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Acceptance of home blood glucose monitoring by owners of recently diagnosed diabetic cats, and impact on quality of life changes in cat and owner

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Keywords

diabetes mellitus, cat, home monitoring, quality of life, glycaemic control, blood glucose, remission

Abstract

Objectives

This study aimed to evaluate the acceptance of home blood glucose monitoring (HBGM) by owners of recently diagnosed diabetic cats, and the impact of choosing HBGM on the quality of life (QoL) changes of cat and owner, in addition to glycaemic changes during 6 months' follow-up.

Methods

Owners of cats diagnosed with diabetes mellitus (DM) and treated with insulin for 6-20 weeks were divided into a HBGM group and a non-HBGM group based on their ability and willingness to perform HBGM after standardised instruction session. The HBGM acceptance level and reasons for acceptance failure were documented; a questionnaire evaluated owners' experiences. For the following 6 months, changes in QoL, measured using the validated DIAQoL-pet quantification tool, and changes in glycaemic control parameters (clinical signs, serum fructosamine, blood glucose curve average/minimal/maximal/pre-insulin blood glucose [BG]) were compared between HBGM and non-HBGM groups at months 1, 3 and 6, as well as within the groups between baseline and months 1, 3 and 6.

Results

Thirty-eight cats were enrolled; 28 (74%) entered the HBGM group. There was no significant difference between groups in overall DIAQoL-pet score or glycaemic control parameters at any time point apart from the maximal BG at month 6 (lower in the HBGM group). However, the DIAQoL-pet score, including indicators of owner worry about DM, worry about hypoglycaemia and costs, as well as glycaemic parameters, improved at all time-points within the HBGM group, but not within the non-HBGM group. Remission occurred in 9/28 (32%) HBGM group cats and 1/10 (10%) non-HBGM group cats (p=0.236).

Conclusions and Relevance

HBGM was adopted successfully by most diabetic cat owners. Despite the extra task, positive changes in QoL-parameters occurred in the HBGM group and not in the non-HBGM group. Although no difference was found in glycaemic control between HBGM and non-HBGM group during the 6 months' follow-up, significant glycaemic improvements were documented in the HBGM group.

Introduction

The management of feline diabetes mellitus (DM) is complex and is facilitated by cat owners understanding the disease and their active participation in treatment. These factors help achieve the main treatment goals, which include resolution of clinical signs and avoidance of hypoglycaemia and diabetic complications.[1,2] However, the daily involvement in the management of their pets' diabetes can also be perceived as a substantial burden by some owners.[3,4] A tool called DIAQoL-pet has been developed and psychometrically validated to qualify and quantify the quality of life (QoL) of diabetic pets and their owners, allowing more specific monitoring of this important aspect of feline diabetes, alongside more traditional glycaemic parameters.[3,4]

Although not considered a main treatment goal,[1,2] some diabetic cats enter diabetic remission. The highest remission rates have been reported in cats where good glycaemic control has been established early in the course of the disease.[5,6] The role of home blood glucose monitoring (HBGM) in achieving early good glycaemic control has been widely acknowledged and has been included in the latest guidelines for management of DM in cats.[2] In human medicine, self-monitoring of blood glucose (SMBG) has been an integral part of management of humans with type 1 and insulin-treated type 2 diabetes for many decades.[7] However, although the recommendations for treatment of human diabetes emphasise the utility of SMBG to assess individual responses to therapy and prevention of hypoglycaemia, concerns about the potential impacts of SMBG on QoL, particularly in people with type 2 DM, have been raised.[8,9] In veterinary medicine, the difficulties pet owners might encounter and the reasons for reluctance to perform HBGM have been sporadically addressed in previous canine and feline studies.[10-13] However, these reports were mostly concerned with biological effects as outcome parameters and merely listed what owners perceived as challenges and benefits of HBGM. A prospective assessment of the possible psychosocial impact of HBGM, using an objective validated measure such as the DIAQoL-pet, in a substantial number of patients with a longer-term follow-up is yet to be reported in veterinary medicine.

The main aim of this study was therefore to evaluate the acceptance of HBGM by cat owners and its impact on QoL changes in diabetic cats and their owners over a 6-month period using the previously validated QoL tool, DIAQoL-pet.[3] A secondary aim was to assess the effect of HBGM on glycaemic changes over the same time period.

Materials and methods

Cats diagnosed with DM ≤5 months previously and treated with insulin for at least 6 weeks prior to enrolment were recruited for the study between October 2013 and September 2015. The study was approved by the institutional Clinical Research and Ethical Review Board and was performed under Home Office Licence no. 70/7393. The diagnosis of DM was made based on a combination of appropriate clinical signs (polyuria, polydipsia, polyphagia, weight loss) and laboratory parameters (hyperglycaemia [blood glucose (BG) >15 mmol/L], glycosuria). Cats were excluded if they received short-acting systemic glucocorticoids in the previous month, depot glucocorticoids in the previous 2 months or progestogens in the previous 6 months. Cats were also excluded if they were diagnosed with diabetic ketoacidosis at initial evaluation, if they were diagnosed and treated for hyperthyroidism (except for cats successfully treated with radioactive iodine or thyroidectomy) or were diagnosed with severe disease that could increase the risk associated with study participation or require long-term medication. All cats were screened for hypersomatotropism and if found positive (based on insulin-like growth factor 1 [IGF-1]>1000 ng/mL)[14] were not included.

On initial presentation, a thorough history was taken and physical examination, including body weight (BW), estimation of body condition score (BCS; 1-9/9)[15] and percentage of body fat (% of BF)[16], were performed. The severity of each cat's clinical signs at trial recruitment was graded using the validated clinical scoring system (Diabetic Clinical Score) shown in Table 1.[17] Cat owners were also asked to complete the DIAQoL-pet survey to assess the influence of DM and its treatment on QoL.[3] The DIAQoL-pet generated an Average-Weighted Impact Score (AWIS) to reflect pet and owner QoL, with more negative values reflecting a more negative impact of DM.[3,4]

All cats underwent initial screening tests including complete blood count (CBC), plasma biochemistry, full urinalysis (including urine culture), and serum fructosamine, total T4 (TT4), feline pancreatic lipase immunoreactivity (fPLI), IGF-1 measurement, and abdominal ultrasound. A 24-hour blood glucose curve (BGC) was performed on each cat after admission, using either a continuous glucose monitoring system for the measurement of glucose in the subcutaneous interstitial fluid (Guardian REAL-Time system, Medtronic) or serial BG measurements in capillary blood collected from the ear using a portable BG meter (AlphaTRAK® 2, Zoetis). In the latter case, BG was measured every 2 hours or more frequently if hypoglycaemia (BG<3 mmol/L) occurred. All cats were then transitioned onto a longer-acting insulin type (recombinant human protamine zinc insulin [PZIR; ProZinc, Boehringer Ingelheim] or synthetic insulin analogue glargine [Lantus, Sanofi]) at an initial dose of 0.2-0.7 U/kg. Cats were fed a low carbohydrate, high protein diet (Purina Pro Plan

DM, Nestle Purina PetCare; wet or dry, depending on cat's preference), which commenced at least 10 days prior to the enrolment visit.

At discharge from the hospital, all cats received comprehensive introduction to HBGM which took at least 30 minutes. Owners were shown how to obtain a blood drop using the marginal ear vein technique and they practised the technique on their own cat with the clinician. Cat owners were also taught how to use the glucometer for measurement and how to calibrate it. To generate data for a BGC, owners were asked to measure BG every 2 hours over a 12-hours period, starting just before morning feeding and insulin injection, and finishing just before evening feeding and insulin injection. Owners were asked to record the data and send the results to the research clinic and describe any clinical signs of diabetes that occurred around the time of the BGC. Owners were asked to perform a BCG at the 1-week and 2-, 4- and 5-month trial time-points, and also 1-2 weeks after any insulin dose adjustments. If owners did not perform HBGM, it was requested that these BGCs were performed at the cat's primary-care practice. Cats that entered diabetic remission were initially monitored using spot blood glucose checks 2-4 times weekly, but spot blood glucose measurements were not otherwise routinely requested for monitoring.

Re-examinations at the research clinic were performed 2 weeks, 1 month, 3 and 6 months after joining the trial. At these time points, a full history and physical examination, serum fructosamine measurement, diabetic clinical score (DCS), and a 24-hour BGC were performed in all cats. Owners were also asked to complete the DIAQoL-pet survey. Additional monthly to bimonthly re-examinations took place at the referring veterinary practices, depending on the needs of individual cats. During the study, insulin dose was adjusted according to a single, nadir-led protocol, based on BGC results.[17] Diabetic remission was defined as not requiring insulin for more than 4 weeks.

Owners were considered to have successfully adopted HBGM ("HBGM group") if they had performed a minimum of 2 BGCs at home within the first 3 months of enrolment. The remaining owners and their cats were included in the "non-HBGM group". This arbitrary cut-off of 2 BGCs was chosen, since the investigators explicitly did not want to include owners into the HBGM group if they had successfully performed one curve, though decided against further testing as a result of this experience.

At the end of the study period, owners were contacted by email and/or telephone and asked to complete a questionnaire to describe their experiences with HBGM. The owners of cats included in the HBGM group were asked about their general opinions of HBGM (e.g. if their lives were restricted by HBGM; advantages/disadvantages of HBGM), the technique used for generating the BGCs, and difficulties they

encountered during HBGM (Supplement 1). The owners of cats in the non-HBGM group were asked why they decided not to perform HBGM, or, if they performed some monitoring but then discontinued, why they discontinued (Supplement 2).

Statistical analysis

The data were tested for normality where appropriate (Shapiro-Wilks test). Signalment, BW, BCS, % of BF, fPLI, total number of BGCs performed during the study period, the time on insulin prior to enrolment, insulin type choice (PZIR vs. glargine) and the insulin dose at enrolment were compared between cats in the HBGM- and non-HBGM group using Mann-Whitney and Chi-Square tests, as appropriate. To evaluate the impact of HBGM on QoL changes in diabetic cats and owners, total DIAQoL-pet score and individual item-weighted impact scores (IWIS) for specific questions (Table 2) were compared between HBGM- and non-HBGM groups at enrolment and 1, 3 and 6 months after joining the trial. Similarly, DCS, twice-daily insulin dose and parameters of glycaemic control (serum fructosamine, average BG, average pre-insulin BG, minimal and maximal BG) were compared between the HBGM- and non-HBGM group at the same time points. Remission rate between groups (HBGM- vs. non-HBGM group) and the effect of the insulin type used (PZIR vs. glargine) on whether owners achieved HBGM, were compared using Chi-Square tests.

DIAQoL-pet score, IWIS for specific questions (as above), DCS, insulin dose and parameters of glycaemic control (as above) were compared within each group to assess changes in QoL and glycaemic control over time. Wilcoxon Signed Ranks test were used to compare values at months 1, 3 and 6 to baseline (enrolment) values.

Statistical analysis was performed using commercially available statistical software (SPSS version 22, IBM Statistics).

Results

Sixty-three cats were initially screened prior to enrolment in the 6-month trial and 46 cats were enrolled. Reasons for exclusion of the 17 cats were as follows: neoplastic disease/mass lesion (n=4); probable hypersomatotropism (on the basis of IGF-1>1000 ng/mL; n=3); excessively fearful or aggressive cats (n=3); cats already non-insulin dependent based on an in-hospital BGC (n=2); hyperthyroidism (n=1); gastrointestinal disease (n=1); clinical signs suggestive of a forebrain disease (n=1); hypertrophic

cardiomyopathy with congestive heart failure (n=1); and cat owners declining study enrolment due to time constraints (n=1).

Among the 46 cats enrolled in the 6-month trial, 8 were already performing HBGM, leaving 38 cats for study inclusion. Owners of 28 cats (74%) were able to perform HBGM (HBGM group). The remaining 10 cats (26%) were included in the non-HBGM group.

There was no significant difference in the signalment, BW, BCS, % of BF, fPLI, time on insulin, insulin dose prior to enrolment, choice of insulin (PZIR vs glargine) between cats in the HBGM- and non-HBGM groups (Table 3). In the non-HBGM group, 90% cats (n=9) were male neutered compared to 46% (n=13) in the HBGM group ($p=0.025$).

Cats in the HBGM group had a median of 5 (range 2-10) BGCs performed at home, while cats in the non-HBGM had a median of 2.5 (range 1-7) BGCs performed at their primary veterinary practices during the 6-months follow-up period. Each cat had additional 4 (range 2-4) BGCs performed at the research clinic during the same time period. The total number of BGCs (including curves performed at home, at the primary veterinary practices and at the research clinic) was not significantly different between the HBGM and non-HBGM group ($p=0.082$).

There was no difference between the HBGM- and non-HBGM group in regard to the total DIAQoL-pet score, scores for specific questions, DCS, insulin dose, or parameters of glycaemic control at any time point during the study, except for maximal BG at month 6, which was lower in the HBGM group ($p=0.03$; data shown in Supplement 3) (Figures 1-3, Table 3, Supplement 3). Total DIAQoL-pet score was significantly improved at months 1, 3 and 6 compared to baseline in the HBGM group but not in the non-HBGM group (Figure 1, Table 4). There were significant decreases in scores (and therefore positive impact) for general worry about diabetes (“worry”; months 1, 3 and 6) and worry about hypoglycaemia in particular (“worry hypo”; months 3 and 6), and worry about costs (months 3 and 6) in the HBGM group. There were also significant decreases in scores (indicating positive impact) for “restriction of owners’ activities” and “work restrictions” (month 6) in the HBGM group (Table 4). Overall, the scores for 6 of 9 specifically examined QoL areas had improved at month 6 compared to baseline in the HBGM group (Table 4) but not in the non-HBGM group (Supplement 4). There were also significant reductions (i.e. improvements) in DCS, insulin dose and most parameters of glycaemic control (fructosamine, average BG, average pre-insulin BG, minimal/maximal BG) at months 1, 3 and 6 compared to baseline in the HBGM group (Figures 2 and 3, Table 5), except for minimal BG at months 3 and 6. In the non-HBGM group, DCS also decreased at months 1, 3 and 6 compared to baseline ($p<0.05$).

Regarding insulin dose and parameters of glycaemic control in this group, only average pre-insulin BG at month 6 and maximal BG at month 1 were significantly different (lower; $p<0.05$) from baseline (Supplement 5). Diabetic remission occurred in 9/28 (32%) cats in the HBGM- and 1/10 (10%) cats in the non-HBGM group ($p=0.236$).

Nineteen (68%) questionnaires were completed by owners of cats in the HBGM group. Ten of the 19 (53%) owners performed >10 BGCs and 17/19 (89%) found HBGM "straightforward" or "mostly straightforward" to perform; 2/19 (11%) respondents described it as "difficult". Technical difficulties (pricking the ear, obtaining sufficient blood) were the most common challenges reported by 10/19 (53%) owners, followed by finding time to perform HBGM (n=6/19; 32%), and gaining confidence (n=5/19; 26%). Ten of the 19 (53%) respondents felt that their lives were not at all/not really restricted by HBGM, while 6/19 (32%) and 4/19 (21%) reported mild or moderate restriction, respectively. Most owners mentioned several advantages of HBGM; not having to take their cat to the veterinarian (n=16/19; 84%) or leave the cat at the practice (n=11/19; 58%) were the most commonly reported. A summary of the advantages and disadvantages of HBGM, and a description of the technique and difficulties encountered during HBGM, can be found in Table 6. Of cats in the HBGM group that were alive at the time of writing, all owners were still performing HBGM.

Three of 10 questionnaires in the non-HBGM group were completed. Two owners managed to perform a few spot blood glucose measurements but not a whole curve; one owner tried performing curves but did not succeed. The reasons for discontinuing HBGM were stated as lack of assistance (n=2); a perception that the cat was anxious (n=3); difficulties obtaining a blood drop (n=2) or using a glucometer (n=2); and the perception that he/she was hurting the cat (n=1). Despite not being successful, one owner expressed a desire to try HBGM again, while the other two would "probably not"/"not" try it again.

Discussion

The main aim of this study was to determine the acceptance, and especially also the impact of HBGM on the QoL of diabetic cats and their owners. Although no significant difference in the overall QoL assessed by the DIAQoL-pet tool was found between the HBGM and non-HBGM group during the 6-months' study period, the overall QoL scores improved at all post-enrolment time-points in the HBGM group and not in the non-HBGM group. This suggests a possible positive impact of HBGM. The acceptance of HBGM by the owners of diabetic cats was high, with approximately 3 out of 4 successfully adopting HBGM. This proportion is similar or higher than in previous studies evaluating HBGM in diabetic cats.[11,12] Importantly, 89% of those performing

HBGM found it “straightforward” or “mostly straightforward” and all questionnaire-respondents in the HBGM group would recommend HBGM to all or at least some owners of diabetic cats. Based on the questionnaire results, for owners practising HBGM, the benefits clearly outweighed any disadvantages. Notably, about half the owners in the HBGM group stated that they did not feel their lives were restricted by HBGM. This agreed with the results of the DIAQoL-pet assessment, indicating improvement of the overall QoL in the group performing HBGM. Further, owners practicing HBGM reported significantly less worry about their cat’s diabetes in general, and particularly about hypoglycaemia, compared to before the trial. This might be due to feeling more in control because of the ability to check blood glucose at home, as has been previously reported.[11] The scores of specific questions about possible restriction of owners’ lives (“restrict your activities”, “social life”, “working life”) did not reveal negative effects associated with HBGM compared with the non-HBGM group. The item “costs” also improved over time in the HBGM group, but not in the non-HBGM group, possibly reflecting cost savings because glycaemic checks were performed at home rather than at the veterinary clinic.

The psychometrically validated DIAQoL-pet tool was used to objectively evaluate QoL in diabetic cats and their owners. Although other factors might have contributed to the score, successful adoption of HBGM was the major difference in the diabetes management after enrolment on the study. It is therefore likely that any negative impact HBGM might have had on the QoL would have been reflected in deterioration of the total DIAQoL-pet score or in the scores for the specific questions mentioned above. Since an improvement in DIAQoL-pet score occurred, HBGM was considered to most likely have a positive effect on QoL, rather than imposing an additional burden. In fact, HBGM group owners reported an improvement in impact on DIAQoL-pet factors relating to life and work restrictions once the trial had started. This improvement was not documented in the non-HBGM group.

Although improvement in QoL was documented in the HBGM group and not in the non-HBGM- group over time, the QoL scores were not different between these 2 groups at any time-point in the study. This lack of statistically significant difference might have several reasons. Firstly, the non-HBGM group was smaller than the HBGM group; secondly, the trial design resulted in cat owners essentially self-selecting group assignments; thirdly, the HBGM group was not absolutely homogenous in terms of the frequency and intensity of performing HBGM. However, the total number of BGCs was not significantly different between the HBGM and non-HBGM group. Finally, lack of randomisation and owners’ self-assignment to the groups might allow for owner- or pet-related characteristics, intrinsic to the decision to accept or decline HBGM, to confound

treatment outcomes. For instance, if HBGM group owners were more motivated to do everything possible to control their cat's diabetes, better treatment outcomes might be expected in that group. Nevertheless, owners in both groups were prepared to follow the other aspects of the clinical trial, which included regular visits to the research clinic, indicating that even the owners in the non-HBGM group were committed to the care of their diabetic cat. Additionally, assigning owners to one of the two groups, and thus forcing some of them to accept HBGM, would not be feasible or ethical. On the basis of direct comparison of QoL and glycaemic parameters, the two groups were very similar at enrolment, further strengthening the validity of the comparisons drawn.

We used a questionnaire to assess the cat owners' experiences with the HBGM. Although closed-ended questions offering fixed answer(s) were used, the option "other" was included in most of the questions, to enable owners to provide additional free text information. Using open-ended questions might have been more suitable to assess the owners' opinions on some issues (e.g. advantages/disadvantages of HBGM) without introducing bias. However, using open-ended questions is also associated with higher risk of larger item non-response or invalid answers, resulting in missing data.[18] Therefore, we compromised by including the option "other".

The maximal BG at month 6 was significantly lower in the HBGM group compared to the non-HBGM group. Additionally, in the HBGM-group, all glycaemic control parameters (except for minimal BG at months 3 and 6) decreased significantly compared to enrolment values. In contrast, in the non-HBGM group, improvement in only 2 glycaemic control parameters (maximal BG at month 1 and average BG at month 6) was identified, and there was no consistent pattern for the remaining parameters. Nevertheless, it should also be emphasised that when performing a direct comparison between cats in the HBGM- and non-HBGM group, a statistical significant difference was not shown at any time point during the study. Superior glycaemic control has been linked with higher remission rates.[19] Also, HBGM was an essential part of management in studies reporting the highest remission rates.[5,6] Interestingly, 9/28 (32%) cats in the HBGM group underwent diabetic remission, but this occurred in only 1/10 (10%) cats in the non-HBGM group. However, the difference between groups in remission rates was not statistically significant. Large randomised prospective studies are recommended to further investigate the impact of HBGM on remission rates.

Finally, random assignment of owners and cats to equally-sized HBGM- and non-HBGM groups might have yielded superior results in this respect. Given the importance of HBGM suggested in previous studies,[5,6] our research group, guided by our ethical committee, considered that it would be inappropriate to not actively offer HBGM to owners as part of best clinical practice. Conversely, forcing owners, who could not or did not want to

perform HBGM to enrol in the HBGM group would not be feasible or ethical either. Although this approach might have introduced selection bias into the study, this situation is more likely to reflect the "real-life" circumstances when, ideally, all owners should be able to make an informed choice about the protocol they use to manage their cat's diabetes.

Conclusions

Most (n=28/38; 74%) owners of diabetic cats were able to perform HBGM and the majority (n=17/19; 89%) considered it to be (mostly) straightforward. Overall QoL evaluated by the validated psychometric tool DIAQoL-pet improved significantly in cats/ owners choosing to perform HBGM. Specifically of interest was an owner-reported decrease in worry about the diabetes and particularly hypoglycaemia in the HBGM group, which did not occur in the non-HBGM group. This study adds to the body of peer-reviewed evidence that suggests HBGM is a practical monitoring tool for many owners of diabetic cats and suggests it is associated with a positive impact on QoL in both the diabetic cat and the owner. Further studies are warranted to assess its possible positive impact on glycaemic control.

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Conflicts of interest

This research was supported by Zoetis, which sells glucometers for use in dogs and cats. However, under the Royal Veterinary College's Code of Research Conduct, the authors performed the research entirely independently, and did not allow external influence over the generation, reporting or interpretation of the results reported in this paper.

Supplementary information:

Supplement 1 - Questionnaire about owner's experience with home blood glucose monitoring – HBGM-group.

Supplement 2 - Questionnaire about owner's experience with home blood glucose monitoring – non-HBGM-group.

Supplement 3 – Supplementary material to Table 1.

Supplement 4 - Comparison of DIAQoL-pet at different time points within the non-HBGM group.

Supplement 5 - Comparison of parameters of glycaemic control at different time points within the non-HBGM group.

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375 **Table 1.** The validated Diabetic Clinical Score (DCS) used to grade the severity of diabetes-associated clinical

376 signs in participating cats

Clinical Sign Being Scored	Severity	Assigned Score
Unintended weight loss over the past 2 months (Assessed using bodyweight records or measurements)	None, or weight gain Mild (<5% loss) Moderate (5-10% loss) Severe (>10% loss)	0 1 2 3
Increased drinking and/or urination (Assessed by questioning owner)	None Mild – some increase noted Moderate – increased filling of water bowl Severe – constantly seen to drink	0 1 2 3
Increased appetite (Assessed by questioning owner)	Normal or decreased appetite Mild – finishes food eagerly Moderate – finishes food eagerly and begs for more Severe – obsessed with food	0 1 2 3
Decreased activity/ attitude (Assessed by questioning owner)	Normal or increased activity Mild – slightly less active Moderate – certainly less active Severe – mainly lying around	0 1 2 3
	Total score	/12

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Table 2. Overview of questions (items) of the DIAQoL-pet survey[3] pertinent with regards to home blood glucose monitoring (HBGM). Each item was scored according to frequency at which it impacted on owner's and pets' lives (all the time [3], often [2], occasionally [1], never [0]) and how important the item was in the individual owner's and pet's lives (very important [4], important [3], moderately important [2], low importance [1], not at all important [0]). Item-weighted impact score (IWIS) was calculated for each item by multiplying frequency and importance ratings for each question.

Abbreviation	Question (item)
More control	Do you ever feel you want to take more control of the diabetes on your own, without the help of vets and other people?
Hypoglycaemia	Does your pet ever show signs of a low blood sugar? (eg, wobbliness, collapse)
Worry hypo	Do you ever feel worried about your pet suffering from an episode of low blood glucose?
Costs	Do you ever worry about how much money your pet's diabetes costs you and your family?
Worry	Do you ever worry about your pet's diabetes?
Restrict your activities	Do you ever find the diabetes of your pet restricts or limits what you are doing or what you want to do, like going on holidays, away on weekends, away for the day/night, working?
Social life	Do you ever find you need to fit your pet's diabetes into your social life? (eg, carrying needles, food, insulin, providing food on time)
Working life	Do you ever find you need to fit your pet's diabetes into your working life? (eg, having to make special arrangements when you need to work late or need to start working earlier)
Special bond	Do you feel you have a more special bond with your pet now that you are managing his/her diabetes?

386 **Table 3.** Comparison of the demographic data, DIAQoL-pet score (quality of life tool) and parameters of
387 glycaemic control (DCS – diabetic clinical score; serum fructosamine; average blood glucose based on blood
388 glucose curve) between the HBGM (home blood glucose monitoring)- and non-HBGM group at enrolment,
389 months 1, 3 and 6.

Parameter	HBGM group	Non-HBGM group	p-value
Number of cats	28	10	
Age (years) (median, range)	12.05 (4-17.2)	9.5 (7-15.5)	0.076
Age (months) (median, range)	144.7 (48.4-206.8)	113.3 (84.1-185.4)	0.085
Breed - Domestic Shorthair+Longhair - Other breed	 25 3	 9 1	1.00
Gender - female spayed - male neutered	 15 13	 1 9	0.025
BW (kg) (median, range)	4.4 (2.8-8.3)	5.1 (3-6.9)	0.226
BCS (median, range)	5 (1-8)	5 (3-8)	0.723
% BF (median, range)	22.8 (2.11-42.5)	21.6 (16.6-32.4)	0.921
fPLI (ug/L) (median, range)	3.55 (0.5-58.0)	3.8 (0.5-50)	0.715
Time on insulin prior to enrolment (days)	59 (36-150)	60.5 (44-108)	0.947
Insulin dose prior to enrolment (U/cat)	2 (1-5)	2.5 (1-6)	0.893
Insulin dose prior to enrolment (U/kg BW)	0.51 (0.22-1.32)	0.54 (0.24-1.16)	0.691
Insulin type subsequently used	14 ProZinc/ 14 Glargine	5 ProZinc / 5 Glargine	1.00
DIAQoL-pet month 0 (median, range)	-1.52 (-4.45 - -0.31)	-1.31 (-5.34 - -0.1)	0.390

DIAQoL-pet month 1 (median, range)	-1.12 (-3.69 - +0.28)	-1.21 (-3.59 - -0.3)	0.940
DIAQoL-pet month 3 (median, range)	-0.95 (-4.83 - +0.38)	-0.76 (-1.59 - -0.3)	0.603
DIAQoL-pet month 6 (median, range)	-0.45 (-3.14 - +0.14)	-0.9 (-2.28 - -0.3)	0.352
Serum fructosamine month 0 (umol/L) (median, range)	476.5 (59-715)	431.5 (168-715)	0.703
Serum fructosamine month 1 (umol/L) (median, range)	380 (232-572)	398.5(233-575)	0.473
Serum fructosamine month 3 (umol/L) (median, range)	302 (215-606)	349 (241-560)	0.406
Serum fructosamine month 6 (umol/L) (median, range)	307 (215-636)	351 (248-561)	0.429
DCS month 0 (median, range)	3.5 (0-11)	3.5 (0-9)	0.651
DCS month 1 (median, range)	1 (0-5)	1.5 (0-5)	0.750
DCS month 3 (median, range)	0 (0-6)	1 (0-4)	0.118
DCS month 6 (median, range)	0 (0-6)	1 (0-2)	0.417
Average BG month 0 (mmol/L) (median, range)	14.2 (7.9-21.7)	12.9 (7.7-22.2)	0.829
Average BG month 1 (mmol/L) (median, range)	10.6 (4.1-21.5)	10.5 (4-19.2)	0.572
Average BG month 3 (mmol/L) (median, range)	10.85 (4.1-21.4)	14.35 (7.6-19.7)	0.234
Average BG month 6 (mmol/L) (median, range)	9.95 (3.4-19.9)	13.75 (7.7-19.3)	0.146
Remission rate (remission/all)	9/28	1/10	0.236
Time to remission	70 (40-130)	45 (n/a)	n/a

390 BW – body weight; BCS – body condition score (1-9/9)[15]; % BF – percentage of body fat[16]; BG – blood

391 glucose; n/a – not applicable

392 **Table 4.** Comparison of DIAQoL-pet (quality-of-life tool), including specific questions (see below), between

393 enrolment and months 1, 3 and 6 within the HBGM group.

Parameter	Enrolment (month 0)	Month 1	Month 3	Month 6
DIAQoL-pet (median, range)	-1.52 (-4.45 - -0.31)	-1.12 * (-3.69 - +0.28)	-0.95 ** (-4.83 - +0.38)	-0.45 **** (-3.14 - +0.14)
"owner wanting more control" (median, range)	0.00 (-12.00 – 0.00)	0.00 (-8.00 – 0.00)	0.00 (-6.00 – 0.00)	0.00 * (-4.00 – 0.00)
"hypo" (median, range)	0.00 (-4.00 – 0.00)	0.00 (-3.00 – 0.00)	0.00 (-8.00 – 0.00)	0.00 (-4.00 – 0.00)
"worry hypo" (median, range)	-3.00 (-8.00 – 0.00)	-3.00 (-9.00 – 0.00)	-1.00 ** (-12.00 – 0.00)	0.00 *** (-8.00 – 0.00)
"costs" (median, range)	-4.00 (-12.00 – 0.00)	-2.00 (-12.00 – 0.00)	-1.00 * (-12.00 – 0.00)	0.00 *** (-12.00 – 0.00)
"worry" (median, range)	-4.00 (-12.00 - -1.00)	-2.00 * (-12.00 – 0.00)	-3.00 ** (-12.00 – 0.00)	-2.00 ** (-12.00 – 0.00)
"restrict your activities" (median, range)	-3.00 (-12.00 – 0.00)	-2.00 (-12.00 – 0.00)	-2.00 (-12.00 – 0.00)	0.00 ** (-9.00 – 0.00)
"social life" (median, range)	-3.00 (-12.00 – 0.00)	-2.00 (-12.00 – 0.00)	-1.00 (-12.00 – 0.00)	0.00 (-9.00 – 0.00)
"working life" (median, range)	-2.00 (-12.00 – 0.00)	0.00 (-12.00 – 0.00)	-2.00 (-12.00 – 0.00)	0.00 * (-12.00 – 0.00)
"special bond" (median, range)	2.00 (0.00 – 12.00)	2.00 (0.00 – 12.00)	1.00 (0.00 – 12.00)	2.00 (0.00 – 12.00)

394 * The value is significantly different from enrolment (month 0) at a level of significance $p<0.05$

395 ** The value is significantly different from enrolment (month 0) at a level of significance $p<0.01$

396 *** The value is significantly different from enrolment (month 0) at a level of significance $p<0.001$

397 **** The value is significantly different from enrolment (month 0) at a level of significance p<0.0001

398

399 **Table 5**. Comparison of parameters of glycaemic control at different time points within the HBGM group.

Parameter	Enrolment (month 0)	Month 1	Month 3	Month 6
DCS (median, range)	3.5 (0-11)	1 **** (0-5)	0 **** (0-6)	0 *** (0-6)
Serum fructosamine (umol/L) (median, range)	476.5 (59-715)	380 ** (232-572)	302 ** (215-606)	307 *** (215-636)
Insulin dose (U/cat) (median, range)	2 (1-5)	2 * (0.25-5.5)	2 * (0-5)	1.5 * (0-6.5)
Insulin dose (U/kg BW) (median, range)	0.51 (0.22-1.32)	0.45 * (0.06-1.36)	0.41 * (0-1.08)	0.32 ** (0-1.65)
Average BG (mmol/L) (median, range)	14.2 (7.9-21.7)	10.6 *** (4.1-21.5)	10.85 *** (4.1-21.4)	9.95 ** (3.4-19.9)
Average pre-insulin BG (mmol/L) (median, range)	18.2 (8.3-23.3)	11.75 **** (5.5-20.6)	11.45 ** (3.6-22.2)	13.1 * (6.7-19.9)
Minimal BG (mmol/L) (median, range)	6.55 (2.2-18.4)	3.5 * (2.2-18.4)	5.7 (2.2-17.1)	4.9 (2.2-12.8)
Maximal BG (mmol/L) (median, range)	22.2 (13.2-22.2)	20.2 * (8.9-22.2)	19.5 ** (6.3-22.2)	14.9 *** (5.4-22.2)

400 DCS – diabetic clinical; BG – blood glucose

401 * The value is significantly different from enrolment (month 0) at a level of significance p<0.05

402 ** The value is significantly different from enrolment (month 0) at a level of significance p<0.01

403 *** The value is significantly different from enrolment (month 0) at a level of significance p<0.001

404 **** The value is significantly different from enrolment (month 0) at a level of significance p<0.0001

405

406 **Table 6.** Summary of advantages and disadvantages of home blood glucose monitoring (HBGM) as well as
407 description of the technique and difficulties encountered during HMBG. Number and percentage of
408 respondents (of 19 returned questionnaires) are given in brackets after the item.

Advantages of HMBG: - not having to take their cat to the veterinarian or leave the cat at the practice (n=16; 84%) - owner feeling to have more control over their cat's diabetes (n=13; 68%) - owner feeling their cat's diabetes is better controlled since performing HMBG (n=12; 63%) - lower costs compared to glucose curves at veterinary practice (n=12; 63%) - less stressful compared to glucose curves at veterinary practice (n=11; 58%)
Disadvantages of HMBG: - no disadvantages (n=6; 32%) - HMBG is time consuming (n=7; 37%) - cat seems uncomfortable during the procedure (n=6; 32%) - owner feeling he/she is hurting the cat (n=6; 32%)
Sampling site: - outer pinna (n=14; 74%), outer + inner pinna (n=1; 5%) - paw pad of the front limb (n=1; 5%), paw pad of the hind limb (n=1; 5%), paw pad of the front and hind limb (n=2; 11%)
Tools used to obtain blood samples: - lancet (n=16; 84%), hypodermic needle (n=1; 5%), insulin needle (n=1; 5%), needle from the lancet (n=1; 5%)
Additional procedures to enhance blood sampling: - massage the ear before puncturing it (n=12; 63%) - apply vaseline (n=7; 37%) - apply anaesthetic cream (e.g. EMLA) (n=5; 26%) - clipping the ear for better visualisation of the marginal ear vein (n=2; 11%) - using a small torch for better visualisation of the marginal ear vein (n=1; 5%)
Need for other person to assist during HBGM: - always (n=7; 37%), sometimes (n=5; 26%), never (n=7; 37%)

Recording of blood glucose readings: - using a diary (not digital) (n=13; 68%) - creating tables/graphs using a computer programme/software, e.g. Microsoft Excel (n=3; 16%) - using a chart supplied with the glucometer (n=2; 11%) - using an App for human diabetics or pets (n=1; 5%)
Difficulties encountered during HMBG: - need for more than 1 puncture due to technical difficulties (n=17; 89%) - obtaining a too small blood drop (n=8; 42%) - difficulties using the glucometer (n=8; 42%) - cat resisting the sampling (n=6; 32%) - bruising (n=1; 5%) or formation of scar tissue (n=1; 5%) at the puncture site
How the difficulties with HMBG could be resolved: - practising the technique and the use of the glucometer (n=13; 68%) - advice given at the re-examination at our clinic or local veterinarian (n=4; 21%)

409

410

411 **Figure 1.** DIAQoL-pet score (quality-of-life tool) in the home blood glucose monitoring (HBGM) and non-
412 HBGM groups over the 6 month study period. Higher scores are suggestive of better quality of life.
413 Circles/squares and error bars represent median and range. Significantly different values (P <0.05) are
414 marked with an asterisk.

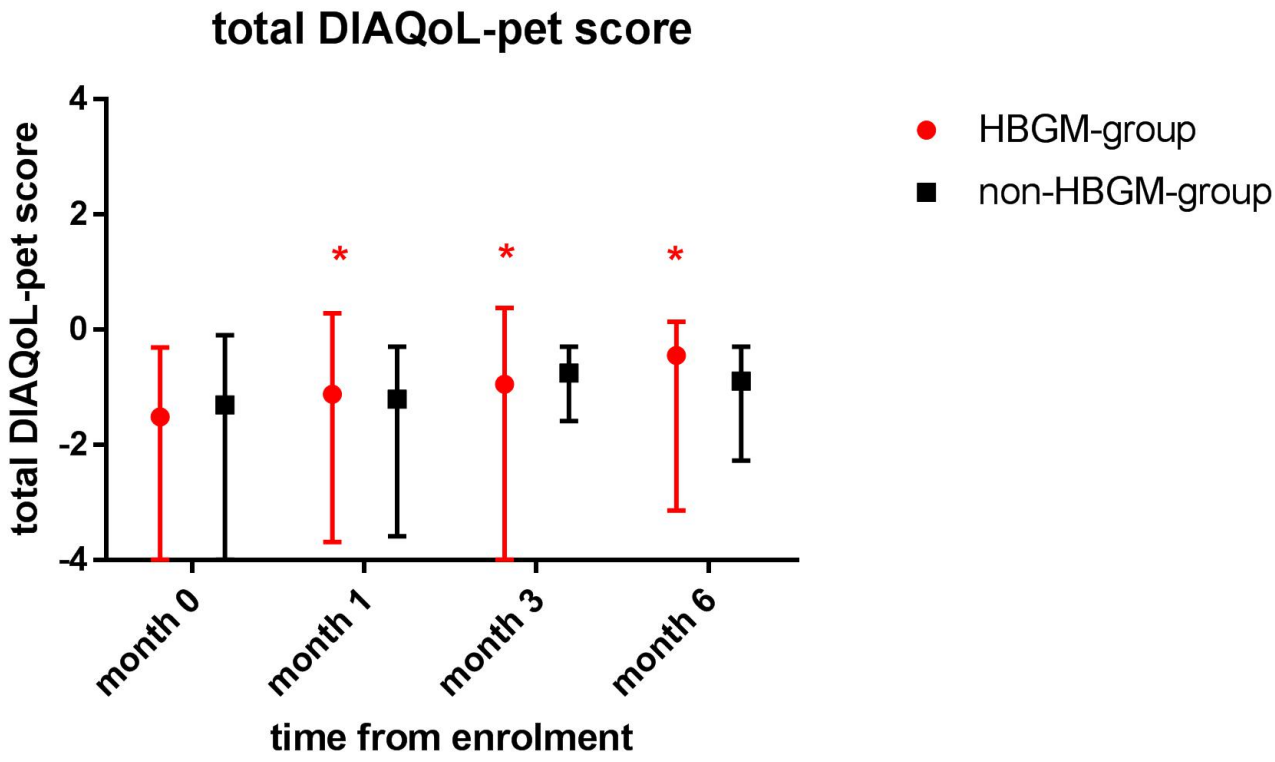

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Figure 2. Average blood glucose (obtained from 24 h blood glucose curves) in the home blood glucose monitoring (HBGM) and non-HBGM groups over the 6 month study period. Circles/squares and error bars represent median and range. Significantly different values ($P < 0.05$) are marked with an asterisk. Average blood glucose was significantly lower at months 1, 3 and 6 compared with baseline in the HBGM group but not in the non-HBGM group. There were no significant differences in average blood glucose between the groups at any time point.

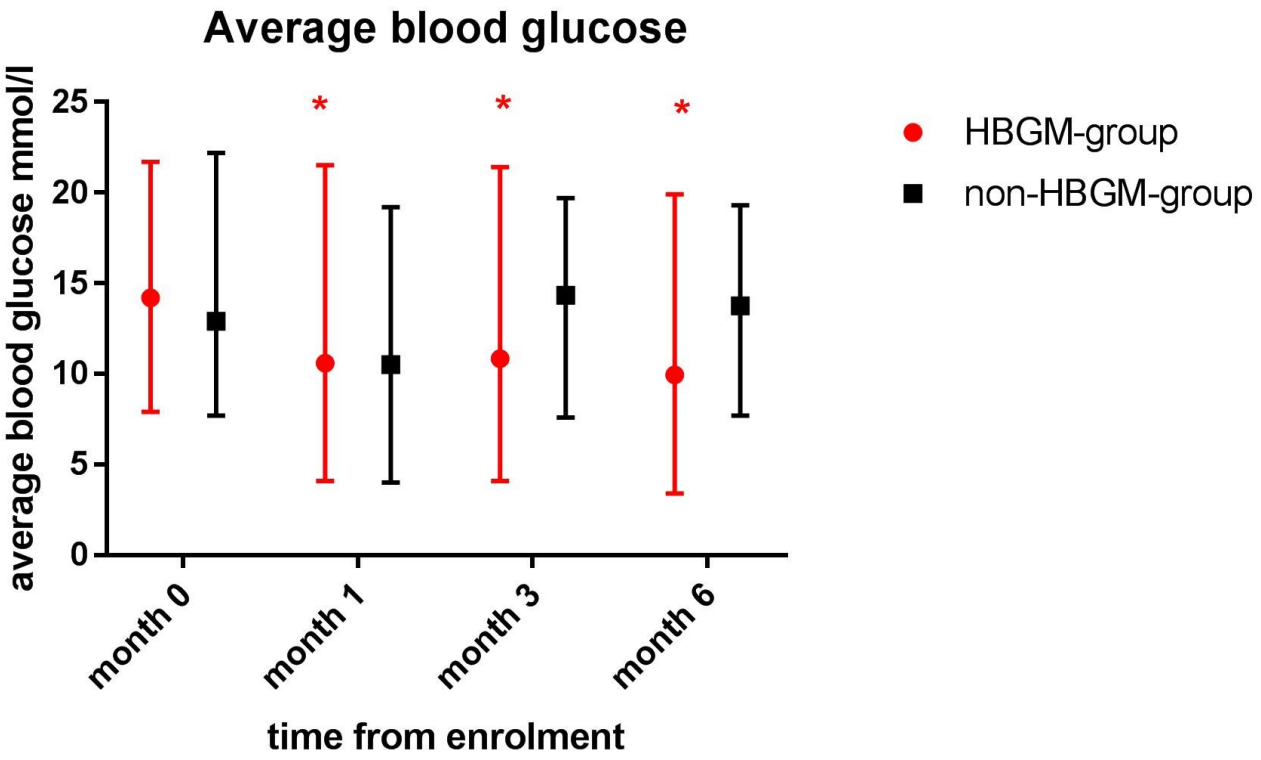

Figure 3. Serum fructosamine concentration in the home blood glucose monitoring (HBGM) and non-HBGM group over the study period. Circles/squares and error bars represent median and range. Significantly different values (P <0.05) are marked with an asterisk. Serum fructosamine concentrations were significantly lower at months 1, 3 and 6 compared with baseline in the HBGM group but not in the non-HBGM group. There were no significant differences in serum fructosamine concentrations between the groups at any time point