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Body Surface Area of the Golden Syrian Hamster

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The body surface areas (BSAs) of 30 Syrian hamsters were actually measured. From these areas, the Mass Coefficients (K values) for the Dubois and Dubois equation (5.31) and for the Meeh-Rubner equation (11.89), were computed. These values were independent of weight and sex. To verify the applicability of the Mass Coefficients, the BSAs of another 20 animals were calculated and compared with the actually measured BSAs. The difference between measured and calculated BSAs was not significant. Therefore, these values can be used with their respective equations to compute BSA in Golden Syrian hamsters. — KEY WORDS : body surface area, K value, Syrian hamster

Body surface area (BSA) is used for calculating indices of energy metabolism, basal metabolism, fluid requirement, cardiac stroke and fluid therapy [5, 6, 8, 9, 10]. When renal or metabolic values are compared between two species of animals, they are expressed in terms of BSA [4].

Dubois and Dubois were the first to introduce an equation for calculating adult human BSA from weight and height [3]. Subsequently, other equations have been reported for humans [12], and other animal species [4, 7, 10].

Although Golden Syrian hamsters are commonly used in biomedical research [1], little information on their BSAs is available.

BSA is usually estimated with the Dubois and Dubois equation [3], $BSA (cm^2) = KD \times \text{body weight (g)}^{0.425} \times \text{body length (cm)}^{0.725}$, or with the Meeh-Rubner equation [13], $BSA (cm^2) = KM \times \text{body weight (g)}^{2/3}$. KD and KM are species-dependent Mass Coefficients (K values). 0.425 and 0.725 in the former equation, and 2/3 in the later, are the exponents used to relate BSA to body weight or length.

Liu [7] reported that KM is exponentially and inversely related to age and body weight, which means that the KM chosen to compute

BSA should be based on the animal's age.

This paper compares the direct skinning method for determining BSA in the Syrian hamster with the Dubois and Dubois equation and the Meeh-Rubner equation.

The other aims of this investigation were to determine whether single or multiple Mass Coefficients should be used to calculate the BSA of Golden Syrian hamsters with different body weights, and to establish a Mass Coefficient to be used with each equation.

Animals : Thirty Golden Syrian hamsters (20 males and 10 females) purchased from a commercial breeder (Nisseiken Co., Ltd.) were used in this study. They were from 3 to 36 weeks of age and weighed from 54.5 to 187.0 g. The animals were housed in plastic cages lined with sterilized wood chips, and were housed in an animal room at an ambient temperature of $22 \pm 1^\circ\text{C}$ and $55 \pm 5\%$ humidity. The animals were given a commercial diet and water *ad libitum* with an auto-watering apparatus. Another 20 animals were used to evaluate the Mass Coefficients. These animals were housed in the same way.

Measurement of body weights and lengths : The body weights (g) were measured on a

Fig. 1. Body surface area (BSA) as a function of body weight in Golden Syrian hamsters weighing from 54.5 g to 187.0 g. Each point represents the value determined from one animal (N=30). The BSA were plotted on a log scale against body weight.

balance scale (CL 4503 : CLEA Japan, Inc.) to the nearest 1×10^{-1} g. The body lengths (cm) were measured from the tip of the nose to the center point of the anus with the body held in the dorsal position.

Direct skinning method : The animals were weighed before being killed with diethyl ether. Their hair was then clipped as short as possible with standard animal clippers. The skin was carefully removed from the body and flattened out on a sheet of white paper with the subcutaneous side down, and its outline was traced. The ears were detached from the head and both the internal and external surfaces were traced. Each limb was amputated at the carpal and tarsal joint, and the palms and backs of the limb surfaces were traced. The outlines were cut out, identified, laid on graph paper, and another outline was drawn. All traced sections were cut out and weighed on a balance scale (ER-180 A : A AND D Co., Ltd.) to the nearest 1×10^{-4} g. Using the appropriate conversion factor ($0.2, 806 \text{ g}/50 \text{ cm}^2$), the paper mass (g) was transformed into the surface area (cm^2).

Calculation of KD and KM : After the body weight, length and BSA of each hamster had been actually measured, KD was computed as $\text{BSA (cm}^2\text{)}/\text{body weight (g)}^{0.425} \times \text{body length (cm)}^{0.725}$, and KM was computed as $\text{BSA (cm}^2\text{)}/\text{body weight (g)}^{2/3}$.

Comparison of K value (KD or KM) at different body weights : To determine whether single or multiple K values (KD or KM) should be used at different body weights, the animals were put into four groups with body weights ranging from 54.5 to 187.0 g. Group 1 (N=7)

included animals with a mean body weight of 70.21 ± 9.24 g ; group 2 (N=12), 15.75 ± 11.89 g ; group 3 (N=6), 143.0 ± 3.62 g ; and group 4 (N=5), 175.4 ± 10.41 g. After each KD and KM had been determined, the differences between groups were examined and the mean KD and KM values of each group were compared to the overall mean values for KD and KM.

Evaluation of KD and KM : To evaluate the applicability of these Mass Coefficients, 20 more animals were used, and the actually measured BSAs were compared to the areas calculated with the previously determined KD and KM. The animals used for this examination were from 6 to 9 weeks of age and weighed from 84.0 to 114.0 g.

Statistical analysis : A personal computer (NEC PC 9801 UX) and statistical software (System Line Co., Ltd.) were used. The means and standard deviations were calculated. The data were analyzed with paired and unpaired Student's t-tests, and the null hypothesis was rejected when $P < 0.05$.

The BSAs of 30 Syrian hamsters are shown as a function of their body weights in Fig. 1. There was a log-linear relationship between the BSAs and body weights.

KD and KM in the various body weight groups are summarized in Table 1. KD ranged from 5.28 (groups 1, 2) to 5.39 (group 3), and KM ranged from 11.75 (group 2) to 12.12 (group 1). There were no significant differences in KD or KM. between the groups.

Table 2 shows the BSAs of Syrian hamsters measured by three methods ; direct skinning,

Table 1. Mass Coefficients (KD and KM) at different body weights and lengths

Group	N	Body weight (g)		Body length (cm)		Mass Coefficients	
		Mean±SD	Range	Mean±SD	Range	Dubois and Dubois (KD)	Meeh-Rubner (KM)
I	7	70.21±9.24	54.5–82.0	13.19±1.60	11.2–16.7	5.28±0.45	12.12±0.37
II	12	115.75±11.90	89.0–129.5	14.68±0.66	14.0–15.9	5.28±0.29	11.75±0.60
III	6	143.00±3.62	137.0–148.0	15.57±0.32	15.3–16.1	5.39±0.20	11.89±0.48
IV	5	175.40±10.41	156.5–187.0	16.76±0.12	16.7–17.0	5.32±0.30	11.92±0.34
	30	120.52±36.05	54.5–187.0	14.86±1.47	11.2–17.0	5.31±0.32	11.89±0.51

Table 2. Actually measured body surface areas and those calculated from body weights and lengths (or body weight alone), classified by sex

Sex	Number	Weight (g)	Length (cm)	Measured BSA (cm ²)	Mass Coefficient		Calculated BSA (cm ²)	
					KD	KM	D-D ¹⁾	M-R ²⁾
♂	20	123.55±37.04 ³⁾ (69.5–182.0) ⁴⁾	15.17±1.39 ³⁾ (12.6–17.0) ⁴⁾	291.14±59.49	5.24±0.36	11.88±0.57	287.93±51.57	291.94±59.21
♀	10	114.45±33.16 (54.5–148.0)	14.17±1.47 (11.2–15.9)	276.96±54.00	5.43±0.51	11.92±0.38	277.54±55.98	277.25±57.25
Pooled	30	120.50±36.10 (54.5–182.0)	14.80±1.50 (11.2–17.0)	286.41±58.10	5.31±0.32	11.89±0.51	286.15±55.82	287.04±58.97

1) Dubois and Dubois equation

2) Meeh-Rubner equation

3) Mean±SD

4) Range

Table 3. Actually measured BSAs and those calculated with determined Mass Coefficients

Number	Body weight (g)	Body length (cm)	Measured BSA (cm ²)	Calculated BSA (cm ²)	
				D–D ¹⁾	M–R ²⁾
20	106.1±16.78 ³⁾ (84.0–134.0) ⁴⁾	14.14±0.67 (13.3–15.3)	254.87±23.89 (221.13–297.12)	262.72±26.20 (230.17–306.45)	265.33±28.56 (223.51–311.35)

1) Dubois and Dubois equation (KD=5.31)

2) Meen-Rubner equation (KM=11.89)

3) Mean±SD

4) Range

Dubois and Dubois equation and Meeh-Rubner equation. KD and KM values are also shown.

The BSAs calculated with computed KD and KM values were not significantly different from the actually measured BSAs. There were no significant sex differences in BSA, KD or KM.

Based on these results we used a KD of 5.31 and a KM of 11.89.

After the KD and KM were determined from 30 hamsters, their applicability was verified in another 20 hamsters. BSAs were calculated with the previously determined KD and KM

and compared with actually measured BSAs. As shown in Table 3, actually measured BSAs were not significantly different from calculated BSAs. The mean ratio of the calculated to measured BSAs, expressed as a percent, was 103.06+/-2.51%, ranging from 98.47 to 108.72%, for the Dubois and Dubois equation, and 104.19+/-2.83%, ranging from 99.23 to 109.80% for the Meeh-Rubner equation. The difference between these means was not significant. These results indicate that a KD of 5.31 and a KM of 11.89 are suitable for regular use.

The mean KM in this study of 30 Syrian hamsters was 11.89 ± 0.51 , and the mean KD was 5.31 ± 0.32 . The former value is higher than that previously reported for guinea pigs [4, 7].

In guinea pigs, the KM is exponentially and inversely related to age and body weight, so the KM chosen to compute BSA should be based on the animal's age [7]. In Golden Syrian hamsters, however, only the Mass Coefficient for each equation was needed to calculate the BSAs of animals with a wide range of body weights. This may be attributable to a species difference.

To verify the applicability of the determined KD and KM, 20 animals' BSAs were calculated and compared with actually measured BSAs. The results show that measured and calculated BSAs were not significantly different. The mean ratios of the calculated to measured BSAs, expressed as percentages, did not differ between the two equations. This means that the area calculated with the Dubois and Dubois equation should be nearly equal to that obtained with the Meeh-Rubner equation.

The direct skinning and graphic measurement technique has the disadvantage that the animal must be killed. In contrast, using the equations only requires knowledge of the body weight, or the body weight and length. Furthermore, these calculations can be done quickly,

the results are accurate, and the measurements can be made repeatedly on live animals.

Although other researchers have determined the constants to be used in calculating the BSA of several species [2, 3, 4, 7, 10, 11, 12, 13], as far as we know, there are no previous reports of actual measurements of BSA in Golden Syrian hamsters, and no other reported values for KD or KM.

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ゴールデンハムスターにおける体表面積の測定

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直接法により、30頭のゴールデンハムスターの体表面積を測定し、その値を基に2つの計算式における恒数(K値)を求めると共にその有効性について検討した。Dubois and Duboisの式における恒数は5.31, Meeh-Rubnerの式では11.89であった。これらの値は動物の体重や性別に関係なく一定の値を示した。求めた恒数の

有効性を確認するために、別の20頭の動物について実測値と計算値との比較を行ったところ、両者に有意な差は認められなかった。従って、今回求めたそれぞれの恒数は、実際に体表面積を計算する場合に使用可能であることが確認された。