Effect of dietary water intake on urinary output, specific gravity and relative supersaturation for calcium oxalate and struvite in the cat

Catherine M. F. Buckley, Amanda Hawthorne, Alison Colyer and Abigail E. Stevenson*

Waltham Centre for Pet Nutrition, Freeby Lane, Waltham-on-the-Wolds, Melton Mowbray, Leicestershire LE14 4RT, UK

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Abstract
It has been reported that daily fluid intake influences urinary dilution, and consequently the risk of urolithiasis in human subjects and dogs. The aim of the present study was to investigate the role of dietary moisture on urinary parameters in healthy adult cats by comparing nutritionally standardised diets, varying only in moisture content. A total of six cats were fed a complete dry food (6.3 % moisture) hydrated to 25.4, 53.2 and 73.3 % moisture for 3 weeks in a randomised block cross-over design. Urinary specific gravity (SG), urine volume, water drunk and total fluid intake were measured daily; relative supersaturation (RSS) for calcium oxalate (CaOx) and struvite was calculated using the SUPERSAT computer program. Cats fed the 73.3 % moisture diet produced urine with a significantly lower SG ($P < 0.001$) compared with diets containing 53.2 % moisture or lower. Mean RSS for CaOx was approaching the undersaturated zone (1.14 (SEM 0.21); $P = 0.001$) for cats fed the diet with 73.3 % moisture and significantly lower than the 6.3 % moisture diet (CaOx RSS 2.29 (SEM 0.21)).

The effect of diet on struvite RSS was less clear, with no significant difference between treatment groups. Total fluid intake was significantly increased ($P < 0.001$) in the 73.3 % moisture diet (144.7 (SEM 5.2) ml, or 30 ml/kg body weight per d) compared with the 6.3 % (103.4 (SEM 5.3) ml), 25.4 % (98.6 (SEM 5.3) ml) and 53.3 % (104.7 (SEM 5.3) ml) moisture diets, despite voluntary water intake decreasing as dietary moisture intake increased. Cats fed the 73.3 % moisture diet had a higher total daily fluid intake resulting in a more dilute urine with a lower risk of CaOx when compared with the lower-moisture diets.

Materials and methods
A panel of six healthy neutered adult cats was studied, consisting of three males and three females, ages ranging from 2 years and 7 months to 6 years and 9 months. The experimental procedures were approved by the WALTHAM® (Melton Mowbray, Leicestershire, UK) ethical review committee. A single batch of complete and balanced dry diet was used in the present study (6.3 % moisture) and this was soaked with de-ionised water where necessary to achieve dietary moisture

Abbreviations: CaOx, calcium oxalate; RSS, relative supersaturation; SG, specific gravity.

* Corresponding author: A. E. Stevenson, fax +44 1664 415440, email abigail.stevenson@effem.com
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The key findings from the present study were that high dietary water intake is related to a significant increase in urine volume, reduction in SG and decrease in CaOx RSS, demonstrating a beneficial effect of high-moisture diets on cat urinary parameters.

Results

The effect of phase was found to be non-significant and was subsequently dropped from the model. The interaction effect of day × diet was not significant overall for SG, water drunk, urine volume and water intake and was therefore dropped from the model. Over the course of the present study, the cats showed a mean increase in body weight of 8·03 ± 3·16%, despite being offered only 188·3 ± 5·4 kJ/kg per day (45 kJ/kg per kg). Faeces quality was excellent, with 100% of faeces voided being acceptable across each phase.

As dietary moisture level increased, the cats compensated by significantly reducing the amount of water they drank voluntarily. There was a significant increase in total water intake (P < 0·001) for the diets with 73·3% moisture compared with all other diets. For the highest moisture diet, mean total water intake was 144·7 (SEM 5·2) ml or 30 ml/kg body weight per day compared with 103·4 (SEM 5·3), 98·6 (SEM 5·3) and 104·7 (SEM 5·3) ml for the 6·3, 25·4 and 53·3% moisture diets, respectively (Fig. 1).

The average 24 h urine volume produced by cats fed the diet containing 73·3% moisture was 86·7 (SEM 6·9) ml, which was significantly higher than all other diets (P < 0·001). Average urine volume did not differ significantly for any of the other diets (P > 0·05).

Mean 48 h urinary pH showed no statistically significant differences according to the diet group (6·22 (SEM 0·053); 6·23 (SEM 0·034); 6·24 (SEM 0·061) and 6·19 (SEM 0·042), respectively for the treatment groups as described previously). For SG, the day × diet interaction was added as a fixed effect to investigate whether any effect of diet changed from day 8 to 21. Adjustments for the water drunk, as a covariate, were investigated but dropped from the model as appropriate. To allow for a six pairwise comparison of the data, a Bonferroni correction was made and is included where it alters the data interpretation. Statistical analyses were performed using Statgraphics Centurion XVI and GenStat® version 12.2 statistical software.

Discussion

The key findings from the present study were that high dietary moisture level increased, the cats compensated by significantly reducing the amount of water they drank voluntarily. There was a significant increase in total water intake (P < 0·001) for the diets with 73·3% moisture compared with all other diets. For the highest moisture diet, mean total water intake was 144·7 (SEM 5·2) ml or 30 ml/kg body weight per day compared with 103·4 (SEM 5·3), 98·6 (SEM 5·3) and 104·7 (SEM 5·3) ml for the 6·3, 25·4 and 53·3% moisture diets, respectively (Fig. 1).

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The data from the present study show that water intake alone has a strong influence on urine parameters. This is in agreement with Gaskell\(^5\) who demonstrated that addition of water to a semi-purified diet to achieve a moisture level of 75% produced a similar water intake and urine SG to the present study. Increasing water intake has been identified as an important strategy in the management of patients with urolithiasis, primarily because of its role in increasing urine volume. The effect of this is a decrease in saturation through dilution of calculogenic material\(^7\), and an increase in the minimum supersaturation required to elicit initiation of crystallisation\(^8,9\), and these benefits outweigh the potential negative effects of dilution of inhibitors of crystallisation or growth\(^10\).

In the present study, each dietary moisture level would have offered the same calculogenic load, because the cats were offered the same amount of food differing only in the levels of water added. This suggests that any effects observed on urine can be attributed to varying degrees of urine concentration as dietary moisture levels are altered, rather than any nutritional differences.

When considering the natural behaviour of the cat’s ancestor, much of their daily water requirement is obtained from their prey (which typically contains 70–75% moisture) and cats have evolved to drink very little water. As a result, cats naturally have a very low thirst drive and are therefore slow to respond to changes in their hydration state. This reluctance to adapt their voluntary water intake sufficiently is illustrated in the present study where cats fed the dry diet (6.3% moisture) consumed approximately 30% less water overall compared with cats fed on the highest-moisture diet, despite the dry-diet group increasing their voluntary drinking by approximately sixfold in comparison. This behaviour puts cats at a higher risk of lower urinary tract disease when fed low-moisture rations. A. E. S. and A. H. conducted the study.

The significant reduction in CaOx RSS in cats fed the high-moisture diet demonstrates that increased water turnover is of real benefit in cats. In terms of the biological relevance of the observations made in the present study, the high-moisture diet resulted in the production of urine approaching the undersaturated zone for CaOx RSS, which is defined as \(< 1\), reducing the risk of both homogeneous and heterogeneous CaOx crystallisation\(^11\). The other diets resulted in mean CaOx RSS values ranging from 1.99 to 2.29, classified as within the metastable zone (RSS = 1–12), indicating that new CaOx stone formation in these cats is possible if fed these diets in the long term. The present study was underpowered, and it is expected that statistically significant differences in struvite RSS would be found in the highest-moisture diet in a suitably powered study. Since literary evidence shows that urinary pH correlates with struvite RSS\(^12\), the lack of significant differences in urinary pH across dietary groups in the present study may explain the similar findings for struvite RSS and indicates that urinary pH may be a more important driver of struvite RSS than SG.

References