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Effects of Nominal Differences in Cage Height and Floor Space on the Wellbeing of Rabbits

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The 8th edition of the *Guide for the Care and Use of Laboratory Animals* recommends a cage height of 16 in. for rabbits, compared with 14 in. in the previous edition. In contrast, the Animal Welfare Act Regulations prescribes a cage height of 14 in. for rabbits. A review of the literature failed to identify published data that support an advantage to rabbits having 16 in. of cage height compared with 14 or 15 in. The study described here evaluated the effect of a 3-in. difference in cage height on the health, growth, behavior, and overall wellbeing of rabbits. Groups of 10 New Zealand white rabbits were housed in cages that provided either 15 in. of interior cage height (720 in^2 of floor space) or 18 in. of interior height (784 in^2 of floor space). The rabbits were observed during 25 periods (1 h each) over 7 wk, and various behavioral parameters were scored. In addition, rabbits were weighed weekly, and general clinical health was assessed. After 4 wk, the groups were switched to the alternate housing. No significant differences in body weight gain or behavioral parameters were detected between groups housed in cages with different heights and amounts of floor space, nor were significant behavioral differences noted in individual rabbits when moved from one cage type to the other. In addition, all rabbits remained clinically healthy throughout the study. These results demonstrate that these differences in interior cage height neither benefit nor harm rabbits.

From the inception of the Animal Welfare Act in 1966, there have been stated expectations for rabbit caging. The original Animal Welfare Act Regulations specified that the floor space needed for each animal was to be based only on the weight of the animal. The space requirements further read, "Primary enclosures shall be constructed and maintained so as to provide sufficient space for the animal to make normal postural adjustments with adequate freedom of movement."[1] There were no stated cage height requirements until amendments to the Animal Welfare Act[2] proposed in 1985 and finalized in 1990 established a requirement of 14 in. for rabbits.[3,4] Revisions to the *Guide for the Care and Use of Laboratory Animals* (the *Guide*) in 1985 also included a recommended cage height of 14 in. for rabbits.[13] The 14-in. height guideline remained until 2011 and the publication of the 8th edition of the Guide,[12] which increased the height recommendation to 16 in.

Although the *Guide* references a performance-based approach,[12] the specific rationale for this recommended increase in rabbit-cage height is unclear. The effect of overall cage size on the behavioral patterns of captive animals has been examined in rabbits and various other species over the years. For example, increasing the cage area 4-fold, from 1904 cm^2 to 7616 cm^2, had no effect on the development of stereotypic digging in gerbils.[21]Studies on the spatial restriction of rabbits revealed that these animals adapt their behavior to their environment.[8] Furthermore, the author of an overview on behavioral deprivation concluded that the restriction of normal behaviors is not indicative of decreased wellbeing of the animal.[7]

The frequency of normal postures and behaviors has been well documented for New Zealand white rabbits.[6,9-11, 14-17,20] A study conducted for the meat industry on the effect of cage height on the growth of Pannon white rabbits, a rabbit similar in size to New Zealand white rabbits, showed that rabbits had a slight preference to open-top pens and preferred to rest in low-profile cages (height,7.9 in.) and that cages offering 11.8 to 13.8 in. of interior height were adequate for normal growth.[18] The current studies were undertaken to evaluate whether a difference in interior cage height, similar to that suggested by the 8th edition of the *Guide* compared with the previous edition, has any behavioral or clinical effect on rabbits suggestive of a benefit or detriment to animal wellbeing.

Materials and Methods

Animals. The subjects for the current study comprised SPF New Zealand white rabbits (n = 20; Harlan, Indianapolis, IN) that were used on an IACUC-approved study of mandible development. In addition to the dietary supplements provided as part of the study on mandible development, the animals were fed 125 g of a commercial feed (High-Fiber Rabbit Diet 5326, Purina Mills International, St Louis, MO) daily. Water purified by reverse osmosis was supplied through an automated watering system to the cages. The room temperature was set at 68 °F (20 °C), humidity was set to a range of 45% to 50%, and a 12:12-h light:dark cycle was provided. All of the rabbits were housed in caging constructed of stainless steel and that met the standards for interior floor square surface area as described in the *Guide* and the Animal Welfare Act Regulations; however, interior cage heights and other dimensions were of 2 types. The shorter caging (Suburban Surgical Company, Wheeling, IL) measured 24 in. wide × 30 in. deep × 15 in. high (720 in^2 of floor area), whereas the taller cages (Allentown Caging, Allentown, NJ) measured 28 in. wide × 28 in. deep × 18 in. high (784 in^2 of floor area). The collection pans underneath the cages were lined with DeoSorb (Shepherd Specialty Papers, Watertown, TN) which was changed twice weekly. The entire cage was changed and sanitized biweekly. The racks were situated to allow visual, auditory, and olfactory stimulation for all rabbits

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Category and subcategory	Behavior	Description
1	Sleeping or dozing	Eyes closed or party open
2	Inactive or alert	Lying alert with forelegs extended
2a	Sitting	Forelimbs tucked under body
2b	Sitting up	Chest or abdomen are clear from the floor with ears either erect or down
2c	Stretched out	Forelimbs and hindlimbs are extended
3	Ambulating or walking calmly around the cage	Movement around the cage
3a	Chin mark	Rubbing chin on caging
3b	Frisky hop	Rapid circling followed by shaking, head toss, and so forth
4	Eating or drinking	Food or water consumption
5	Stereotypies	Abnormal repetitive behaviors
5a	Coprophagy	Eating of feces, other than night feces
5b	Hair chewing	Nibbling of fur, distinguished from normal grooming by repetitiveness and occasional hair pulling
5c	Head sway	Repeatedly moving the head back and forth
5d	Nose slide	Sliding the head up and down with the nose pressed between the cage bars
5e	Licking objects	Obsessive licking of objects
5f	Pawing or digging	Pawing or digging at cage
5g	Excessive thumping	Chronic hind leg thumping
5h	Head in corner	Facing the back of the cage with the head lowered
5i	Hunched	Back hunched, not relaxed
5j	Chewing only	Chewing movements but not on objects
6a	Play or active	Movements other than ambulation
6b	Chewing	Gnawing, biting, pulling on objects in the environment
6c	Grooming	Licking fur, using teeth to comb through hair, or using forepaws to clean face
6d	Nose pressing	Nose pressed between bars but not sniffing
6e	Nudging	Pushing objects in the cage with head
6f	Roll	Rolling onto back or completely over
6g	Scratching	Using hind legs for scratching
6h	Shaking	Body or head shaking
6i	Snuffle	Sneezing bouts
6j	Sniffing	Sniffing the air throughout the enclosure and through the bars of the cage front
6k	Rearing	Leaning back fully or half way with the front paws off of the floor
6l	Stretching	Rabbit extends forepaws forward with the head tipped
6m	Thumping	Hindleg stomping

This chart was adapted from the inventory of behaviors described in reference 9.

Figure 1. The list used for scoring the rabbits' behaviors during the observation sessions.

in the room. Animals were housed individually as part of the IACUC-approved study on mandible development. Throughout the study, all of the rabbits were anesthetized biweekly for a CAT scan of the jaw, specifically the temporomandibular joint. A 10:1 mixture of ketamine and acepromazine (10 parts ketamine 100 mg/mL and 1 part acepromazine 10 mg/mL) was used at a dose of 0.3 mL, given intramuscularly.

Ten rabbits were housed in cages offering 15 in. of interior height, and 10 rabbits were housed in cages offering 18 in. of interior height. Both groups were evaluated for a total period of 7 wk. The rabbits were in 2 groups: group 1 spent the first 4 wk of the study period in the taller caging and the final 3 wk in the shorter caging. Conversely, group 2 rabbits spent the first 4 wk in the shorter caging and the last 3 wk in the taller caging. When moved to the other caging type, rabbits were placed in the same position on the rack to avoid introducing another variable.

Observations. Observed behaviors were placed into 1 of 6 categories according to a previously developed ethogram[9] (Figure 1). The categories used were: sleeping (category 1); inactive, but alert (category 2); movement (category 3); eating or drinking (category 4); stereotypies (category 5); and play (category 6).

Play is defined as behaviors that are stimulating to the animal, such as interaction with environmental enrichment items or chewing behaviors. Stereotypies are behaviors that are intentional and repetitive but nonfunctional.[5] According to these definitions, we classified chewing as a normal activity and play behavior, although chewing was a considered a stereotypy when it was excessive (that is, accounted for more than 10% of the observed behavior time). Other stereotypic behaviors included coprophagy (other than night feces), hair chewing, head sway, nose slide (along the cage wall), excessive licking of objects, pawing or digging, excessive thumping or foot stomping, head tucking, and hunched posture. We presumed that the most common normal postures would be lying in a full or partial stretch or sitting on all 4 limbs, both of which were feasible in either cage system. In addition, behaviors categorized as inactive but alert included lying alert with forelegs extended, sitting with forelimbs tucked under the body, sitting up with the chest or abdomen clear of the floor, and stretched out with forelimbs and hindlimbs extended.

A team of 4 trained observers monitored rabbit behavior. Specifically, behaviors were recorded at 10 time points for each animal during each hour, with a total of 25 h recorded for each rabbit. The observations were made in 1-h intervals with the observers sitting in the rooms for a 15-min acclimation period prior to each session. A total of 250 behaviors were recorded for each rabbit over the 7-wk study. Observations were made between 0700 and 1900. The rabbits were housed in 4 racks, 2 of each type, and were positioned such that the observer could visualize all racks from the chair that was place approximately 4 ft from the racks. Behaviors were recorded in the following categories: sleeping; inactive but alert; locomotion within the

cage; eating or drinking; active play; and stereotypies. Behavioral observations were tabulated for 2 time intervals, weeks 1 through 4 and 5 through 7.

To establish the benefits of the additional floor space and 3 in. of cage height afforded by the taller cages, rabbits were evaluated 4 times weekly for: contact of the tips of the pinnae with the cage ceiling (scored as yes or no); evidence of trauma to the pinnae (recorded as none, mild [tips abraded], moderate [ongoing abrasion, infection], or severe [loss of tips, ongoing open lesions with or without infection and necrosis]); appetite (scored according to the amount of the feed portion that was consumed—full, 3/4, 1/2, 1/4, or none); general demeanor (recorded as normal, cautious, lethargic, or aggressive); and overall clinical health. In addition, body weight was measured weekly, with weight gain calculated for each rabbit during weeks 1 through 4, 5 through 7, and 1 through 7.

Data evaluation. Body weight data were compared (Prism 6, GraphPad Software, San Diego, CA) between groups by using the paired 2-tailed *t* test. Differences were considered to be significant when the *P* value was 0.05 or less. Data for behavioral observations were analyzed by using the paired 2-tailed *t* test, with differences considered to be significant when the *P* value was 0.05 or less. In addition, each behavior type was evaluated as a percentage of the total observed behaviors so that relative frequency could be compared readily.

Results

Evaluation of body weight demonstrated that all rabbits gained weight over the course of the study; however, there were no significant differences in weight gain over any time interval (weeks 1 through 4, 5 through 7, and 1 through 7) between rabbits housed in the 2 cage types. The average weight of the rabbits was 3295 g at the start of this study and 3417 g at the end, yielding an average weight gain of 3.68%. The weight gain remained consistent throughout the 7-wk study (Figures 2 and 3). There were no observed events of pinnae touching the tops of the cages and no trauma to the pinnae; and the rabbits' appetite, general demeanor, and clinical health were all normal for the entire study period, with no changes noted when rabbits were moved between caging types.

Behavioral observations were tabulated for 2 intervals, weeks 1 through 4 and 5 through 7. At the end of week 4, the rabbits were switched the alternate caging type. Group 1 (rabbits ND21 through ND30) was housed first (weeks 1 to 4) in the taller caging, whereas group 2 (rabbits ND31 through ND40) was housed in the shorter caging first. Rabbits in both caging types demonstrated a wide behavioral repertoire that was generally consistent across both caging types. The most common behavior noted was inactive but alert (38%). The other commonly reported behaviors were sleep (19%) and active or play (19%; chewing, biting, and pulling on objects in the environment; grooming using teeth to groom fur or licking coat or using forepaws to clean face area; nose pressing between the bars; nudging objects in the environment with the head, rolling onto the back or over completely; scratching with hindlegs; body and head shaking; rearing fully, half way, or leaning back with the forepaws off of the floor; stretching the front paws forward with its head tipped back or a cat like stretch; and thumping with hind legs). Stereotypies were the least reported behaviors, with an average of only 2% of the total behaviors. The occurrence of the behaviors seen with both cage designs was consistent with published data.[6]

When switched from one cage type to the other, 6 of the rabbits displayed some changes in behavior, but the changes

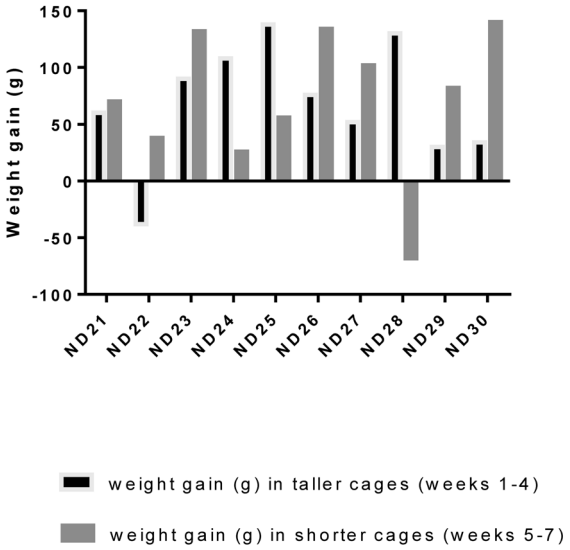

Figure 2. Weight gain of the rabbits in group 1, which initially was housed in the taller cages. A 2-tailed unpaired *t* test revealed no significant difference in weight gain in this group between the 2 cage heights.

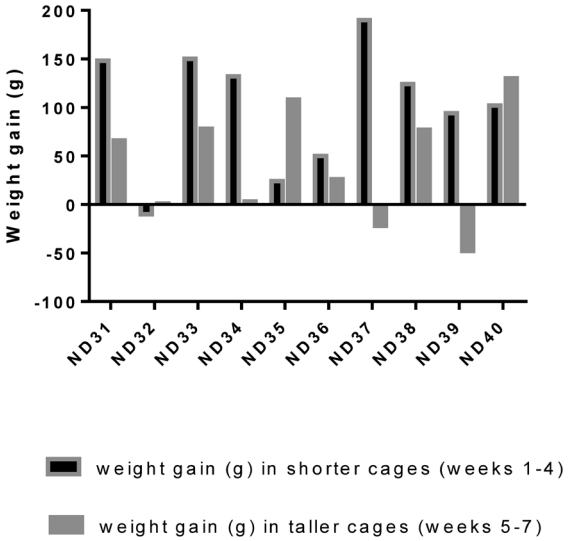

Figure 3. Weight gain of the rabbits in group 2, which initially was housed in the shorter caging. A 2-tailed unpaired *t* test revealed no significant difference in weight gain in this group between the 2 cage heights.

were not consistent across animals, and the differences were not significant. Specifically, group 1 rabbits ND22 and ND23 demonstrated more play activity while in the taller cages compared with the shorter caging. In addition, rabbit ND22 showed more sleep and less stereotypy, and ND23 showed less sleep and more movement around the cage when moved to the shorter caging. Group 2 rabbits ND31, ND33, ND34, and ND37 exhibited nonsignificant changes in behavior when moved from the shorter to taller caging; these changes were not consistent within the group. For example, in the inactive but alert category, 2 of the group 2 rabbits demonstrated more inactive but alert behavior, whereas one had no change and the other had a decrease in that category. Furthermore, active play increased in 2 of the group 2 rabbits but decreased in the other 2 when these animals were moved to the taller caging. In addition, 2 of the rabbits showed a change in stereotypies, one an increase and the other a decrease. Therefore, the overall comparison of behaviors revealed no significant difference between cage types (Figures 4 and 5).

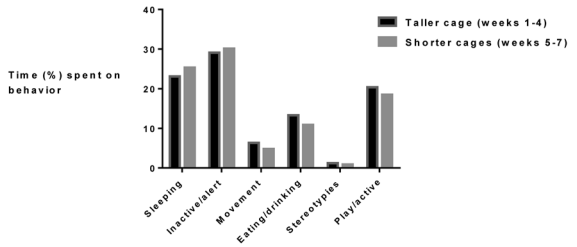

Figure 4. The percentage of time that the rabbits in group 1 exhibited various behaviors did not differ between when they were housed in taller cages (weeks 1 through 4) compared with (2-tailed unpaired *t* test) shorter caging (weeks 5 through 7).

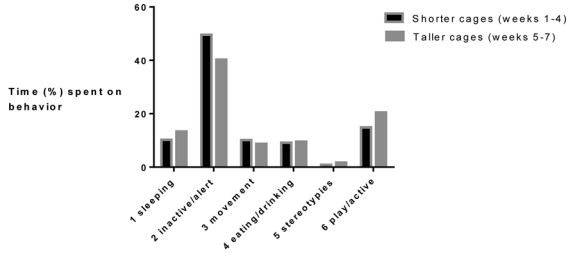

Figure 5. The percentage of time that the rabbits in group 2 exhibited various behaviors did not differ between when they were housed in shorter cages (weeks 1 through 4) compared with (2-tailed unpaired *t* test) taller caging (weeks 5 through 7).

Discussion

The study described here was undertaken to evaluate the effect of a 3 in. difference in cage height on the wellbeing of rabbits. All of the rabbits appeared to thrive throughout the study. They consistently gained weight and showed no signs of trauma or abrasions to the ears. Appetite, general demeanor, and clinical health of the rabbits all remained normal. The additional 3 inches of height offered by the taller cages neither benefitted nor harmed the rabbits.

Given the broad behavioral repertoire noted for rabbits in our study, it seems reasonable that altering cage dimension might influence the ethogram. Doubling cage volume has been shown to reduce fecal corticosterone, which was interpreted as evidence of reduction of chronic stress.[19] In contrast, the data presented here indicate that, according to behavioral and clinical criteria, a 3-in. difference in cage height and size does not affect the wellbeing of rabbits within the limits tested. These data suggest that, from a performance standpoint, this nominal difference in cage height is unlikely to enhance the wellbeing of rabbits similar to those used in the study described here.

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