PURINA Institute

Advancing Science for Pet Health

HYDRATION IN PETS

Strategies To Manage Water Balance In Cats And Dogs

Water is an essential nutrient and is considered the nutrient most critical for survival. Losses in body water of just 10-15% can cause death, with animals able to tolerate much higher fat or protein losses.[1]

Several methods exist for estimating water requirements for cats and dogs. In general, healthy pets can self-regulate their water intake to match losses and meet their needs.[1] However, whether this is 'optimal water intake' or whether such pets are 'optimally hydrated' is not clear. Research in humans suggests that even mild dehydration (<3% of body weight) can affect performance and cognition.[2-5] It is not yet known whether this is the case in pets.[6]

There are a number of recognized indications, such as urolithiasis, where pets may benefit from a higher water intake via increased drinking, and there may be additional indications.[6] Some research has evaluated the effects of increased water intake on hydration indices as well as the efficacy of methods to increase intake. However, a greater understanding of hydration and how its status affects overall health and well-being in cats and dogs is desired.[6,7]

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WATER AS AN ESSENTIAL NUTRIENT AND WELFARE REQUIREMENT

Water has many essential functions in the body. Water is the solvent in which many of the body's chemical reactions take place, and it makes up the fluid portion of blood, transporting nutrients including oxygen, and metabolic waste products. Water helps regulate body temperature and supports digestion of food and elimination of waste via urine and feces.[1,8]

A number of authorities in some markets, e.g., UK, US, New Zealand, and Australia, also consider water to be a 'welfare requirement'.[9-12] The World Small Animal Veterinary Association (WSAVA) recommends adhering to the Five Animal Welfare Needs, an animal welfare framework that under the provision of 'a suitable diet' requires access to fresh, clean water.[13] The Five Animal Welfare Needs were developed as a part of the Animal Welfare Act of 2006 in the UK.[9] In the United States, the USDA recently published a new ruling (May 2020) updating a requirement such that dogs should have 24 hour access to drinking water.[10]

TOTAL BODY WATER

Reported values for total body water in dogs and cats as a percentage of body weight have ranged from a surprising 37% in a Husky to approximately 80% in newborn kittens. Values have varied depending on age, breed, methods used, and amount of body fat (where water as a percentage of body weight decreases with increasing body fat).[14-23] Since intracellular water is almost exclusively in lean body mass rather than in fat, a relative increase in body fat results in a decrease in water as a percent of body weight.[17,18,24,25] Several Purina studies showed that total body water averaged approximately 60% of body weight in lean adult cats and dogs.[17,18] About two thirds of total body water is found intracellularly and one third extracellularly, but water is always in a state of flux. Extracellular fluid includes blood plasma and interstitial fluid.[24] Total body water is maintained as the balance between water intake and water losses.

WATER INTAKE IN PETS

Water intake includes:

- Free water, or the water that the pet drinks; healthy pets typically self-regulate their intake to maintain homeostasis.[1]
- The water found in food, which is also referred to as the 'moisture content'.

  Moisture content in commercial canned food can be as high as 80-85% while commercial dry food usually contains less than 10% water.[8]

- Metabolic water, produced in the body via oxidation of energy-containing nutrients.[1]

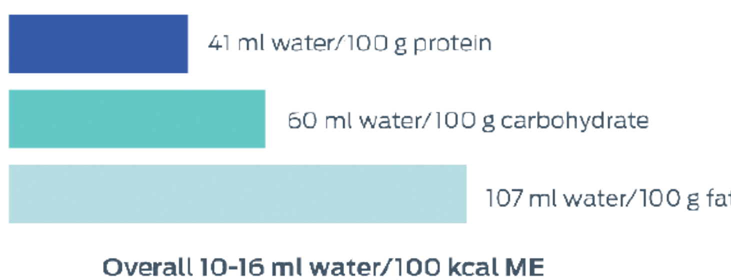


Figure 1:
Amount of water produced via oxidation of energy-containing nutrients[1]

An individual pet's water intake requirements can be estimated based on the following criteria:[1]

- Body weight – 50-60 ml/kg/day.
- Food intake on dry matter basis – 2-3 ml/g food (dry matter)/day.
- Food intake on energy basis – approximately 1:1 ratio of ml water to kcal metabolizable energy (ME) consumed.

FACTORS AFFECTING FREE WATER INTAKE IN CATS AND DOGS

Several factors, including diet, environment, and activity level may affect a pet's voluntary water intake. Drinking is stimulated by eating, whether with the number of meals or the quantity of food, but also the specific nutrient content of the diet affecting free water intake.[1,26-29]

A study found that when cats were fed the same calories but divided into 2 or 3 meals per day, they drank more than when they were fed the same calories but in just one meal.[29] Another study showed cats fed *ad libitum* had a higher food and water intake than when fed once daily.[26] Research in dogs has shown post-prandial free water intake increases when fed a higher quantity of food and when fed higher carbohydrate foods.[27,28] In cats, increased dietary protein results in increased water intake,[30] while research has shown that increased dietary sodium (provided as sodium or sodium chloride) increases free water intake in both cats and dogs (see further discussion under *Methods To Increase Total Water Intake In Pets*).[31-35]

Cats and dogs adjust their free water intake dependent on the moisture content of their food, consuming less free water as food moisture increases. There appears to be an upper limit above which they cannot further decrease free water intake. It has not been clearly established whether a species difference exists in how cats and dogs adapt to water in their food (see further discussion under *Methods To Increase Total Water Intake In Pets*).[8,35-39] A pet also may increase its voluntary water consumption to compensate for increased water losses secondary to high ambient temperatures or high activity, e.g., working dogs.[1]

Although most cats maintain normal hydration, several unique factors may contribute to low water intake in cats:

- Cats evolved as obligate carnivores, eating wild prey, such as birds and mice. The moisture content of prey is typically high (approximately 70%)[40], and in general prey is more palatable than water. With the prey contributing moisture, little if any free water intake is needed to meet a cat's daily water requirements.[41]
- Cats have a lower physiological thirst drive than dogs.[8,35,42] They are able to concentrate their urine to a greater degree than dogs, which helps to conserve water.[8,35] Dogs begin to drink and will replace a water deficit more rapidly than cats.[35]
- In multi-pet households when sharing a drinking bowl, cats may feel at risk of being attacked by another pet in the home and may be less likely to drink. Veterinarians may recommend using multiple water bowls and avoiding placement of bowls in room corners in these households.
- Since a cat's ability to focus on an object closer than 25 cm away is poor, a cat may have trouble seeing the surface of still water in a bowl.[43]

Decreased water intake can be a risk with senior dogs and cats,[6,44,45] and those recovering from surgery or illness who may be less inclined to drink. High activity working dogs or other very active dogs may not meet their water needs if not specifically encouraged to drink by their handler or owner.[46] A low water intake is also a risk if pets are not provided access to fresh water, or are outdoors in cold climates where the water supply is allowed to freeze.

WATER LOSSES IN PETS

Water is lost from the body via several routes:

- Urine is the primary way water is lost. It includes

  Obligatory (solute-driven) water loss – *affected by the amount of food consumed and the nutrients in the food, e.g., protein and minerals.*

Free (facultative) water loss – *regulated by arginine vasopressin in response to plasma osmolality (see discussion of water balance in next section).*[1,8]

- Feces.[1,8]

Research has found that relative amounts of water excreted in the urine and the feces are affected by the energy content, fat content, and digestibility of the diet in cats. A more energy-dense, higher fat, or highly digestible diet leads to a lower dry matter food intake, lower fecal water, and a higher proportion of water lost in urine.[8]

- Insensible water losses, i.e., evaporation during respiration, especially panting in dogs or grooming in cats, their primary cooling mechanisms.[1,8]

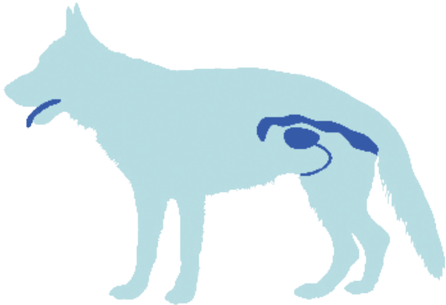


Figure 2:
Routes of water loss in dogs – urine, feces, and panting

High water losses may be associated with specific health or environmental conditions:

- Vomiting or diarrhea.[24]
- Chronic kidney disease – dehydration may be an issue in pets with existing chronic kidney disease and also a risk factor for its development.[47,48]
- Diabetes – glucosuria increases obligatory urinary water losses.[49]
- Loss of blood or plasma.[24]
- High ambient temperatures due to increased respiratory losses.[35]
- Working or sporting dogs through increased panting.[8]

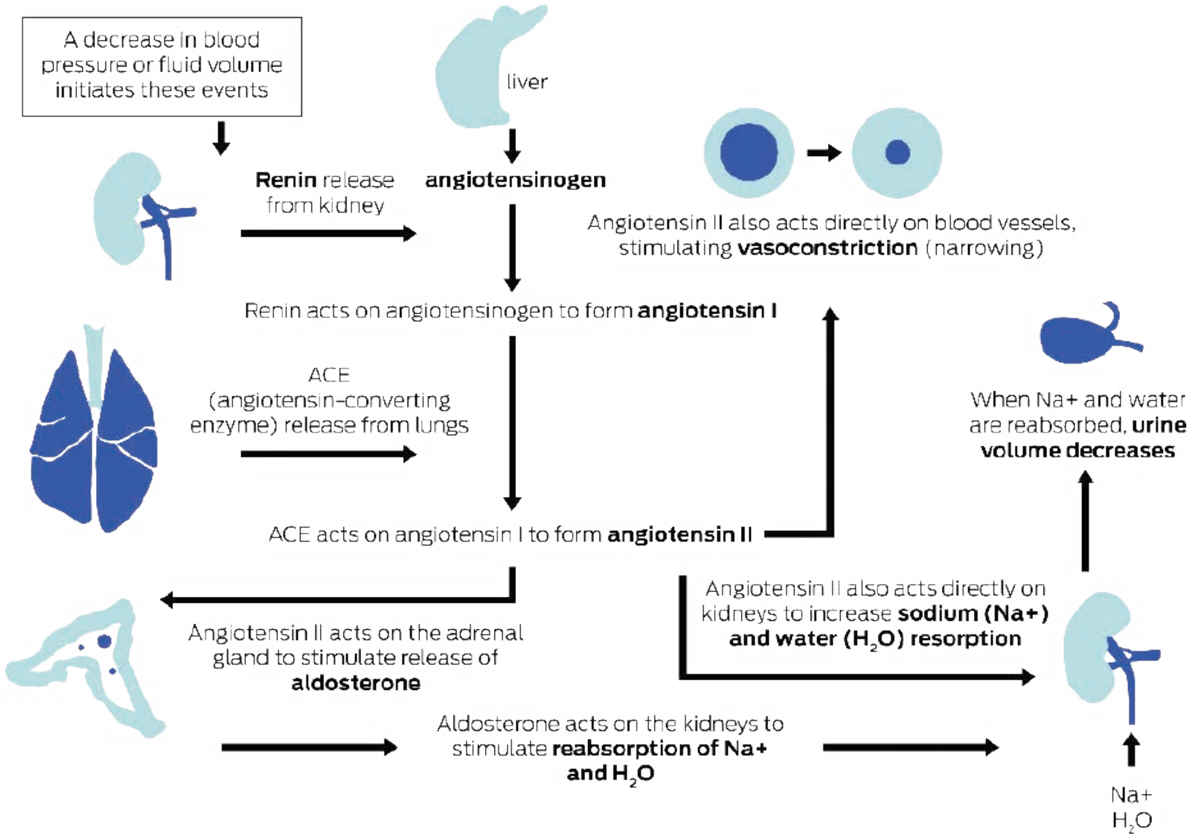
REGULATION OF WATER BALANCE

Water balance is defined as water intake minus losses.[1,8] Healthy pets can typically self-regulate their water intake to match losses.[1] Water balance is regulated in the body by several hormones that respond to changes in blood volume or osmolality. This regulation involves primarily arginine vasopressin (AVP, also known as vasopressin or antidiuretic hormone) and the renin-angiotensin-aldosterone system.

Plasma osmolality is influenced mainly by the concentration of sodium and to a lesser degree by glucose and urea concentrations.

Increased plasma osmolality stimulates thirst, which increases water intake, and also triggers the release of AVP from the pituitary gland. AVP enhances water resorption by the renal collecting tubules, thereby helping to normalize plasma osmolality while decreasing urine production and producing a more concentrated urine. Decreased blood volume also causes the release of AVP which constricts arteries and raises blood pressure. However, the primary response to changes in blood volume is mediated by the renin-angiotensin-aldosterone system. A drop in blood volume or pressure lowers renal perfusion which is sensed by the juxtaglomerular cells causing the enzyme renin to be secreted. Renin converts angiotensinogen to angiotensin I. Angiotensin converting enzyme then converts angiotensin I to angiotensin II. Angiotensin II stimulates the adrenal cortex to release aldosterone, which causes the distal renal tubules to retain sodium and subsequently conserve water (resulting in decreased urine volume). Angiotensin II also has direct effects on the proximal renal tubules, increasing sodium and thereby water resorption at the proximal tubules, and raises blood pressure by constricting arterioles.[1,8,25,50]

Figure 3:
Renin-angiotensin-aldosterone system



ASSESSING HYDRATION IN CATS AND DOGS

Several methods are used to assess hydration in clinical practice. These include evaluation of a pet's capillary refill time; feel of the mucous membranes, i.e., tacky (sticky) or moist, cold or warm to the touch; skin tent time; hematocrit, and urine specific gravity (USG, a measure of urine concentration).

A Purina study evaluated several of these hydration assessment methods in exercising working dogs with the goal of identifying a sensitive method that could be performed in the field by non-veterinary staff. The scientists found that skin tent time, but not capillary refill time, was a reliable and easy-to-perform indicator of hydration in these exercising dogs to assess very mild levels of dehydration of approximately only 1% loss of body water (measured as acute body weight loss).[46] Ultimately, this is valuable as it provides a convenient and sensitive method to facilitate earlier intervention for rehydration in order to minimize progression of dehydration to a more severe state while in a field setting. Research has also shown that USG varies widely in healthy dogs. A wide range of 'normal' values can occur – both over the course of the day in an individual dog and among dogs,[51,52] which can be a potential confounding factor in defining 'optimal hydration' status.

Methods of assessing hydration used in a research/ laboratory setting (all of which are non-invasive) include quantitative magnetic resonance imaging (QMR), deuterium oxide dilution, and dual-energy x-ray absorptiometry.[17,18,53] However, while these offer excellent research tools, these are not currently viable clinical tools.

INDICATIONS FOR INCREASING WATER INTAKE IN PETS

Dehydration, or a negative water balance, can occur in pets with a decreased water intake, increased water losses, or both. While increasing water intake is beneficial in affected pets or those likely to become dehydrated (e.g., pets exercising in high ambient temperatures), a general recommendation to increase water intake is also often made for pets with urolithiasis and cats with idiopathic cystitis.[54-56] Consumption of low moisture diets has been shown to be a potential risk factor for urolithiasis in dogs and cats.[57-59]

The primary goal behind increasing water intake is the production of larger amounts of more dilute urine, resulting in a reduction in the relative super-saturation (RSS) of urolith-forming minerals and the concentration of other irritating substances in the urine. Increased water consumption also may increase voiding frequency, shortening the length of time compounds remain in the bladder to form uroliths or cause irritation.[56,60]

Increased water intake is also recommended for cats prone to constipation,[61] as this helps to soften the stool.

METHODS TO INCREASE TOTAL WATER INTAKE IN PETS

Various methods have been utilized to increase water intake in cats. Although cats will drink more free water when eating dry food compared to eating wet food to compensate for the lower moisture content in dry food, they may have a lower total daily water intake (a lower water to calorie ratio) when eating dry food.[35-37,62] A number of studies suggest that dietary moisture levels greater than 70-75% (a canned diet or food with added water) result in increased water throughput.[37,62,63] One study showed that cats fed a 70% 'hydrated' diet (dry diet with added water) produced an increased volume of a more dilute urine than cats fed the dry diet.[63] A second study in which voluntary water intake was also measured showed that cats fed a canned diet (82% moisture) or a 70% hydrated diet had a significantly higher water intake, greater urine volume, and a more dilute urine than cats fed the dry diet (3% moisture).[62] Researchers in another study measured total daily water intake in healthy cats fed a dry diet (6.3% moisture) or the same dry food with varying amounts of added deionized water (producing hydrated diets of 25.4, 53.2, and 73.3% moisture). Results showed that cats eating the 73.3% moisture diet had a significantly increased total daily water intake and a decrease in USG and calcium oxalate RSS.[37]

A diet with increased levels of sodium is another method to encourage drinking. Diets with increased levels of sodium[32] or sodium chloride (salt)[31,33] have been shown to boost water intake in cats while increasing urine volume and/or decreasing USG. A Purina study found that cats fed a diet with an increased level of salt produced significantly higher urine volumes and had an increase, though not statistically significant, in water intake.[64] Other research showed cats fed dry diets with increased levels of sodium had significantly lower calcium oxalate RSS than cats fed lower sodium diets.[32] Another study found both calcium oxalate and struvite RSS were significantly lower in cats fed dry diets with increased levels of salt compared to cats fed lower salt diets.[33] Despite potential health concerns with such diets in humans, research has demonstrated that increased levels of sodium[32] or salt[31,65-69] in diets fed to healthy and aging cats do not raise blood pressure or adversely affect heart or kidney function.

The use of a water fountain or another source of free-falling water, e.g., water from a tap, or circulating water has been recommended to help increase water intake in cats. However, research has also shown that neither was uniformly superior at encouraging water intake,[69,70] although individual cats did show increases in water intake thus suggesting personal preferences.[70] Other recommendations include offering multiple water bowls, using dog sized bowls (wide bowls so that cats' whiskers do not touch the sides of the bowl), using stainless steel or crockery receptacles, and locating water bowls so cats do not feel threatened when drinking.

In dogs, similar to cats, one strategy to increase water intake involves feeding wet food (or adding water to dry food). Some research in dogs has shown that total water intake is similar whether eating dry or wet food, with dogs drinking more or less to compensate for the level of moisture in the food.[35,38,39] However, one study has shown that this is only true up to a point. Researchers fed the same quantity of a dry diet to dogs, but varied the amount of water added to it (ranging from ¼ to 5 times the volume of the food), and measured free water intake. They found that with an increase in the amount of water added to the food, dogs drank decreasing amounts of free water, keeping total water intake constant. However, once the volume of added water equaled twice the volume of the dry food, the addition of more water to the food did not decrease voluntary free water intake further. This resulted in greater total water intakes when dogs were fed diets with more than 66% moisture.[39]

Another approach to increase total water intake in dogs is to feed a diet with an increased level of sodium or salt.[1] A Purina study found that dogs fed a diet with an increased level of salt produced significantly higher urine volumes and more dilute urine and had a directional, but not statistically significant, increase in water intake.[71] Other research has shown increased water intake or urine volume and decreased calcium oxalate RSS when dogs were fed a dry diet with increased sodium[34] or a canned diet with increased salt[72] levels. Another study found feeding healthy dogs dry diets with increased levels of salt, resulted in higher water intakes and urine volumes and decreased calcium oxalate and struvite RSS.[33]

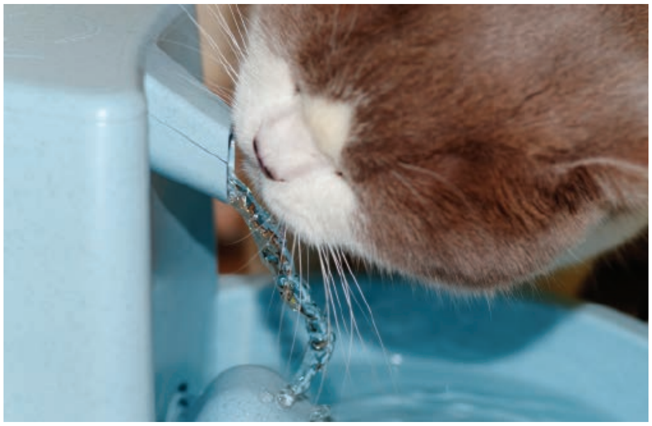


Figure 4:

Water fountains are sometimes used in an attempt to increase water intake in cats.

USE OF A NOVEL NUTRIENT-ENRICHED WATER TO ENCOURAGE INCREASED DRINKING

A new approach designed to increase total water intake is through feeding nutrient-enriched water. The nutrient-enriched, flavored water developed and formulated by Purina scientists is supplemented with organic osmolytes, including amino acids from a whey protein isolate and hydrolyzed protein from poultry, and glycerol. These solutes help regulate the movement of water across cell membranes in response to osmotic pressure gradients.[73]

Purina scientists have conducted multiple studies evaluating the effects of the nutrient-enriched water on daily water intake and measures of hydration in cats and dogs.[6,7,74-77]

Study in cats demonstrates benefits of a nutrient-enriched water on hydration[7]

In this study, 18 healthy adult cats were offered *ad libitum* access to a dry diet and tap water (TW) for a one-week baseline period (days -7 to -1). The cats were then randomized into two groups (each group, n=9). The TW group continued to be offered TW as their water source. The second group of cats – the NW group – was offered nutrient-enriched water (NW) as their only water source for 11 days (days 0 to 10) then offered TW and NW (in separate bowls with bowl locations alternated daily) to determine water preference for the duration of the study (days 11 to 56).

Free liquid intake was measured daily using an automated monitoring system. Blood and urine samples were collected on days -1, 8, 15, 30, and 56, and QMR was performed on days -1, 8, 15, 30, 43, and 56 to assess hydration status. Urine was obtained via cystocentesis, except over a 48-hour period on days 28-30 or 31-33 when voided urine was collected to measure the volume of each cat's total urine output.

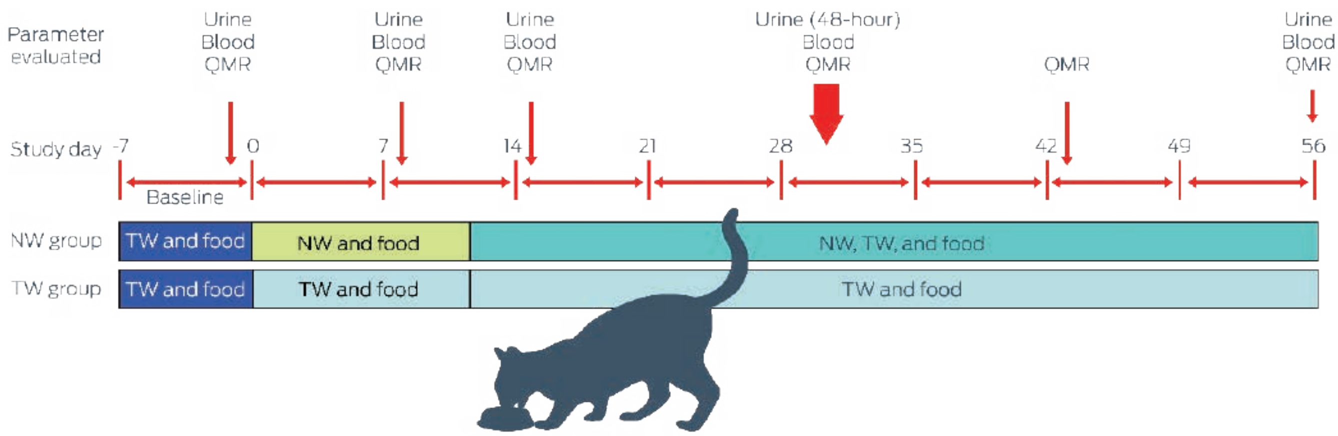


Figure 5:

Design of a study evaluating the effects of a nutrient-enriched water (NW) on hydration indices. TW = tap water. QMR = quantitative magnetic resonance imaging.

Results showed that at baseline, TW and food intake were similar between groups. Free liquid intake increased significantly during week 1 for the NW group (mean 148 +/- 26 g/day for week 1 versus 93 +/- 9 g/day at baseline), an increase of nearly 60% (P = 0.01), while there was no significant change for the TW group. Week 1 free liquid intake for the NW group was significantly greater than that of the TW group (P = 0.03).

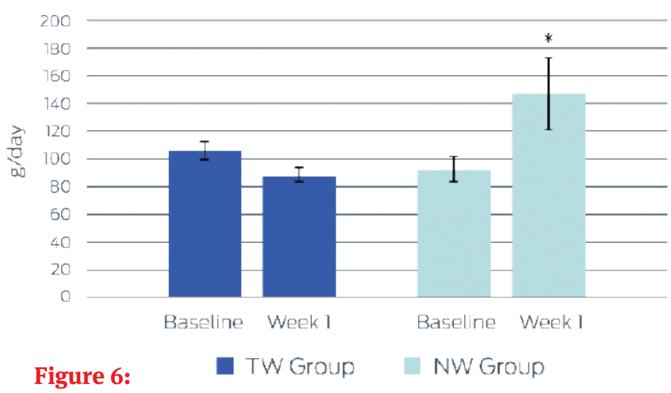


Figure 6:

Mean free liquid intake in cats offered tap water (TW) or nutrient-enriched water (NW). * indicates significant change from NW Group Baseline and significant difference from TW Group Week 1.

For the duration of the study, mean weekly free liquid intake for the NW group ranged from approximately 40-118% greater than baseline, while that for the TW group remained stable, ranging from -15 to +14% different from baseline. While there was individual variability in response (three of the NW group cats increased their free liquid intake less than 25%; 3 increased free liquid intake between 25-75%; and 3 increased intake by more than 75%), overall mean free liquid intake was significantly higher for the NW group at 153 +/- 26 g/d than for the TW cats at 104 +/- 5 g/d (P <= 0.05). **When cats in the NW group were offered a choice between TW and NW, they overwhelmingly chose NW,** regardless of bowl position, with NW intake at an overall mean of 96.6 +/- 3% of total daily intake. This showed that the increase in free liquid consumption by the NW group was due to the cats having a high NW intake.

The increased water intake in the NW group resulted in production of a significantly higher urine volume and more dilute urine. Mean urine output was 15.2 +/- 1.8 ml/kg/d for cats in the NW group versus 10.3 +/- 0.7 ml/kg/d for TW group cats (P = 0.010). Mean USG was 1.040 +/- 0.002 g/ml for the NW group versus 1.054 +/- 0.001 g/ml for the TW group (P < 0.001). QMR found no significant changes in total body water, lean body mass, or fat mass in either group over the course of the study.

Feline study shows nutrient-enriched waters with and without flavoring affect water intake and urine measures of hydration[74]

The study evaluated feeding nutrient-enriched water (NW) to 36 healthy adult cats eating a dry kibble diet. The cats were divided into 3 groups: TW (tap water) (n=4), NW (non-flavored nutrient-enriched water (n=16), and NWP (NW with poultry flavoring) (n=16). All groups were offered TW *ad libitum* with the dry diet fed to maintain body weight for a 1-week period (period 1) to measure baseline intake. The TW group was offered only TW *ad libitum* as their water source throughout the study, while cats in the NW and NWP groups were offered either NW or NWP, respectively, at a volume equal to 1x baseline water intake for 17 days (period 2), followed by 1.5x baseline intake for 10 days (period 3), and then 2x baseline intake for 10 days (period 4), in addition to TW *ad libitum*. Free liquid and food intake were measured. Voided urine was collected over 48 hours near the end of each study period to measure urine output and specific gravity.

Mean TW intake for all cats during period 1 was 118 +/- 26 ml/d. Among individual cats, water consumption was highly variable ranging from 79- 200 ml/d. Mean daily free liquid intake for NW group cats significantly increased by 25% in period 3 and by 44% in period 4 compared to period 1 ($P < 0.01$). For the cats in the NWP group, mean daily free liquid intake significantly increased by 18% in period 2 ($P = 0.04$), 57% in period 3 ($P < 0.01$), and 96% in period 4 ($P < 0.01$) compared to period 1 consumption. Mean daily free liquid intake did not significantly change over the course of the study for the cats in the TW group. Consumption of TW by cats in the NW and NWP groups decreased considerably once they were offered NW or NWP, respectively, as a water option, and then remained relatively stable during the rest of the study.

Mean daily urine volume did not change significantly for cats in the TW group, while it significantly increased in period 3 and 4 versus period 1 in NW and NWP cats ($P < 0.01$).

Urine from NW and NWP cats was more dilute with USG significantly decreasing by between 21-31% in NW cats and 39-62% in NWP group cats in periods 2-4 relative to period 1 ($P < 0.001$).

An additional Purina study utilizing QMR to assess percentage total body water showed that offering nutrient-enriched water to healthy cats 2-3 hours prior to a brief routine anesthetic procedure may be an option to help ensure adequate hydration prior to, during, and immediately after the procedure.[76]

This body of research in healthy cats has demonstrated that consumption of a nutrient-enriched water enhances water intake and improves measures of hydration. The findings from these studies also suggest that feeding nutrient-enriched water may provide a way to encourage water consumption in cats with health issues or those otherwise prone to dehydration that would benefit from an increased intake.

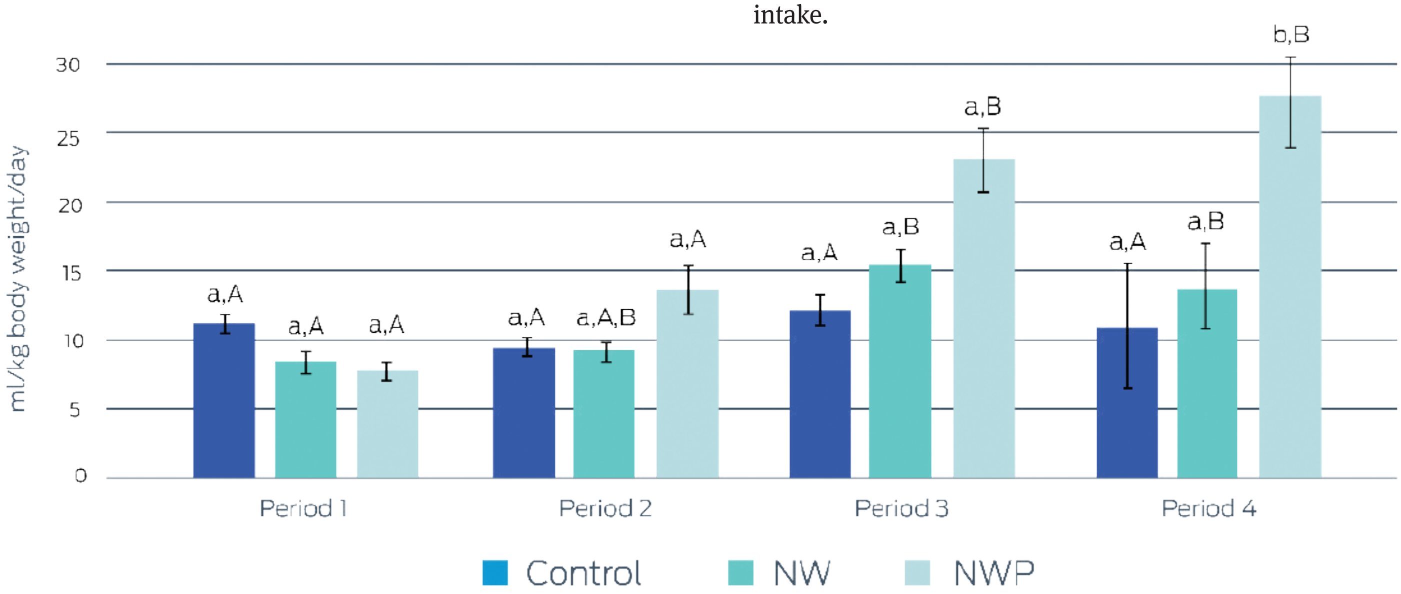


Figure 7:

Voided urine volume in cats offered tap water (Control), non-flavored nutrient-enriched water (NW), or nutrient-enriched water with poultry flavoring (NWP). [a-c]Different superscript lowercase letters indicate significant differences between groups within a time period. [A-C]Different superscript uppercase letters indicate significant differences within a group over time.

Study in dogs shows nutrient-enriched water affects total water intake and urine measures of hydration[6]

Findings from an unpublished pilot study by Purina scientists showed that increasing water intake in healthy dogs with a baseline USG of less than 1.015 had no impact on urine dilution. Thus a parameter for future studies required prescreening and enrollment of healthy dogs with a USG of at least 1.015 in order to detect decreases in USG with increased water intake.

In this study 16 adult small breed dogs were fed a dry kibble diet with study groups balanced according to baseline USG. The dry diet was fed to maintain body weight throughout the study. After a baseline period of 9 days in which all dogs had *ad libitum* access to tap water (TW) presented in a bucket, half of the dogs were offered TW and half nutrient-enriched water (NW) in a bowl in addition to the bucket of TW *ad libitum* for the 56-day study. The TW or NW in the bowl was offered at 0.5 ml/kcal dietary ME divided twice daily for 49 days in order to evaluate 'moderate' intake. This was followed by offering 2.1 ml/kcal dietary ME divided twice daily for days 50-56, to evaluate the short-term consumption of a 'high' intake. The kcal dietary ME was calculated based on the food intake over the baseline period. After measurement at baseline (day -7), USG was measured on days 14, 42, and 56 of the study. Total liquid intake (sum of TW and NW consumed) and food intake were measured daily. Total water intake was calculated as the sum of free water consumed by drinking (TW plus water only component of NW), food moisture, and estimated metabolic water.

The mean baseline total liquid intake did not significantly differ between the two groups, and food calorie intake did not differ over the course of the study. While total liquid intake did not change significantly in the TW group in the treatment phase compared to baseline, total liquid intake in NW group dogs was significantly increased over baseline every week ($P < 0.05$), except week 2. Total liquid intake in NW dogs increased further at week 8 during the high intake phase ($P < 0.001$). On a body weight basis, mean total water intake increased from 71 +/- 12 ml/kg/day during baseline to 156 +/- 13 ml/kg day during the high intake period for the NW dogs ($P < 0.001$).

Purina research has shown an increase in daily water intake and improved measures of hydration when pets drink a nutrient-enriched water.

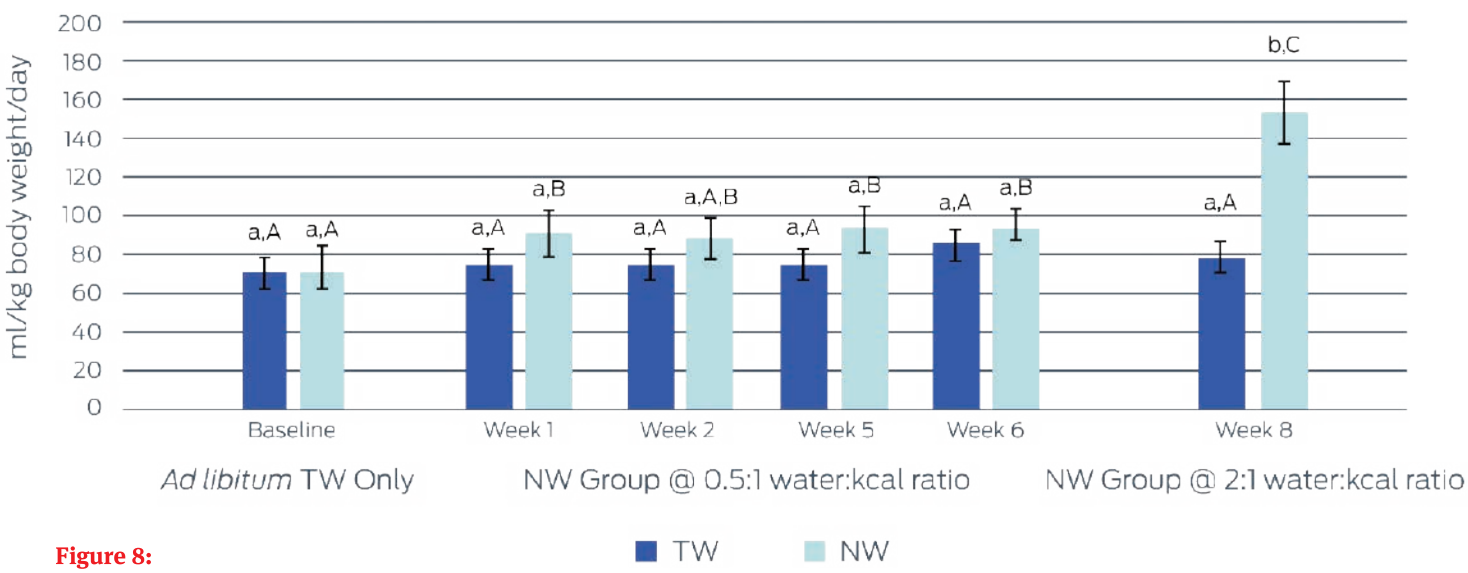


Figure 8:

Total water intake in dogs offered tap water (TW) or nutrient-enriched water (NW). [a-c]Different superscript lowercase letters indicate significant differences between groups within a time period. [A-C]Different superscript uppercase letters indicate significant differences within a group over time.

Consumption of water from the bowl during the treatment phase was significantly different between groups ($P < 0.001$). From weeks 1-7 when offered water at the moderate level, the NW group dogs drank nearly 100% of the NW, while the TW dogs drank between 10-20% of the bowl water. In the final week when offered water in the bowl at the high intake level, NW group dogs drank an average of 91% of the NW, but intake in TW dogs did not significantly change. Consumption of tap water from the bucket decreased between 10-30% compared to baseline for NW dogs, but varied less than 2% for TW group dogs over the course of the treatment phase, except at week 6. These results demonstrated a preference for the NW in the NW group dogs.

USG and osmolality were similar between groups at baseline. In the NW group dogs, USG was significantly lower at 1.018 g/ml on day 42 and at 1.014 g/ml on day 56 compared to the baseline USG of 1.026 g/ml ($P < 0.01$) and urine osmolality decreased significantly ($P < 0.05$). Neither USG nor osmolality changed significantly in the TW group compared to baseline values.

Study with working dogs finds nutrient-enriched water impacts body temperature and pulse rate recovery after exercise[77]

A crossover study in conditioned working dogs undergoing up to 30 minutes of exercise under warm, moderately humid conditions evaluated the effects of nutrient-enriched water (NW) on exercise recovery. After a 4-day baseline period, 12 young adult dogs fed a dry diet were offered tap water (TW) in a bucket *ad libitum* and a portion-controlled amount of NW or TW in a bowl during the 11-day treatment phase. Exercise bouts were conducted on days -4, 3, and 11. Core body and ear temperatures and pulse rate were measured just prior to and several times after exercise. Water intake was not measured as dogs were in training each weekday and lived in homes overnight and on weekends. Body weight was measured just prior to and immediately after exercise as an indicator of water loss.

On day 3, core body temperature during the recovery period was 0.6 degrees C (1 degree F) lower in the NW group versus the TW group ($P = 0.002$). On day 11, mean ear temperature was 0.6 degrees F ($P = 0.003$) and pulse rate 3.4 beats per minute ($P = 0.03$) lower during the recovery period in the NW group compared to the TW group. Dogs appeared similarly hydrated based on changes in body weight pre to post exercise.

Scientists concluded that ingestion of NW along with TW *ad libitum* improved post-exercise recovery. Since hyperthermia and elevated pulse rate may contribute to fatigue, decreased performance, or heat stress, offering a nutrient-enriched water to exercising dogs may be beneficial.

The impact of water on the health of the pet is often overlooked, despite the fact that it is the most critical nutrient for survival. Water balance in the body is always in a state of flux. Healthy animals appear to be able to self-regulate their water intake to match losses. However, it is not completely understood whether this is optimal hydration, and how hydration status affects overall health, including whether healthy pets may benefit from a higher water intake.

Increased water intake is recommended for cats and dogs that are predisposed to becoming dehydrated and those with health conditions such as urolithiasis. Historically, various methods for encouraging water intake in pets have been utilized but recent published research has shown that the use of a nutrient-enriched water increases total water intake and improves measures of hydration in cats and dogs.

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