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Body Surface Areas and *K* Values in Strain 13 Guinea Pigs with Different Body Weights and Ages[1] (42808)

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Abstract. Body surface areas (BSA) were determined for strain 13 guinea pigs with body weights ranging from 191 to 1011 g. For this determination, the entire skin of each animal was removed immediately after death and flattened on a wax film with a homogeneous paper. The skin outlines on the papar were cut and weighed for determining BSA. The *K* value was calculated for each guinea pig as the ratio of BSA (cm^2)/body weight $(g)^{2/3}$. Significantly different *K* values of 11.31 ± 0.11, 9.66 ± 0.09, 9.22 ± 0.05, and 9.17 ± 0.05 were determined for average body weights of 218 ± 24, 527 ± 33, 706 ± 60, and 943 ± 30 g, respectively. By plotting these *K* values on semilog paper and determining the best fit curve of the slope, it was possible to extrapolate exponentially the *K* values for different body weights. The relationship between age and body weight was also established for guinea pigs, and a series of *K* values were determined from birth to 35 weeks of life. We conclude that a different *K* value should be used for calculating BSA for various ages and body weights of strain 13 guinea pigs.

Body surface areas (BSA) of man or animals are commonly used for calculating oxygen consumption (1, 2), unifying organ functions (3), and serving as the basis for drug and fluid administration (4, 5). After a *K* value is determined for a given animal species (6–9), the BSA (cm^2) of that animal can be estimated by multiplying a *K* value to the 2/3 power of the body weight (g). Since body weight changes are not always linear as a function of age, a question remains as to the validity of using a single *K* value to calculate BSA during the entire life span of a given animal. This study was conducted to determine whether single or multiple *K* values should be used to calculate the BSA of strain 13 guinea pigs at different stages of life. One other aim for this investigation was to establish the relationship between age and body weight during the first 35 weeks of life for strain 13 guinea pigs.

Materials and Methods. *Organization of animals.* Eighteen normal, healthy, male strain 13 guinea pigs, obtained in-house, were allocated into four groups with body weights ranging from 191 to 1011 g. Group I ($N = 4$) included animals with a mean body weight of 218 ± 24 g; Group II ($N = 5$), 527 ± 33 g; Group III ($N = 4$), 706 ± 60 g; and Group IV, 943 ± 30 g.

Determination of BSA. Body surface areas of strain 13 guinea pigs were determined by using the surgical skinning technique previously reported for the rhesus monkey (6). Briefly, after the guinea pig was killed with an overdose of sodium pentobarbital (>100 mg/kg, ip), the skin was detached in several pieces, laid flat on the wax surface of a Parafilm[2] paper, and fixed to a wooden board with thumbtacks. Outlines of the entire skin were cut, and the homogeneous paper was separated from the wax sheet. Paper representing the entire skin, including the head and four paws, was weighed, and an identical paper standard of known area (25 cm^2) was also weighed in order to determine BSA of the animal indirectly.

[1] In conducting the research described in this report, the investigators adhered to the "Guide for the Care and Use of Laboratory Animals," as prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Animal Resources Commission on Life Sciences—National Research Council. The facilities are fully accredited by the American Association for Accreditation of Laboratory Animal Care. The views of the author(s) do not purport to reflect the positions of the Department of the Army or the Department of Defense.

[2] Parafilm: Laboratory film, American Can Co., Greenwich, CT.

0037-9727/88 $1.50

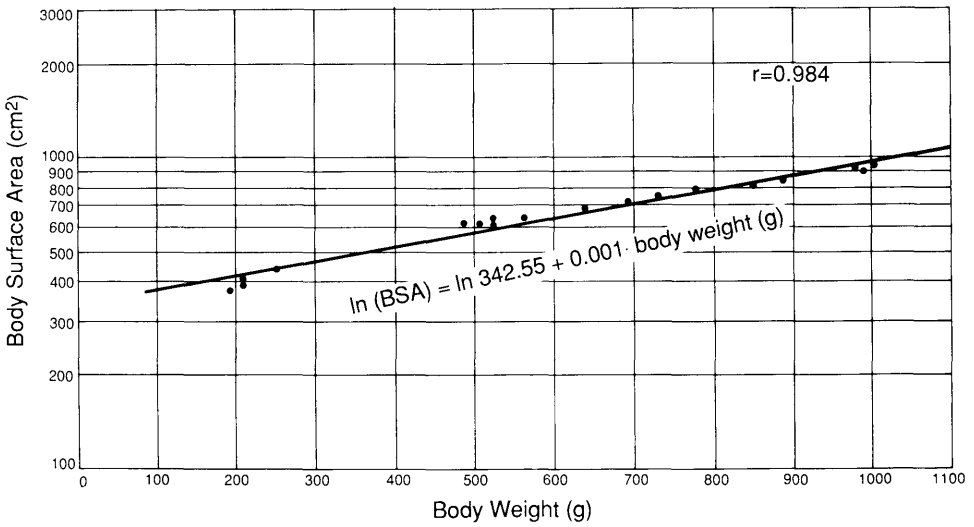

FIG. 1. Changes in body surface area as a function of body weight from 80 g to 1.1 kg for strain 13 guinea pigs. Each point represents the actually determined value of one animal (N = 18). SEM = 1.267 cm^2.

Calculation of K value constant. After the body weight and BSA of each guinea pig were determined, a K value was computed as the ratio of BSA (cm^2)/body weight (g)$^{2/3}$. All K values of 18 strain 13 guinea pigs were plotted on semilog paper as a function of body weight. The established linear curve was further extrapolated to include the 80 g weight at birth to mature, old guinea pigs of 1.1 kg body weight.

Relationship between age and body weight. Changes in body weight as a function of time (age) were studied by starting with seven new-born strain 13 guinea pigs with an average birth weight of 78 g, ranging from 60 to 90 g. As soon as the animals were weaned from their mothers at approximately 21 days, all young guinea pigs were individually caged in a climate- and humidity-controlled room (23°C, 60% relative humidity). The guinea pigs were fed NIH 34M chow.[3] Both food and water were given *ad libitum* under standardized conditions (2, 10). Body weights and rectal temperatures of all animals were measured daily. Rectal temperatures were determined with a small temperature probe,[4] which was connected to a thermister thermometer.[5]

Extrapolated K values during a life span. A Mathcad program[6] and an IBM microcomputer (AT) were used to determine the best-fit curve of the slope for the four experimentally determined K values. The K values were plotted on a log scale against various body weights (linear scale) from birth to 35 weeks of age. Based on the slope of the curve, multiple K values were derived at intervals corresponding to the age and body weight.

Statistics. Mean values and standard error of the mean (SEM) were calculated for the collected data. Data were also compared statistically, and differences were considered significant at the $P < 0.05$ level by using an independent t test.

Results. *Body surface area and calculated K values.* A linear relationship between BSA and body weights of strain 13 guinea pigs is illustrated in Fig. 1. K values of BSA were calculated for four groups of guinea pigs. Results are summarized in Table I. The average

[3] NIH 34M guinea pig chow, National Institutes of Health, Bethesda, MD.

[4] Model YSI 401, Yellow Springs Instrument Co., Inc., Yellow Springs, OH.

[5] Digi-Sense Model 8523-00, thermistor thermometer, Cole-Parmer Instrument Co., Chicago, IL.

[6] Mathcad, Mathsoft, Inc., Cambridge, MA.

TABLE I. BODY SURFACE AREAS (BSA) IN STRAIN 13 GUINEA PIGS WITH DIFFERENT BODY WEIGHTS

Group	Range and average of body weight (g)	*K* value (±SEM)
I (*N* = 4)	191–250 (218)	11.31 ± 0.11
II (*N* = 5)	488–575 (527)	9.66 ± 0.09[a]
III (*N* = 4)	634–770 (706)	9.22 ± 0.05[a,b]
IV (*N* = 5)	852–1011 (943)	9.17 ± 0.05[a,b]

[a] $P < 0.001$ (Group I vs Groups II, III, and IV).
[b] $P < 0.01$ (Group II vs Groups III and IV).

K values were determined as 11.31, 9.66, 9.22, and 9.17 for Groups I, II, III, and IV, respectively. All *K* values were significantly different ($P < 0.01$–0.001) except the values for Groups III and IV.

Extrapolated K values during the life span. When *K* values from 18 guinea pigs determined for body weights from 191 to 1011 g were plotted on a semilog scale and analyzed by Mathcad, a linear curve was obtained as a function of body weight or age (Figs. 2–3). Since *K* values decreased exponentially in relation to increasing in body weight or age, greater changes in *K* values were observed early in life and decreased gradually with advances of age (Table II).

Relationship between age and body weight. The relationship between age and body weight was established for strain 13 guinea pigs from birth to 35 weeks. During the entire experimental period, the guinea pigs were well-maintained and appeared healthy. Their average rectal temperature was 37.1 ± 0.15°C, varying from 36.2 to 38.4°C.

As presented in Fig. 4, the animals weighed 77.7 ± 3.6 g at birth and had a rapid growth until weaned at 23 days. After weaning, the guinea pigs adapted to the new experimental environment with delayed growth for approximately 1 week and then continued to grow steadily in a linear pattern. However, when the animals were 14–15 weeks old, the growth rate began to decline, and the grwoth curve gradually leveled off and reached a plateau at approximately 32 weeks.

Based on the growth curve of seven strain 13 guinea pigs, we were able to estimate the ages of experimental animals for BSA studies to be 22, 77, 126, and 245 days in Groups I, II, III, and IV, respectively.

Discussion. Strain 13 guinea pigs have been used commonly as an animal model for studying the pathogenesis of arenavirus-induced disease (10–13). For physiologic studies, body and organ functions, including O_2

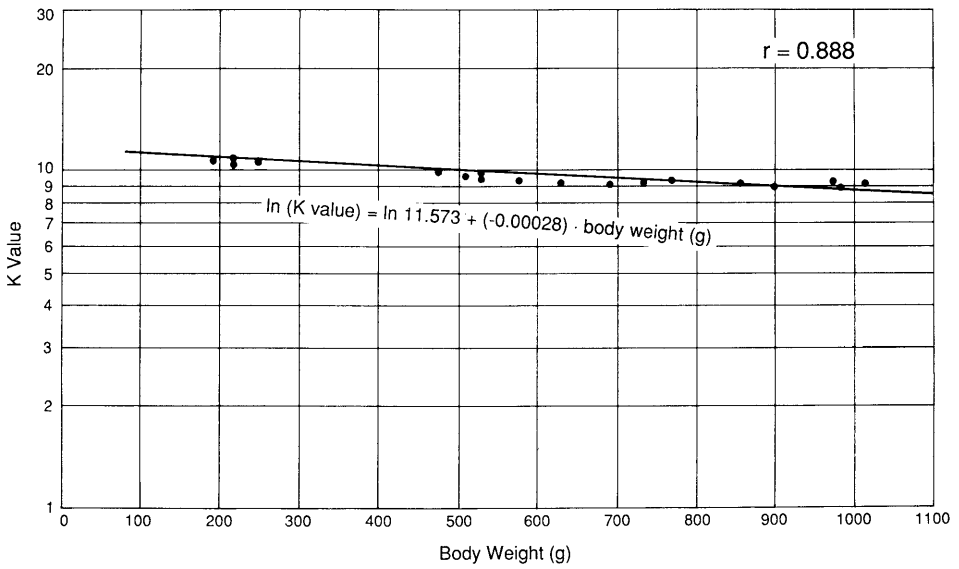

FIG. 2. Changes in *K* values as a function of body weight from 80 g to 1.1 kg for strain 13 guinea pigs. Each point represents the actually determined value of one animal (*N* = 18). SEM = 0.111.

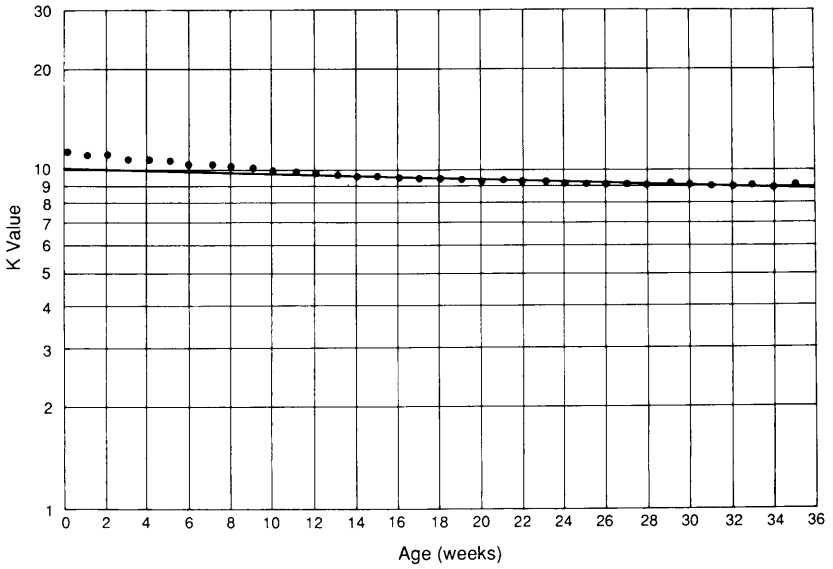

FIG. 3. Changes in K values as a function of age from birth to an age (35 weeks) of strain 13 guinea pigs. K value = $-0.005 \cdot \text{day} + 10.093$. The line represents a linear fit. ●, Actual values at a certain age, taken directly from known body weight (Fig. 4).

consumption, cardiac index, and stroke index, are unified with BSA. After Pichinde viral infection (10, 11), however, drastically decreased body weight (~28%) has generated problems for standardizing organ functions for comparative purposes.

At the present, no information is available concerning the K value for calculating BSA in either healthy or diseased strain 13 guinea pigs. When the K is known, values of BSA can be calculated from the determined body weight. Although other investigators have re-

TABLE II. VARIOUS K VALUES FOR CALCULATING BODY SURFACE AREAS AT DIFFERENT BODY WEIGHTS AND CORRESPONDING AGES IN STRAIN 13 GUINEA PIGS

Body weight (g)	Age (weeks)	K value	Body weight (g)	Age (weeks)	K value
80	0	11.318	700	18	9.525
110	1	11.224	730	19	9.446
140	2	11.131	750	20	9.394
230	3	10.856	770	21	9.342
230	4	10.856	770	22	9.342
280	5	10.706	800	23	9.264
320	6	10.587	800	24	9.264
380	7	10.412	810	25	9.238
430	8	10.268	820	26	9.213
460	9	10.183	830	27	9.817
510	10	10.042	840	28	9.162
550	11	9.931	850	29	9.136
590	12	9.821	860	30	9.111
610	13	9.767	870	31	9.086
620	14	9.740	870	32	9.086
640	15	9.686	870	33	9.086
670	16	9.632	880	34	9.060
680	17	9.579	880	35	9.060

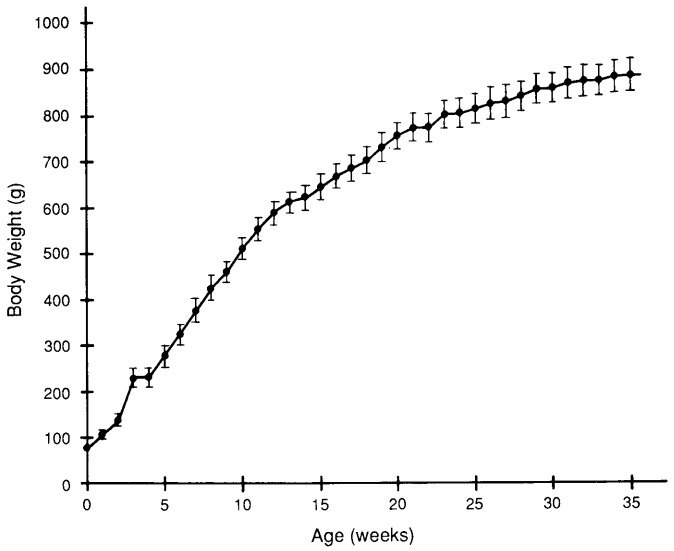

FIG. 4. Changes in body weight as a function of time in strain 13 guinea pigs from birth to 35 weeks old.

ported K values for calculating BSA for outbred guinea pigs (7–9), we are the first to measure BSA for inbred guinea pigs (strain 13) and for establishing multiple K values from birth to 35 weeks of life. The finding that K values are exponentially and inversely related to age and corresponding body weight indicates that an appropriate K value should be used to calculate BSA at different stages of life. Because the concept of applying multiple K values to calculate BSA at different ages or body weights was not previously established, our experimental results support this new concept and emphasize the importance of this unique phenomenon.

Regardless of the differences in K values at various stages of life, K values obtained for strain 13 guinea pigs are markedly higher than those for outbred guinea pigs (7–9). For example, Hong *et al.* (9) reported a K value of 8.054 at 848 ± 26 g of mean body weight as compared to our K value of 9.136 with a similar body weight. This discrepancy in K values between inbred strain 13 and outbred strains of guinea pigs could be due to differences in the precision of the approach for skinning the animal. Perhaps other investigators did not select guinea pigs with similar body weights when measuring BSA (7–9). The fact is that during BSA determinations, a mixing of older and heavier guinea pigs with a younger group tends to lower the K value.

The body weight is usually used to unify body and organ functions for comparative purposes between two groups of animals. However, it is also important to know the animal's age for physiological evaluations (2). In this study, we established the relationship between body weight and age of strain 13 guinea pigs from birth to 35 weeks of life. Results from these studies emphasize that (a) no single K value should be used to calculate BSA for the different life stages of strain 13 guinea pigs, and (b) different K values should be applied to estimate BSA in guinea pigs with distinctive ages and body weights. Thus, a single K value may be questionable for calculating BSA of any species of animals at any point of the life span.

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