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Measurements of body surface area and volume in laboratory rabbits (New Zealand White rabbits) using a computed tomography scanner

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Abstract: The body surface area (BSA) of an organism is one of the important parameters for evaluating physiological functions. In drug development, normalization by BSA is an appropriate method for extrapolating doses between species. The BSA of animals has generally been estimated by multiplying the *k* value by 2/3 of the power of the body weight (BW) (Meeh's formula). In mathematics, if it is assumed that the density and body shape of the animals are essentially constant, the BSA is proportional to $BW^{2/3}$. In this study, we measured the BSA and volume (*V*) of 72 laboratory rabbits (48 males and 24 females of New Zealand White rabbits [NZW]), using a computed tomography scanner. After BSA and *V* determination, the *k* value, density, and sphericity were calculated. We analyzed variations in the *k* value, density, and body shape of laboratory rabbits. The mean *k* value of the 72 NZW was 11.0. We advocate using Meeh's formula, as follows, for estimating BSA of laboratory rabbits (NZW): $100 \times BSA\ [m^2] = 11.0 \times BW\ [kg]^{2/3}$.

Key words: body surface area, computed tomography, CT image, CT scanner, rabbit

Introduction

The body surface area (BSA) of an organism is one of the parameters used for evaluating physiological functions, such as an essential requirement in calculating the cardiac index [5], assessing the basal metabolic rate [3, 8], and determining the burn surface area as a percentage of the total. BSA has also been used as a criterion for drug dosage determination since the 1950s [13]. In drug development, the no observed adverse effect levels in laboratory animal species have been converted to human equivalent doses using scaling factors. Normalization by BSA (i.e., conversion of a dosage from mg/kg to mg/m^2) is an appropriate method for extrapolating doses between species. The Food and Drug Administration Center for Drug Evaluation and Research guidance recommends the use of BSA to estimate starting doses in the initial clinical trials for therapeutics in volunteer subjects [2]. In addition, the procedures for assessing dermal toxicity are described in the guidelines issued by the Organization for Economic Cooperation and Development and these guidelines recommend that the test substance be applied to not less than 10% of the total BSA [10–12]. Thus, accurately determining the BSA of laboratory

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animals is extremely important.

The BSA of animals has generally been estimated by multiplying a constant by 2/3 of the power of the measured body weight (BW) [9]. Using BSA values, which have been determined by classic methods such as skinning, triangulation, surface integrator, paper cover, the mold method, and the perimeter method, the *k* values ($100 \times$ BSA [m^2] $= k \times$ BW [kg]$^{2/3}$, i.e., Meeh's formula) for various species have been published. The *k* value for rabbits was reported to be 5.7–10.0 by Spector [14], and 12.0–12.9 by Fougère and Wynn [4]. Additionally, Bai *et al*. reported the *k* value of Japanese White rabbits (JW) to be 11.30–11.35 [1]. Owing to the complex structural features of animal bodies, it is difficult to accurately measure the BSA of animals. Despite obvious limitations in their accuracy and reproducibility, these classic methods are still currently used to determine the BSA values.

Computed tomography (CT) scanners can generate detailed 3-dimensional (3D) images of an object, and the analysis of these CT images is expected to determine BSA more precisely than the classic measurement techniques. In previous reports [6, 7], we measured the BSA of laboratory miniature pigs using a CT scanner and 3D analysis software. Applying our measurement results, we calculated the *k* value for peripubertal- or mature-miniature pigs to be 7.98 [6] and the *k* value for juvenile miniature pigs to be 8.58 [7].

For rabbits, Zehnder *et al*. measured the BSA of 12 rabbits (multiple breeds of rabbits including New Zealand White rabbits [NZW]) using a CT scanner and analyzed the CT images using their own procedure. They reported the *k* value for rabbits to be 9.9 [15]. In the present study, we measured the BSA of 72 laboratory rabbits (NZW) using a CT scanner and employing our measurement methods to verify the *k* value of laboratory rabbits.

In mathematics, if it is assumed that the density and body shape of the animals are essentially constant, the BSA is proportional to BW$^{2/3}$. In other words, density and sphericity (i.e., index of the body shape) are inversely correlated with the *k* value. Therefore, we determined the volume (V) of the rabbits from the CT images and calculated density and sphericity. We analyzed variations in the *k* value, density, and body shape of laboratory rabbits.

Materials and Methods

Animals

NZW (Kbl: NZW) were obtained from Kitayama LABES Co., Ltd., Nagano, Japan. The BSA and V were measured for 72 rabbits (42 males at 11–41 weeks of age, 6 males at 260 weeks of age, and 24 females at 15–36 weeks of age) that had been used in other non-clinical studies and euthanized by anesthesia with sodium pentobarbital according to the protocols of the previous studies. No critical abnormalities in clinical signs or BW changes were noted in these rabbits during the time that they were alive. All studies were conducted in compliance with the Guidelines for Management and Welfare of Experimental Animals of Nihon Bioresearch Inc.

Experimental procedures

The BSA measuring methods followed those described previously [6], except for the slice thickness and the reconstruction interval (previously, the slice thickness and the reconstruction interval were 5 mm and 2.5 mm, but were 3 mm and 1.5 mm, respectively, in the present study); these were modified based on body size. The body of each rabbit was set in the prone position for whole-body CT scanning on the day of euthanasia. Images were obtained using a Multislice CT scanner (Alexion TSX 033A, Toshiba Medical Systems Co., Ltd., Tochigi, Japan, tube voltage: 120 kV, tube current: 150 mA, helical pitch: 5.5). The BSA of each animal was determined from the 3D CT images (Fig. 1) using high-speed 3D analysis software (TRI-3D/VOL, Ratoc System Engineering Co., Ltd., Tokyo, Japan). Analysis of the 3D CT images was based on the computer graphics algorithm known as Marching Cubes and Discriminant Analysis Method. As shown in Fig. 1, the fur of the rabbits was not reflected the analyzed 3D CT images, because the fur including abundant air has a very low CT value. After the BSA had been determined, the *k* value was calculated.

The V of each animal was determined from axial multi-planar reconstruction (MPR) of CT images. The total area of each section of the CT images was calculated using image processing software (Win ROOF, Mitani Co., Fukui, Japan) and multiplying the value by 1.5 mm (the reconstruction interval). After V had been determined, the density (= BW [kg]/V [l]) and the sphericity ($= \pi^{1/3}[6V]^{2/3}/100$ BSA) were calculated. The sig-

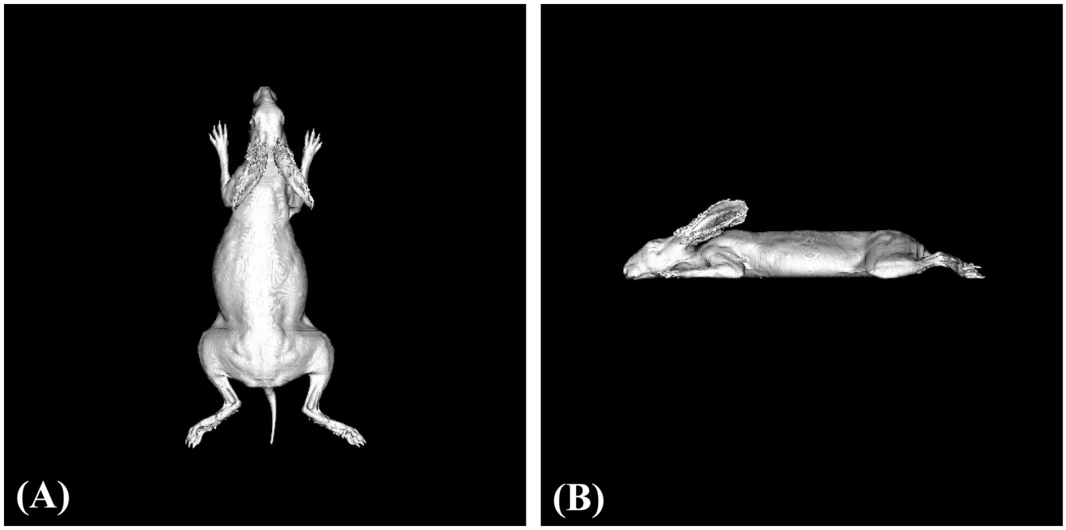

Fig.1. CT images of NZW. (A) NZW in dorsal aspect. (B) In lateral side.

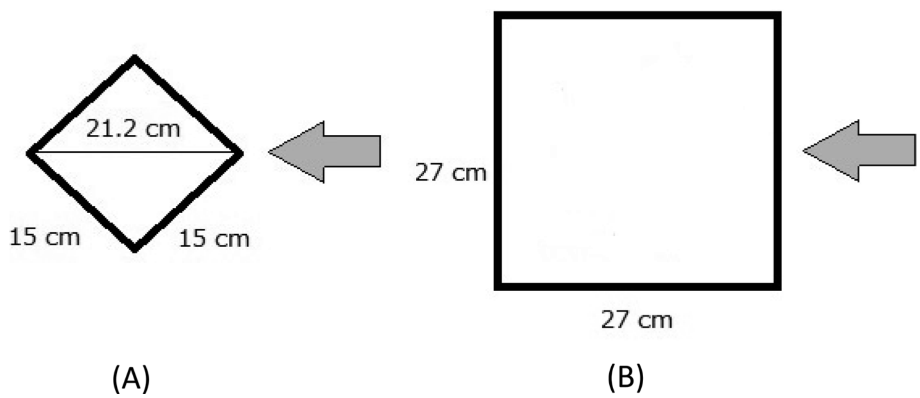

Fig.2. Direction of the CT scanning of an acrylic cuboid. (A) For the small cuboid, a diagonal of the bottom was set parallel to a moving direction. (B) For the large cuboid, 2 sides of the bottom were set parallel to a moving direction. Square; bottom of the cuboid, arrow; moving direction of the bed of the CT scanner.

nificant figure was set to three digits.

Statistical methods

The mean, SD, coefficient of variation (CV), the median, the correlation coefficient between the BW (r), and the probability of r (P) for the k value, the density, and the sphericity were calculated using statistical software (Pharmaco Basic, Scientist Press Co., Ltd., Tokyo, Japan).

Accuracy confirmation

To confirm the accuracy of the method used in this study, the surface areas and V of 2 acrylic cuboids (small cuboid: d=15 cm, w=15 cm, and h=15.5 cm; calculated surface area=0.138 m^2, calculated V=3.49 l, and large cuboid: d=27 cm, w=27 cm, and h=30 cm; calculated surface area=0.470 m^2, calculated V=21.9 l) were measured. For the small cuboid, a diagonal of the bottom of the cuboid form was set parallel to the moving direction of the bed of the CT scanner. For the large cuboid, 2 sides of the bottom were set parallel to the moving direction (Fig. 2). Measurements were repeated 5 times employing the same method as that used for the rabbits.

Results

Male (11–41 weeks of age)

As shown in Table 1, the mean age of the 42 male

Table 1. Age, BW, BSA, *V*, *k* value, density, and sphericity in male NZW (11–41 weeks of age)

	Age (week)	BW (kg)	BSA (m^2)	*V* (l)	*k* value	density (kg/l)	sphericity
	11	2.22	0.191	2.04	11.2	1.09	0.407
	11	2.26	0.187	2.04	10.9	1.11	0.416
	12	2.29	0.195	2.37	11.2	0.97	0.441
	11	2.33	0.190	2.11	10.8	1.10	0.419
	11	2.34	0.190	2.18	10.8	1.07	0.428
	12	2.34	0.198	2.27	11.2	1.03	0.422
	11	2.35	0.185	2.18	10.5	1.08	0.439
	11	2.38	0.202	2.17	11.3	1.10	0.401
	12	2.43	0.209	2.45	11.6	0.99	0.421
	12	2.48	0.209	2.45	11.4	1.01	0.421
	12	2.50	0.209	2.50	11.3	1.00	0.426
	11	2.51	0.206	2.27	11.2	1.11	0.405
	11	2.51	0.206	2.28	11.2	1.10	0.407
	11	2.52	0.205	2.35	11.1	1.07	0.417
	12	2.53	0.209	2.47	11.3	1.02	0.423
	12	2.57	0.211	2.48	11.2	1.04	0.420
	12	2.57	0.210	2.60	11.2	0.99	0.435
	12	2.58	0.212	2.58	11.3	1.00	0.429
	12	2.59	0.212	2.57	11.2	1.01	0.428
	12	2.60	0.206	2.46	10.9	1.06	0.428
	12	2.61	0.213	2.51	11.2	1.04	0.419
	12	2.64	0.212	2.64	11.1	1.00	0.436
	16	2.67	0.215	2.53	11.2	1.06	0.418
	12	2.68	0.218	2.68	11.3	1.00	0.428
	18	2.78	0.220	2.64	11.1	1.05	0.420
	24	2.82	0.232	2.66	11.6	1.06	0.400
	18	2.89	0.224	2.75	11.0	1.05	0.424
	18	2.92	0.229	2.77	11.2	1.05	0.417
	18	2.95	0.232	2.77	11.3	1.06	0.411
	18	3.04	0.229	2.83	10.9	1.07	0.423
	24	3.06	0.236	2.94	11.2	1.04	0.421
	18	3.06	0.242	2.98	11.5	1.03	0.414
	24	3.19	0.243	3.06	11.2	1.04	0.419
	16	3.20	0.233	2.79	10.7	1.15	0.411
	24	3.23	0.253	3.03	11.6	1.07	0.400
	16	3.27	0.230	2.83	10.4	1.16	0.421
	24	3.33	0.248	3.18	11.1	1.05	0.422
	24	3.45	0.254	3.25	11.1	1.06	0.418
	24	3.49	0.247	3.21	10.7	1.09	0.426
	24	3.64	0.257	3.47	10.9	1.05	0.431
	41	3.66	0.269	3.48	11.3	1.05	0.413
	41	3.69	0.256	3.53	10.7	1.05	0.438
Mean	16.6	2.79	0.220	2.65	11.1	1.05	0.421
SD	7.4	0.42	0.022	0.39	0.3	0.04	0.010
CV					2.46%	3.97%	2.40%
Median	12.0	2.63	0.213	2.59	11.2	1.05	0.421

rabbits was 16.6 weeks (median: 12.0 weeks), and their BWs ranged from 2.22 to 3.69 kg (mean: 2.79 kg, median: 2.63 kg). The BSA and the *V* values ranged from 0.185 to 0.269 m^2 and from 2.04 to 3.53 l, respectively.

The mean ± SD, CV, the median, *r*, and *P* for the *k* value were calculated to be 11.1 ± 0.3, 2.46%, 11.2, −0.189, and 0.231, respectively; those for density were 1.05 ± 0.04, 3.97%, 1.05, 0.175, and 0.266; and those for sphericity were 0.421 ± 0.010, 2.40%, 0.421, −0.017, and 0.917 (Fig. 3).

The CV for the *k* value, density, and sphericity each were small (<4%), and $P>0.05$ for all of these values. These results suggest that these values could be essentially constant in male NZW at 11–41 weeks of age.

Male (260 weeks of age)

As shown in Table 2, the BWs of the 6 male rabbits ranged from 3.89 to 4.27 kg (mean: 4.05 kg, median:

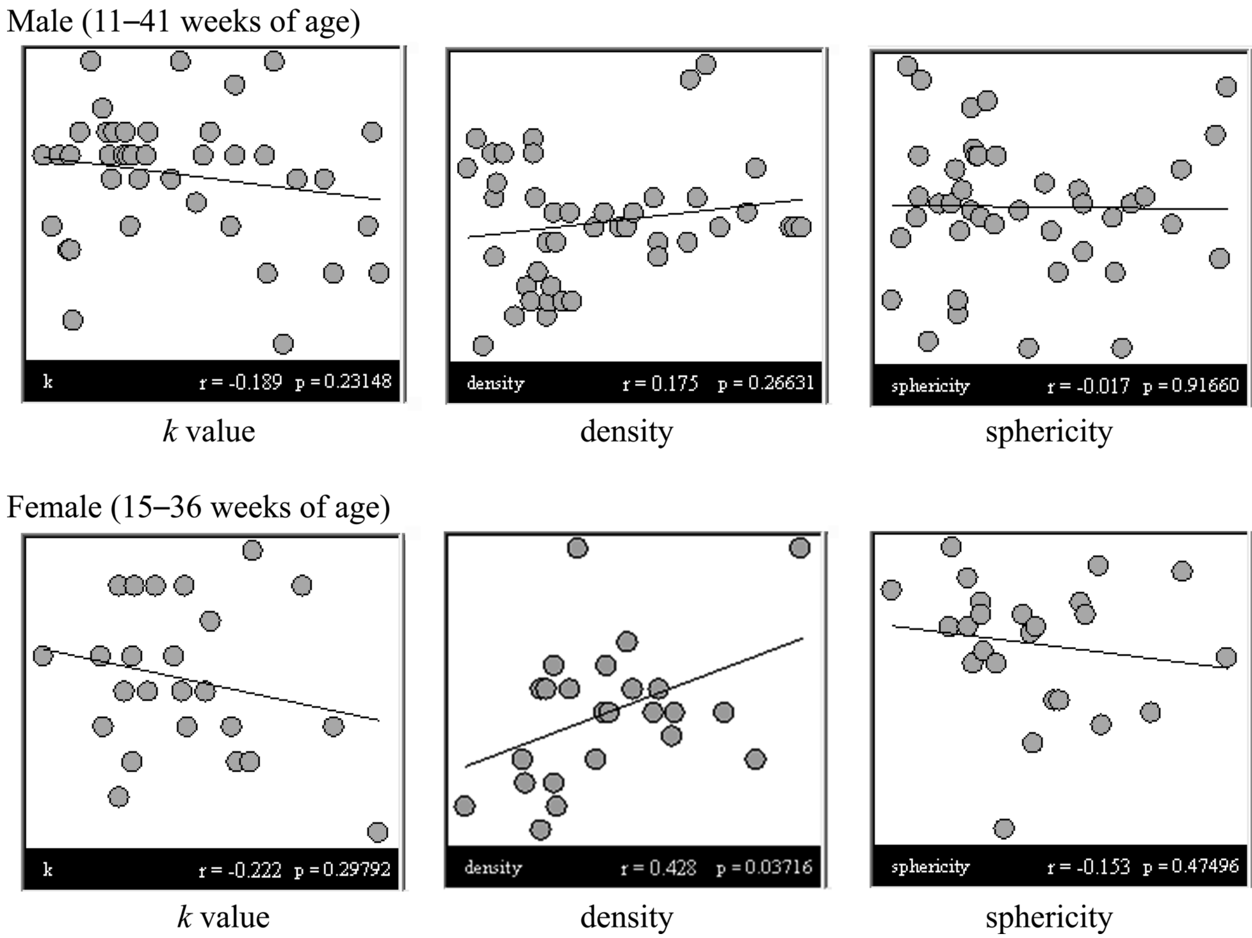

Fig.3. Scatter diagrams representing the *k* value, the density, or the sphericity on the vertical axis and the BW on the horizontal axis in the 42 male (11–41 weeks of age) or the 24 female (15–36 weeks of age) NZW.

Table 2. BW, BSA, *V*, *k* value, density, and sphericity in male NZW (260 weeks of age)

	BW (kg)	BSA (m^2)	*V* (l)	*k* value	density (kg/l)	sphericity
	3.89	0.272	3.76	11.0	1.03	0.430
	3.89	0.271	3.59	11.0	1.08	0.418
	4.04	0.276	3.86	10.9	1.05	0.431
	4.04	0.276	3.78	10.9	1.07	0.425
	4.14	0.279	3.99	10.8	1.04	0.436
	4.27	0.287	4.10	10.9	1.04	0.432
Mean	4.05	0.277	3.85	10.9	1.05	0.429
SD	0.15	0.006	0.18	0.1	0.02	0.006
Median	4.04	0.276	3.82	10.9	1.05	0.431

4.04 kg). The BSA and the *V* values ranged from 0.271 to 0.287 m^2 and from 3.59 to 4.10 l, respectively.

The calculated *k* value, density, and sphericity ranged from 10.8 to 11.0 (mean ± SD: 10.9 ± 0.1, median: 10.9), 1.03 to 1.08 (mean ± SD: 1.05 ± 0.02, median: 1.05), and 0.418 to 0.436 (mean ± SD: 0.429 ± 0.006, median: 0.431), respectively.

All *k* values, densities, and sphericities were within the range of these values and the mean ± 2 SD at 11–41 weeks of age. Therefore, our results suggest that these values are essentially equal in male NZW at 260 and 11–41 weeks of age. The mean ± SD of the *k* value of the 48 males (42 males at 11–41 weeks of age and 6 males at 260 weeks of age) was 11.1 ± 0.3.

Table 3. Age, BW, BSA, V, k value, density, and sphericity in female NZW

	Age (week)	BW (kg)	BSA (m^2)	V (l)	k value	density (kg/l)	sphericity
	15	2.71	0.213	2.70	11.0	1.00	0.440
	15	2.93	0.225	2.87	11.0	1.02	0.434
	15	2.94	0.221	2.92	10.8	1.01	0.447
	15	3.00	0.233	3.02	11.2	0.99	0.434
	19	3.00	0.221	2.87	10.6	1.05	0.442
	23	3.02	0.228	2.87	10.9	1.05	0.428
	15	3.05	0.224	2.89	10.7	1.06	0.438
	19	3.05	0.232	3.02	11.0	1.01	0.436
	15	3.06	0.237	3.06	11.2	1.00	0.430
	19	3.11	0.233	2.96	10.9	1.05	0.428
	19	3.14	0.241	2.82	11.2	1.11	0.401
	15	3.21	0.239	3.16	11.0	1.02	0.436
	23	3.24	0.238	3.11	10.9	1.04	0.433
	23	3.25	0.246	3.07	11.2	1.06	0.415
	23	3.26	0.238	3.12	10.8	1.04	0.434
	36	3.33	0.244	3.11	10.9	1.07	0.422
	19	3.35	0.248	3.18	11.1	1.05	0.422
	23	3.43	0.245	3.31	10.8	1.04	0.438
	19	3.45	0.245	3.28	10.7	1.05	0.436
	23	3.50	0.246	3.39	10.7	1.03	0.444
	23	3.51	0.260	3.37	11.3	1.04	0.418
	36	3.70	0.268	3.55	11.2	1.04	0.420
	36	3.82	0.263	3.74	10.8	1.02	0.443
	36	3.99	0.265	3.60	10.5	1.11	0.429
Mean	21.8	3.25	0.240	3.12	10.9	1.04	0.431
SD	7.2	0.30	0.014	0.26	0.2	0.03	0.011
CV					1.98%	2.89%	2.47%
Median	19.0	3.23	0.239	3.09	10.9	1.04	0.434

Female (15–36 weeks of age)

As shown in Table 3, the mean age of the 24 female rabbits was 21.8 weeks (median: 19.0 weeks), and their BWs ranged from 2.71 to 3.99 kg (mean: 3.25 kg, median: 3.23 kg). The BSA and the V values ranged from 0.213 to 0.268 m^2 and from 2.70 to 3.74 l, respectively.

The mean ± SD, CV, the median, r, and P for the k value were calculated to be 10.9 ± 0.2, 1.98%, 10.9, −0.222, and 0.298, respectively; those for density were 1.04 ± 0.03, 2.89%, 1.04, 0.428, and 0.037; and those for sphericity were 0.431 ± 0.011, 2.47%, 0.434, −0.153, and 0.475 (Fig. 3).

The r for density was 0.428 and $P<0.05$. Hence, density showed a positive correlation with BW; however, the CV for density was slight (2.89%). Furthermore, the value of r for sphericity was −0.153. Thereby, the CV for the k value was small (1.98%), and the P for the k value was higher than 0.05. It follows that the k value hardly correlated with BW. We consider that the k value is essentially constant in female NZW at 15–36 weeks of age.

Surface area and V of the cuboid

The mean ± SD and CV of surface area of the small cuboid were 0.138 ± 0.001 m^2 and 0.08%, respectively. The average value of the measured surface area was entirely in agreement with the calculated value (0.138 m^2). The mean ± SD and CV of surface area of the large cuboid were 0.476 ± 0.012 m^2 and 0.26%, respectively. The average value was 101% of the calculated value (0.470 m^2).

The mean ± SD and CV of V of the small cuboid were 3.48 ± 0.04 l and 1.29%, respectively. The average value of the measured V was 99.7% of the calculated value (3.49 l). The mean ± SD and CV of V of the large cuboid were 21.9 ± 0.00 l and 0.00%, respectively. The average value of the measured V was entirely in agreement with the calculated value (21.9 l).

Discussion

Formula for BSA of laboratory rabbits (NZW)

Applying the results of the present measurement, the mean k value of the 48 males was 11.1, and the mean k

value of the 24 females was 10.9. The difference between the mean *k* values of the males and the females was very slight. We propose the following formula for estimating BSA of laboratory rabbits (NZW): 100 × BSA [m^2] = 11.0 × BW [kg]$^{2/3}$ on the basis of the mean *k* value of the 72 NZW.

Comparison with the previous k value

Based on the results of this study, the *k* value of NZW was determined to be 11.0. In comparison with the previous data, the *k* value in this study was larger than the *k* values (5.7–10.0) for rabbits determined by use of skinning and triangulation reported by Spector [14], and smaller than the *k* value (12.0–12.9) reported by Fougère and Wynn (The method of BSA determination was not shown.) [4]. Additionally, the present *k* value was slightly smaller than the *k* values (11.30–11.35) of JW determined by use of paper cover and skinning reported by Bai *et al*. [1]. It have been pointed out that the accuracy and reproducibility of these classic methods have limitations [6].

The present *k* value was larger than the *k* value (9.9) of rabbits (NZW, Mini-lop, Netherland Dwarf, Dutch Belted, Chinchilla, Flemish Giant, and breed unknown) analyzed the CT images using their own procedure reported by Zehnder [15]. The surface area of the small cuboid was computed to be 0.111 ± 0.001 m^2 (mean ± SD) from the MPR of CT images by Zehnder's procedure (i.e., summing the lengths of contour for each slice and multiplying this total length by the reconstruction interval. Additionally, the areas of the end slices were added to this value [15]). The average value computed by Zehnder's procedure was 80.4% of the calculated value (0.138 m^2). In mathematics, the lengths of 2 vertical sides of the contour for each slice (2 × h of cuboid = 2 × 15.5 cm = 31 cm) should be multiplied by 2.12 mm (1.5 mm × √2). The total multiplied length is the 2 sides of the bottom of the cuboid form (15 + 15 = 30 cm) to transform from the lengths of the contour into surface area (31 cm × 30 cm + 2 × 225 cm^2 [the areas of the top and bottom square] = 0.138 m^2); however, Zehnder's procedure multiplied by 1.5 mm and total multiplied length is the diagonal of the bottom (21.2 cm: total of the reconstruction interval) (Fig. 2A). Thereby, the surface area of the small cuboid computed by Zehnder's procedure was small (31 cm × 21.2 cm + 2 × 225 cm^2 = 0.111 m^2). To be more precise, the BSA and the *k* value computed by Zehnder's procedure may be smaller than the actual value.

Although the difference between the present *k* value of NZW and the previous data for rabbits might be attributable to the differences in the density and body shape of the measured rabbits, the difference in the measurement method should also be considered. Since accuracy and reproducibility were confirmed by measuring the surface area and the *V* of the acrylic cuboids, we concluded the measurement method employed in this study was reliable. Furthermore, we expect that the *k* value for other laboratory animals will be verified by this measuring method.

Conflict of Interest

The authors declare that there is no conflict of interest.

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References

1. Bai, L., Huang, B., Chen, Y., Zhao, S., Fan, J., and Liu, E. 2017. Determination of body surface area in Japanese White Rabbits. *Scand. J. Lab. Anim. Sci.* 43: 637–644.
2. Center for Drug Evaluation and Research 2005. Estimating the maximum safe starting dose in initial clinical trials for therapeutics in adult healthy volunteers. *In*: Guidance for Industry. https://www.fda.gov/ucm/groups/fdagov-public/@fdagov-drugs-gen/documents/document/ucm078932.pdf.
3. Dale, H.E. 1970. Energy metabolism. pp. 619–633. *In*: Duke's physiology of domestic animals, 8th ed. (Swenson, M.J., ed.), Cornel University Press, Ithaca.
4. Fougère, B.J. and Wynn, S.G. 2007. Herb manufacture, pharmacy and dosing. pp. 221–236. *In*: Veterinary Herbal Medicine. (Wynn S.G., and Fougère, B.J. eds.), Mosby Inc., St. Louis.
5. Hall, J.E. 2011. Cardiac output, venous return, and their regulation. pp. 229–241. *In*: Textbook of medical physiology, Saunders, Philadelphia.
6. Itoh, T., Kawabe, M., Nagase, T., Endo, K., Miyoshi, M., and Miyahara, K. 2016. Body surface area measurement in laboratory miniature pigs using a computed tomography scanner. *J. Toxicol. Sci.* 41: 637–644. [Medline] [CrossRef]
7. Itoh, T., Kawabe, M., Nagase, T., Matsushita, H., Kato, M., Miyoshi, M., and Miyahara, K. 2017. Body surface area measurement in juvenile miniature pigs using a computed tomography scanner. *Exp. Anim.* 66: 229–233. [Medline] [CrossRef]
8. Kleiber, M. 1965. Metabolic body size. pp. 427–435 *In*: Energy metabolism (Blaxter, K.L., ed.), Academic Press, Lon-

don.
9. Meeh, K. 1879. Oberflächenmessungen des menschlichen Körpers. *Z. Biol.* 15: 425–458 (in German).
10. OECD 1981. Test No. 410: Repeated Dose Dermal Toxicity: 21/28-day Study. *In*: OECD Guidelines for the Testing of Chemicals, Section 4. http://www.oecd-ilibrary.org/environment/test-no-410-repeated-dose-dermal-toxicity-21–28-day-study_9789264070745-en.
11. OECD 1981. Test No. 411: Subchronic Dermal Toxicity: 90-day Study. *In*: OECD Guidelines for the Testing of Chemicals, Section 4. http://www.oecd-ilibrary.org/environment/test-no-411-subchronic-dermal-toxicity-90-day-study_9789264070769-en.
12. OECD 2017. Test No. 402: Acute Dermal Toxicity. *In*: OECD Guidelines for the Testing of Chemicals, Section 4. http://www.oecd-ilibrary.org/environment/test-no-402-acute-dermal-toxicity_9789264070585-en.
13. Pinkel, D. 1958. The use of body surface area as a criterion of drug dosage in cancer chemotherapy. *Cancer Res.* 18: 853–856. [Medline]
14. Spector, W.S. 1956. Constants for estimating surface area: mammals. p. 175. *In*: Handbook of biological data. W. B. Saunders Company, Philadelphia.
15. Zehnder, A.M., Hawkins, M.G., Trestrail, E.A., Holt, R.W., and Kent, M.S. 2012. Calculation of body surface area via computed tomography-guided modeling in domestic rabbits (Oryctolagus cuniculus). *Am. J. Vet. Res.* 73: 1859–1863. [Medline] [CrossRef]