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Evaluation of the accuracy of urine analyzers in dogs and cats

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ABSTRACT. The accuracy of urine analyzers used for dogs and cats has remained uncertain. This study examines the agreement between results of urine analysis obtained using two devices marketed for animals and for humans and the results of quantitative biochemical analysis. The degrees of concordance for bilirubin and ketones in the same category were ~80%, but for pH these were only ~60% in dogs and cats. Degrees of concordance for protein and the UP/C ratio clearly differed between the devices for animals and humans. We found that values for bilirubin and ketones obtained using urine analyzers may be reliable, but pH is unlikely to be accurate enough to be clinically useful for dogs and cats.

KEY WORDS: cat, dog, pH, urine analyzer

Urinalysis is an important screening test for evaluation of the status of kidneys and metabolic activity. Semiquantitative urinalysis with urine dipsticks and an analyzer readily provides multiple semiquantitative biochemical data, including glucose, protein, albumin, pH, bilirubin, and ketones [4]. Many factors influence the results, including age, sex, food, and living environment. Inaccurate values may be caused by errors in the treatment of urine samples, contamination by bacteria, degradation products from cells, and abnormal color tone of urine samples [3, 4, 12, 13]. There have only been a few studies on the accuracy of the urine analyzer in veterinary medicine. The present study assesses the accuracy of the two urine analyzers in dogs and cats.

A total of 310 dogs and 480 cats were included in this study. These animals were presented for treatment of various disorders, including urinary tract diseases (557 cases) or kidney diseases (84 cases) at the Yasuda Animal Hospital and the Fukatsu Animal Hospital. Urine samples were collected using a bladder catheter or cystocentesis, and were analyzed immediately using urine dipsticks and urine analyzers marketed for animals (the dipstick was the thinka Urine Test Strip and the analyzer was the Urine Analyzer thinka RT-4010, Arkray, Kyoto, Japan) and the same for humans (AUTION Sticks and the Compact Urine Analyzer PocketChem UA PU-4010, Arkray). The samples also underwent quantitative biochemical assays using automated analyzers for glucose (ADAMS Glucose GA-1152, Arkray), proteins (Micro TP-AR, Wako Pure Chemical Industries, Osaka, Japan), albumin (Canine μ Alb or Feline μ Alb, SHIMA Laboratories, Tokyo, Japan), creatinine (Diacolor CRE-V, Toyobo, Osaka, Japan), pH (Twin pH Meter, Horiba, Kyoto, Japan), bilirubin (Aqua-auto Kainos T-BIL, Kainos, Belfast, Ireland), and ketones (Total Ketone Body Kainos, Kainos). These quantitative biochemical assays have been reported to be reliable in dogs and cats [7, 10, 14, 15]. The ranges of quantitative values matching the categories defined by the urine analyzer results are shown in Table 1. The urine samples for quantitative biochemical assays were stored at −30°C until analyses. Urine sample numbers were different by the quantitative biochemical assays because some assays could not be performed owing to the small quantity of some urine samples. Urine sample numbers analyzed by these quantitative biochemical assays are listed in Table 2. Quantitative biochemical analysis results were classified based on results of analysis using analyzers for animals and humans. We calculated degrees of concordance between urine analyzer results and quantitative biochemical analysis results in the same category (main diagonal; Table 2) or in ± 1 category (main + first lateral diagonal; Table 3), which were described in previous reports [2, 8]. We compared these between two

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Table 1. The ranges of quantitative values matching categories defined by the urine analyzer results

A. The ranges of glucose, protein, pH, bilirubin, and ketones

	Category of the urine analyzer results (bold letters) Range of quantitative values								
Glucose (mg/d*l*)	**–**	**50**	**100**	**200**	**500**	**1,000**			
	<30	30–75	75–150	150–350	350–750	>750			
Protein (mg/d*l*)	**–**	**15**	**30**	**100**	**300**	**1,000**			
	<10	10–22.5	22.5–65	65–200	200–650	>650			
pH	**5.0**	**5.5**	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**
	<5.25	5.25–5.75	5.75–6.25	6.25–6.75	6.75–7.25	7.25–7.75	7.75–8.25	8.25–8.75	>8.75
Bilirubin (mg/d*l*)	**–**	**0.5**	**2.0**	**6.0**	**OVER**				
	<0.35	0.35–1.25	1.25–4	4–8	>8				
Ketones (mg/d*l*)	**–**	**5**	**15**	**40**	**80**	**150**			
	<2.5	2.5–10	10–27.5	27.5– 60	60–115	>115			

B. The ranges of albumin

	Category of the urine analyzer results (bold letters) Range of quantitative values				
Dogs and cats (mg/d*l*)	**1**	**5**	**10**	**>15**	
	<3	3–7.5	7.5–15	>15	
Humans (mg/*l*)	**10**	**30**	**80**	**150**	**OVER**
	<20	20–55	55–115	115–225	>225

C. The ranges of UP/C

	Category of the urine analyzer results (bold letters) Range of quantitative values				
Dogs (mg/mg Cre)	**<0.20**	**0.35**	**0.75**	**1.50**	**2.00**
	<0.2	0.2–0.5	0.5–1.0	1.0–2.0	>2.0
Cats (mg/mg Cre)	**<0.20**	**0.30**	**0.75**	**1.50**	**2.00**
	<0.2	0.2–0.4	0.4–1.0	1.0–2.0	>2.0
Humans (mg/g Cre)	**<80**	**200**	**400**	**>500**	**OVER**

Table 2. The degrees of concordance between the urine analyzer results and the quantitative biochemical analysis for results in the same category

		Number	Animal (%)	Human (%)
Dogs				
	Glucose	365	77	73
	Protein	329	72 a)	46
	pH	296	63	63
	Bilirubin	152	88	82
	Ketone	150	82	81
	Albumin	152	58	55
	UP/C	320	77 a)	64
Cats				
	Glucose	307	83 b)	75
	Protein	276	49 b)	39
	pH	245	64	64
	Bilirubin	102	86	86
	Ketone	102	85	81
	Albumin	99	64 a)	29
	UP/C	119	81 b)	66

a) $P<0.01$ and b) $P<0.05$ between animal and human analyzers.

Table 3. The degrees of concordance between the urine analyzer results and the quantitative biochemical analysis results in the ± 1 category

		Number	Animal (%)	Human (%)
Dogs				
	Glucose	365	100	100
	Protein	329	97 a)	89
	pH	296	96	96
	Bilirubin	152	100	99
	Ketone	150	100	100
	Albumin	152	93 a)	78
	UP/C	320	97	96
Cats				
	Glucose	307	100	99
	Protein	276	95 a)	80
	pH	245	100	100
	Bilirubin	102	100	100
	Ketone	102	100	100
	Albumin	99	90 a)	59
	UP/C	119	97	93

a) $P<0.01$ between animal and human analyzers.

devices using Fisher's exact test. Examples of data for calculation of degrees of concordance in the same category or in ± 1 category are shown in Table 4. The main diagonal is shown in bold letters and the main + first lateral diagonal is shown in gray cells in Table 4. The quantitative biochemical analysis data in the same categories [1] were compared between two devices using Mann-Whitney's

Table 4. The degrees of concordance of glucose between the results of the urine analyzer for animals and the quantitative biochemical analysis results in dogs

		The quantitative biochemical analysis results					
		<30	30–75	75–150	150–350	350–750	>750
The urine analyzer results	-	**210**	42				
	50	27	**22**				
	100		4	**8**			
	200			1	**13**	1	
	500				5	**12**	3
	1,000					2	**15**

Concordance: The same category (main diagonal; bold letters): 77% (280/365), ± 1 category (main + first lateral diagonal; gray cells): 100% (365/365).

Table 5. The sensitivities and specificities of the urine analyzers

	Number	Animals		Humans		Expected category	
		Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)	Animals	Humans
Dogs							
Glucose	365	67.2	88.6	50.0	100.0	-	-
Protein	329	87.1	81.7	98.6	60.0	-	-
pH	296	63.4	97.0	63.4	97.0	6.0–7.5	6.0–7.5
Bilirubin	152	75.7	93.9	75.7	93.9	-	-
Ketone	150	65.1	95.3	65.1	95.3	-	-
Albumin	152	94.1	58.2	93.2	57.8	1.0	10.0
UP/C	320	90.2	91.9	96.0	86.4	<0.2	200.0
Cats							
Glucose	307	77.4	95.3	69.6	100.0	-	-
Protein	276	87.3	67.3	99.5	49.1	-	-
pH	245	70.4	100.0	70.4	100.0	6.0–7.5	6.0–7.5
Bilirubin	102	69.6	100.0	69.6	100.0	-	-
Ketone	102	80.6	100.0	80.6	100.0	-	-
Albumin	99	84.8	81.1	93.5	18.9	1.0	10.0
UP/C	119	90.3	94.3	65.4	98.9	<0.2	200.0

U test. Statistical significance was set at $P<0.05$. All analyses were performed using GraphPad Prism 7 software (MDF, Tokyo, Japan). Using quantitative biochemical analysis results as the "gold standard", sensitivities and specificities of the urine analyzers for animals and humans were calculated. The expected values (Table 5) were defined according to a previous article [14].

The degrees of concordance for glucose, protein, pH, bilirubin, ketones, albumin, and the UP/C ratio in the same category are shown in Table 2, and the degrees of concordance for these in ± 1 category are shown in Table 3. The sensitivities and specificities of the urine analyzers for animals and humans are shown in Table 5. In dogs, the degrees of concordance for bilirubin and ketones in the same category were approximately 80%, but for pH and albumin these were approximately 60% for both devices (Table 2). The degrees of concordance for glucose in the same category were approximately 70% for both devices. The degrees of concordance for protein and the UP/C ratio in the same category for the device designed for animals were significantly higher than those for the device designed for humans ($P<0.01$). The degrees of concordance in ± 1 category, other than for protein and albumin, were 96–100% for both devices (Table 3). The degrees of concordance for protein and albumin in the ± 1 category for the device designed for animals were significantly higher than those for the device designed for humans ($P<0.01$). The quantitative biochemical analysis data for protein in categories from minus to 100 for the device designed for humans were significantly lower than data for the device designed for animals (Fig. 1). The quantitative biochemical analysis data for albumin and the UP/C ratio in dogs could not be compared because the scales of the categories were different for animals and humans. The urine analyzers for glucose, pH, bilirubin, and ketones showed sensitivities of under 80% and specificities of over 80% for both devices (Table 5). The urine analyzers for albumin showed sensitivities of over 90% and specificities of approximately 60% for both devices. The urine analyzers for the UP/C ratio showed sensitivities and specificities of approximately 90% for both devices. Although the urine analyzer designed for animals showed sensitivities and specificities of over 80% for protein, the device designed for humans showed specificities of 60% for protein.

In cats, the degrees of concordance for bilirubin and ketones in the same category were approximately 80%, but for pH these were approximately 60% for both devices (Table 2). The degrees of concordance for protein in the same category were below 50% for both devices. The degrees of concordance for glucose, protein, albumin, and the UP/C ratio in the same category in the

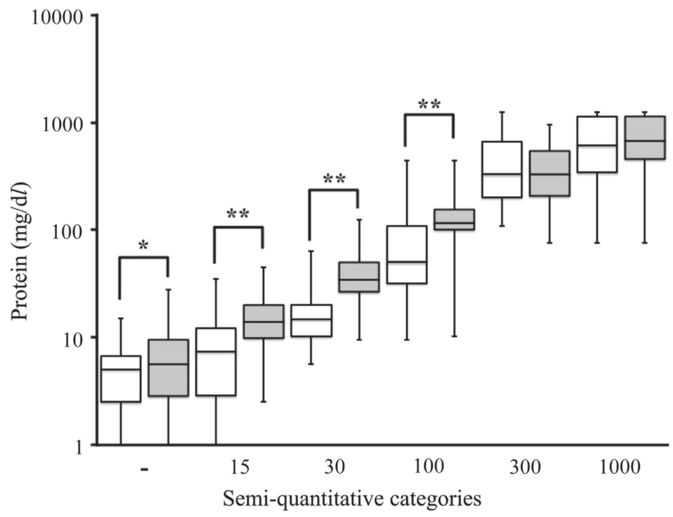

Fig. 1. Data for quantitative biochemical analysis of protein in dogs. The data are shown as box and whisker plots. Box whisker plots represent the 25th/75th percentile, median, and range. The white and gray boxes represent the quantitative data categorized by human and animal analyzers, respectively. *P<0.05 and **P<0.01 between animal and human analyzers in the same categories.

device designed for animals were significantly higher than those in the device designed for humans (albumin: P<0.01, glucose, protein and the UP/C ratio: P<0.05). The degrees of concordance in the ± 1 category for values, other than those for protein and albumin, were 93–100% for both devices (Table 3). The degrees of concordance for protein and albumin in the ± 1 category for the device designed for animals were significantly higher than those for the device designed for humans (P<0.01). The quantitative biochemical analysis data for glucose in categories from 50 to 500 for the device designed for humans were significantly higher than data in the same categories for the device designed for animals (Fig. 2A). The quantitative biochemical analysis data for protein in categories from minus to 100 for the device designed for humans were significantly lower than data in the same categories for the device designed for animals (Fig. 2B). The quantitative biochemical analysis data for albumin and the UP/C ratio in cats could not be compared because the scales of the categories were different for animals and humans. The urine analyzers for glucose, pH, bilirubin, and ketones showed sensitivities of approximately 70–80% and specificities of 95–100% for both devices (Table 5). The urine analyzers for protein showed specificities of under 70% for both devices. Although the urine analyzers for albumin and the UP/C ratio for the device designed for animals showed sensitivities and specificities of over 80%, albumin showed specificities of under 20% for the device designed for humans and protein showed sensitivities of under 70% for the device designed for humans.

Urinalysis is essential for evaluating kidney status and systemic metabolism. Semiquantitative urinalysis with the urine dipsticks and an analyzer can be performed easily and quickly in a veterinary clinical practice. In this study, the accuracy of the urine analyzer was assessed using the degrees of concordance between the urine analyzer results and the quantitative biochemical analysis results in the same category. The degrees of concordance in the ± 1 category were also evaluated because the urine sample with boundary values for categories in semiquantitative urinalysis with urine dipsticks and the analyzer could show the results of an adjacent category. The degrees of concordance in the same category and those in the ± 1 category were used to assess the accuracy of semiquantitative analyses in previous reports [2, 8]. The sensitivities and specificities of the urine analyzers for animals and humans were calculated on the basis of expected values defined in a previous article [14]. Our results showed that the values for bilirubin and ketones were consistent with the quantitative data in dogs and cats. The value of pH was incongruous with the data obtained by the quantitative method in dogs and cats; however, a previous study also determined that the values of pH in the urine analyzer were not accurate enough to be clinically useful [5]. Our results indicated that the accuracy of the values of glucose, protein, albumin, and the UP/C ratio may depend on the type of device used in veterinary medicine. In particular, the accuracy of values for protein and albumin were significantly different according to the type of device in the ± 1 category and the urine analyzers designed for humans showed quite low specificities for protein and albumin. An increase in urine protein and albumin indicates an abnormality of the glomerulus and is important to early diagnosis and monitoring of diabetic nephropathy in humans. An increase in the UP/C ratio suggests kidney disorders, including glomerular disease or tubular disease, and the UP/C ratio is necessary for diagnosing the extent of chronic kidney disease (CKD) in dogs and cats [6]. Proteinuria and albuminuria have previously been assessed by a urine analyzer, using devices designed for humans [9, 16]. Our results indicate that a urine analyzer for humans may estimate lower values for protein and incongruous values for the UP/C ratio in dogs and cats. Detection of glycosuria is critical for the diagnosis of diabetes mellitus (DM) [11]. The urine analyzer for humans may estimate higher values of urine glucose in cats. Our results indicate that the values obtained by the urine dipsticks and the analyzer designed for humans could lead to unnecessary additional examinations, false diagnoses, and false treatments in veterinary clinical practice. Our results suggested that the urine dipsticks and analyzer designed for animals are more suitable for semiquantitative urinalyses of glucose,

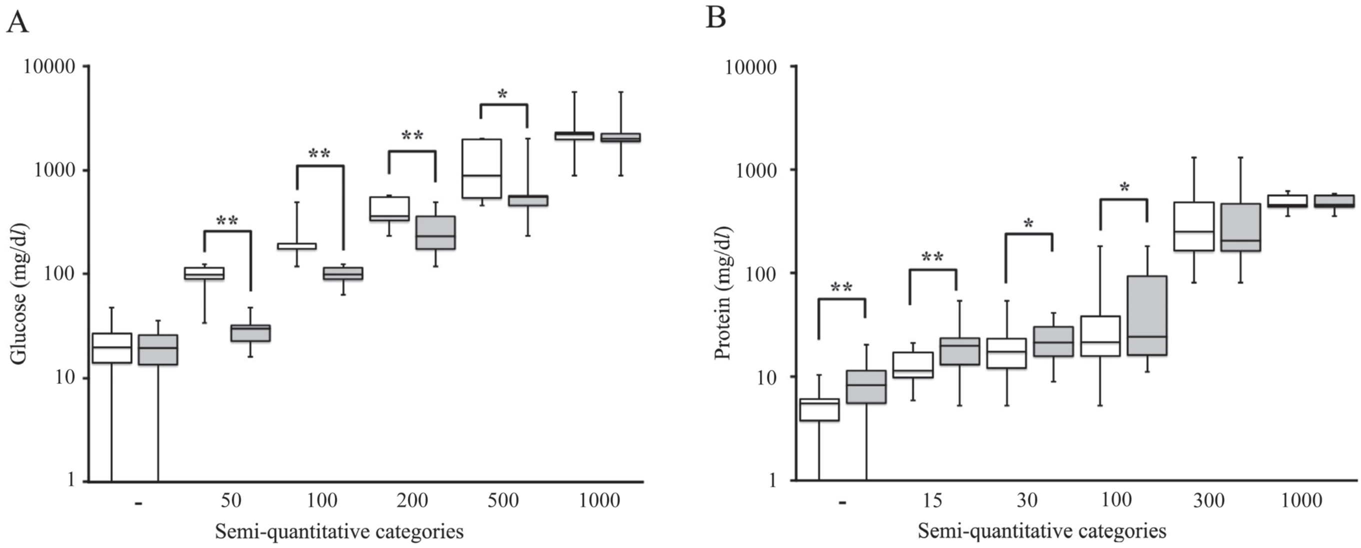

Fig. 2. Data for quantitative biochemical analysis of glucose and protein in cats. (A) glucose, (B) protein. The data are shown as box and whisker plots. Box whisker plots represent the 25th/75th percentile, median, and range. The white and gray boxes represent the quantitative data categorized for human and animal analyzers, respectively. *$P<0.05$ and **$P<0.01$ between animal and human analyzers in the same categories.

protein, albumin, and the UP/C ratio in dogs and cats.

In conclusion, the degrees of concordance for glucose, protein, albumin, and the UP/C ratio clearly differed between two devices. We found that the values for bilirubin and ketones may be reliable, but that of pH might not be accurate enough to be clinically useful and might be considered to shift to the first lateral category in the urine analyzers used for dogs and cats.

REFERENCES

1. Bauer, N., Rettig, S. and Moritz, A. 2008. Evaluation the Clinitek status automated dipstick analysis device for semiquantitative testing of canine urine. *Res. Vet. Sci.* **85**: 467–472. [Medline] [CrossRef]
2. Cho, M. C., Ji, M., Kim, S. Y., Choe, W., Lee, W., Chun, S. and Min, W. K. 2014. Evaluation of the URiSCAN super cassette ACR semiquantitative urine dipstick for microalbuminuria screening. *J. Clin. Lab. Anal.* **28**: 281–286. [Medline] [CrossRef]
3. Duffy, M. E., Specht, A. and Hill, R. C. 2015. Comparison between urine protein: creatinine ratios of samples obtained from dogs in home and hospital settings. *J. Vet. Intern. Med.* **29**: 1029–1035. [Medline] [CrossRef]
4. Elliott, J. and Grauer, G. F. 2007. BSAVA Manual of Canine and Feline Nephrology and Urology, 2nd ed., British Small Animal Veterinary Association, Gloucester.
5. Heuter, K. J., Buffington, C. A. and Chew, D. J. 1998. Agreement between two methods for measuring urine pH in cats and dogs. *J. Am. Vet. Med. Assoc.* **213**: 996–998. [Medline]
6. International Renal Interest Society website. IRIS Guidelines. http://www.iris-kidney.com/guidelines/index.html [accessed on March 30, 2018].
7. Kuwahara, Y., Nishii, N., Takasu, M., Ohba, Y., Maeda, S. and Kitagawa, H. 2008. Use of urine albumin/creatinine ratio for estimation of proteinuria in cats and dogs. *J. Vet. Med. Sci.* **70**: 865–867. [Medline] [CrossRef]
8. Kwon, H. J., Lee, J., Park, H. I. and Han, K. 2017. Evaluation of a novel point-of-care test kit, ABSOGEN™ PCT, in semi-quantitative measurement of procalcitonin in whole blood. *J. Clin. Lab. Anal.* **31**: e22111. [Medline] [CrossRef]
9. Lyon, S. D., Sanderson, M. W., Vaden, S. L., Lappin, M. R., Jensen, W. A. and Grauer, G. F. 2010. Comparison of urine dipstick, sulfosalicylic acid, urine protein-to-creatinine ratio, and species-specific ELISA methods for detection of albumin in urine samples of cats and dogs. *J. Am. Vet. Med. Assoc.* **236**: 874–879. [Medline] [CrossRef]
10. Mizutani, H., Koyama, H., Watanabe, T., Kitagawa, H., Nakano, M., Kajiwara, K. and King, J. N. 2006. Evaluation of the clinical efficacy of benazepril in the treatment of chronic renal insufficiency in cats. *J. Vet. Intern. Med.* **20**: 1074–1079. [Medline] [CrossRef]
11. Nelson, R. W. and Couto, C. G. 2009. Small Animal Internal Medicine, 4th ed., Elsevier, Philadelphia.
12. Prober, L. G., Johnson, C. A., Olivier, N. B. and Thomas, J. S. 2010. Effect of semen in urine specimens on urine protein concentration determined by means of dipstick analysis. *Am. J. Vet. Res.* **71**: 288–292. [Medline] [CrossRef]
13. Raskin, R. E., Murray, K. A. and Levy, J. K. 2002. Comparison of home monitoring methods for feline urine pH measurement. *Vet. Clin. Pathol.* **31**: 51–55. [Medline] [CrossRef]
14. Sink, C. A. and Weinstein, N. W. 2012. Routine urinalysis: chemical analysis. pp. 29–51. *In*: Practical Veterinary Urinalysis, Wiley-Blackwell, Chichester.
15. Trumel, C., Diquélou, A., Lefebvre, H. and Braun, J. P. 2004. Inaccuracy of routine creatinine measurement in canine urine. *Vet. Clin. Pathol.* **33**: 128–132. [Medline] [CrossRef]
16. Welles, E. G., Whatley, E. M., Hall, A. S. and Wright, J. C. 2006. Comparison of Multistix PRO dipsticks with other biochemical assays for determining urine protein (UP), urine creatinine (UC) and UP:UC ratio in dogs and cats. *Vet. Clin. Pathol.* **35**: 31–36. [Medline] [CrossRef]