A STUDY OF HEIGHT AND WEIGHT CORRELATION IN THE AMERICAN ESKIMO DOG[1]

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This study of the heights and weights of 570 American Eskimo Dogs determined three equations, one for dogs, one for bitches, and one for all AEDs, which can be used to calculate height or weight for any AED when only one of the two parameters is known. Using these equations, height equivalents for the original weight-based UKC Breed Standard were calculated: Miniature dogs would have been 12 to 13.5 inches, and Standard dogs from over 13.5 to 18 inches; Miniature bitches would have been from 11 to 13 inches, and Standard bitches from over 13 to 16.5 inches. No difference between the heights of dogs and bitches within each of the three AKC Divisions was found using a 95% confidence level.

INTRODUCTION

Breeders and owners of American Eskimo Dogs ("AEDs" or "Eskies") have long grappled with the question of height versus weight of individual dogs. Since many owners often take their dogs to the veterinarian for medical check-ups and procedures, most owners typically know their dog's weight but not height.

Height determinations are relatively simple to make within the constraints of a dog show: A wicket quickly ascertains if the dog is over or under a set standard. Unfortunately, many owners do not measure the exact height of their dogs so easily.

Knowing some type of correlation between adult AED height and weight can also provide an understanding of the breed's true history. Prior to the mid-1980s, the official United Kennel Club ("UKC") Breed Standard provided for a weight basis for the classification of Miniatures and Standards for show purposes only. However, no published research was used as the basis for the Breed Standard definition. Additionally, over- and under-sized AEDs were permitted to be shown since the UKC Breed Standard did not, and still does not, provide for a disqualification based on weight, or height. Some modern breeders question the effect of the change in the UKC Breed Standard to allow for height measurement to be the basis for Miniature and Standard.

Additional debate has raged on and off for years among breeders regarding whether any size difference between dogs and bitches can be substantiated. The Breed Standard of The American Kennel Club ("AKC") makes no allowance for differences between the sexes, but that of the UKC does.

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METHODOLOGY

The data used as the basis for this study were the heights and weights as listed in the Stud Book of the AEDCA, the National Parent Club for the AKC-registered Eskie. The AEDCA maintained its Stud Book from 1986 through August 31, 1993.

Eskies which were Single-Registered into the Stud Book were entered based upon the presentation of UKC papers from the owner. Other requirements were also met before each AED could be assigned a number and placed into the Stud Book.

When presenting dogs for Single-Registration, the height and weight data presented by the owner were entered directly into the Stud Book. When registering puppies produced from the mating of two AEDCA-registered Eskies, only the Division ("Toy", "Miniature", or "Standard") was placed in the Stud Book. Occasionally, an owner would update the height and weight of the adult Eskie, but this was not required.

The limitations of these data include:

1. Each owner measured their Eskie- no one person or committee performed any type of Quality Assurance/Quality Control (QA/QC) on these measurements. While this may be a problem as far as accuracy and precision of the measurements are concerned, the fact that many owners participated can act as a randomizing factor- some owners measured too high, but others likely measured too low. The overall result should be a balancing of any error.

2. Owners did not use the same measuring devices, nor were those devices calibrated. These present the same problems as in number 1, above, and can be considered to be a randomizing factor.

3. Some of the Eskies presented for Single-Registration were puppies rather than adults, as the age of the AED was not a requirement for registration. It is not possible to ascertain from the Stud Book which Eskies were puppies and which were adults. Using puppy data probably caused the data scatter which will be discussed later in this paper.

A total of 570 AEDs listed in the Stud Book were used as a basis for this study. Of these, 250 were males, and 320 were females. Table 1 presents the number of dogs and bitches of each Division.

The summarized raw data regarding size and sex are presented in Table 2. For each quarter-inch height increment, the number of dogs and bitches are shown, along with the range of weights for those dogs or bitches. Note that it is possible for two or more Eskies to have exactly the same height and weight.

Figure 1 presents a scatter-plot, or X,Y graph, of all AEDs used in this study. Height is presented on the x-axis and weight on the y-axis. Since more than one Eskie can have the same height and weight, one particular mark on the graph may represent more than one Eskie. Figure 2 presents the same graph for dogs and Figure 3 for bitches.

HEIGHT VERSUS WEIGHT

Observation of Figures 1, 2, and 3 show that the data points tend to be distributed in a linear fashion. Computers can find the "best fit" line by calculating the constants in any line equation.

Any line can be given in the equation:

$$y = mx + b$$

where

m = the slope of the line, and
b = the y-intercept of the line.

From Figures 1, 2, and 3 the "x" is the height of any Eskie, and the "y" is the weight of the same Eskie. Therefore, "height" and "weight" can be substituted into the line equation:

$$weight = (m \times height) + b$$

Now to determine the values for m and b: After entering all of the height-weight data into the computer, the values are as easy to find as a single keystroke for each term.

Additionally, the computer can provide the value of "r", or how good the "fit" of the data and the line is. If the data perfectly fit a line with no scatter, r will be 1.000.

Table 3 presents the values for r, m, and b for all AEDs, all dogs, and all bitches. Also shown are the means, or averages, (shown by the symbol "μ") for the heights and weights for all AEDs, all dogs, and all bitches.

The r values show that the data are a relatively good fit. These values are probably a little lower than many mathematicians would prefer because of the scattering of the data points, probably caused by the inclusion of puppies in the sampling.

After filling in the values, the equations for dogs, bitches, and all AEDs now looks like:

Dogs:
$$weight = (3.322 \times height) - 28.168$$

Bitches:
$$weight = (2.895 \times height) - 22.268$$

All AEDs:
$$weight = (3.118 \times height) - 25.292$$

BREED STANDARD CHANGE

The question regarding height equivalents prior to the change in the UKC Breed Standard from weights to heights can now be answered. Since the weights are known, the equations can be rewritten to allow for a solution for height:

Dogs:
$$height = \frac{weight + 28.268}{3.322}$$

Bitches:
$$height = \frac{weight + 22.268}{2.895}$$

All AEDs:
$$height = \frac{weight + 25.292}{3.118}$$

Table 4 presents the ranges of weights used by the UKC for the Divisions for dogs and bitches (Beynon, 1990). It also presents the ranges of heights, based upon calculations using the equations shown above.

The height equivalents to the weights used in the former UKC Breed Standard, after averaging and rounding to the nearest half-inch, would equal:

Miniature Dogs: 12 to 13.5 inches
Miniature Bitches: 11 to 13 inches
Standard Dogs: Over 13.5 to 18 inches
Standard Bitches: Over 13 to 16.5 inches

Based upon these approximations, the impact of the change in the Breed Standard is clear- dog and bitches that were too large under the old weight standard (dogs over 18 inches and bitches over 16.5 inches) were suddenly within the height standard.

Breeders must remember that when the UKC Breed Standard was developed, no studies to determine the true size, either height or weight, of the American Eskimo Dog had been published. The UKC Breed Standard simply defined "Miniature" and "Standard" and stated that the designations were "for show purposes only" (Beynon, 1990).

Additionally, the change in the "break-over" point between Miniatures and Standards was changed when the revised height standard was implemented. Previously, under the weight standard, the maximum height for a Miniature dog was 13.5 inches, which was changed to 15 inches. Under the weight standard the maximum height for a Miniature bitch was 13 inches, which was changed to 14 inches.

As with the original weight standard, no published record exists of any type of height/weight study which was used as the basis for the revised height standard. Instead, breeders agreed on a change and adopted it.

The new height standard still did not take into account dogs under 12 inches and bitches under 11 inches. Just as the breed always had oversized specimens, which were suddenly within the new height standard, smaller Eskies had always been around as well. The AEDCA

Breed Standard, which later became the AKC Breed Standard, took in these smaller Eskies by creating the Toy Division, from 9 to 12 inches.

MALES VERSUS FEMALES

The world of dog breeds is divided on the subject of male size versus female size. Some breeds allow different sizes for each sex, while others allow one size for both. Another breed in the Non-Sporting Group, the Poodle, has three Varieties; and its Breed Standard makes no allowance for difference in size based on sex.

Based upon anecdotal breeder surveys, the writers of the AEDCA Breed Standard did not feel that sufficient justification existed for separate heights based on sex. When the AEDCA started working for AKC recognition, it set up all of its sanctioned shows with the different Divisions competing as separate Varieties. However, the AKC did not grant Varieties to the American Eskimo Dog when it gave recognition; instead the AKC allows for Divisions of Open classes.

Statistics makes use of several mathematical terms:

1. The *mean* (μ) is the average of the sample, in this case height and weight. Statisticians debate the definition of "mean", with some saying that unless every possible sample is taken, the mean can only be estimated. The estimation of the mean based upon the samples in a given study is technically known as "$\bar{x}$", pronounced "x-bar". For the purposes of this paper, "μ" is used as the mean.

2. The *variance* (s^2) measures the amount of scatter of the observations around their mean (Hogg and Ledolter, 1987). Because of its mathematical derivation, the units of the variance are in squared units; therefore, statisticians and breeders prefer to deal in real, whole units; in this case "inches" or "pounds" (rather than "inches^2" or "pounds^2").

Statisticians also debate the calculation of "s^2" in the same manner as "μ" and "$\bar{x}$". Some statisticians say that unless every possible sample is used in the calculation of the variance, the result is "s^2" rather than another symbol, "σ^2".

For the purposes of this paper, "s^2" is used for variance.

3. The *standard deviation* (s) is the square root of the variance and returns to the original units, in this case either "inches" or "pounds". Because of the relationship between the variance and standard deviation, this paper uses "s" rather than "σ" for standard deviation.

4. The *sample size* (n) is the number of samples taken, in this case measurements of heights and weights of individual AEDs.

Tables 5 presents the mean (μ), variance (s^2), standard deviation (s), and sample size (n) for the height of dogs and bitches of each of the three Divisions. Table 6 presents the same data for the weight of dogs and bitches of the three Divisions.

From the data in Tables 5 and 6, three observations can be made: 1) The average Toy dog is slightly taller than the average Toy bitch, but the average Toy bitch weighs slightly more than the average Toy dog. 2) The average Miniature dog is slightly taller and heavier than the average Miniature bitch. 3) The average Standard dog is slightly taller and weighs more than the average Standard bitch.

From studying these data, two hypotheses can be made: 1) dogs and bitches are the same size (statisticians call this the "null hypothesis", or H_0); or 2) dogs and bitches are not the same size (statisticians call this H_1). A statistical test can be performed to verify which hypothesis is true.

The H_0 and H_1 hypotheses can be written:

$$H_0: \mu_{Dogs} = \mu_{Bitches}$$
$$H_1: \mu_{Dogs} \neq \mu_{Bitches}$$

From Table 5, the average Toy dog is 11.25 inches in height, which does not equal the average Toy bitch's height of 11.099 inches. The average Miniature dog is 13.785 inches in height, which does not equal the average Miniature bitch's height of 13.713 inches. The average Standard dog is 16.876 inches in height, which does not equal the average Standard bitch's height of 16.026 inches.

From Table 6, the average Toy dog weighs 9.775 pounds, which does not equal the average Toy bitch's weight of 10.338 pounds. The average Miniature dog weighs 17.219 pounds, which does not equal the average Miniature bitch's weight of 17.098 pounds. The average Standard dog weighs 28.087 pounds, which does not equal the average Standard bitch's weight of 24.198 pounds.

But while these numbers are true for a sample population of 570 American Eskimo Dogs, of which 92 were Toys, 217 were Miniatures, and 261 were Standards, are they true for all Eskies?

Statistics provides a method to quantify the *confidence level*, or the probability that these data reflect the real world of Eskies. Hogg and Ledolter (1987) provide the following formula for use to test the H_0, H_1 hypotheses:

$$z = \frac{\mu_2 - \mu_1}{\sqrt{\dfrac{s_2^2}{n_2} + \dfrac{s_1^2}{n_1}}}$$

Comparing the height of Toy dogs to Toy bitches yields $z = 0.815$; comparing the height of Miniature dogs to Miniature bitches yields $z = 0.647$; and comparing the height of Standard dogs to Standard bitches yields $z = 0.901$. Comparing the weight of Toy dogs to Toy bitches yields $z = 1.073$; comparing the weight of Miniature dogs to Miniature bitches yields $z = 0.223$; and comparing the weight of Standard dogs to Standard bitches yields $z = 6.558$.

A Standard Normal Distribution Function table (Pearson and Hartley, 1954) will provide the value of z below which H_0, or that dogs and bitches are the same size, is accepted. A z value with a relatively high confidence interval of at least 95% should be selected so that the conclusion can be made with certainty. If the calculated value of z is greater than the table value of z (1.960), the H_0 hypothesis is rejected and the H_1 hypothesis, or that dogs and bitches are not the same size, is accepted.

In the case of the Toys, dogs are taller than bitches, but bitches weigh more than dogs. However, are the calculated z values (0.815 for height and 1.073 for weight) greater than 1.960? The answer is no, so the H_0 hypothesis for Toy AEDs, that dogs and bitches are the same size, is accepted.

In the case of the Miniatures, dogs are taller and heavier than bitches. But the calculated z values (0.647 for height and 0.223 for weight) are less than 1.960. So the H_0 hypothesis for Miniature AEDs, that dogs and bitches are the same size, is accepted.

In the case of the Standards, dogs are taller and heavier than bitches. The calculated z values of 0.901 for height is less than 1.960. So the H_0 hypothesis for Standard AEDs, that dogs and bitches are the same height, is accepted. However, the calculated z value for the weight comparison is 6.558, which is greater than 1.960. This means that the H_0 hypothesis is rejected; and the H_1 hypothesis for Standard AEDs, that dogs weigh more than bitches, is true.

The weight difference among the Standards is an interesting, unexpected conclusion. However, since the Breed Standard relies on height rather than weight, this difference has no real impact. It is possible that this difference is caused by the presence of puppies in the population, as evidenced by the relatively higher variance as compared to the Toys and Miniatures.

However, this difference could be real. The cause may be that as the AED gets taller, more weight change will be seen in the same interval of height (i.e., a 0.25-inch height increment) as opposed to a Toy or Miniature. It is clear that further work will be required to confirm this question of weight among the Standard dogs and bitches.

CONCLUSIONS

Based upon this brief study, the following conclusions can be made:

1. Of the 250 Eskie dogs used as the basis for this study, the average height was

15.264 inches and the average weight was 22.535 pounds.

2. Of the 320 Eskie bitches used as the basis for this study, the average height was 14.027 inches and the average weight was 18.338 pounds.

3. Based upon the height and weight data for all 570 AEDs in this study, equations were determined to be used to calculate height or weight when only one parameter is known. Based upon the data scatter, some degree of uncertainty exists in these equations, and further study is required to verify and quantify this uncertainty.

4. Using the equations derived in this study, it is possible to calculate the height equivalents from the original UKC weight standard. Based upon these calculations, Miniature dogs would have ranged in height from 12 to 13.5 inches; Miniature bitches would have ranged from 11 to 13 inches in height; Standard dogs would have ranged from over 13.5 to 18 inches in height; and Standard bitches would have ranged from over 13 to 16.5 inches in height.

5. Based upon a statistical analysis of the height and weight data for dogs and bitches within the Divisions, it can be demonstrated with a 95% confidence interval that no real size difference in heights between the sexes of the same Division exists. However, among the Standards, dogs weigh more than bitches. This could be caused by the presence of puppy data in the study, and more work will be necessary to determine if this difference is real.

Obviously more work remains to be done in the study of the height and weight of American Eskimo Dogs. The AEDCA should appoint a committee to devise, record, and maintain a voluntary database to track statistical data. Especially important should be tracking the growth rates of puppies as they mature into adults.

Statistics should be kept even though a particular dog or bitch may be outside the range of the required heights. It is vitally important that any other study of this type to ascertain the relationship between height and weight be done only on adult dogs, preferably those two years or older. All data should be kept anonymous unless the individual breeder approves their release.

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	Dogs	Bitches	Total
Toy	20	72	92
Miniature	94	123	217
Standard	136	125	261
Total	250	320	570

Table 1. Numbers of dogs and bitches of each Division in the study.

	μ Height	μ Weight	m	b	r
Dogs	15.264	22.535	3.322	-28.168	0.868
Bitches	14.027	18.338	2.895	-22.268	0.887
All	14.567	20.135	3.118	-25.292	0.882

Table 3. Average height and weight and values for m, b, and r for all dogs, all bitches, and all AEDs.

	Miniature			Standard		
	Weight Range	Height Range (Dog/Bitch Equation)	Height Range (All AED Equation)	Weight Range	Height Range (Dog/Bitch Equation)	Height Range (All AED Equation)
Dogs	12 - 16	12.09 -13.30	11.96 - 13.24	17 - 30	13.60 - 17.51	13.56 - 17.73
Bitches	10 - 15	11.15 - 12.87	11.32 - 12.92	16 - 25	13.22 - 16.33	13.24 - 16.13

Table 4. Height range calculated for the weight range from the former UKC Breed Standard.

	Mean (μ)		Standard Deviation (s)		Variance (s^2)		Sample Size (n)	
	Dog	Bitch	Dog	Bitch	Dog	Bitch	Dog	Bitch
Toy	11.25	11.099	0.739	0.710	0.546	0.504	20	72
Miniature	13.785	13.713	0.795	0.837	0.632	0.701	94	123
Standard	16.876	16.026	0.941	0.547	0.885	0.299	136	125

Table 5. Mean, standard deviation, variance, and sample size for heights of dogs and bitches by size Division.

	Mean (μ)		Standard Deviation (s)		Variance (s^2)		Sample Size (n)	
	Dog	Bitch	Dog	Bitch	Dog	Bitch	Dog	Bitch
Toy	9.775	10.338	1.881	2.662	3.538	7.086	20	72
Miniature	17.219	17.098	3.839	4.120	14.738	16.974	94	123
Standard	28.087	24.198	5.531	3.980	30.592	15.840	136	125

Table 6. Mean, standard deviation, variance, and sample size for weights of dogs and bitches by Division.

Size (to Nearest 0.25 inch)	Dogs		Bitches	
	Number	Range of Weight (Pounds)	Number	Range of Weight (Pounds)
9	0	---	1	7
9.25	1	6.5	0	---
9.5	0	---	1	6
9.75	0	---	0	---
10	0	---	7	5.5 - 11
10.25	2	7.5 - 8	3	7.5 - 8.75
10.5	1	9	7	6 - 8
10.75	0	---	4	8 - 9
11	3	9 - 11	18	8 - 15
11.25	3	6.5 - 12	1	8
11.5	4	10 - 10.5	15	8 - 16
11.75	0	---	0	---
12	6	9 - 14	15	8 - 18
12.25	2	12 - 13	6	9 - 16
12.5	11	9 - 21.5	12	10 - 16
12.75	1	12	1	16
13	11	11 - 18	17	11 - 18
13.25	1	13	5	10.7 - 20
13.5	12	14 - 19	24	13 - 24
13.75	8	10 - 21	3	13 - 16
14	16	12 - 30	17	13 - 24
14.25	4	19.75 - 22	2	13 - 21
14.5	13	14 - 23	16	15 - 27
14.75	7	16 - 23.25	3	19.5 - 23
15	8	17 - 25	17	14 - 32
15.25	5	17 - 28	5	18 - 22
15.5	11	20 - 34	37	16 - 30
15.75	5	20 - 34	10	19- -25
16	20	19 - 32	35	16 - 32
16.25	5	19 - 34	6	21.5 - 32
16.5	14	22 - 36	11	22 - 31
16.75	2	25 - 36	2	28
17	18	20 - 38	18	23 - 33
17.25	6	19 - 34	0	---
17.5	28	23 - 36.5	1	31
17.75	3	32 - 33	0	---
18	8	20 - 38	0	---
18.25	2	29.25 - 33	0	---
18.5	4	31 - 40	0	---
18.75	1	29.5	0	---
19	4	25 - 42	0	---
		Total: 250 Dogs		Total: 320 Bitches

Table 2. Range of weight for each 0.25-inch height increment.

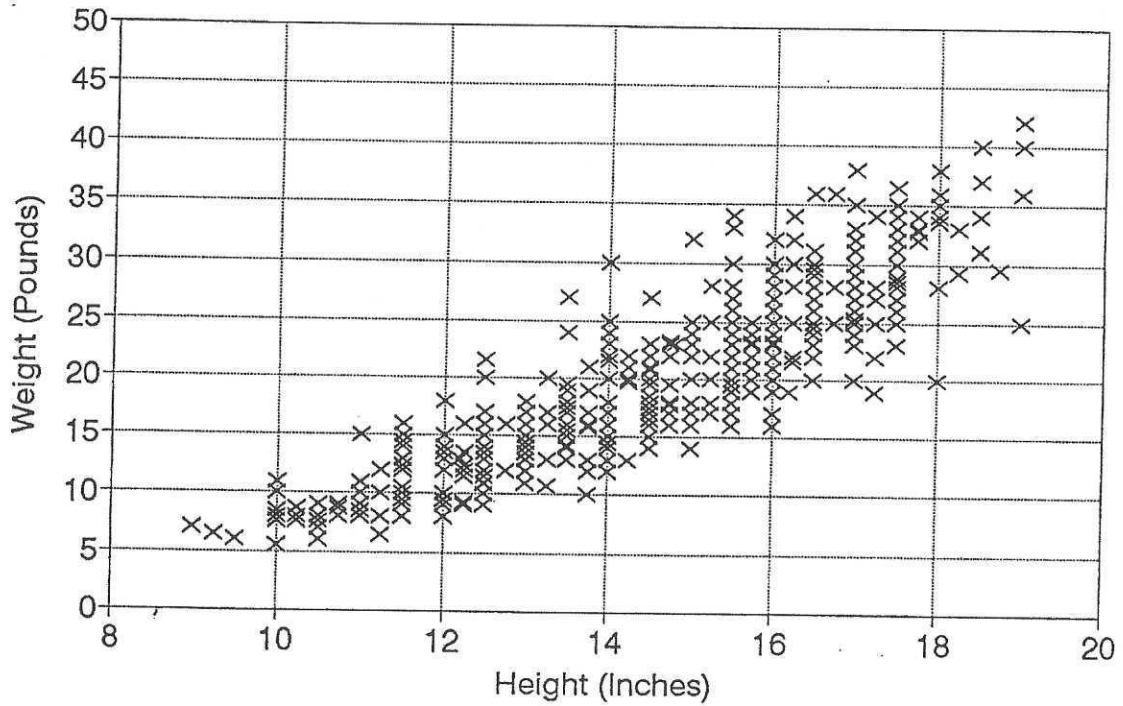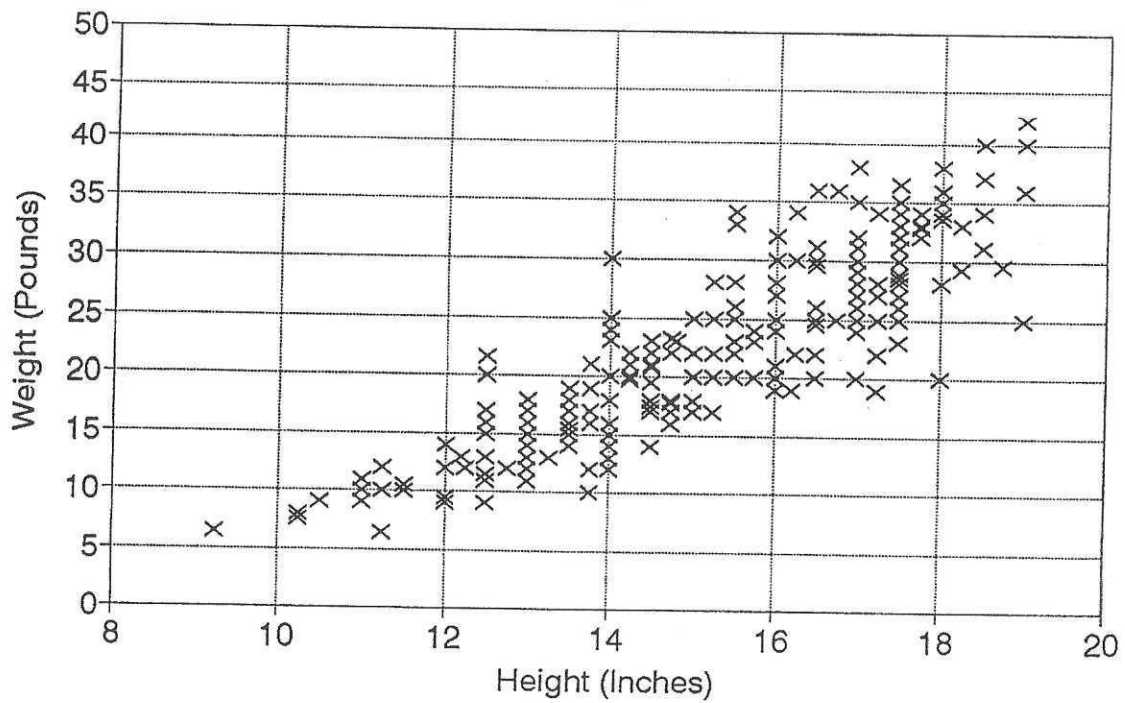# FIGURE 1: HEIGHT/WEIGHT PLOT
ALL AEDs

FIGURE 2: HEIGHT/WEIGHT PLOT
All Dogs

FIGURE 3: HEIGHT/WEIGHT PLOT
All Bitches