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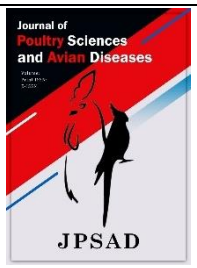

Determination of normal radiographic indices of heart size in pigeon

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A B S T R A C T

Respiratory and cardiovascular diseases are pigeons' most common health problems, which usually change cardiac size. This study aimed to establish a normal radiographic reference value for cardiac size in pigeons. After clinical and radiographic (lateral and ventrodorsal views) evaluations of 27 adult pigeons, the indices below were measured: the cardiac and thoracic widths, the space between the third and fourth ribs on the left and right sides, the synsacrum width, the coracoids width on both sides and the distance between both femoral heads and the clavicles. The ratio between cardiac width and the mentioned indices has been calculated. A linear regression test evaluated the correlation of anatomical indices with cardiac width. The results indicated a significant positive correlation between cardiac width and thoracic width, with the distance between the femoral head, synsacrum width, and the distance between clavicles. Regression models showed a significant association between thoracic and synsacrum width and cardiac width. However, sex and weight factors were not correlated with cardiac width and were removed from the models. However, in regression models with a significant correlation between the distance of both femoral heads and between clavicles with cardiac width, the sex factor was correlated with the dependent variable and was not omitted from regression models. Thus, the results and values obtained from this study can be used as a normal cardiac size of pigeons in radiology to diagnose cardiomegaly in this bird.

Keywords: *Cardiac size, Pigeon, Radiology, Thoracic width.*

1 Introduction

Pigeon husbandry has always been widespread worldwide. In recent years, there has been an increasing trend, making it inevitable that we should not study and diagnose pigeons' common diseases and health problems on a broader scale. Respiratory and cardiovascular diseases are among the significant health problems in

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pigeons, affecting the heart's size and bronchial diameter, in which the secreted mucus blocks or narrows the air passage. Respiratory diseases caused by bacteria, viruses, fungi, and seldom tumors could affect pigeons with clinical signs such as sinusitis, rhinitis, and respiratory rales. Such diseases can cause hypoxia, and in chronic cases, they result in cardiac hypertrophy and heart failure (1). Pericardial effusion, epicarditis, and pericarditis are cardiovascular diseases causing acute respiratory failure in birds (1). In addition, granulomatosis and vegetative endocarditis are common bacterial infections in birds. Since there are limitations of physical examinations (such as heart and lung auscultation) in birds, radiology as a non-invasive diagnostic imaging technique can assist in diagnosing cardiac and respiratory diseases in pigeons. Radiology is one of the easiest, most accessible, and most economical methods, which provides practical information on cardiopulmonary complications in ventrodorsal positioning (2). Cardiomegaly and microcardia can often be easily diagnosed in radiography. Generally, morphological changes that affect the heart, such as neoplasia, congenital heart defects, or soft tissue tumors, can be identified in cardiac radiography. Increased heart opacity in some cardiac inflammatory changes of the heart is distinguishable in radiography (3). It is essential to acknowledge the natural size and anatomy of the organs in radiography for a proper diagnosis. Therefore, the first step is to be informed of the standard indices of each organ's anatomy to determine the changes caused by the disease that are relevant to radiographs. This study was initiated because there was not enough information about pigeons' radiographic size and reference values of cardiac width.

2 Materials and Methods

In the current study in the Radiology department of the Ferdowsi University of Mashhad, 27 adult pigeons (10 females and 17 males) with an average weight of 320.461 g were collected from one of the breeders. The feeding and living conditions of all the 27 pigeons were alike. After the sex determination by cloacal evaluation (a prominent phallus indicates the pigeon is male, and being female equals the absence of the phallus), the pigeons were weighed and positioned accurately on a digital scale. The birds were considered normal when there was no evidence of dyspnea and no signs of cardiac problems or any other abnormality on physical examination. The birds were physically restrained by specially designed positioning equipment made of two radiolucent acrylic glass boards of different sizes (24×30 and 10×14 cm). The wings and the hindlimbs were positioned with some masking tape on the larger board, while the smaller movable board was set vertically over the neck. A 15-mm half-circle hole in the bottom center of this board allowed for neck restraint (Figure 1).

High-quality ventrodorsal and lateral radiographic projections were obtained using a commercial x-ray unit (Soyee® SY-HF-110, Soyee Product, Inc., Kangnam-Ku, Seoul, Gyeonggi, 135–729, Korea), mammographic cassette, and film (CAWO® Mammo R200, Agfa HealthCare N.V., Mortsel, Antwerp, 2640, Belgium). The exposure factors were 58 kVp and 0.8 mAs. The focus film distance was 100 cm. After obtaining the radiographs and endorsing them in terms of radiation, symmetry (superimposition of the vertebral column with the sternum is a symmetrical feature in ventrodorsal radiograph), and positioning, photographs were taken from the radiographs by a digital camera in uniform light intensity conditions of megascope. The indices with the least superimposition above were only recognizable in ventrodorsal radiographs. Consequently, the measurements were done solely on ventrodorsal radiographs. With the use of Image J software 1.42q edition (general software for the image analysis) on the photographs, the below evaluations were carried out: the maximum width of the heart, the width of the thorax at the level of the maximum width of the heart, the distance between two clavicles, the maximum width of the synsacrum, the width of the coracoid, just caudal to the facies articularis humeralis on the left and right sides, the distance between the 3rd and the fourth ribs, along the vertebral column on the left and right sides of the bird's body and distance between femoral heads (Figure 1).

Figure 1. Positioning equipment used to Restrain physically; b, Ventrodorsal view of a radiographic image of a pigeon, illustrating the measurements obtained to determine heart size compared to anatomic structures. The cardiac width is measured between points 1 and 2, the thoracic width between points 3 and 4, the third and fourth rib distance between 5 and 6, the coracoid width between points 7 and 8, the clavicle distance between 9 and 10, synsacrum width between 11 and 12, and femoral heads distance between 13 and 14

The widest cardiac silhouette's real diameters and the above values were assessed by a scaled 15 cm aluminum step-wedge (the length of each step was 10 mm). The length of one of the steps, as an indicator, was used to calibrate measurements.

2.1 Statistical analysis

The statistical analysis was done using SPSS software (16th version). Mean, standard deviation, and minimum and maximum measurements for each indices were assessed, and the cardiac width ratio to each anatomical indices was calculated accordingly. The correlation between all the revised anatomical indices and cardiac width was examined by regression analysis, in which the weight and gender of the birds were taken into account in all regression models. Additionally, those variables that had no significant correlation with the cardiac width were gradually removed from the model, providing a situation where all the remaining variables of $P<0.05$ could be correlated with cardiac width.

3 Results

In Table 1, the mean, standard deviation, 95% confidence intervals, the minimum and maximum cardiac width, thoracic width, clavicles distance, coracoids width on both sides of the bird's body, the maximum width of synsacrum, the distance between the third and fourth ribs on both sides and finally, the distance between femoral heads are presented for each gender separately.

Table 1. Measurements were obtained for evaluating the cardiac size and some of the anatomical indices in 27 healthy adult pigeons (10 females and 17 males) with an average weight of 320.461 g (Mean ± SD body weight, 32.46 ± 4.71g)]

Variable (mm)	Mean (95%CI)	SD	Min	Max
Cardiac width	25.28 (24.76- 26.6)	2.3	18.21	29.9
Thoracic width	43.72 (41.6- 43.8)	2.19	35.9	47
Coracoid width	4.11 (3.9- 4.2)	0.4	3.1	5.71
Synsacrom width	6.83 6.46- 7.2)	0.9	5.27	9.02
Clavicles distance	18.02 (17.19- 18.84)	2.06	15.00	21.84
Femoral heads distance	30.90 (29.2- 30.9)	2.21	26.40	34.40
Ribs distance	6.95 (6.6- 7.2)	0.62	5.53	8.03

Abbreviations: SD indicates standard deviation; CI is the confidence interval.
aRibs distance= the distance between the 3th and 4th ribs

In addition, this study measured the cardiac width ratio to anatomical indices, including thoracic width, the distance between the 3rd and 4th ribs, maximum synsacrum width, clavicle distance, coracoid width on both sides and femoral head distance. The cardiac width ratio correlates significantly with other indices, as shown in Table 2. The cardiac width to thoracic width ratio has the minimum coefficient of variation compared to cardiac width to different indices.

Table 2. The ratio of cardiac width to other anatomical indices obtained from healthy adult pigeons (10 females and 17 males) with an average weight of 320.461 g (Mean ± SD body weight, 32.46 ± 4.71g)]

Variable	Mean(95% CI)	SD	Min	Max
CW: TW	0.62(0.58- 0.63)	0.03	0.54	5.37
CW:CoW	7.34(7.08-7.60)	0.70		
CW: SW	3.39 (3.1- 3.5)	0.5	1.5	4.16
CW: ClD	1.46 (1.38- 1.53)	0.18	1.07	1.74
CW:RD	3.30(3.18-3.42)	0.31		
CW:FHD	0.84 (0.82- 0.86)	0.55	0.77	0.96

Abbreviations: SD indicates standard deviation; CI, confidence interval; CW, cardiac width; TW, thoracic width; CoW, coracoid width; SW, synsacrum width; ClD, clavicles distance; RD, ribs distance (3rd and 4th ribs); FHD, femoral heads distance

Among all the analyzed indices, only thoracic and synsacrum width, clavicle, and femoral head distance positively correlated with cardiac width, among which thoracic and synsacrum width were independent of weight and gender.

Cardiac and thoracic widths positively correlated, independent of weight and gender. The correlation is as follows:

Cardiac width (mm) = 1.9 + [thoracic width (mm) × 0.5]

The correlation coefficient of cardiac and thoracic widths is 0.5, which signifies that 0.5 units are added to cardiac width for each unit of increase in thoracic width.

Cardiac width had a strong positive correlation with clavicle distance, which was sex-dependent, and the bird's sex had to be considered;

Cardiac width (mm) = 21.09 + [(-2× female) + (clavicle distance (mm) × 0.4)]

Cardiac width also had a strong positive correlation with synsacrum width, which was sex and weight-independent. The correlation coefficient of cardiac width with synsacrum width equals 1.76, which signifies that 1.76 units are added to cardiac width for each unit of increase in synsacrum width. The correlation is presented below:

Cardiac width (mm) = 17.64 + [synsacrum width (mm) × 1.76]

Cardiac width had a strong positive correlation with femoral head distance, which was sex-dependent, and the bird's gender had to be considered.

Cardiac width (mm) = 7.9 + [(-1.41× female) + (femoral heads distance (mm) × 0.6)]

Figure 2a, b, c, and d graphically display the below correlations: cardiac width with thoracic width, synsacrum width, and clavicle and femoral head distances. Other anatomical indices had no positive association with cardiac width.

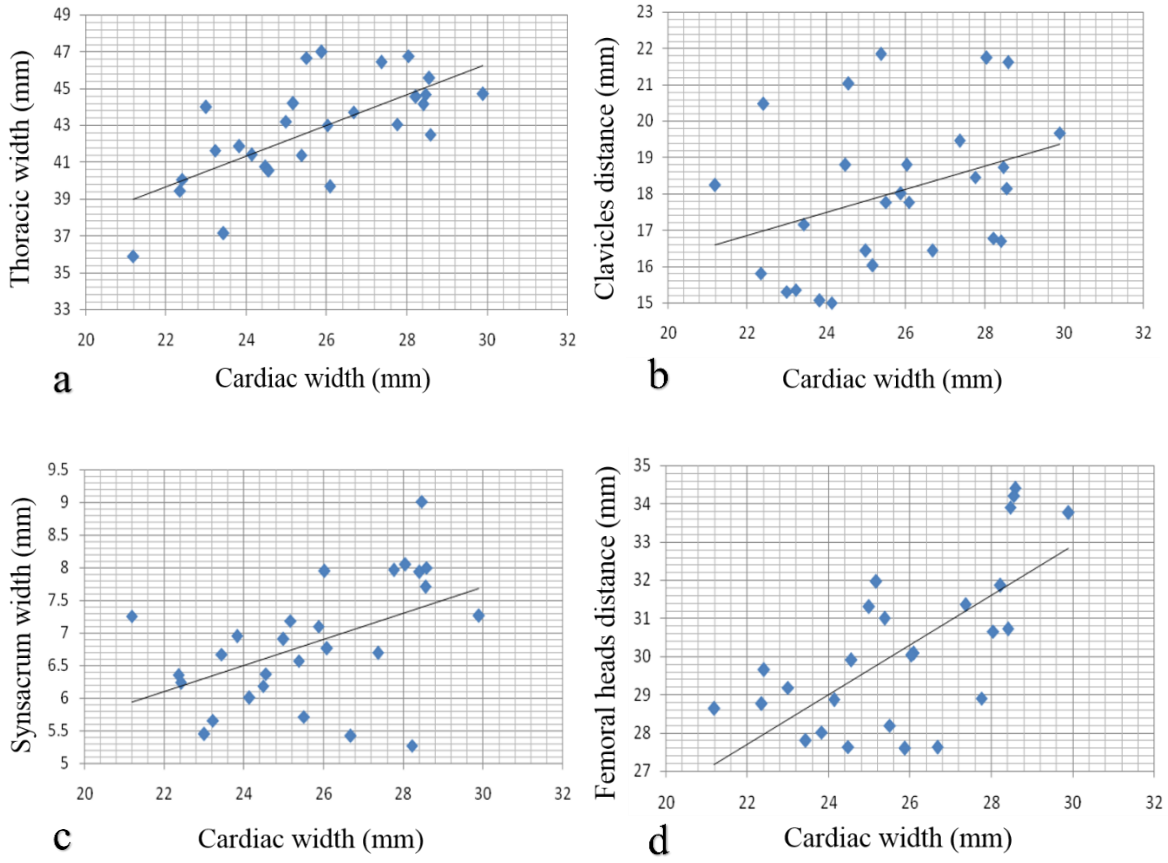

Figure 2. Positive correlations between cardiac width whit thoracic width (a), clavicles distance (b), synsacrum width (c) and femoral heads distance (d)

4 Discussion

In the current study, the normal size of the pigeon's heart and its correlation with anatomical indices have been evaluated in radiology. Statistical analysis showed a positive correlation between cardiac width and synsacrum, thoracic width, clavicle distance, and femoral head distance. It is worth mentioning that thoracic and synsacrum widths were independent of weight and sex. Other measured indices, such as coracoid width on both sides and the distance between the

3rd and the 4th ribs on both sides, were not correlated with cardiac width.

Because of the lack of complementary diagnostic imaging facilities in this research (such as echocardiography), clinical examination, status, and radiography were heavily relied on to approve the bird's cardiac health.

Barbon *et al*. studied radiographs taken from ventrodorsal positioning in 4 *Falconiform: Falco peregrines, Falcocherrug, Falcobiarmicus, and Parabuteo unicinctus*. Their research evaluated and studied the maximum cardiac width to thoracic and coracoid widths and cardiac length to carina's length. The average ratio of cardiac to thoracic width in the four species of Falconiform was as follows: 0.69, 0.68, 0.68, 0.58. Furthermore, the average cardiac to coracoid width ratio of these four species was 8.61, 9.25, 9, and 7.06 (4).

In Barbon *et al*. 's study, the estimated ratios (cardiac to thoracic width and coracoid width) were greater than the ratios of all the same indices in our study. Accordingly, birds of prey have bigger hearts than pigeons because of their highly intense body activity, especially while hunting.

Straub *et al*. studied the indices' ratios based on the ventrodorsal radiographs obtained by different species of Psittaciformes. They concluded that cardiac width is 38% of sternum length, 55% of thoracic width, and 60% of coracoid width. There was a significant association between cardiac width and thoracic width and between coracoid width and sternum length. It has also been mentioned that these values are similar in different Psittaciformes (5).

In another study, Hanley et al. estimated cardiac width in Canadian geese, in which the ratio of cardiac width to thoracic width was 47-57% (6).

The research was done by Rettmer et al. to present radiographic indices of Spix macaow's internal organs (including the heart, the liver, the spleen, and the proventriculus). The average cardiac width in adult macaws was 19.8 mm, and in young ones was 21.2 mm. The ratio of cardiac width to thoracic width in adults was 0.86, and in young macaws was 0.94 (7). In their study, the cardiac width to thoracic width ratio was higher than that of the current study; this would suggest that the smaller the bird, the bigger the heart ratio to the body's size (1). Therefore, since pigeons are smaller than macaws, the cardiac width to thoracic width ratio is more significant than that in macaws.

Gardner et al. studied three species of flying foxes: *Pteropus rodricensis, Pteropus Hypomelanus, and Pteropus Vampyrus.* They evaluated and studied cardiac width and other anatomical indices in the ventrodorsal view. They indicated that the cardiac width to thoracic width ratio was approximately the same in all three species of flying foxes, the average of which was 0.56 (8). According to this ratio, compared with the ratios achieved in the current research, it can be inferred that despite flying foxes being mammals, the cardiac width ratio to thoracic width was very close to that in pigeons. Hence, since the two species are approximately the same size, their cardiac width was almost identical.

Several studies have been done on cardiac width ratio to thoracic width, one of the most prominent of which is the various research on dogs and cats in this area. Such values and ratios are used in clinical radiology to diagnose dogs' and cats' cardiomegaly. In the lateral view, the heart's length (Base to apex) was approximately 70% of the thoracic ventrodorsal distance. Cardiac width (craniocaudal direction) must be 2.5 times (in deep chest breeds) and 3.5 times (in shallow chest breeds) of intercostal spaces. Cardiac width in ventrodorsal view often equals 60-65% of thoracic width; it should not be more than 2/3 of thoracic width at the level of the maximum width in ventrodorsal view (9).

In a recent paper by Velayati et al. on assessing cardiac index in Australian parrots, the following indices were measured: cardiac width, synsacrum width, clavicle distance, the distance between 3rd and fourth ribs, and thoracic width. Subsequently, there was only a significant correlation between the cardiac and thoracic width ratio, which equaled 0.62. There was no association of cardiac width with age or sex in the examined subjects (10).

Based on the results of this study, its ratio was higher than that of the current study. This would suggest the idea that the smaller the bird, the bigger the heart's ratio to the body's size (1). This difference is because of the bigger size of the pigeon compared to that of the Australian parrot. Like in previous studies, cardiac width was not correlated with the weight and sex of the subjects in this research.

Considering the values and ratios used in this study as standard values of the pigeon's cardiac size, we could determine the heart's dimensions in birds. In addition, by using correlations such as the one between cardiac and thoracic width, we could discover the changes in the size of the heart. Nevertheless, based on the results obtained in the current study, cardiac width was not correlated with some anatomical indices, such as coracoid width on both sides and the rib distance on both the left and right sides.

Since cardiac diseases account for many problems found in pigeons, determining the heart's standard index is significant, as it makes it possible to detect health problems and diseases such as cardiomegaly, pericarditis, and

pericardial effusion. Like many other birds, practicing diagnostic techniques such as electrocardiography is difficult for pigeons since the process is stressful and might cause the bird's myocardial infarction (heart syncope). Moreover, auscultation of the avian heart is difficult due to birds' relatively high heart rate. Since distinguishing the heart rate sound from other internal sounds like respiratory and digestive sounds is complicated, radiography is a safe, practical diagnostic method for determining a bird's cardiac health.

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Conflict of Interest

All authors declare that they have no conflicts of interest.

Author Contributions

Conception and design: Mirshahi, A. Acquisition of data: Khaksar Bajestani, M., Mirshahi, A. Analysis and interpretation of data: Azizzadeh, M. Critical revision of the manuscript for important intellectual content: Mirshahi, A., Azizzadeh, M. Statistical analysis: Azizzadeh, M. Administrative, technical, or material support: Mirshahi, A.

Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Ethical Considerations

Not declared.

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References

1. Ritchie BW, Hsarrison GJ, Zantop D, Harrison LR. Avian medicine: principles and application, abridged edition. Idaho Falls, ID: Wingers Publishing. 1997.
2. Hochleithner M. Biochemistries. Avian medicine: principles and application. 1994:223-45.
3. Isaza R, Buergelt C, Kollias GV. Bacteremia and vegetative endocarditis associated with a heart murmur in a blue-and-gold macaw. Avian diseases. 1992:1112-6. [PMID: 1485868] [DOI]
4. Barbon AR, Smith S, Forbes N. Radiographic evaluation of cardiac size in four Falconiform species. Journal of avian medicine and surgery. 2010;24(3):222-6. [PMID: 21046942] [DOI]
5. Straub J, Pees M, Krautwald-Junghanns M-E. Measurement of the cardiac silhouette in psittacines. Journal of the American Veterinary Medical Association. 2002;221(1):76-9. [PMID: 12420828] [DOI]
6. Hanley CS, Murray HG, Torrey S, Pokras MA. Establishing cardiac measurement standards in three avian species. Journal of avian medicine and surgery. 1997:15-9.
7. Rettmer H, Deb A, Watson R, Hatt J-M, Hammer S. Radiographic measurement of internal organs in Spix's macaws (Cyanopsitta spixii). Journal of avian medicine and surgery. 2011;25(4):254-8. [PMID: 22458180] [DOI]
8. Gardner A, Thompson MS, Fontenot D, Gibson N, Heard DJ. Radiographic evaluation of cardiac size in flying fox species (Pteropus rodricensis, P. hypomelanus, and P. vampyrus). Journal of Zoo and Wildlife Medicine. 2007;38(2):192-200. [PMID: 17679502] [DOI]
9. Schwarz T, Johnson V. BSAVA manual of canine and feline thoracic imaging: British Small Animal Veterinary Association; 2008.
10. Velayati M, Mirshahi A, Razmyar J, Azizzadeh M. Radiographic Reference Limits For Cardiac Width of Budgerigars (Melopsittacus Undulatus). Journal of Zoo and Wildlife Medicine. 2015;46(1):34-8. [PMID: 25831574] [DOI]