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The effect of dry food on hypertension and kidney function among cats

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Hypertension is an important clinical condition in the domestic cat. It is frequently associated with renal and cardiovascular disorders. Although hypertension is usually a secondary consequence of an underlying clinical condition, the influence of dietary composition and, especially, the exclusive consumption of dry foods is controversial and has been understudied. The objective of the study was to assess the impact of the exclusive consumption of dry food on arterial blood pressure and renal function indicators in clinically normal domestic cats. In a comparative study carried out on 41 apparently healthy domestic cats aged 1–7 years and monitored over 60 days, 19 were fed on dry foods and 22, the control group, fed on either wet foods or natural foods. The blood pressure of the cats was monitored using non-invasive validated techniques. Blood tests were carried out on the cats to determine serum levels of sodium, urea, and creatinine. For cats fed dry food, a highly significant increase in systolic arterial pressure was found from a baseline of a mean of 119 to 211 mmHg ($P < 0.001$). There was no such effect in the controls. There was a marked increase in the levels of serum sodium in the dry food group from 147.6 to 387.5 mEq/L ($P < 0.001$). For the controls, the levels of serum sodium were within normal limits throughout the period of the study. Significant changes in the levels of urea from 9.4 to 14.6 mmol/L and creatinine from 138.8 to 168.7 µmol/L were also found in the dry food group. Diet consisting exclusively of dry foods for a short period resulted in a marked increase in blood pressure and impaired renal function indicators in healthy cats. These effects underscore the need to balance moisture and sodium content in feline foods.

Keywords: cats; sodium; dry food; blood pressure; renal function.

Introduction

Systemic hypertension in domestic cats is an increasingly acknowledged clinical entity that appears to affect middle-aged to aged cats. It is characterized by end organ damage that involves renal and cardiovascular systems and is typically related to co-existing diseases such as chronic kidney disease and endocrine diseases (Luckschander et al., 2004; Chetboul et al., 2014; Reynolds et al., 2024). Though much is understood about the co-existing causes of hypertension in cats, the role that nutritional influences play in relation to the control of hypertension is not well understood.

Dry cat foods are commonly used across the globe due to their convenience, cost-effectiveness, and easy storage. They are known to have low water content and varying concentrations of sodium and other electrolytes compared to wet or natural foods (Chetboul et al., 2014; Reynolds et al., 2024). This raises a health risk due to the potential for dehydration when the cat is fed a diet of solely dry foods (Chetboul et al., 2014; Reynolds et al., 2024). Cats are known to have low thirst centers and obtain their water from their prey in the wild, making the potential for dehydration a risk when they are fed a diet of solely dry foods (Nguyen et al., 2017).

Some studies that examined the effect of sodium on the health of the cat found that increased sodium content does not significantly increase blood pressure in normal adult or aged cats, indicating that the cat appears to be salt-resistant compared with other species (Buranakarl et al., 2004; Chetboul et al., 2014; Finch et al., 2016). Long-term studies on high-sodium content in dry food did not demonstrate any negative effect on blood pressure or kidney function in normal aged cats after prolonged feeding (Reynolds et al., 2024). Other reviews on the sodium content in the nutrition of the cat emphasized that even though increased sodium content in food increased water intake or urinary output, there is no clear evidence that sodium directly affects hypertension in the cat (Nguyen et al., 2017).

In light of these results, however, there is a need to carry out specific research on the effect that the consumption of dry foods exerts on systemic hypertension, especially in cats that have co-existing disease states, as well as various states of hydration/dietary patterns. The study aims to assess the effect that dry foods have on systemic blood pressure in domestic cats, especially regarding renal function markers, as well as blood pressure measurements.

Materials and methods

Permission was obtained from the Institutional Animal Care and Use Committee (IACUC) for the study. Informed consent was obtained from the cat owners prior to the study. International standards of animal welfare were respected during the study. No harm was done to the animals during the study.

This study utilized a comparative experimental research design to examine the effect of consumption of dry food on blood pressure in arteries and kidney function in domestic cats. The research design allowed a comparison to be drawn between domestic cats fed on exclusive dry food and others fed on non-dry food.

The study was conducted in various veterinary clinics and animal care establishments. All biochemical and laboratory procedures were conducted in certified veterinary diagnostic laboratories to ascertain the accuracy of the data obtained.

The study population was composed of clinically healthy domestic cats of both sexes with an age range of between 1 and 7 years and no prior history of hypertension, chronic kidney disease, and metabolic diseases.

Inclusion criteria: domestic cats 1–7 years old; clinically healthy based on comprehensive physical examination; no history of renal, cardiovascular, or systemic diseases; not receiving medications known to affect blood pressure or renal function.

Exclusion criteria: cats with diagnosed systemic or metabolic illnesses; pregnant or lactating cats; cats fed on therapeutic, prescription, and/or special veterinary foods.

For the sampling design, a purposive sampling technique was used to choose the eligible cats that satisfied the selection criteria. The total number of cats was equally divided into two groups:

– dry food (DF) group: domestic cats were fed commercially available dry cat food as the exclusive source of nutrition;

– control group: cats fed wet food or natural food of appropriate nutritional balance.

The sample size was determined based on feasibility and the availability of eligible subjects in the setting.

Cats in Group A were fed with dry cat food available for purchase, while cats in Group B were fed with wet or natural cat food prepared to meet the necessary nutritional needs of the cat. The cats were fed according to the necessary caloric needs for each cat's body weight. The dietary intervention for the cats took 8-12 weeks.

The measurement of the systolic arterial blood pressure in cats was done by a non-invasive technique such as a Doppler or oscillometric device that has been validated in a veterinary setting. The measurement was done in a quiet setting after a proper rest period in order to minimize the effect of stress, which could interfere with the measurement. Three measurements were made, and the mean value was calculated.

Renal functions were assessed by blood and urine studies that included: serum creatinine, blood urea.

The samples were taken before the intervention began (at baseline) and at the end of the intervention period.

Pre-intervention measurements of the parameters of blood pressure and renal functions were taken. These measurements were taken before the dietary regimen was initiated. Subsequent measurements of the parameters of interest were taken at the termination of the dietary regimen. These measurements were taken by trained veterinary personnel.

The data was analyzed statistically, typically through software packages like SPSS. The results were then interpreted based on descriptive statistics, where the values are expressed as a measure, like the standard deviation, to obtain the results. In addition, inferential statistics, like the t-test, are also used to analyze the results, especially to compare results from various groups in a study. The results are also interpreted based on a $P < 0.05$.

The validity of the measurements was ensured by the standardized measurement instruments and the certified methods used in the laboratory. Reliability was ensured by the repetition of blood pressure measurements and the standardized procedures used in the laboratory. The equipment was calibrated to ensure accurate measurements.

Results

Over a period of 60 days, two groups of cats were fed two different types of food (dry and homemade), and their arterial blood pressure was monitored along with their urea, creatinine, and sodium levels. Forty-one cats were meticulously chosen, as they exhibited no diseases, optimal kidney function, or blood pressure. The subjects were categorized into two groups, with a mean age of 2.3 years, comprising 24 males and 17 females, and an average weight of 3.9 kg (Table 1).

Table 1
The study distribution of samples according to demographical data

Characteristics	Group dry food N = 19		Group control N = 22	
Age, mean ± SD	2.31 ± 1.88		2.46 ± 1.97	
Sex, n (%)	male	female	male	female
	11 (57.9)	8 (42.1)	13 (68.4)	9 (31.7)
Weight, mean ± SD	3.78 ± 2.81		4.11 ± 3.57	

The blood pressure (mmHg) in dry food group (211 ± 11) after using dry food had significantly higher values compared to before dry food (119 ± 10) or control group (122 ± 13, Fig. 1).

The serum sodium (mEq/L) in the dry food group (388 ± 11) after using dry food had significantly higher values compared to before dry food (148 ± 13) or the control group (165 ± 12, Fig. 2).

The serum creatinine (µmol/L) in the dry food group (169 ± 12) after using dry food had significantly higher values compared to before dry food (139 ± 14) or the control group (131 ± 13, Fig. 2).

The blood urea (mmol/L) in the dry food group (14.6 ± 2.4) after using dry food had significantly higher values compared to before dry food (9.4 ± 1.3) or the control group (10.2 ± 1.1, Fig. 2).

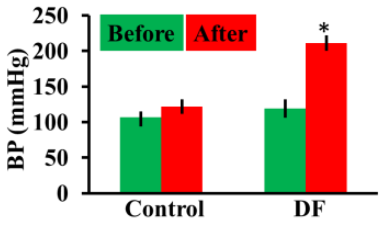

Fig. 1. Arterial blood pressure (BP) in mmHg of cats using dry food (DF) group (n = 19) compared to control group (n = 22): data expressed as mean ± SD; * indicates $P < 0.05$ compared to the control group using paired t-test

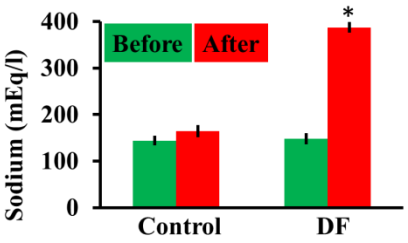

Fig. 2. Serum sodium levels (mEq/L) of cats using dry food (DF) group (n = 19) compared to control group (n = 22): data expressed as mean ± SD; * indicates $P < 0.05$ compared to the control group using paired t-test

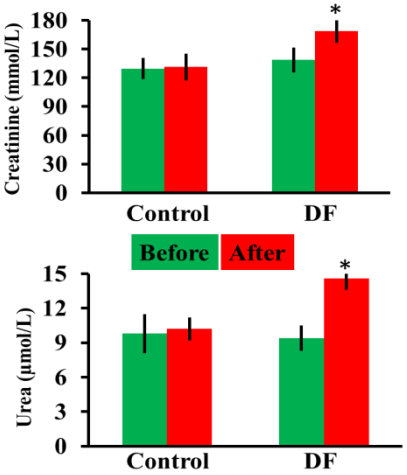

Fig. 3. Renal function test of cats using dry food (DF) group (n = 19) compared to control group (n = 22): data expressed as mean ± SD, * indicates $P < 0.05$ compared to the control group using paired t-test

Discussion

The average age of the cats was 2.3 years. Male cats were more common than females. It was also discovered that when the cats were fed dry food, their weakness was greatly increased compared to cats of the control group. The current study was designed as an experimental study to assess the influence of exclusive consumption of dry food on arterial blood pressure, as well as renal function parameters, in healthy domestic cats. The study findings revealed that there was a significant rise in arterial blood pressure, serum sodium, serum urea, and serum creatinine levels in the cats that consumed dry food compared to the cats that consumed either a wet or natural diet. Therefore, it may be stated that the composition of food, especially in respect to sodium levels, has a significant influence in maintaining homeostasis in felines.

This study found that the intake of dry cat food increased blood pressure at twice the previous rate. In the control group who ate normal food, blood pressure increased in the normal range. Sodium levels in both groups were approximately equal before initiating the diet program; in other words, before initiating a diet program, both groups'

sodium levels were within the normal range. Subsequently, a sharp rise in sodium levels beyond the normal range was observed in the group undergoing the diet program, whereas in the control group, sodium levels were observed to be within the normal range.

One of the most significant findings was the rise in systolic blood pressures among the cats that ate dry food. In particular, the results after the experiment nearly doubled the values obtained at the beginning of the experiment. In contrast, the cats that belonged to the control group only had a very slight rise in their blood pressures, which remained within normal physiological limits. These findings support the hypothesis that dry cat food predisposes cats to hypertension. A mechanistic link can be proposed in the form of dietary sodium. Dry cat food formulations are often fortified with higher amounts of dietary sodium to increase palatability and prolong storage life. In the current study, the level of dietary sodium was found to rise significantly in the group consuming dry food; the level was much higher than the normal range in the control group. Intake of higher amounts of dietary sodium has been correlated with the dysregulation of blood pressure as an effect of increased plasma osmolality and activation of the neurohormonal axis.

Similar associations between the consumption of dry food products and increased levels of blood pressure have been noted in the past. For instance, cats were more prone to increased levels of systolic blood pressure after the consumption of a high-sodium diet as opposed to a wet diet (Reddy et al., 2015). Similarly, Ana et al. noted increased levels of blood pressure in cats after the consumption of dry food products, which could be attributed to altered renal function as well as increased water loss. These results were similar to the present study.

Our findings are consistent with previous studies that have suggested that diet may affect blood pressure in felines. Blood pressure is linked to high-sodium diets in cats and that it could be a cause of hypertension. Dry food diets have higher levels of sodium and other preservatives than wet or standard diets. This could be a cause of hypertension (Sansom et al., 2004; Reddy et al., 2015).

Moreover, a study by Ana et al. reported that domestic cats that consumed dry foods had a higher systolic blood pressure than those that consumed home-prepared foods, as well as wet foods. The suggested mechanisms include changes in renal function, as well as increased water loss, which can lead to increased blood pressure. The results corroborate the findings reported by Ana et al., thereby supporting the suggested hypothesis that the formulation of dry foods for cats can lead to increased blood pressure in these animals.

On the other hand, other research has also presented conflicting results. Steffen et al. (2022) did not find significant changes in blood pressure or renal function in healthy cats fed high-sodium diets over a period of 28 days under controlled conditions. There were also no effects of sodium supplementation on blood pressure over a period of six months. These discrepancies may be due to the differing durations of the studies, the hydration status of the animals, the environmental conditions, as well as the type of diets (Steffen et al., 2022). Cats fed diets under natural conditions may also suffer from cumulative effects of dehydration as well as sodium overload.

One of the best examples of a mechanistic rationale can be found in the degradation of thiamine in dry diets. Thiamine is a critical nutrient in the metabolism of carbohydrates as well as in the neuromuscular system. Its deficiency has been well-documented in cats to cause lethargy, ataxia, and weakness in cats. A very relevant stability study conducted by DiSabatino et al. (2021) has shown the thiamine content in dry cat foods to degrade over a period of time even when they are stored in a frozen environment at –20 °C. This indicates that the dry diets used in cat nutrition have the potential to fall short of the required amount over a period of time. This has been supported by the clinical manifestations of a defective dry cat food used in an outbreak investigation conducted by earlier studies (Markovich et al., 2013; Chang et al., 2017). A defective dry cat food was found to have a low thiamine intake in cats, causing severe neurological manifestations such as weakness and vestibular signs in cats fed the defective dry cat food.

Low moisture content of dry foods may be considered another major factor to affect blood pressure and renal markers. It is observed that cats have low thirst motivation and rely on the moisture content of the dry foods to keep themselves hydrated. Therefore, the consumption of dry foods may cause subclinical dehydration.

In the present study, the cats fed dry food had increased levels of urea and creatinine, showing evidence of renal stress rather than renal failure. The increased levels of urea may be due to the increased protein content of the dry food, which increases the synthesis of urea by the liver and increases the blood urea nitrogen level (DiSabatino et al., 2021). Low urine dilution due to low water intake may impair the excretion of urea.

The slight but clinically relevant increase in creatinine values in the dry food group supports the possibility of changes in renal function. Though the values were near the upper limits for creatinine values, the trend observed is clinically relevant with respect to dry food ingestion. The study observed similar trends in cats and animal studies that were given high-protein and dry food diets (Ephraim, 2021; Machado et al., 2022).

Other variables like calorie density, hydration level, or palatability can also be contributing factors to the differences found in blood pressure (Ephraim, 2021). Limitations of the study were the sample size used in the study, as well as the length of the study. Further study needs to be done on the effect that dry cat food has on the blood pressure of the feline species, including the mechanisms that are possibly involved.

Similarly, an investigation was made regarding dogs during winter to examine changes in vital signs; some of them showed an increase in vital signs like blood pressure. This was similar to a study that had already been done (Martin et al., 2005). If a cat is fed foods that are high in protein or fat over a long time, there is a significant rise in the blood pressure of the cat. This is due to the high amount of triglycerides and sugars that are found in the blood, which may lead to heart diseases in the cat (Machado et al., 2022).

The levels of urea showed a notable increase when comparing before and after feeding dry food; however, when comparing cats fed with wet foods, there was no notable increase. This study's results have shown that feeding dry food to cats leads to a moderate rise in levels of creatinine compared to those fed with wet food. The results of other experiments (Freeman et al., 2014; Ephraim, 2021), conducted on cats in similar conditions revealed that food with high protein content causes an increase in urea and creatinine content. The increase in protein content with dry food may stimulate the production of urea by the liver and increase the level of BUN in the blood after food ingestion. Additionally, the low content of moist food may decrease the efficiency of urea elimination with urine and increase its content in the blood.

Besides this composition of macronutrients, stability of other micronutrients may also cause these clinical presentations. Extruded dry diets can degrade nutrients during processing and storage, especially thiamine (vitamin B_1). Thiamine deficiency has already been proven to cause neuromuscular weakness, lethargy, and neurological abnormalities in cats.

DiSabatino et al. (2021) have shown that the amount of thiamine in dry cat foods that have been extruded decreases over time, even if stored frozen. These results are similar to an investigation done by Chang et al. (2017), where defective dry foods were associated with a lack of thiamine, leading to severe neurologic disease in cats. Even though the amount of thiamine was not measured in the study, its instability is a logical explanation for the increased weakness observed in cats that consumed dry foods.

Based on the findings of this study, it was established that when one eats dry foods, it leads to high levels of sodium that result in high blood pressure. Several studies were carried out on whether increased dietary intake of sodium can lead to increased blood pressure in normal cats. In one of the studies, it was found that “an increase in dietary intake of sodium does not lead to increased blood pressure in healthy adult cats. In fact, it does not adversely affect renal function. In one of the pivotal studies on the subject, 24 healthy adult cats were fed a diet containing three times the recommended level of sodium. The result of the study showed that there was no significant increase in blood pressure.” Recently, it has been found in a controlled trial that “despite

supplementation of increased dietary intake of sodium, there was no significant effect on blood pressure in healthy adult cats. The result of the study showed that there was no significant increase in blood pressure." In another study on mice, "sodium intake in mice can lead to increased blood pressure in mice after 12 weeks of high salt intake".

The results of the current study are supported by other animal models. Studies conducted on rodent models have indicated the adverse effects of long periods of high salt intake on hypertension and renal damage, especially when the exposure to such conditions is for longer periods of time (Zhang et al., 2017; Sugiura et al., 2018). Even though there are interspecific variations, the results of these studies support the idea of the role of sodium and moisture balance in the control of blood pressure among mammals.

However, several limitations need to be considered. For one, the small sample size and short period of dietary exposure could have affected the results. Moreover, hormonal mechanisms regulating hypertension, such as the renin-angiotensin-aldosterone system, were not evaluated. It is suggested that more studies need to be conducted to better understand the mechanisms involved and to support the current findings.

Conclusion

This study proves that the exclusive consumption of dry food can negatively influence the mechanisms that regulate arterial blood pressure and the level of kidney function in domestic cats. This is supported by the high levels of systolic blood pressure, sodium, urea, and creatinine that were found in the study on the effect of the exclusive consumption of dry food. This indicates the significance that needs to be attached to the balance of moisture content in the food that is consumed, as well as the sodium content.

The authors declare no conflict of interest.

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