Correlation between live weight and body measurements in certain dog breeds

B. Yüceer Özkul[1#], P.C.K. Doka[2], D. Özen[3], F.T. Özbaşer[4], B. Özarslan[5] & F. Atasoy[1]

[1]Ankara University, Faculty of Veterinary Medicine, Department of Animal Husbandry, Ankara, Turkey
[2]AKD, Kids, Ankara, Turkey
[3]Ankara University, Faculty of Veterinary Medicine, Department of Biostatistics, Ankara, Turkey
[4]Namık Kemal University, Faculty of Veterinary Medicine, Department of Animal Husbandry, Tekirdağ, Turkey
[5]Kırıkkale University, Faculty of Veterinary Medicine, Department of Animal Husbandry, Kırıkkale, Turkey

Abstract

The purpose of this study was to determine the correlation between live weight and body measurements in Zağar, Zerdava, and Çatalburun dogs. Animal materials were obtained from various regions of Turkey. A total of 304 dogs from three breeds were used: Zağar (45 females, 59 males), Zerdava (50 females, 50 males), and Çatalburun (62 females, 38 males). Live weights and certain body measurements were determined. A linear regression model was created using the parameters obtained in this study. The bodyweights calculated with the body measurements were found to be at a high or acceptable level in the Zağar, Zerdava, and Çatalburun genotypes (R^2 = 0.902, 0.467, and 0.697, respectively).

Introduction

Turkey is rich in animal genetic resources. As a result of the various geographical structures and the large surface area there are many genetic types of dog in Turkey. They have been bred to maintain breed purity in Anatolia for centuries and are adapted to the conditions of the region. Most of these dogs are used to herd sheep or to hunt. The Zağar, Zerdava, and Çatalburun breeds are hunting dogs (Atasoy, 2009). Zağar dogs (Figure 1A) are raised mainly in the mountainous regions of Turkey, where a nomadic culture is dominant, and are used for rabbit hunting in particular. Zerdava dogs (Figure 1B) are bred in Trabzon and other parts of the Black Sea region. This dog is the only Turkish native breed with upright ears, and is used primarily as a guard dog and for boar hunting (Atasoy, 2009). Çatalburun dogs (Figure 1C) are bred in Mersin. In addition to being preferred as hunting dogs, they have recently been used to detect narcotics (Atasoy, 2009; Petek & Dinçel, 2012).

The bodyweights of dogs influence their usefulness for breeding, racing and as watch dogs. Çelik & Yilmaz (2018) found withers height, abdominal width, rump height and chest depth were predictive of the bodyweight of Turkish Tazi dogs. Thus, the aim of this study was to develop equations that could be used to predict the bodyweight of Zağar, Zerdava, and Çatalburun dogs, using linear measures of the dimensions of their bodies.

Figure 1 Examples of the Zağar Zerdava, and Çatalburun breeds

Materials and Methods

This study was carried out after obtaining ethical approval (No. 2013-18-135; dated 23/10/2013) from Ankara University Animal Experiments Local Ethics Board. The data originated from Zağar (n = 104; 45 females, 59 males), Zerdava (n = 100; 50 females, 50 males), and Çatalburun (n = 100; 62 females, 38 males) dogs that were at least 12 months old and bred in various regions of Turkey. Data were obtained from Project No: 115 0 613, supported by The Scientific and Technological Research Council of Turkey. The dogs were weighed on a scale with 100 g precision. Withers height, rump height, body length, chest width, and chest depth were measured with a ruler. Chest circumference, front and hind cannon bone circumference, head, face, ear, and tail length, ear width, ears and eyes interval, mouth circumference and tail width were measured with a measuring tape (Spira, 1991; Tepeli & Çetin, 2000; Tepeli & Çetin, 2003).

Stata 14 (StataCorp, LLC, College Station, Texas, USA) was used for the statistical analyses. Pearson correlation coefficients were calculated to determine the strength and direction of the relationship between pairs of variables. Backward stepwise multiple linear regression was used to estimate live weights of the dogs from the measurements that describe each of the breeds. Tolerance and the variance inflation factor were used to assess collinearity among the predictor variables. Variables entered the model with probability P =0.05 and exited at probability P =0.10. Durbin-Watson statistics were used to examine the presence of autocorrelation.

Results and Discussion

The dogs that provided the data used in this study were described by their weight, age and 17 linear measures (Table 1). A portion of these data were reported in Özbaşer *et al.* (2020) and have been provided here to describe the origins of the data used in this study more completely.

The estimated correlation coefficients between the body measurements of Zağar, Zerdava, and Çatalburun dogs are shown in Appendix Tables 1, 2 and 3. There have been no previous scientific studies of the relationships between bodyweight and dimensions using samples of these breeds of dog. The correlations among the body dimensions and with weight were generally positive and significantly greater than zero. For all three breeds, the relatively large and highly significant correlations among the body dimensions led to the anticipation of potential issues with collinearity among the independent variables that were to be used in developing the prediction equations. For the Zağar dogs, the correlations of most of the body dimensions with age were not significantly different from zero, indicating that these dogs were essentially full grown when the data were recorded. However, many of the correlations between body dimensions and age were significant for the Zerdava and Çatalburun dogs, which may still have been growing when the data were recorded. This observation is consistent with the difference in the average age of the dogs from which data were recorded.

For the Zağar dogs, the regression analysis resulted in a prediction equation for bodyweight that was based on five independent variables (Table 2). It was concluded that live weight could be adequately predicted from body length, chest width, chest circumference, behind cannon bone circumference, and ears interval. This equation explained 90.2% of the total variance in the live weight. The tolerance statistics and variance inflation factors for this final model suggest there was not a problem with multi-collinearity.

Table 1 Estimates of the mean and standard deviation describing Zağar, Zerdava, and Çatalburun dogs that were used in this study

Measurement	Zağar dogs		Zerdava dogs		Çatalburun dogs	
	Mean	SD	Mean	SD	Mean	SD
Bodyweight, kg	18.24	3.83	15.96	3.64	19.9	4.09
Age, years	3.12	1.02	2.08	1.62	2.12	1.76
Withers height, cm	50.51	4.03	48.07	2.54	47.8	3.65
Rump height, cm	50.28	4.05	47.11	2.86	48.68	3.51
Body length, cm	56.42	3.97	52.28	3.16	53.80	3.34
Chest width, cm	17.78	1.68	17.56	1.83	19.24	1.9
Chest depth, cm	21.01	2.05	20.36	1.56	22.21	1.7
Chest circumference, cm	58.11	4.89	53.35	3.94	59.07	4.26
Circumference front cannon bone, cm	9.83	0.86	9.04	0.58	9.18	0.75
Circumference hind cannon bone, cm	8.97	0.85	8.54	0.64	8.51	0.58
Head length, cm	23.58	1.50	20.97	1.06	19.87	1.71
Face length, cm	9.67	0.85	8.48	0.56	7.25	0.83
Ear length, cm	14.26	1.30	10.03	0.76	14.7	1.69
Ear width, cm	10.96	1.17	8.73	0.63	11.68	0.85
Distance between ears, cm	13.39	1.26	10.80	1.58	13.68	1.04
Distance between eyes, cm	4.52	0.60	4.55	1.56	4.90	0.37
Mouth circumference, cm	20.75	2.01	18.13	1.19	18.91	1.44
Tail length, cm	35.43	3.48	28.97	2.96		
Tail width, cm			6.88	2.77		

Table 2 Final regression model to predict bodyweight in Zağar dogs from their body dimensions

Independent variable	b ± SE	*P*-value	Bounds of 95% CI	Tolerance	VIF
Intercept	-30.446 ± 1.879	<0.001	-34.175<b<-26.716		
Body length	0.148 ± 0.048	0.002	0.054<b<0.243	0.409	2.443
Chest width	0.285 ± 0.126	0.026	0.035<b<0.534	0.330	3.032
Chest circumference	0.432 ± 0.047	<0.001	0.338<b<0.526	0.273	3.660
Hind cannon bone circumference	0.821 ± 0.246	0.001	0.333<b<1.308	0.335	2.984
Ear interval	0.208 ± 0.110	0.062	-0.010<b<0.427	0.766	1.306

b: regression coefficient, CI: confidence interval, VIF: variance inflation factor

Descriptive statistics that characterize the distribution of predicted live weight of Zağar dogs in comparison with their observed live weights are presented in Table 3. As expected, the means of the predicted and observed values were identical. The distribution of the predicted values was trimmed only slightly compared with the observed values.

Table 3 Correspondence of observed and predicted live weights of Zağar dogs

	Arithmetic mean	SE	Standard deviation	Median	Minimum	Maximum
Observed live weight	18.24	0.38	3.83	17.85	9.80	28.00
Predicted live weight	18.24	0.36	3.64	17.91	9.86	26.85

For the Zerdava dogs, the regression analysis resulted in a prediction equation for bodyweight that was based on four independent variables (Table 4). It was concluded that live weight could be predicted from wither height, chest width, chest circumference, and head length. This equation explained 47.5% of the total variance in the live weight. The tolerance statistics and variance inflation factors for this final model suggest there was not a problem with multi-collinearity.

Table 4 Final regression model to predict body weight in Zerdava dogs from their body dimensions

Independent variable	b ± SE	*P*-value	Bounds of 95% CI	Tolerance	VIF
Intercept	-33.219 ± 6.182	<0.001	-45.495<b<-20.943		
Wither height	0.304 ± 0.141	0.034	0.023<b<0.584	0.577	1.733
Chest width	0.547 ± 0.165	0.001	0.219<b<0.875	0.821	1.219
Chest circumference	0.251 ± 0.093	0.008	0.066<b<0.435	0.563	1.775
Head length	0.554 ± 0.334	0.090	-0.109<b<1.217	0.611	1.636

Descriptive statistics characterizing the distribution of predicted live weight of Zerdava dogs in comparison with their observed live weights are presented in Table 5. As expected, the means of the predicted and observed values were identical, as they were for the Zağar. However, as indicated by the lower R^2 value for this equation, the predicted variables were substantially less variable than the observations and this was particularly notable for the heavier dogs.

Table 5 Correspondence of observed and predicted live weights of Zerdava dogs

	Arithmetic mean	SE	Standard deviation	Median	Minimum	Maximum
Observed live weight	15.96	0.36	3.64	15.00	10.00	29.50
Predicted live weight	15.96	0.25	2.51	16.01	11.16	24.32

For the Çatalburun dogs, the regression analysis resulted in a prediction equation for bodyweight that was based on three independent variables (Table 6). It was concluded that live weight could be predicted from withers height, body length, and chest circumference. This equation explained 69.7% of the total variance in the live weight. The tolerance statistics and variance inflation factors for this final model suggested there was not a problem with multi-collinearity.

Table 6 Final regression model to predict bodyweight in Çatalburun dogs from their body dimensions

Independent variable	b ± SE	*P*-value	Bounds of 95% CI	Tolerance	VIF
Intercept	-23.73 ± 3.917	<0.001	-31.512<b<-15.962		
Withers height	0.194 ± 0.096	0.046	0.003<b<0.384	0.432	2.317
Body length	-0.203 ± 0.091	0.029	-0.384<b<-0.021	0.568	1.760
Chest circumference	0.767 ± 0.081	<0.001	0.605<b<0.928	0.443	2.259

Descriptive statistics characterizing the distribution of predicted live weight of Çatalburun dogs in comparison with their observed live weights are presented in Table 7. As indicated by the R^2 value for this equation being intermediate between the high value that for Zağar dogs and the lower value for Zerdava dogs, the predicted variables were less variable than the observations, but not so much as for the Zerdava dogs.

Table 7 Correspondence of observed and predicted live weights of Çatalburun dogs

	Arithmetic mean	SE	Standard deviation	Median	Minimum	Maximum
Observed live weight	19.90	0.41	4.09	19.05	12.50	28.60
Predicted live weight	19.90	0.34	3.42	19.67	13.83	29.20

The prediction equations were specific to the breed of dog, although chest circumference was included as a dependent variable in all of the equations. The correlation coefficients of chest circumference with body weight were quite high in the Zağar (r = 0.914) and Çatalburun (r = 0.822) breeds, but much lower in the Zerdava (r = 0.232). Whether these equations were adequate would depend on the accuracy of prediction that was needed in any particular application.

In this study, significant positive correlations were found between live weight and body measurements. Similar results were obtained by Dirlik (2008) for the German Shepherd, Labrador Retrievers, and Belgian Malinois breeds and by Emehelu *et al.* (2012) for Nigerian native dogs. In their study, chest circumference had the highest correlation with bodyweight among the morphometric measurements. However, unlike the present study, ear length was found to be a significant predictor of live weight in a study conducted on German Shepherd dogs by the Gemlik Military Veterinary School (Elmaz *et al.*, 2006).

Çelik and Yilmazn (2018) explained 68% and 91% of the variation in live weight bodyweight of Turkish Tazi dogs with morphometric measures using the classification and regression tree method and multivariate adaptive regression splines, respectively. It is noteworthy that the less computationally demanding methods used in this study achieved similar accuracy in prediction of live weight.

Conclusion

The measured live weights of the Zağar, Zerdava, and Çatalburun genotypes and predictions of live weight from morphometric measures indicate that the weight of these dogs can be estimated with reasonable accuracy. Thus, linear measures of the body dimensions of these dogs may be indicative of their usefulness in breeding, racing, and keeping watch.

Authors' Contributions
This article was produced from PCKD's master's thesis completed under the supervision of BYO. FA, BYO, FTO, and BO contributed to the concept, design and execution of the study. PCKD and DO conducted the statistical analyses. BYO supervised the experiment and wrote the manuscript.

Conflict of Interest Declaration
        The authors declare there are no competing interests.

References
Atasoy, F., 2009. Kedi - köpek ırkları ve yetiştiriciliği ders notları. Ankara Üniversitesi, Veteriner Fakültesi, Zootekni
        Anabilim Dalı, Ankara.
Çelik, S. & Yilmaz, O., 2018. Prediction of body weight of Turkish Tazi dogs using data mining techniques: Classification
        and regression tree (CART) and multivariate adaptive regression splines (MARS). Pakistan J. Zool. 50(2), 575-
        583. DOI: 10.17582/journal.pjz/2018.50.2.575.583
Dirlik, H., 2008. Gemlik askeri veteriner okulu ve eğitim merkezi komutanlığında yetiştirilen bazı köpek ırklarında vücut
        ölçüleri ve bu ölçüler arasındaki fenotipik korelasyonlar. Adnan Menderes Üniversitesi Sağlık Bilimleri Enstitüsü
        Yüksek Lisans Tezi.
Elmaz, O., Aksoy, O.A., Dikmen, S. & Zonturlu, A., 2006. Growth performance, survival ratio and body measurements
        until weaning age of German Shepherd dog. World Small Animal Veterinary Association, Proc. 31st World
        Congress, Prague, Czech Republic.
Emehelu, C.O., Eze, J.I., Akune, A. & Chah, K.F., 2012. Estimation of live body weight from body measurements in
        Nigerian local dogs. Tropical Veterinarian 30, 65-73.
Petek, M. & Dinçel, D., 2012. Çatalburun köpekleri ve ırk özellikleri. Uludağ Üniv. J. Fac.Vet. Med. 1, *25* - 28.
Özbaşer, F.T., Atasoy, F., Erdoğan, M., Yüceer Özkul, B. & Özarslan. B., 2020. Morphological and genetic
        characteristics of Zerdava, a native Turkish dog breed. Kafkas Univ. Vet. Fak. Derg. 26(5), 617-623, DOI:
        10.9775/kvfd.2020.24004
Spira, R.H., 1991. Canine terminology. Howell Book House, New York, USA.
Tepeli, C. & Çetin, O., 2000. Kangal ırkı Türk çoban köpeklerinde büyüme, bazı vücut ölçüleri ve döl verimi özelliklerinin
        belirlenmesi. Vet. Bil. Derg. 16 (1), 5-16.
Tepeli, C. & Çetin, O., 2003. A study on head measurements of Kangal and Akbas Turkish shepherd dogs. The Journal
        of Veterinary Science 19 (1-2), 17-20.

Appendix Table 1 Estimates of phenotypic correlations among age and body dimensions in Zağar dogs

	Age	WH	RH	BL	CW	CD	CC	FC	BC	HL	FL	EL	EW	EAI	EYI	MC	TL
Age	1	0.089	0.130	0.072	0.131	0.186	0.198*	0.010	0.038	-0.001	0.007	-0.063	-0.018	0.094	0.115	0.061	-0.041
WH		1	0956**	0.713**	0.453**	0.575**	0.651**	0.565**	0.685**	0.650**	0.631**	0.553**	0.483**	0.445**	0.391**	0.481**	0.512**
RH			1	0.728**	0.493**	0.600**	0.670**	0.587**	0.710**	0.621**	0.623**	0.541**	0.496**	0.484**	0.449**	0.522**	0.517**
BL				1	0.568**	0.583**	0.663**	0.730**	0.740**	0.581**	0.537**	0.594**	0.630**	0.430**	0.548**	0.615**	0.517**
CW					1	0.531**	0.806**	0.657**	0.674**	0.433**	0.391*	0.408**	0.434**	0.108**	0.463**	0.551**	0.357**
CD						1	0.678**	0.602**	0.595**	0.511**	0.483**	0.532**	0.541**	0.341**	0.433**	0.510**	0.401**
CC							1	0.678**	0.725**	0.515**	0.513**	0.488**	0.543**	0.410**	0.494**	0.631**	0.359**
FC								1	0.786**	0.619**	0.591**	0.589**	0.610**	0.405**	0.622*	0.667**	0.406**
BC									1	0.597**	0.673**	0.551**	0.501**	0.437**	0.538**	0.711**	0.408**
HL										1	0.699**	0.463**	0.413**	0.417**	0.446**	0.533**	0.359*
FL											1	0.418**	0.484**	0.416**	0.491**	0.480**	0.239*
EL												1	0.645**	0.458**	0.385**	0.401**	0.412**
EW													1	0.435**	0.520**	0.398**	0.394**
EAI														1	0.322**	0.404**	0.304**
EYI															1	0.604**	0.241*
MC																1	0.348**
TL																	1

*P <0.05; **P <0.01
LW: live weight, WH: withers height, RH: rump height, BL: body length, CW: chest width, CD: chest depth, CC: chest circumference, FC: front cannon bone circumference, BC: behind cannon bone circumference, HL: head length, FL: face length, EL: ear length, EW: ear width, EAI: ears interval, EYI: eyes interval, MC: mouth circumference, TL: tail length

Appendix Table 2 Estimates of phenotypic correlations among age and body dimensions in Zerdava dogs

	Age	WH	RH	BL	CW	CD	CC	FC	BC	LW	TL	TW	HL	FL	EL	EW	EAI	EYI	MC
Age	1	0.242*	0.349**	0.172	0.320**	0.543**	0.457**	0.270**	0.226*	0.410**	0.134	0.128	0.263**	0.072	0.06	0.167	0.175	0.189	0.221*
WH		1	0.835**	0.487**	0.142	0.577**	0.540**	0.429**	0.385**	0.496**	0.375**	0.405**	0.567**	0.517**	0.447**	0.324**	0.027	0.253*	0.393**
RH			1	0.490**	0.208*	0.539**	0.556**	0.460**	0.410**	0.444**	0.317**	0.379**	0.549**	0.426**	0.454**	0.305**	0.015	0.219*	0.466**
BL				1	0.17	0.605**	0.554**	0.564**	0.471**	0.343**	0.197*	0.431**	0.418**	0.308**	0.467**	0.308**	-0.045	0.183	0.522**
CW					1	0.344**	0.417**	0.379**	0.423**	0.461**	-0.058	0.274**	0.238*	0.227*	0.224*	0.163	0.099	0.028	0.325**
CD						1	0.798**	0.571**	0.592**	0.557**	0.309**	0.424**	0.526**	0.291**	0.352**	0.314**	0.129	0.19	0.458**
CC							1	0.531**	0.515**	0.590**	0.335**	0.476**	0.517**	0.421**	0.313**	0.193	0.029	0.183	0.340**
FC								1	0.773**	0.468**	0.337**	0.249*	0.559**	0.393**	0.370**	0.259**	0.241*	0.151	0.537**
BC									1	0.475**	0.315**	0.322**	0.572**	0.392**	0.425**	0.294**	0.181	0.087	0.530**
LW										1	0.242*	0.382**	0.485**	0.438**	0.349**	0.256*	-0.018	0.241*	0.333**
TL											1	0.305**	0.453**	0.272**	0.126	0.025	0.126	0.317**	0.121
TW												1	0.322**	0.331**	0.142	0.267**	-0.035	0.388**	0.137
HL													1	0.611**	0.433**	0.276**	0.301**	0.345**	0.469**
FL														1	0.406**	0.268**	0.042	0.213*	0.335**
EL															1	0.289**	0.047	-0.02	0.473**
EW																1	0.1	0.213*	0.411**
EAI																	1	-0.033	0.111
EYI																		1	0.074
MC																			1

*P <0.05, **P <0.01
WH: withers height, RH: rump height, BL: body length, CW: chest width, CD: chest depth, CC: chest circumference, FC: front cannon bone circumference, BC: behind cannon bone circumference, LW: live weight, TL: tail length, TW: tail white, HL: head length, FL: face length, EL: ear length, EW: ear width, EaI: ears interval, EyI: eyes interval, MC: mouth circumference

Appendix Table 3 Estimates of phenotypic correlations among age and body dimensions in Çatalburun dogs

	Age	WH	RH	BL	CW	CD	CC	FC	BC	LW	HL	FL	EL	EW	EAI	EYI	MC
Age	1	0.264**	0.243*	0.232*	0.236*	0.262**	0.422**	0.460**	0.419**	0.317**	0.325**	0.386**	0.249*	0.283**	0,008	0,145	0.276**
WH		1	0.878**	0.616**	0.363**	0.485**	0.718**	0.675**	0.502**	0.644**	0.586**	0.633**	0.443**	0.432**	0.199*	0.225*	0.634**
RH			1	0.465**	0.381**	0.545**	0.738**	0.709**	0.581**	0.653**	0.628**	0.613**	0.521**	0.526**	0.289**	0.255*	0.627**
BL				1	0.326**	0.542**	0.602**	0.451**	0.346**	0.421**	0.423**	0.489**	0.267**	0.337**	0.357**	0,152	0.494**
CW					1	0.398**	0.554**	0.537**	0.389**	0.501**	0.454**	0.425**	0.444**	0.364**	0.207*	0.212*	0.460**
CD						1	0.714**	0.505**	0.434**	0.571**	0.480**	0.476**	0.375**	0.398**	0.400**	0,179	0.477**
CC							1	0.681**	0.563**	0.822**	0.603**	0.640**	0.525**	0.500**	0.416**	0,147	0.655**
FC								1	0.806**	0.625**	0.641**	0.640**	0.628**	0.595**	0.321**	0.349**	0.657**
BC									1	0.531**	0.550**	0.532**	0.509**	0.636**	0.353**	0.252*	0.551**
LW										1	0.553**	0.600**	0.452**	0.410**	0.319**	0,079	0.555**
HL											1	0.756**	0.558**	0.562**	0.341**	0.296**	0.609**
FL												1	0.545**	0.527**	0.363**	0.299**	0.575**
EL													1	0.538**	0.207*	0.397**	0.537**
EW														1	0.398**	0.317**	0.418**
EAI															1	0,038	0.249*
EYI																1	0.403**
MC																	1

*P <0.05, **P <0.01, **P <0.001
WH: withers height, RH: rump height, BL: body length, CW: chest width, CD: chest depth, CC: chest circumference, FC: front cannon bone circumference, BC: behind cannon bone circumference, LW: live weight, HL: head length, FL: face length, EL: ear length, EW: ear width, EAI: ears interval, EYI: eyes interval, MC: mouth circumference