Assessment of body weight for age determination in kittens

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Abstract

Objectives The objective of this study was to assess the utility of using body weight for age determination in kittens.
Methods Medical records were reviewed for serial body weight measurements collected from neonatal kittens (up to 8 weeks of age) from a breeding colony of specific pathogen-free domestic shorthair cats and for single-point body weight measurements of privately owned pediatric kittens (6–20 weeks of age) presenting for elective sterilization. Body weights were compared with known dates of birth and age assessed by dental eruption in combination with developmental characteristics.
Results The coefficient of determination (R^2) between age and body weight in longitudinally sampled neonatal kittens was 0.88, while that for pediatric kittens sampled at a single time point was 0.54. Among neonatal kittens, predicted age based on the 1 lb (0.45 kg) of body weight gain per month of age guideline corresponded to within 1 week of actual age for 243 (98.8%), 234 (95.1%), 203 (82.5%) and 191 (77.6%) kittens at 2, 4, 6 and 8 weeks of age, respectively. Among pediatric kittens, predicted age based on this guideline corresponded to within 1 week of actual age for 24 (77.4%), 411 (67.5%), 170 (57.0%), 96 (46.6%), 23 (28.8%), 15 (27.8%), one (25%) and five (17.9%) kittens at 6, 8, 10, 12, 14, 16, 18 and 20 weeks, respectively.
Conclusions and relevance Body weight was an effective means of predicting age in kittens through 10 weeks of age. Factors other than body weight should be considered when estimating kitten age beyond that time point.

Keywords: Body weight; age determination; growth; aging

Introduction

Assessment of kitten age is commonplace in animal shelters and veterinary practices; unfortunately, actual ages are seldom known, necessitating the use of clinical estimates. In addition to ensuring completeness of medical records, age assessment is important for the implementation of medical protocols and, for shelters, in the social and legal determination of adoptability.[1] Various methods of estimating age in kittens include assessment of developmental milestones, permanent tooth eruption and body weight.[2–6]

Many practitioners consider the degree of tooth eruption an objective method of determining a cat's age, though estimated eruption times vary and their consistency is unknown. Typically, deciduous incisors erupt within 2–4 weeks of birth, followed by deciduous canines at 3–4 weeks and deciduous premolars at 4–6 weeks. At 11–22 weeks of age, permanent incisors begin to erupt, followed by permanent canines, premolars and molars between 12 and 24 weeks.[6–8] Assessment of dental eruption may be challenging in cats, particularly for lay persons or in the case of unsocialized and/or fearful animals. Despite the lack of an accurate, consistent and practical means of its determination, age is a common factor in the development of vaccination, deworming and anesthetic protocols, and as a determining factor in suitability for adoption.[5,9–14]

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In contrast to the exponential growth rate of puppies regardless of adult size,[2] the growth rate of kittens is generally linear in nature, allowing for weight-based age prediction.[4] For many shelters, whose employees include lay persons without specific veterinary medical or animal husbandry training, using the clinical guideline of 1 lb (0.45 kg) of body weight gain per month of age is the simplest and quickest method available.[5] This guideline does not take into account the many unknown factors that may influence growth rate (eg, litter size, sex, birth weight, nutritional status) and the literature describing the duration of linear weight gain is variable.[2–4] The objective of this study was to compare body weight measurements of kittens 2–20 weeks of age to the clinical guideline of 1 lb (0.45 kg) of weight gain per month of age. We hypothesized that age and body weight will have a sex-dependent, direct correlation that will weaken over time.

Materials and methods

Neonatal growth rate

Medical records of a group of specific pathogen-free (SPF) domestic shorthair kittens maintained in a breeding colony at a university-based research laboratory were reviewed for serial body weight measurements through 8 weeks of age (described as 'neonatal kittens'). Kittens whose body weights were recorded at 2 week intervals from birth to 8 weeks of age were eligible for inclusion in the data set. A digital gram scale was used to record all body weights.

Pediatric body weight

Medical records of a group of healthy privately owned kittens 6–20 weeks of age (described as 'pediatric kittens') presenting for elective surgical sterilization were reviewed for single-point body weight measurements. Age was recorded by two experienced veterinarians as 6, 8, 10, 12, 14, 16, 18 or 20 weeks based on known dates of birth or as determined by physical examination of dental eruption in combination with developmental characteristics according to standardized clinic aging protocols. Body weights were recorded using a digital baby scale.

Weight-based aging guidelines

Observed body weight was compared with that predicted by the weight-based guideline of 1 lb (0.45 kg) of body weight gain per month of age. Weight-based age predictions within 1 week of the known (neonatal kittens) or clinically determined (pediatric kittens) age were considered accurate.

Statistical analysis

Descriptive statistics were calculated for both neonatal and pediatric sample populations. Data were evaluated using the Shapiro–Wilk test for normality. A linear mixed model was used to compare weights between male and female neonatal kittens repeatedly sampled at each time point and a two-sample two-tailed *t*-test (normally distributed data) or Wilcoxon Mann–Whitney test (non-normally distributed data) was used to compare weights for male and female pediatric kittens at each time point. For each group of kittens, a scatter plot was created comparing body weight and age. A linear trendline was plotted and the coefficient of determination (R^2) was calculated. Comparisons were made between predicted ages, based on the 1 lb (0.45 kg) of body weight gain per month of age guidelines, and the kittens' recorded ages. Weight for each kitten was then predicted based on these guidelines and compared with the kittens' actual weights at each age using a one-sample two-tailed *t*-test (normally distributed data) or Wilcoxon Signed Rank test (non-normally distributed data). *P* values <0.05 were considered significant for all analyses.

Results

Neonatal growth rate

A total of 246 SPF domestic shorthair kittens were eligible for inclusion. These kittens comprised 111 females, 115 males and 20 kittens for whom sex was not recorded. Mean body weight increased at each 2 week time point and was higher for male than for female kittens at 6 and 8 weeks of age (*P* <0.001) (Table 1, Figure 1). The coefficient of determination (R^2) between age and body weight in neonatal kittens was 0.88 (y = 8.9x – 0.4, where 'y' is age in weeks and 'x' is body weight in kg); that for females and males alone was 0.81 and 0.83, respectively.

Pediatric growth rate

A total of 1310 kittens between the ages of 6 and 20 weeks were included in the data set (643 females and 667 males). Most kittens were identified as domestic shorthairs (n = 1009 [77.0%]) or domestic longhairs (n = 187 [14.3%]). The remaining kittens were reported to be Siamese (n = 91 [6.9%]), Russian Blue (n = 10 [0.8%]) and Abyssinian (n = 1 [0.1%]), or no breed was recorded (n = 12 [0.9%]). Body weight was higher for males than for females from 10 weeks (*P* = 0.007) through 14 weeks (*P* <0.001) of age (Table 2, Figure 2). The coefficient of determination (R^2) between age and body weight in pediatric kittens was 0.54 (y = 5x + 3.8, where 'y' is age in weeks and 'x' is body weight in kg); that for females and males alone was 0.55 and 0.57, respectively. Four kittens were identified as being 18 weeks of age, resulting in a notably decreased mean body weight than expected for that age; recalculation of R^2 excluding these kittens yielded the same values.

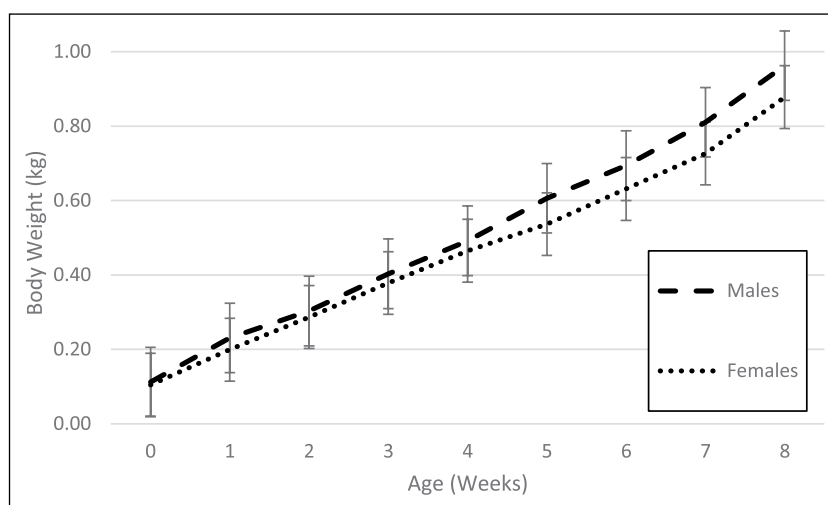### Weight-based age determination of neonatal kittens

Among neonatal kittens, the weight-based guidelines correctly predicted the age within 1 week in 243 (98.8%), 234 (95.1%), 203 (82.5%) and 191 (77.6%) kittens at 2, 4, 6 and 8 weeks of age, respectively. The predicted weight,

Table 1 Distribution of body weight of 115 male and 111 female kittens from birth through 8 weeks of age

Age (weeks)	Weight (kg)*	Male weight (kg)	Female weight (kg)	*P* value (male vs female)
0	0.11 ± 0.02	0.11 ± 0.02	0.11 ± 0.01	1.00
2	0.30 ± 0.05	0.30 ± 0.05	0.29 ± 0.04	0.489
4	0.48 ± 0.10	0.49 ± 0.1	0.47 ± 0.11	0.128
6	0.66 ± 0.12	0.69 ± 0.12	0.63 ± 0.11	<0.001
8	0.92 ± 0.14	0.96 ± 0.14	0.88 ± 0.13	<0.001

Data are mean ± SD
*Column also includes weights from an additional 20 kittens of unknown sex

Figure 1 Mean body weight of 246 neonatal kittens followed from birth through 8 weeks of age

based on the 1 lb (0.45 kg) of body weight gain per month of age guidelines, underestimated the observed weights of female kittens at 2 weeks of age and male kittens at 2, 4 and 8 weeks of age (*P* <0.001). Predicted weight overestimated the observed weights of female kittens at 6 (*P* <0.001) and 8 (*P* = 0.011) weeks of age (Table 3).

Weight-based age determination of pediatric kittens
Among pediatric kittens, the weight-based guidelines correctly predicted the age in 24 (77.4%), 411 (67.5%), 170 (57.0%), 96 (46.6%), 23 (28.8%), 15 (27.8%), one (25%) and five (17.9%) kittens at 6, 8, 10, 12, 14, 16, 18 and 20 weeks, respectively. The predicted weight, based on the 1 lb (0.45 kg) of body weight gain per month of age guidelines, underestimated the observed weights of female kittens at 8 weeks of age (*P* <0.001) and male kittens at 8–14 weeks of age (*P* <0.001) (Table 4).

Discussion
Assessment of body weight, specifically 1 lb (0.45 kg) of body weight per month of age, was an accurate means of determining the age of a majority of kittens through 10 weeks of age. In general, the assessment scale tended to underestimate the age of male kittens.

In addition to its clinical usefulness as part of patient signalment, age is a key determinant of a variety of preventive healthcare protocols, assists the practitioner in advising on behavioral health milestones and is of great interest to pet owners. Data indicate the most common sources of the >94 million pet cats in the USA include sheltering organizations, adoption of strays and acquisition from friends or relatives[15] – sources unlikely to be associated with precise age determination. A national database of shelter animal population dynamics indicates that 47% of shelter cat adoptions in 2017 were comprised of kittens <5 months of age, while another 8% were made up of cats of unknown ages; combined, this equates to nearly 500,000 cats adopted in just 1 year whose true age is likely unknown.[16]

Deviations in age greater than ± 1 week can be considered clinically relevant as they are likely to result in over- or underestimation of age that would impact preventive healthcare protocols such as the timing of vaccination or elective sterilization. Within those parameters, a majority of age estimations based on observed body weights were clinically accurate in a majority of kittens from 2 to 10 weeks of age. Clinically relevant overestimations of age were most frequent at 14 and 16 weeks of

Table 2 Distribution of body weight of 667 male and 643 female kittens between 6 and 20 weeks of age*

Age (weeks)	No. of kittens	Weight (kg)	Male weight (kg)	Female weight (kg)	P value (male vs female)
6	31	0.69 ± 0.14	0.68 ± 0.14	0.71 ± 0.12	0.619
8	609	1.02 ± 0.18	1.01 ± 0.18	1.03 ± 0.19	0.390
10	298	1.22 ± 0.26	1.27 ± 0.31	1.18 ± 0.20	0.007
12	206	1.45 ± 0.34	1.54 ± 0.38	1.36 ± 0.26	<0.001
14	80	1.73 ± 0.43	1.90 ± 0.46	1.55 ± 0.29	<0.001
16	54	1.93 ± 0.46	2.0 ± 0.49	1.82 ± 0.37	0.152
18	4†	1.83 ± 0.24	1.92 ± 0.15	1.54 ± 0.0	–
20	28	2.18 ± 0.40	2.25 ± 0.40	2.13 ± 0.39	0.454

Data are mean ± SD
*Data for 6–14-week-old kittens were not normally distributed
†Group included only one female kitten, precluding statistical comparison between sexes
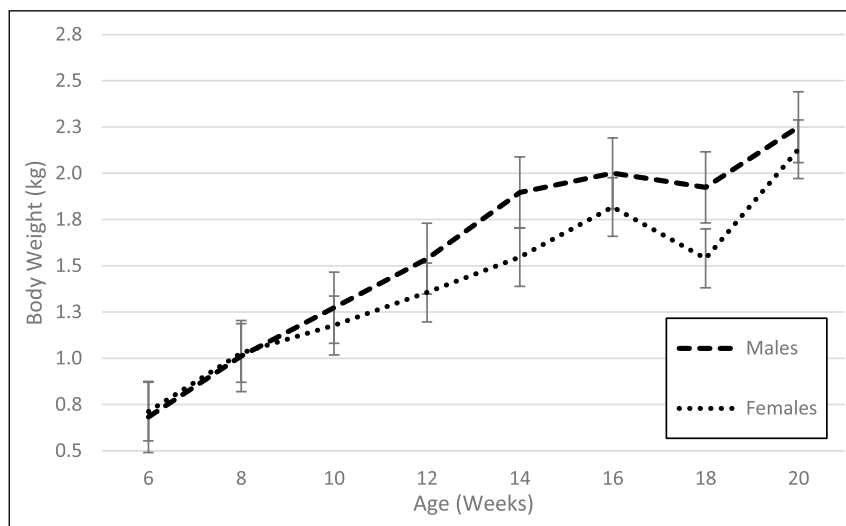
Figure 2 Mean body weight of 1310 pediatric kittens sampled at one time point between 6 and 20 weeks of age

age; clinically relevant underestimations of age were most frequent at 18 and 20 weeks of age (Figure 3). In these latter age groups, sample sizes were small and likely influenced this finding. Individuals aging kittens with the weight-based guideline of 1 lb (0.45 kg) of body weight gain per month of age should be mindful of the potential for these clinically relevant deviations and may wish to adjust their assessment accordingly (ie, decrease the age estimate for kittens between 1.6 and 1.8 kg [3.5 and 4 lb] and increase the estimate for those between 2.0 and 2.3 kg [4.5 and 5 lb]).

Especially in the case of those coming from sheltering organizations, an inaccurate age assessment of kittens can have substantial implications. Underestimation of age can result in delayed initial vaccination owing to concerns about adverse events,[17] thus leaving kittens vulnerable to infectious disease. With standard feline vaccination protocols starting at 4 weeks of age and variation in maternal antibody levels even in kittens from dams with known vaccination history, such risks are not insignificant.[11,18] Despite widespread vaccination in

owned cat populations, shelter cats remain vulnerable to infection and outbreaks of vaccine-preventable infectious disease are regularly reported.[19–21]

Delays in the timing of surgical sterilization are also likely in the event of age underestimation. Standard operating procedures for many shelters and high-quality, high-volume spay–neuter clinics and professional guidelines recommend sterilization as early as 6 weeks of age to optimize both physical and behavioral health benefits of the procedure.[22–24] Age of young feline patients may also influence anesthetic and other pharmacologic protocols as both renal and hepatic function are less developed than that of adults prior to 8 weeks of age.[25,26]

Finally, underestimation of age can prevent the relocation of kittens for adoption or the adoption itself. Published best practices for animal relocation express a minimum age of travel of 8 weeks of age and many state import requirements prohibit the importation of cats less than this age, particularly when unaccompanied by a queen.[27,28] There are also legal restrictions on the age of

Table 3 Growth of 246 neonatal kittens vs predicted weight using the clinical guideline of 1 lb (0.45 kg) of body weight per month of age

Age (weeks)	Predicted weight (kg)	Observed mean weight (kg)	
		Male (*P* value)	Female (*P* value)
2	0.23	0.30 (<0.001)	0.29 (<0.001)
4	0.45	0.49 (<0.001)	0.47 (0.167)
6	0.68	0.69 (0.226)	0.63 (<0.001)
8	0.91	0.96 (<0.001)	0.88 (0.011)

Table 4 Growth of 1310 pediatric kittens vs predicted weight using the clinical guideline of 1 lb (0.45 kg) of body weight per month of age

Age (weeks)	No. of kittens	Predicted weight (kg)	Observed mean weight (kg)	
			Male (*P* value)	Female (*P* value)
6	31	0.68	0.68 (0.674)	0.71 (0.460)
8	609	0.91	1.01 (<0.001)	1.03 (<0.001)
10	298	1.14	1.27 (<0.001)	1.18 (0.064)
12	206	1.36	1.54 (<0.001)	1.36 (0.424)
14	80	1.59	1.90 (<0.001)	1.55 (0.468)
16	54	1.82	2.0 (0.051)	1.82 (0.973)
18	4	2.05	1.92 (0.350)	1.54*
20	28	2.27	2.25 (0.870)	2.13 (0.169)

*Group included only one female kitten, precluding statistical comparison between sexes

adoption in many jurisdictions.[10] As kittens are more likely to get adopted and more quickly adopted than adult cats,[29,30] timing their availability for adoption with the earliest age possible is of utmost importance in minimizing their length of stay in the shelter and maximizing the opportunity for a positive outcome.

Overestimation of kitten age is also not without risk. Most notably, premature cessation of the initial vaccination series could leave a kitten vulnerable to vaccine-preventable illness. Data indicate maternal antibody interference can occur through 20 weeks of age and standard vaccination protocols reflect this possibility.[11,31]

One previous study recording the growth rates of SPF kittens through 17 weeks of age had similar findings to those reported here.[32] Although precise analyses are not provided, that report suggests that the growth rate of male kittens was faster and more directly correlated with age than in female kittens. In that report, strictly relying on body weight tended to underestimate the age of female kittens after approximately 8 weeks. An earlier report also described a faster growth rate in laboratory-reared males as compared with females after 12 weeks of age.[33] Applying the weight-based aging guideline used in the current report to that data set would similarly result in underestimation of the age of female kittens at 12, 20 and 24 weeks of age. A third report describes the growth of 70 laboratory-reared kittens through 7 weeks of age.[34]

Although the impact of sex was not evaluated in that report, growth rate was linear and slower than that predicted by the weight-based guideline used in the current study.

This study has several limitations, particularly related to age determination of the pediatric kittens. The pediatric kittens presenting for elective surgical sterilization originated from a variety of sheltering organizations and, as such, actual dates of birth were often unknown. Consequently, rearing conditions that likely influenced growth including maternal factors, age of weaning, dietary composition, housing and husbandry conditions, and preventive healthcare were all variable. In purebred cats, birth weight may also be affected by breed, although this does not appear to impact the rate of growth during the first 12 weeks of life.[35] The impact of all this variability on the current data is unknown; however, relative concordance with existing growth scales suggests it is minimal. In addition, for the age ranges that overlapped between neonates and pediatric kittens in the current report (ie, 6- and 8-week-old kittens), the mean body weight reported for pediatric kittens fell within the range of that reported for the neonates of the same age (for which these variables were well controlled), suggesting these approximations are reasonable. Body condition score was also not taken into consideration in this report. Over- or under-conditioning could have led to variations in expected body weight. Any such effect would
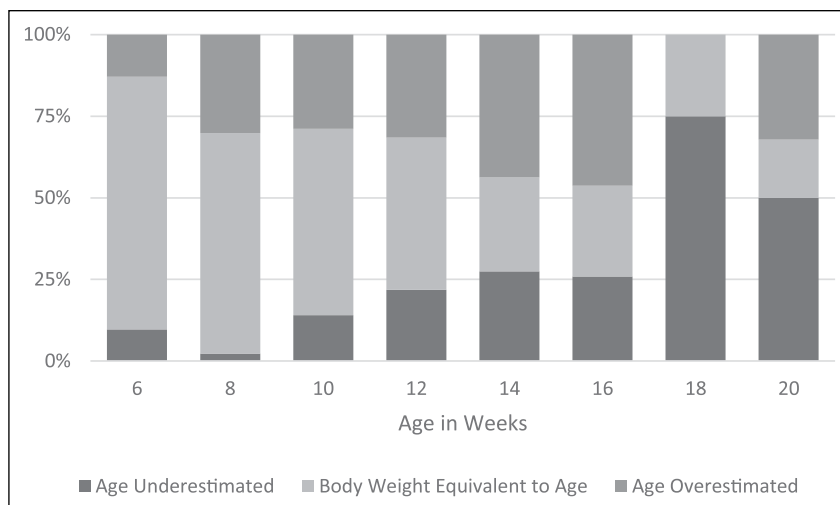
Figure 3 Proportion of clinically relevant differences (ie, >± 1 week) in age predictions based on the body weight of 1310 pediatric kittens

presumably be more likely in the pediatric age group given the variation in source, history and husbandry conditions; however, all kittens in this group were deemed healthy for elective surgical sterilization, so extreme variations that substantially impact these findings are unlikely. Each of the aforementioned variations would be the case for any clinical patient in which the aging scale evaluated would be utilized.

The mechanism for definitive age determination used also warrants cautious interpretation of these findings. In this report, age of pediatric kittens was determined by dentition, developmental characteristics and historical information, and may not have been representative of the true age. In a few cases, actual dates of birth were recorded on the medical record, though this data point was not identified consistently enough to allow for more detailed analysis. Similarly, although consistently determined across the study population, as dental eruption times can vary between individuals the ages assigned may not have represented the true age. Variation in definitive age determination between clinicians was also possible. It is also possible that subjective assessment, if not actual measurement, of body weight played a role in determining the age of some kittens. Presumably, this was most likely to occur in kittens aged at 6, 8 and 18 weeks as no specific dental eruption patterns correspond with these ages in the system utilized. Only four kittens were included in the group determined to be 18 weeks of age, which likely explains the likely artifactual decrease in body weight in this group and may suggest the inclusion of additional 18-week-old kittens in the 16 or 20 week age groups.

Conclusions

Body weight was an effective means of predicting age in kittens through 10 weeks of age, but often either over- or underestimated the ages of older kittens in the study population. Factors other than body weight should be considered when estimating kitten age, particularly in those thought to be beyond 10 weeks of age.

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