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Body Measurements Reflect Body Weights and Carcass Yields in Karayaka Sheep

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Abstract: This study was designed to estimate body weight from various body measurements in Karayaka sheep reared under rural extensive production systems. Animals were brought from different regions to slaughterhouse. Approximately 8 to 18 months-aged of Karayaka male (n = 67) and female (n = 55) sheep were used to investigate the relationships between bodyweights and body measurements such as Heart Girth (HG), Wither Height (WH), Chest Depth (CD), Chest Width (CW), Body Length (BL), Rump Height (RH), Thigh Circumference (TC) and Canon Circumference (CC). The R^2 values between body weight and body measurements ranged from 0.130 to 0.773. The highest R^2 values were found between body weight and chest depth (0.814, $p<0.001$) and between heart girth (0.792, $p<0.001$) for male and female, respectively. Correlation and regression analysis were applied to estimate the relationship among these traits. Therefore, it was concluded that body weight could be estimated by using a general equation from pooled data of Y = -25.8+2.10 CD; R^2 = 0.773 regardless of gender. Also, there were higher correlations (R^2 = 0.954) between body weight and both hot and cold carcass weight.

Key words: Karayaka, sheep, liveweight estimation, body measurement, hot carcass

INTRODUCTION

Body measurements and live weights taken on live animals have been used extensively for a variety of reasons both in experimental work and in selection practices (Lawrence and Fowler, 2002; Cam *et al*., 2010). The accuracy of functions used to predict liveweight or growth characteristics from live animal measurements is of immense financial contribution to livestock production enterprise (Afolayan *et al*., 2006). Especially in extensive production systems knowing an animal live weight are very important both in market and breeding aspects. Sheep production is the most widespread form of extensive animal husbandry systems in Turkey. And under these farmer conditions weight determination is a major concern for sheep breeder and buyers in the market perspective. On the other hand, sheep breeders maintain flock size as sold their aged animals and outer-breed young male and female lambs. In this purchase process a merchant determines animal price roughly and this is disadvantageous to breeders, because breeders do not know what their animals' actual weight and value.

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Animals have a balanced relationship between body weights and body measurements. From this standpoint, liveweight is determined to the nearest kilogram (kg). and thereafter it could be evaluated for selling. On the other hand, productivity in livestock industry can be determined by using some phenotypic measurements. Using body measurements can be useful in defining performance in many cases. In literature, there are reports showing relationships between body measurements and performance traits (Riva *et al*., 2004; Janssens *et al*., 2004; Janssens and Vandepitte, 2004; Atta and El Khidir, 2004; Afolayan *et al*., 2006).

As it is seen the above mentioned literature, there are many studies about morphometric body measurement and body weight estimation from body measurements in different sheep breeds all over the world, but to the extent we know, there have not been any work about Karayaka sheep breed. Therefore, the present study was conducted both to determine morphometric measurements and to examine for breeders and buyers a simple way of determining live weight using the morphometrics variables such as Heart Girth (HG), Chest Depth (CD), Chest Width (CW), Withers Height (WH), Rump Height (RH), Body Length (BL), Thigh Circumstances (TC) and Canon (Shin) Circumstances (CC) of male and female Karayaka sheep. And also our purpose is a general and simple solution to offer making decisions both breeder and buyer to the nearest bodyweight prediction in Karayaka sheep.

MATERIALS AND METHODS

Karayaka sheep were brought to Samsun slaughterhouse from different Districts in Middle Black Sea region in Turkey in October 1997. A total of 122 ewes were selected for data collection comparing a random sample of 67 males and 55 females from 8 (2-4 tooth, N = 61) to 18 (6-8 tooth, N = 61) months aged. A total of 122 ewes were selected for data collection comparing a random sample of 67 males and 55 females from 8 (2-4 tooth, N = 61) to 18 (6-8 tooth, N = 61) months aged. All ewes were ear-tagged and weighed. The body measurements mentioned below were taken pre-slaughter after exposed to 8 h fasting by using a tape; included the following traits; Heart Girth (HG): the body circumference immediately posterior to the front leg (cm), Chest Depth (CD): behind the shoulder (cm), Chest Width (CW): between the shoulder blades (cm), Withers Height (WH): the vertical distance from the top of the scapula to the ground (cm), Rump Height (RH): the vertical distance from the top of the pelvic girdle to the ground (cm), Body Length (BL): the distance between the point of the shoulder corresponding to the outer and central tuberosity of the left humerus to the left tuber ischii (cm), Thigh Circumstances (TC): girth from the posterior extremity of the pin bone to the top of the pin bone (cm) and Canon Circumstances (CC) of the front leg: the finest of metacarpus. All linear measurements were obtained with specially designed calipers.

After cutting 33 male and 33 female animal's tag numbers were written on carcass and post slaughter data were obtained. Hot carcasses were weighed and then chilled at -4°C. Head, four legs, hide and internal organ (heart, liver and lung) weights were also recorded.

Descriptive statistics and regression analysis of all data were carried out using General Linear Model (GLM) and correlation procedures in SPSS software (SPSS, 1999). As there were no significant differences among age's groups so data were pooled. Simple and stepwise multiple regression analysis were fitted to calculate the prediction equations of body weight from body measurement variables as reported by Heinrichs *et al*. (2007). Separate and pooled prediction equations were developed for male and female sheep. The comparison of actual body weight with prediction body weight was made by paired t test.

RESULTS

Significant differences were found between male and female sheep with regards to pre-slaughter weights and rump height ($p<0.05$) and chest depth, wither height and canon circumferences ($p<0.01$, Table 1). The highest variation coefficients were found for body weight, chest width and chest depth. For the morphological viewing it was found that rump height is 2.2 and 2.5 cm higher for males and for females, respectively, than wither height in Karayaka breed.

Body weight and other body measurements (CD, HG, RH, WH) have positive and the highest correlations ($p<0.001$) except canon circumstances for females (Table 2). Also, positive and the highest correlations were found between body measurements ($p<0.001$).

Table 1: Descriptive values for male (n = 67) and female (n = 55) sheep are shown related to liveweight and linear and circumferences body measurement

	Mean±SEM				
Measurement	Male (M)	Female (F)	Overall (O)	CV (%)	p-value*
Body weight (BW, kg)	27.5±0.83	25.0±0.72	26.4±0.57	23.80	0.05
Wither height (WH, cm)	53.5±0.50	51.4±0.47	52.6±0.36	7.49	0.01
Chest depth (CD, cm)	25.5±0.35	24.3±0.29	24.9±0.24	10.57	0.01
Chest width (CW, cm)	18.5±0.29	18.9±0.31	18.7±0.21	12.47	NS
Body length (BL, cm)	52.3±0.61	50.9±0.61	51.7±0.45	9.71	NS
Rump height (RH, cm)	55.7±0.51	53.9±0.52	54.9±0.38	7.56	0.05
Hearth girth (HG, cm)	75.0±0.80	74.1±0.87	74.6±0.59	8.74	NS
Thigh circumstances (TC, cm)	74.5±0.84	72.8±0.70	73.7±0.56	8.44	NS
Canon circumstances (CC, cm)	10.6±0.10	10.1±0.08	10.4±0.07	7.67	0.01

CV: Coefficient of variation, *There were significant differences means between male and female, NS: Non significant at p>0.05

Table 2: The correlations amongst different body measurements in Karayaka male and female sheep

Variables	Sex	BW	WH	HG	CD	CW	BL	TC	RH
WH	M	0.808**							
	F	0.812**							
	O	0.817**							
HG	M	0.835**	0.630**						
	F	0.890**	0.717**						
	O	0.846**	0.658**						
CD	M	0.902**	0.777**	0.814**					
	F	0.817**	0.697**	0.719**					
	O	0.879**	0.763**	0.766**					
CW	M	0.828**	0.638**	0.718**	0.777**				
	F	0.580**	0.533**	0.538**	0.455**				
	O	0.701**	0.556**	0.631**	0.619**				
BL	M	0.784**	0.737**	0.729**	0.709**	0.664**			
	F	0.806**	0.722**	0.681**	0.666**	0.601**			
	O	0.791**	0.732**	0.709**	0.693**	0.619**			
TC	M	0.344**	0.336**	0.268*	0.322**	0.363**	0.289*		
	F	0.343*	0.367**	0.341*	0.260ns	0.054ns	0.271*		
	O	0.361**	0.367**	0.299**	0.323**	0.234**	0.293**		
RH	M	0.852**	0.894**	0.690**	0.804**	0.691**	0.734**	0.406**	
	F	0.804**	0.927**	0.694**	0.719**	0.542**	0.569**	0.396**	
	O	0.838**	0.910**	0.689**	0,775**	0.597**	0.750**	0.417**	
CC	M	0.571**	0.479**	0.463**	0.428**	0.486**	0.501**	0.350**	0.478**
	F	0.258ns	0.214ns	0.190ns	0.266*	0.163ns	0.131ns	0.104ns	0.191ns
	O	0.497**	0.440**	0.360**	0.421**	0.313**	0.376**	0.300**	0.415**

BW: Body weight, WH: Wither height, BL: Body length, CD: Chest depth, RH: Rump height, HG: Heart girth, CW: Chest width, TC: Thigh circumference, CC: Canon circumference. Correlations are significant at the *p<0.05, **p<0.001 and Ns: Non significant at p>0.05 levels

The regression equations of Karayaka male and female sheep were calculated to predict body weight from body measurements in reference to male and female and mixed sex (shown in Table 3) lead us to prediction a good application of the simple formulations for the body weight. The R^2 values from the regressions show that chest depth in the male and heart girth in the female and the regressions from the general pooled data chest depth to be most highly related to body weight.

Concordantly obtained body weight using the first simple equations for each gender and mix (female + male, Table 4) compared the reel body weight and shown nearest value and there was no significant between them.

Also, stepwise regression analysis was used to obtain best prediction equations for body weight from body measurement variables (Table 5) and the presented regression equations (Table 5) were obtained.

The result of stepwise regression analysis indicated that other measurements related to the chest depth would result in significantly improvement in accuracy of prediction in overall assessment even though the extra gain was small as seen in R^2 change.

Table 3: The simple regression equations to predict body weight from body measurement

Males	Females	Overall
BW = -27.0+2.14 CD, R^2=0.814**	BW = -29.3+0.73 HG, R^2=0.792**	BW = -25.8+2.10 CD, R^2=0.773**
BW = -49.2+1.38 RH, R^2=0.725**	BW = -23.5+2.00 CD, R^2=0.667**	BW = -34.5+0.82 HG, R^2=0.716**
BW = -37.4+0.86 HG, R^2=0.697**	BW = -39.6+1.26 WH, R^2=0.660**	BW = -43.3+1.27 RH, R^2=0.703**
BW = -16.4+2.37 CW, R^2=0.685**	BW = -18.6+0.86 BL, R^2=0.649**	BW = -42.1+1.30 WH, R^2=0.668**
BW = -44.3+1.34 WH, R^2=0.654**	BW = -34.5+1.11 RH, R^2=0.647**	BW = -24.8+0.99 BL, R^2=0.626**
BW = -28.8+1.08 BL, R^2=0.615**	BW = -0.56+1.36 CW, R^2=0.336**	BW = -8.9+1.89 CW, R^2=0.491**
BW = -22.7+4.73 CC, R^2=0.326**	BW = -0.71+0.35 TC, R^2=0.117*	BW = -14.3+3.92 CC, R^2=0.247**
BW = +2.23+0.34 TC, R^2=0.119**	BW = 3.49+2.14 CC, R^2=0.067^{NS}	BW = -0.49+0.36 TC, R^2=0.130**

BW: Body weight, WH: Wither height, BL: Body length, CD: Chest depth, RH: Rump height, HG: Heart girth, CW: Chest width, TC: Thigh circumference, CC: Canon circumference, *p<0.05; **p<0.0001; ^{NS}p>0.05

Table 4: Body weights from reel and calculated from simple equations related to sex and mix data

Sex	Body weight from measurments	Body weight from simple regression equations (BW=-27.0+2.14 CD for male and BW=-29.3+0.73 HG for female)	Body weight from simple regression equations (BW=-25.8+2.10 CD for both male and female)
M	27.48±0.83	27.46±0.75	27.05±0.74
F	25.04±0.72	24.78±0.66	25.09±0.61
O	26.38±0.57	26.41±0.50	26.25±0.51

Table 5: Multiple regression analysis of live weight on chest depth, hearth girth and other variables

Variables	Intercept	B1	B2	B3	B4	B5	B6	R^2	R^2 change
Males									
CD	-27.02	2.14	–	–	–	–	–	0.814	0.000
CD+RH	-41.87	1.46	0.58	–	–	–	–	0.859	+0.045
CD+RH+CW	-41.39	1.06	0.50	0.77	–	–	–	0.887	+0.028
CD+RH+CW+CC	-48.05	1.09	0.42	0.63	1.18	–	–	0.901	+0.015
CD+RH+CW+CC+HG	-50.61	0.83	0.42	0.55	1.02	0.19	–	0.911	+0.010
Females									
HG	-29.3	0.73	–	–	–	–	–	0.792	0.000
HG+RH	-33.89	0.52	0.40	–	–	–	–	0.869	+0.078
HG+RH+CD	-36.85	0.42	0.30	0.64	–	–	–	0.895	+0.027
HG+RH+CD+BL	-41.46	0.37	0.24	0.54	0.26	–	–	0.905	+0.010
Overall									
CD	-25.83	2.10	–	–	–	–	–	0.773	0.000
CD+HG	-36.86	1.33	0.40	–	–	–	–	0.845	+0.072
CD+HG+RH	-46.50	0.89	0.34	0.47	–	–	–	0.881	+0.037
CD+HG+RH+CC	-51.65	0.83	0.33	0.44	0.85	–	–	0.891	+0.009
CD+HG+RH+CC+CW	-51.13	0.78	0.29	0.40	0.82	0.32	–	0.898	+0.008
CD+HG+RH+CC+CW+BL	-50.77	0.76	0.26	0.33	0.79	0.27	0.15	0.903	+0.005

CD: Chest depth, RH: Rump height, CW: Chest width, CC: Canon circumference, HG: Heart girth, BL: Body length

There were no significant differences in respect to live body weight (27.3±1.37 kg vs. 25.8±1.22 kg), hot carcass (13.75±0.75 kg vs. 12.70±0.67 kg) and cold carcass (13.57±0.76 kg vs. 12.49±0.68 kg) yields between male and female sheep in randomly selected for post-slaughter assessments. With respect to head (2.40±0.03 kg vs. 1.74±0.08kg, $p<0.01$), four legs (0.81±0.02 kg vs. 0.75±0.02 kg, $p<0.05$), hide (3.81±0.18 kg vs. 3.29±0.12 kg, $p<0.05$) and inner edible organs (1.48±0.13 kg vs. 1.24±0.07 kg, $p>0.01$) males have higher weights than those of female. Also, it was found positive and significant correlations ($p<0.001$) between live weight and both hot or cold carcass weight.

DISCUSSION

Body weight is a very important characteristic in animal husbandry due to selection criteria and economical profit. Live weight might be affected by different management, environment and enterprise feeding conditions. In this study, gender and farm condition might be contributed to live weight and body measurement differences between male and female. Also, it is accepted that males have heavier live weights than female due to their natural hormonal status in most animal species. Simply these variations in this study can be attributed enterprise to farm conditions such as altitude of the pasturelands, quality, quantity and availability of grazing feed and health care (Riva *et al*., 2004). When we compared the mentioned measurements in present study to results of Olfaz *et al*. (2005) for yearling Karayaka sheep were seen lower.

The highest variation coefficients were found for body weight, chest width and chest depth. Of body weight of these variables is influenced both genetically and environmental factors such as age, sex, feeding and care etc. It is generally known that fattening can affect and change both body weight and body measurements, but these changes at body weight and body measurements could not affect heavily correlations or balances between animal's body parts. However, the relationships and balance of animals' body parts is more stable and reflects breed characteristics when they grow under nearer management conditions (Afolayan *et al*., 2006). Salako (2006) reported that various body measurements and calculated indices from body measurements are important indicators of breed characteristics and production type of animals. In these sense, when compared the rump height and wither height it is seen that rump height is higher 2 cm higher than wither height. There is an advantage of Karayaka sheep due to its raising conditions and its breed characteristics. This finding is in accord with the results of Olfaz *et al*. (2005).

The correlation is one of the most common and most useful statistics that describes the degree of relationship between two variables. We attempted to predict accuracy body weight from body measurements by making use of this characteristic of correlations. The accuracy estimation of live weight from live animal's simple body measurements is making a fortune for rural livestock enterprises especially without cooperate characteristics. Due to profitable aims a producer can measure all the body measurements easily from a live animal and can determine body weight approximately. Sarti *et al*. (2003), Janssens and Vandepitte (2004), Riva *et al*. (2004), Afolayan *et al*. (2006), Salako (2006) and Çankaya *et al*. (2009) reported similar results between body weight and body measurements. In this study the highest correlations were found between body weights and wither height, heart girth and chest depth and wither height and rump height, while the lowest correlations were found between thigh circumferences or canon circumferences and others. Generally looking at the correlations between males and females sheep showed different values in the same body measurement and in females' canon circumference was a lower tendency relationship than that of males.

According to the correlation modules, live weight was found very highly ($p<0.001$) correlated with body dimensional traits (0.36-0.88). Of the body dimensional characters, chest depth was the most related trait to weight and the correlation between these two traits was 0.88. Variables such as wither height, heart girth, rump height, body length, which are directly related to the size and weight of animal, showed moderate to very high positive correlations with each other (0.70-0.84). However, the measure of thigh circumference and canon circumference was lower correlated (0.29-0.50) in mixed appraisal. Similarly, low and sometimes non-significant correlations were obtained for the body dimensional traits in females (0.05-0.27) especially for the thigh and canon circumferences. This result is accordance with findings of Janssens and Vandepitte (2004).

Smaller data sets often show equally high correlation coefficients between body weight and heart girth when narrow ranges of animal age are used (Heinrichs *et al*., 1992). From this point of view it could be said that similarly in narrow data sets in sheep and various enterprise conditions might be varied correlation coefficients amongst body measurements and sex. In most studies heart girth was found to be highly correlated with body weight in sheep (Topal and Macit, 2004; Atta and Khidir, 2004; Afolayan *et al*., 2006), in cattle (Heinrichs *et al*., 1992, 2007; Koenen and Groen, 1997; Goe *et al*., 2001) and in goat (Khan *et al*., 2006; Nsoso *et al*., 2003). The difference between our study and the mentioned literatures can be attributed to the differences among rearing conditions.

Fattening status should be taken into consideration in order to predict an animal's bodyweight from its body measurements. The predictions of live body weight from the measurement of wither height, rump height and body length is unplausible. Because these measurements do not reflect an animal's fattening status, they combined with the measurements such as heart girth, chest depth and chest widths that vary according to an animal's fattening condition. As mentioned by Lawrence and Fowler (2002) hearth girth which is affected by fattening status exhibits the highest correlation with body weight. Notwithstanding, Heinrichs *et al*. (1992) suggested that some body measurements such as wither height and hip width may be best skeletal parameters to measure in certain instants because they are not influenced by body condition. Hence, we thought that fattening performance would not change the relationships and balance between body parts under the acceptable ranges.

No matter what in this study results suggest that variables with high correlation coefficients might be used to predict body weight. Also, the highest relationships amongst body measurement may be used as selection criteria (Khan *et al*., 2006) in traditional production systems in rural conditions. And it is necessary to develop new selection indices on body parts such as balance indices and shape indices for Karayaka sheep breed in detailed studies.

The regression equations lead us to prediction a good application of the simple formulations for the body weight (Table 3). All the body traits except for thigh and canon circumferences could be used to predict body weight accurately.

Generally buyers purchase animals from producers who live in rural conditions and without reel value availing oneself of this opportunity. Afolayan *et al*. (2006), Riva *et al*. (2004), Topal and Macit (2004) and Heinrichs *et al*. (1992, 2007) used heart girth because heart girth exhibited the highest correlation to the body weight; unlike it does not in our study for the male and pooled data.

Heart height, rump height and body length are not affected by animal condition (Heinrichs *et al*., 1992; Olfaz *et al*., 2005) and fattening status (condition score) reflects body lipid content more than body weight (Nsoso *et al*., 2003). On the other hand, Janssens and

Vandepitte (2004) reported that fattening status was an important explanatory variable their analysis. Considering these comments, even though under rural conditions animals suffer to different breeding and management systems, various body measurements could be used to estimate body weight more accurately. Most of studies about body weight prediction from body measurements indicated that hearth girth to be highly correlated with body weight, but in this study body weight prediction from male and pooled data were found to have higher correlations with chest depth. Chest depth, chest width and hearth girth might be little affected by animal conditions compared to body weight. On the other hand the body measurements vary from age, sex and also seasons in related to feeding status (Janssens and Vandepitte, 2004) in adults and due to these factors correlations between variations could be varied. Hence, the effectiveness of the body parts in body weight prediction could be changed.

The estimation of body weight from body measurements reflects carcass yield because there were higher relationships between body weight and hot carcass (Y = -1.329+ 0.545 BW) and cold carcass (Y = -1.113+0.540 BW) and the R^2 is 0.954. These findings are in accord with those of Çankaya *et al*. (2009).

CONCLUSION

Consequently, it could be said that there were a balance and correlations between an animal's body parts. Using these correlations body weight can be calculated or estimated from body measurements more accurately. The body weight estimations come nearer real body weights if animals grow under the same breed, age, sex, feeding and care conditions. It could be said that the best chest depth and then heart girth measurements are the best measurements to predict body weight in Karayaka sheep breed .

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