight 3, respectively).

RESULTS AND DISCUSSION

The means and standard errors of the studied body indices are presented in Table 1. It could be observed from Table 1, that most studied indices differed significantly ($p \le 0.05$) among the studied ages; this mean that the goat's age plays a vital role to determining such measures and indices. For proportionality index (IPr) and Width slope (WS), it could be notice that older animals resulted in smaller indices, and such findings confirm that smaller goat are wider than bigger one, where both recorded averages from (80.91-85.66) and (0.026-0.033), respectively. On the contrary, the weights at different stages (1, 2 and 3) have reverse trend of the previous index, where older animals resulted in higher weight, these findings are logical results due to fattening. The other studied characteristics were non-significant ($p>0.05$). However, some investigators found results that disagreed with the present results, the Cephalic index (IC) and proportionality index for Creole animals estimated by (63.65) and (93.19), respectively which were disagreed with the present results (Chacon et al., 2011); but the same author reported similar IB (85.29) result.

Table (1): Mean and Standard error of the studied body indices for the studied goats

		N	Mean	± Std. Error	Sig. (p)
Cephalic	1-2 year	13	53.07	1.61	N.S
	2.5-3.5 year	20	55.09	1.46	
	4-6 year	42	55.42	.82	
Body	1-2 year	13	83.52	2.24	N.S
	2.5-3.5 year	20	85.84	1.41	
	4-6 year	42	79.74	1.64	
Proportionality (IPr)	1-2 year	13	85.66 a	1.74	*
	2.5-3.5 year	20	85.54 a	1.29	
	4-6 year	42	80.91 b	.85	
Pelvic (IP)	1-2 year	13	137.97	4.90	N.S
	2.5-3.5 year	20	129.15	3.81	
	4-6 year	42	136.56	3.76	
Weight 1	1-2 year	13	123.59 b	7.13	*
	2.5-3.5 year	20	137.85 b	5.06	
	4-6 year	42	165.53 a	4.28	
Weight 3	1-2 year	13	30.16 b	.70	*
	2.5-3.5 year	20	31.88 b	.55	

	4-6 year	42	37.28 a	.73	
Weight 4	1-2 year	13	37.24 b	.89	*
	2.5-3.5 year	20	39.40 b	.70	
	4-6 year	42	46.21 a	.92	
Width slope (WS)	1-2 year	13	.032 a	.0017	*
	2.5-3.5 year	20	.033 a	.00088	
	4-6 year	42	.026 b	.0013	
Transverse pelvic (IPT)	1-2 year	13	27.03	1.24	N.S
	2.5-3.5 year	20	26.02	.46	
	4-6 year	42	24.92	.59	
Longitudinal pelvic (IPL)	1-2 year	13	73.73	2.98	N.S
	2.5-3.5 year	20	78.77	2.42	
	4-6 year	42	75.87	2.40	

One-way ANOVA was performed for the analysis
Means of each character having common letter are didn't differed significantly.
N.S= Non-significant (p>0.05); *= Significant (p≤0.05)

Table (2): The studied indices derived from studied body measurements

Index	Age	N	Mean	Std. error	Sig.
Relative body index (RBI)	1-2 year	13	110.37 b	1.92	
	2.5-3.5 year	20	114.19 ab	1.30	*
	4-6 year	42	118.19 a	1.23	
Dactyl thorax index (DTI)	1-2 year	13	.142 a	.0067	
	2.5-3.5 year	20	.126 b	.0028	*
	4-6 year	42	.122 b	.0021	
Pectoral Index (PI)	1-2 year	13	1.62 a	.047	
	2.5-3.5 year	20	1.53 b	.024	*
	4-6 year	42	1.64 a	.025	
Thoracic development (TD)	1-2 year	13	1.32 b	.033	
	2.5-3.5 year	20	1.33 b	.024	*
	4-6 year	42	1.50 a	.029	
Body ratio (BR)	1-2 year	13	.93	.010	
	2.5-3.5 year	20	.94	.010	NS
	4-6 year	42	.94	.0073	
Baron & amp; Crevat (BC)	1-2 year	13	120.21 b	4.67	
	2.5-3.5 year	20	125.13 b	3.21	*
	4-6 year	42	158.28 a	5.01	
Compact index 1 (CI1)	1-2 year	13	.0060 b	.00016	
	2.5-3.5 year	20	.0062 b	.00015	*
	4-6 year	42	.0071 a	.00014	
Compact index 2	1-2 year	13	.0061 b	.00017	
	2.5-3.5 year	20	.0064 b	.00015	*
	4-6 year	42	.0073 a	.00014	

One-way ANOVA was performed for the analysis
Means of each character having common letter are didn't differed significantly.
NS= Non-significant (p>0.05); *= Significant (p≤0.05);

Table 2, represents the studied indices. It could be noticed that all indices differed significantly ($p \leq 0.05$) among the studied ages except Body ratio (BR). Relative body index (RBI), Thoracic development (TD), Baron & Crevat (BC), Compact index 1 (CI1) and Compact index 2 are shown to be increased as animal's age increased; while Dactyl thorax index (DTI) appeared in reverse trend where the older goats resulted in smaller DTI; but Pectoral Index (PI) had no obvious trend. These results showed the importance of age for the studied indices, where some indices declined with older age, while some others had a reverse trend. These results may reflect the relationship among body regions of an animal; for goat these findings confirm that most indices are increase as the age increases. The present result is in agreement with (Getaneh et al., 2022; Chacon et al., 2011) for body ratio index; also, compact index 1 is in agreement with the findings of (Getaneh et al., 2022); while our results are disagreement with (Chacon et al., 2011) for Pectoral Index and Thoracic development. However, Body Ratio results reflect that both studied groups were lower for the withers than the rump. Also, Dactyl Thorax Index resulted in how fine the skeleton is, therefore it seems greater in meat type animal than milk one, because cannon bone circumference gave higher body size (Peña et al., 1990).

Table (3): Correlation Coefficients between the studied body indices and indices

	IB	IPR	IP	W1	W3	W4	WS	IPT	IPL
Ic	.220	.138	-.132	.349**	.035	.035	.028	.273*	.185
IB	1	.510**	-.520**	.094	-.710**	-.710**	.547**	.321**	.515**
IPR		1	-.478**	-.255*	-.476**	-.476**	.520**	-.055	.462**
IP			1	.068	.308**	.308**	-.787**	.211	-.977**
W1				1	.472**	.472**	-.523**	.165	-.028
W3					1	1.00**	-.597**	-.407**	-.257*
W4						1	-.597**	-.407**	-.257*
WS							1	-.096	.777**
IPT								1	-.258*

IC = cephalic; IB = body; IPR = proportionality; IP = pelvic; W1 = weight 1; W3 = weight 3; W4 = weight 4; WS = width slope; IPT = transverse pelvic; IPL= longitudinal pelvic.
*= Significant ($p \leq 0.05$), ** = Significant ($p \leq 0.01$)

Table 3, presents the correlation coefficients between the studied parameters. It could be observed that most coefficients were highly significant ($p \leq 0.01$). It is correlated positively and significantly with both W1 and IPT (0.35 and 0.27, respectively), these mean that when the cephalic index increases both previous indices are increased, due to common measures. Also, IB is correlated significantly ($p \leq 0.01$) and positively with IPR, WS, IPT and IPL, but it associated negatively with IP, W3 and W4; these may reflect the positive relationship between body index with positive coefficients because the body weight trait is included in all positive indices; on contrary, body index that even related with negative coefficients included body weight trait as nominator. Regarding IPR it correlated significantly ($p \leq 0.01$) and positively with IB, WS and IPL; while it associated negatively with IP, W1, W3, W4 and IPT; the highest coefficient was recorded for both W3 and W4 (-0.71). However, the positive or negative coefficient for the same character with different indices is dependent on whether the body weight or body length is representing a nominator or dominator. Also, IP associated significantly and positively with both W3 and W4; while it correlated negatively and significantly ($p \leq 0.01$) with WS and IPL, and this last correlation represents the highest negative coefficient (- 0.98) as shown in Table 3. As it expected W1 is correlated significantly ($p \leq 0.01$) and positively with both W3 and W4, while it is associated significantly and negatively with WS (-0.52). Moreover, both W3 and W4 recorded the same coefficients as all other indices, this because the correlation coefficient between both of them is maximized (1.0) as shown in Table 3. WS is correlated positively and significantly ($p \leq 0.01$) with IPL (0.78). Finally, both IPL and IPT is correlated significantly ($p \leq 0.05$) and negatively (-0.26).

Similar to these results, IB with Ic association was insignificant ($p > 0.05$) as reported by (Putra and Ilham, 2019); and also, the findings indicated by (Getaneh et al., 2022) were similar to the present results for IPT, IPL and WS associations.

Table (4): Correlation Coefficients between some studied body indices

	RBI	DTI	PI	TD	BR	BC	CI1	CI2
RBI	1	-.178	-.112	.395**	-.040	.358**	.501**	.502**
DTI		1	-.102	-.566**	.167	-.595**	-.420**	-.421**
PI			1	.491**	-.339**	.475**	.356**	.357**
TD				1	-.388**	.969**	.732**	.735**
BR					1	-.282*	-.222	-.225
BC						1	.767**	.768**
CI1							1	1.000**

Relative body index= (RBI); Dactyl thorax index= (DTI); Pectoral Index = (PI); Thoracic development =(TD); Body ratio= (BR); Baron & Crevat = (BC); Compact index 1 =(CI1); Compact index 2=(CI2).
*= Significant (p≤0.05), ** = Significant (p≤0.01)

Table 4, shows the correlation coefficients between some body measurements and indices. It could be observed that most coefficients were highly significant (p≤0.01). For RBI it obviously shown its association positively and significantly (p≤0.01) with TD, BC, CI1 and CI2; these because body weight is a main variable included in all mentioned incises. On contrary, the negative significant coefficients are founded for DTI with the same previous mentioned measurements/indices; while PI correlated positively and significantly (p≤0.01) with all mentioned measures/indices except BR (-0.34); the same trend of previous index was found for TD with the mentioned measures. For BR and BC, the association is significant (p≤0.05) and negative (-0.28); while BC correlated positively and significantly (p≤0.01) with both CI1 and CI2, those two coefficients considered the highest values and are almost the same value (0.77). However, the present results disagreed with most findings reported by (Chacon et al., 2011), but it is in agreement for the relationship between BC and both CI1 and CI2 (0.98). Also, the relationship between DTI and TD in the present study is in agreement with the finding reported by (Putra and Ilham, 2019).

Table (5): The stepwise analysis of multiple regression for Body ratio (BR) from the Body and Weight 3

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	
		B	Std. Error	Beta			R2
1	(Constant)	.786	.042		18.713	.000	0.158
	Body	.002	.001	.397	3.700	.000	
2	(Constant)	.592	.097		6.111	.000	0.212
	Body	.003	.001	.631	4.244	.000	
	Weight 3	.003	.001	.329	2.212	.030	

a. Dependent Variable: Body ratio (BR)

However, it could be predicted by Body ratio (BR) via the following two equations:
Expected Body ratio (BR) = 0.786 + 0.002 * (Body) …………………………………...………..Model 1
Expected Body ratio (BR) = 0.592 + 0.003 * (Body) + 0.003 * (Weight 3) ……………………..Model 2

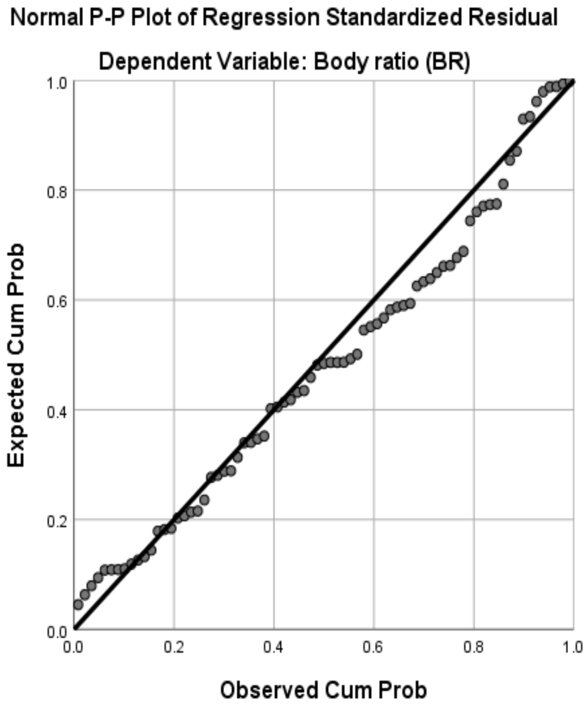

Fig. (2): The residual fitting curve of better model (Model 2)

Table 5, presents the partial regression coefficients of the analysis of stepwise regression. The resulted significant (p≤0.01) models illustrating two models; the first one is depending of Body ratio (BR) on body with the intercept (constant), which has relatively low coefficient of variation (R^2 = 0.158), where the regression coefficient estimated as 0.002, that indicates the presence of other factors affecting the model but non studied here. Another model is that predicted with BR from both body and weight 3 characters, which resulted in the same regression coefficient estimate (0.003), with higher R^2 (0.21) than previous model; but in spite of significant model, the coefficient of variation still relatively low, which indicate the presence of other factors affecting the model. However, Figure 2, illustrating the standardized residual values around the predicted slope line, which are very close without extreme values. However, the present results disagreed with the findings reported by (Hassen et al., 2012; Putra and Ilham, 2019; Ofori et al., 2021), where their findings recorded higher R^2 for similar predictions. Moreover, the present low R^2 results may be attributed to the wide variations among the studied animals due to their different ages which reflect the same variations related body weight and body indices.

CONCLUSION

The present study concluded that the local goats of Kurdistan Region (Duhok governorate) have special characteristics regarding body measurements that related with certain ages. Where opposite to body weight the most body indices (that taken from body measurement) were decreased when the age increased.

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