



# Use of Morphometric Variables for Differentiating Breed Variations in Turkish Tazi (Sighthound) Population

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## ABSTRACT

Tazi is a Turkish sighthound breed that has not yet been officially recognized by the world canine organization - *Fédération Cynologique Internationale* (FCI). Research and analysis of morphometric parameters are required in order to write an official breed standard and recognize this breed. Previous research on this sighthound breed has shown only average values of individual morphological parameters and differences in them depending on gender, age or place of origin. However, the premise of this research is that there are several different varieties of Tazi, depending on the proportions of the body. Measurement results of 19 morphometric parameters showed that there are statistically significant differences between three sub-populations of Tazi, one with a format index greater than 100, the other with a format index less than 100 and third with a format index equal to 100. Such results are significant for setting the official breed standard in which the proportions of the body characteristic of this breed should be emphasized.

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## Authors' Contribution

UM and OU measured exterior parameters in all individuals. MM, UM and DD processed the data, performed statistical data analysis and interpreted the results.

## Key words

Turkish tazi, Dog breeds, Morphometry, Morphological traits, Sighthounds

## INTRODUCTION

Today, there are several groups of hunting dog breeds. Hunters could hunt with hounds, pointers, retrievers, flushing dogs, leash (scent) hounds, dachshunds and each of these group has its own hunting characteristics (Matejević, 2017). Hunting dog should help the hunter in various ways by showing, raising, chasing, bringing or finding wounded game. Sighthounds are also classified as hunting breeds of dogs, one of the oldest, but they are rarely used today for hunting purposes (Taubert *et al.*, 2007; Matejević, 2017). Sighthounds were the main hunting assistants or more precisely, the main actors of the hunt. Namely, they were chasing game, as well as the hounds. However, their goal was not to help the hunter to find the game more easily to shoot it himself, but to catch the game themselves. Sighthounds would raise their game and then use their speed to get and catch the game. The basic difference between hounds and sighthounds is that sighthounds chase game when see it, as opposed to hounds who are required to use their nose to chase game (Urosević, 2006, Taubert *et al.*, 2007). According to the world canine organization - *Fédération Cynologique Internationale* (FCI),

sighthounds belong to group 10. All sighthounds are divided into three sections – (1) long-haired or fringed sighthounds, (2) rough-haired sighthounds and (3) short-haired sighthounds (<http://www.fci.be/en/nomenclature/10-Sighthounds.html>). Tazi, the subject of this research, is a Turkish sighthounds breed that has not yet been officially recognized by the *Fédération Cynologique Internationale*.

The Tazi is a Turkish sighthound breed that has been historically bred for hunting (Yilmaz and Ertugrul, 2011; Yilmaz *et al.*, 2012). Tazi is a dog breed with long and slender skull, long neck, slim body, deep chest, curved spine, long forequarters and hindquarters and a thin tail (Yilmaz, 2008). Some authors indicate that Tazi resembles, but is larger than the Saluki (Yilmaz and Ertugrul, 2012; Yilmaz, 2018). In their research, Yilmaz and Ertugrul (2011) indicate that Turkish Tazi are moderate in size and weight. Average withers height established in their study was 62 cm. However, earlier Tepeli (2003) states that Tazi is 68 cm high at rump and 49.9 cm long in the body (body length). Yilmaz and Ertugrul (2011) calculated longer mean body length (60.3 cm) indicating that it is a mid-size sighthound dog. They also found out that Turkish Tazi reached the mature body weight and size around 2 years of age, but in their next study they indicate that Tazis reach the mature body weight and size around 1 years of age (Yilmaz and Ertugrul, 2012). Celik and Yilmaz (2018)

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later, analyzed body weight of Turkish Tazi dogs and most important body measurements that can predict the body weight of Turkish Tazi. Tazi represents sighthound with short coat, and mostly black and dun. [Yilmaz \*et al.\* \(2012\)](#) have been analyzed body measurements of the Tazi raised in Turkish province of Konya. They found out that mean withers height is  $62.0 \pm 0.44$ , height at rump  $2.1 \pm 0.50$ , body length  $60.7 \pm 0.55$ , heart girth circumference  $63.9 \pm 0.64$ , chest depth  $23.1 \pm 0.21$ , abdomen depth  $13.9 \pm 0.21$ , chest width  $17.4 \pm 0.25$ , haunch width  $16.4 \pm 0.18$ , thigh width  $2.3 \pm 0.26$ , tail length  $45.7 \pm 0.37$ , limb length  $38.9 \pm 0.31$ , cannon circumference  $10.2 \pm 0.11$ , head length  $24.0 \pm 0.36$  and ear length  $12.8 \pm 0.19$  cm. [Yilmaz and Ertugrul \(2012\)](#) have been analyzed some morphological characteristics of Tazi raised in Turkish province of Sanliurfa. Their results were similar to previous - withers height  $62.5 \pm 0.49$ , height at rump  $62.8 \pm 0.48$ , body length  $60.9 \pm 0.54$ , heart girth circumference  $63.5 \pm 0.57$ , chest depth  $22.8 \pm 0.36$ , abdomen depth  $14.4 \pm 0.21$ , chest width  $17.3 \pm 0.20$ , haunch width  $16.1 \pm 0.16$ , thigh width  $21.7 \pm 0.23$ , tail length  $44.6 \pm 0.41$ , limb length  $39.7 \pm 0.25$ , cannon circumference  $10.3 \pm 0.09$ , head length  $23.8 \pm 0.30$  and ear length  $12.2 \pm 0.17$  cm. Previous research on this sighthound breed has shown only average values of individual morphological characteristics and the observed differences within trait were depending on gender, age or place of origin.

The aim of this paper is to determine if there are different groups of individuals in the population of Tazi, from the aspect of body proportions. Previous research on this sighthound breed has shown only average values of individual morphological characteristics and differences in them depending on gender, age or place of origin. However, the premise of this research is that there are three different varieties of Tazi, depending on the proportions of the body. The results of this research should determine whether there is a subpopulation of different body proportions within the population of Tazi in Turkey. Determining the existence of such varieties within a breed is of great importance for the constitution of an official breed standard in order to recognize the breed as purebred.

## MATERIALS AND METHODS

Morphological parameters were measured on a total 155 individuals representing population sample of Tazi breed. Among them were 56.8% males (88 males) and 43.2% females (67 females). These measurements were carried out during 2015 and 2016 in Turkey (region of Anatolia). The following exterior parameters i.e. the withers height (WH), height of the back (HB), height at rump (HR), height of the tail root (HTR), height of the hock (HH), elbow height (EH), body length (BL), chest

depth (CD), chest width (CW), chest circumference (CC), pastern circumference (PC), pelvis length (PL), rump width (RW), head length (HL), head width (HW), muzzle width (MW), muzzle length (ML), ear length (EL), hair length (HL) were measured in all individual dogs included in research ([Figs. 1 and 2](#)). These measurements do not have an invasive character and in no way endanger animal health. All Tazi dogs were aged between 12 months and 6 years.

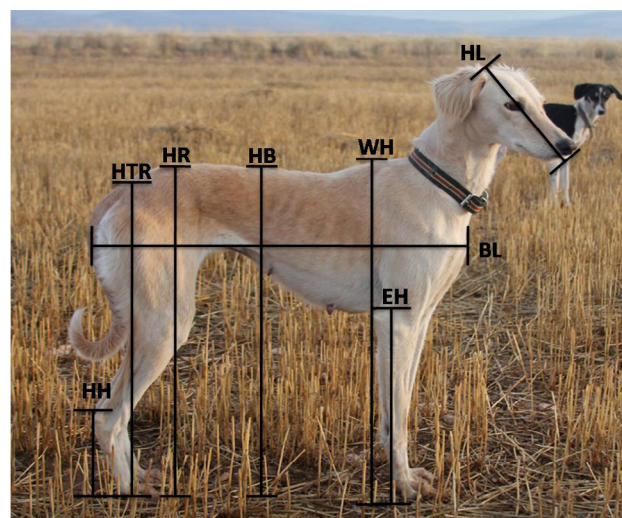


Fig. 1. Part of exterior parameters that were measured.

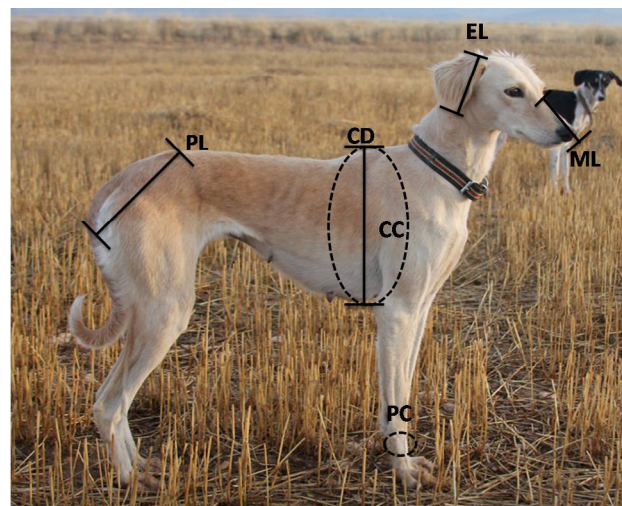


Fig. 2. Part of measured exterior parameters.

A Lydthin's measurement stick was used to measure the height at the withers ([Urosević and Drobnjak, 2019](#)). For the other parameters, a tape measure was used and all measurements were in centimeters. Conformation

characterization was based on the mean value (M) and standard deviation (SD) of the variables. Then, the T-test was applied in order to determine whether there is statistically significant difference among the individual characteristics and the sexes within the breed, and results are presented with t-value (t), degrees of freedom value (df) and significance value (sig).

For the further analysis, the frame index in this population was analyzed. The frame index in dogs is the ratio of body length to height at the withers (Urosević and Drobnjak, 2019). The frame index is calculated by formula: (body length / height of the withers) x 100. For breeds of square body, the index is 100, which means that the length of the body is equal to the height of the withers. If the frame index is greater than 100, then it is a more or less elongated body, that is, a rectangular format. As Urosević and Drobnjak (2019) state, if the frame index is greater than 100, then it is a more or less elongated body, meaning a rectangular body frame.

An analysis of variance (ANOVA) was conducted to determine differences in values of measured parameters, at the *P* level is less than 0.05, between the three groups formed within the observed population. Results of ANOVA are presented with F-statistic value (F), degrees of freedom value (df) and significance value (sig).

Collected data were processed using the Statistical Package for Social Sciences (SPSS) for Windows Release 23.0.0 software.

#### Ethical approval

No ethical approval was obtained because this study did not involve laboratory animals and only involved non-invasive procedures.

## RESULTS

Official standards of every recognized breed include great number of morphometric traits, and among them the most important are WH, BL and CC. This study included larger number of morphometric characteristic. Descriptive statistics for the 19 variables used here are shown in Tables I and II.

The results show that the mean WH is 60.45 cm, and the mean value of BL was 60.40 cm. The characteristics with the lowest coefficients of variation were: PC, ML, EL, HW and HL. The greatest variability was found for CC, and significant variability was also shown in BL and HB.

Table II shows the differences in the average values of the basic morphometric parameters between males and females. The results showed that there were no significant statistical differences between males and females between

mean chest depth, rump width, muzzle width, muzzle length and hair length. T-test showed statistically significant difference between males and females for morphometric variables: HL (t = 5.546, df = 149, sig = 0.000), HW (t = 4.126, df = 153, sig = 0.000), CC (t = 4.888, df = 153, sig = 0.000), BL (t = 5.804, df = 153, sig = 0.000), EH (t = 2.209, df = 153, sig = 0.029), HR (t = 6.114, df = 151, sig = 0.000), HB (t = 5.840, df = 151, sig = 0.000), WH (t = 7.873, df = 153, sig = 0.000), CW (t = 2.102, df = 153, sig = 0.037), HTR (t = 4.775, df = 150, sig = 0.000), HH (t = 2.858, df = 153, sig = 0.005), PC (t = 3.640, df = 153, sig = 0.000), PL (t = 4.074, df = 153, sig = 0.000) and EL (t = 4.763, df = 134, sig = 0.000). The values of the height of the withers, the height of the back, the height at the rump, the height of the tail root in males were higher compared to the same parameters in females.

**Table I. Descriptive statistic for morphometric parameters in Tazi.**

	N	Min-Max	Mean±Stand- ard deviation	Vari- ance
Withers height (cm)	155	49.00-68.50	60.44±3.37	11.364
Height of the back (cm)	153	46.00-68.50	58.39±3.57	12.755
Height at rump (cm)	153	51.00-68.50	60.41±3.39	11.548
Height of the tail root (cm)	152	48.00-67.50	55.83±3.33	11.100
Height of the hock (cm)	155	13.00-19.00	15.92±1.34	1.820
Elbow height (cm)	155	23.50-38.00	32.70±2.02	4.084
Body length (cm)	155	51.00-68.00	60.40±3.62	13.128
Chest depth (cm)	155	18.50-36.00	24.65±2.49	6.245
Chest width (cm)	155	10.50-19.00	15.53±1.62	2.650
Chest circumference (cm)	155	51.00-76.00	63.34±5.06	25.605
Pastern circumference (cm)	155	6.00-11.50	9.50±.81	.667
Pelvis length (cm)	155	11.00-18.00	15.58±1.41	2.005
Rump width (cm)	155	4.00-10.00	7.16±1.14	1.306
Head length (cm)	151	19.00-26.00	22.84±1.17	1.381
Head width (cm)	151	9.00-14.00	11.53±1.08	1.174
Muzzle width (cm)	151	4.00-8.00	6.18±1.18	1.396
Muzzle length (cm)	151	5.00-9.50	7.59±1.07	1.151
Ear length (cm)	136	9.00-15.00	11.69±.90	.812
Hair length (cm)	89	.50-5.00	2.84±.83	.697
Valid N (listwise)	87			

If only the mean values of withers height and body length are observed for the total observed sample of Tazi, it can be seen that, generally, Tazi has a body whose length



is almost equal to the height of the withers. The format index is 99.92.

**Table II. Descriptive statistic for morphometric parameters separately in males Tazi and females Tazi.**

	Sex	N	Mean±Standard deviation	Standard error mean
Withers height	Male	88	62.02±2.88	0.30761
	Female	67	58.38±2.80	0.34326
Height of the back	Male	86	59.74±3.25	0.35135
	Female	67	56.66±3.20	0.39191
Height at rump	Male	86	61.75±3.27	0.35348
	Female	67	58.70±2.73	0.33409
Height of the tail root	Male	85	56.90±3.31	0.35948
	Female	67	54.47±2.83	0.34692
Height of the hock	Male	88	16.19±1.382	0.14734
	Female	67	15.58±1.22	0.15023
Elbow height	Male	88	32.99±3.79	0.40435
	Female	67	31.88±1.77	0.21657
Body length	Male	88	61.73±3.18	0.33922
	Female	67	58.64±3.42	0.41888
Chest depth	Male	88	24.95±2.11	0.22550
	Female	67	24.26±2.89	0.35401
Chest width	Male	88	15.77±1.67	0.17905
	Female	67	15.22±1.51	0.18488
Chest circumference	Male	88	64.96±5.15	0.54988
	Female	67	61.22±4.07	0.49777
Pastern circumference	Male	88	9.71±.79	0.08504
	Female	67	9.24±.77	0.09414
Pelvis length	Male	88	15.96±1.31	0.14016
	Female	67	15.07±1.39	0.17022
Rump width	Male	88	7.28±1.00	0.10684
	Female	67	7.00±1.29	0.15825
Head length	Male	84	23.27±1.06	0.11655
	Female	67	22.29±1.08	0.13198
Head width	Male	84	11.84±1.04	0.11424
	Female	67	11.14±1.00	0.12310
Muzzle width	Male	84	6.98±5.52	0.60242
	Female	67	5.94±1.24	0.15267
Muzzle length	Male	84	7.78±1.00	0.10953
	Female	67	7.35±1.11	0.13618
Ear length	Male	75	12.00±.92	0.10633
	Female	61	11.31±.71	0.09206
Hair length	Male	60	2.83±.81	0.10474
	Female	29	2.86±.89	0.16627

When looking at the frame index separately for each gender, it can be observed that males have an average format index of 99.5. On the other hand, females on average have a body that is square, that is, the length of the body is approximately equal to the height of the withers. The frame index in females is 100.44.

During the analysis of the measured parameters, the frame index for each individual dog was also calculated. The minimum value of frame index established in the observed population sample was under 89, and the maximum frame index established was over 115 (Table III). The highest percentage of individuals in the observed sample (41.3%) has a frame index greater than 100, while the smallest percentage (18.1%) of the individuals in the observed sample has a frame index equal to 100. Other individuals in the observed population (40.6%) have frame index minor than 100. These results indicate that there are three groups within dog of Tazi breed, from the aspect of frame index. For further analysis, they were divided into three subpopulations. The first group consisted of individuals whose height of the withers was less than the length of the body (frame index was greater than 100) and this group was called the “rectangular frame dogs”. The second group consisted of individuals whose height at the withers was equal to the length of the body (frame index was equal to 100). This group was called the “square frame dogs”. The third group consisted of individuals whose body length was inferior to the height at the withers (frame index was less than 100). This group was called the “inverted rectangular frame dogs”.

**Table III. Body frame index.**

	N	Min-Max	Mean±SD
Body frame index	155	88.89-115.38	100.004±4.65
Valid N (listwise)	155		

An analysis of variance (ANOVA) was conducted to determine if there were differences in the mean values of the measured parameters between these three groups revealed within the observed population. The “homogeneity of variance test” examined the equality of variance in each of the three groups. The homogeneity of variance was determined at the HR, HTR, HH, EH, CD, CC, RW, HL, HW, ML, EL and HL ( $P > 0.05$ , Table IV). Other parameters were  $P < 0.05$  and Welch and Brown-Forsythe test was used.

The results of the ANOVA show that among the mentioned groups there is a significant statistical difference in the mean values of the parameters of the HR F (2, 150) = 8.067,  $P = 0.000$ ; HTR F (2, 149) = 4.269,  $P = 0.016$  and

EH  $F(2, 152) = 3.416$ ,  $P = 0.035$  (Table V).

**Table IV. Equality of variance in each of the three groups.**

	Levene statistic	df1	df2	Sig.
Withers height	3.70	2	152	0.027
Height of the back	4.02	2	150	0.020
Height at rump	2.54	2	150	0.082
Height of the tail root	0.53	2	149	0.590
Height of the hock	0.27	2	152	0.766
Elbow height	1.26	2	152	0.286
Body length	4.95	2	152	0.008
Chest depth	0.27	2	152	0.760
Chest width	6.06	2	152	0.003
Chest circumference	1.33	2	152	0.268
Pastern circumference	0.53	2	152	0.590
Pelvis length	8.57	2	152	0.000
Rump width	2.19	2	152	0.115
Head length	0.62	2	148	0.537
Head width	0.69	2	148	0.545
Muzzle width	4.44	2	148	0.013
Muzzle length	1.28	2	148	0.280
Ear length	0.48	2	133	0.621
Hair length (HL)	1.59	2	86	0.208

Sig, significance; df, degrees of freedom.

**Table V. Analysis of variance – ANOVA.**

		Sum of squares	df	Mean square	F	Sig.
Heights at the rump	Between groups	170.45	2	85.23	8.07	0.000
	Within groups	1584.77	150	10.57		
	Total	1755.23	152			
Height of the tail root	Between groups	90.83	2	45.42	4.27	0.016
	Within groups	1585.19	149	10.64		
	Total	1676.03	151			
Elbow height	Between groups	64.77	2	32.38	3.42	0.035
	Within groups	1440.94	152	9.48		
	Total	1505.71	154			

Df, degrees of freedom; F-value, variation between sample means / variation within the samples; Sig, significance.

The Welch and Brown-Forsythe test indicate that there is a statistically significant difference between the three groups of dogs in the parameters of withers height,

height of the back, body length (Table VI).

**Table VI. Analysis of variance, the Welch and Brown-Forsythe test.**

		Statistic <sup>a</sup>	df1	df2	Sig.
Withers height	Welch	7.51	2	89.97	0.001
	Brown-Forsythe	8.66	2	146.07	0.000
Height of the back	Welch	5.35	2	90.19	0.006
	Brown-Forsythe	6.89	2	148.57	0.001
Body length	Welch	12.95	2	89.50	0.000
	Brown-Forsythe	16.20	2	142.64	0.000

a, asymptotically f distributed; Sig, significance; df, degrees of freedom.

Thus, for these parameters there are statistically significant differences between these groups. At least one of the group means is significantly different from the others (or at least two of the group means are significantly different from each other). Subsequent comparisons using the Tukey HSD test and the Games-Howell test also show the exact differences between the groups, that is, how the groups differ statistically at the  $P$  level is less than 0.05. The “inverted rectangular frame dogs” were statistically significantly different in mean withers height values ( $M = 61.67$ ,  $S = 3.234$ ) than “square frame dogs” ( $M = 60.00$ ,  $SD = 2.56213$ ) and “rectangular frame dogs” ( $M = 59.40$ ,  $SD = 3.52532$ ), while there is no difference in withers height between square and rectangular dogs. The “inverted rectangular frame dogs” differed significantly in HB ( $M = 59.4921$ ,  $SD = 3.68026$ ) with “rectangular frame dogs” ( $M = 57.3417$ ,  $SD = 3.64121$ ). The “inverted rectangular frame dogs” were significantly different in mean values of HR ( $M = 61.6746$ ,  $SD = 3.24803$ ) than “square frame dogs” ( $M = 59.7167$ ,  $SD = 2.65123$ ) and “rectangular frame dogs” ( $M = 59.4500$ ,  $SD = 3.50991$ ), while there is no difference in HR between square and rectangular frame dogs. The “inverted rectangular frame dogs” statistically significantly differed in HTR ( $M = 56.7079$ ,  $SD = 3.30148$ ) with “rectangular frame dogs” ( $M = 54.9915$ ,  $SD = 3.35088$ ). They also statistically significantly differed in EH ( $M = 33.0952$ ,  $SD = 2.25198$ ) with “rectangular frame dogs” ( $M = 31.7083$ ,  $SD = 4.19068$ ). “Rectangular frame dogs” were statistically significantly different in mean BL ( $M = 62.1500$ ,  $SD = 3.87441$ ) from “square frame dogs” ( $M = 60.0625$ ,  $SD = 2.58641$ ) and “inverted rectangular frame dogs” ( $M = 58.9048$ ,  $SD = 3.11197$ ), however, there is no statistically significant difference in body length between square and “inverted rectangular frame dogs”.

## DISCUSSION AND CONCLUSION

Previous research on this sighthound breed has shown only average values of individual morphological parameters and differences in them depending on gender, age or place of origin. However, the premise of this research was that there are several different varieties of Tazi, depending on the proportions of the body. This research has found that, generally, dogs of this breed are of square body, but there are varieties with other body frames. Within the observed population, which is, generally, square body frame, there are varieties with extremely shorter and extremely longer bodies relative to the height of the withers. This is very important, because when formulating an official breed standard, all possible variations of the frame index must be taken into account.

The results obtained in this study show that the mean height of the withers is 60.45 cm which is smaller than those obtained in previous studies (Yilmaz and Ertugrul, 2011; Yilmaz *et al.*, 2012), although the maximum height that approximated to the one mentioned was established by Tepeli (2003). The mean value of body length was 60.40 which is similar to the results of previous studies. Chest depth has been shown to be slightly larger than in previous studies (Yilmaz *et al.*, 2012), but on the other hand, chest width and head length are slightly smaller. The values of the height of the withers, the height of the back, the height at the rump, the height of the tail root in males were higher compared to the same parameters in females. These indicate that sex dimorphism has been developed. The Tazi males have slightly smaller length compared to the withers height. On the other side, Tazi females are proportionally longer in body. Although the absolute mean values of body length in females are smaller than in males, the proportions of females' bodies indicate that females are slightly longer in body than males. This is expected, given the reproductive function that females have.

Measurement results of 19 morphometric parameters showed that there are statistically significant differences between three sub-populations of Tazi, one with a frame index greater than 100, the other with a frame index less than 100 and a third with a frame index equal to 100. "Inverted rectangular frame dogs" are generally taller than others, with higher back, higher rumps and body lengths shorter than withers height. Their tail is a bit more set than in other dogs. Such results are significant for setting the official race standard in which the proportions of the body

characteristic of this race should be emphasized.

### Statement of conflict of interest

The authors have declared no conflict of interest.

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