



The effect of photobiomodulation therapy on the management of chronic idiopathic large-bowel diarrhea in dogs

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Received: 31 August 2021 / Accepted: 11 November 2021

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Abstract

To evaluate photobiomodulation therapy's effectiveness (PBMT) in managing chronic idiopathic large-bowel diarrhea. Thirty dogs were selected and divided into a control (CG) and treatment group (TG). CG received psyllium husk at the dose of 4 tablespoons/day for 30 days. TG received PBMT with a Class IV therapeutic laser, divided into three sessions on week 1, two sessions on week 2, and one session on week 3. A daily log of fecal characteristics was maintained, and on days 0, 8, 15, and 30, a canine inflammatory bowel disease index (CIBDAI) and body condition scores (BCS) were obtained. Results were compared using a Mann–Whitney test. Multiple regression was run to predict CIBDAI, Bristol stool scores, and diarrhea from different parameters. The Kaplan–Meier test was used to compare the occurrence rate of ≥ 1 day of diarrhea and ≥ 2 days of diarrhea by 30 days. Cox regression analysis to investigate interest covariates influences the same outcome. A $p < 0.05$ was set. The sample included 15 Belgian Malinois Shepherd Dogs, 10 German Shepherd Dogs, and 5 Dutch Shepherd Dog, with a mean age of 3.6 ± 2.3 years and a bodyweight of 24.6 ± 8.0 kg. TG showed an improvement in all scores and clinical signs, increased body weight, and BCS. An increased time of appearance of a second episode of diarrhea was observed in both groups. Activity level contributed to the prediction of defecation frequency and CIBDAI. PBMT significantly improved clinical signs and frequency of diarrhea episodes compared to psyllium husk.

Keywords Dog · Photobiomodulation · Diarrhea · Canine inflammatory bowel disease index · Bristol stool chart · Therapeutic laser Class IV

Introduction

Chronic inflammatory enteropathies, defined as gastrointestinal diseases present for three or more weeks, are considered the most common cause of chronic gastrointestinal disorder in dogs [1, 2]. Diarrhea is a significant clinical sign, consisting of increased fecal water content, fecal volume, and frequency of defecation [3, 4]. Chronic idiopathic large bowel diarrhea may occur in dogs without any evidence of inflammation [5]. Patients often present negative fecal examinations without laboratorial changes

or abnormalities on colonoscopy and histopathology [5]. These patients typically present with signs of colitis, but no pathologic lesions are found in the investigation [6]. For its diagnosis, it is essential to rule out other systemic disorders and other primary gastrointestinal diseases [7]. This condition is frequently observed in working and sporting dogs and may be linked to their high drive, excitable nature [6], and stressful [8], and competition events [9].

Prebiotics, most of them being fiber sources, can be defined as compounds that selectively stimulate the growth and/or activity of beneficial microbial genera/species in the gut, conferring a health benefit to the host [10, 11]. They have been used to alter the quality of feces in multiple species [10]. Psyllium is a source of predominantly soluble fiber [12] and has been described to improve clinical signs with working dogs with diarrhea [13, 14]. The use of photobiomodulation therapy (PBMT) has gained an increasing role in treating several conditions in dogs [15–17]. It uses red/near infrared light to produce a clinical effect that includes the stimulation of tissue healing, analgesia, and

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reduced inflammation, allied to a non-invasive nature and a lack of adverse effects [18–21]. PBMT, as a whole, is gaining increasing interest and applications in multiple areas of medicine, from surgery to dermatology, cardiology, and aesthetics procedures [22]. In particular, its use as a part of cancer treatment, through the stimulation of nanoparticles that induce apoptosis of tumor cells, speaks to the variety of innovative applications in which PBMT can be used [23, 24]. Despite a growing number of studies on PBMT being available, there is still a need to outline and test specific protocols for particular conditions. PBMT has been described as having a significant positive effect on disease progression in mice with induced colitis [21]. However, the effect of PBMT in the case of naturally occurring disease is still to be determined.

For patient follow-up, management, and response to treatment assessment, the canine inflammatory bowel disease Index (CIBDAI) has been frequently used [25, 26]. The Bristol stool scoring system has been validated and extensively used in humans, sharing similarities with other non-validated scoring scales previously used in other studies evaluating diarrheic dogs [27].

This study aimed to evaluate the effectiveness of PBMT in reducing the clinical signs of chronic inflammatory large bowel diarrhea and frequency of diarrhea episodes in police working dogs, compared to psyllium husk. We hypothesize that PBMT can produce a similar effect to Psyllium. Secondly, we looked to determine predisposing factors of chronic idiopathic large bowel diarrhea in this population of police working dogs.

Materials and methods

Thirty dogs constituted a convenience sample, selected after screening the population of police working dogs of the Guarda Nacional Republicana (Republican National Guard Canine Unit, Portugal). To be included in the study, animals should be active police working dogs, have a bodyweight ≥ 15 kg, and age > 2 years. Animals were selected based on history, trainer complaints, physical and laboratory examination consistent with chronic idiopathic large-bowel diarrhea. Considered clinical signs included low body weight, body condition score (BCS) < 4 , frequency of defecation > 3 , soft or liquid stool, excess fecal mucus, and difficulty maintaining a good body condition score, continuously or intermittently. Patients with other illnesses (ruled out through physical examination, complete blood count, and serum biochemistry profile) and any different treatment protocol were excluded. Laboratory testing included complete

blood counts, serum biochemistry panels, urinalyses, direct fecal smears, sugar, and zinc sulfate fecal flotations [28]. Faecal Clostridium (SBA), clostridial enterotoxin (ELISA), and Salmonella media screening (blood agar, MacConkey's agar, Hektoen enteric agar, or Campy BAP, then placed in selenite enrichment) were also performed. All patients were regularly vaccinated and dewormed and feed the same commercially available dog food.

After selection, 15 dogs were assigned to a control group (CG) and 15 to a treatment group (TG). Patients in the CG psyllium husk, commercially available as a powder, at the dose of 4 tablespoons/day for 1 month [8, 14]. On the same days as the treatment group, they were submitted to a sham laser therapy session (the operator conducted the same procedures as if a laser therapy session was conducted without starting the laser, 0 J/cm²). Patients in TG received PBMT with a therapeutic laser (CTC Class IV Laser, Companion, Litecure LLC). PBMT parameters can be observed in Table 1. The parameters were based on the set protocol determined with the equipment's software. Sessions were conducted for three consecutive weeks in the following fashion: on week 1, three sessions on every other day; on week 2, two sessions, two days apart; on week 3, a single session [29]. No additional session was conducted after this moment.

On days 0, 8 (+ 8d), 15 (+ 15d), and 30 (+ 30d), a CIBDAI score [25] and BCS [30] score were obtained, and patients weighed. This period is generally considered adequate to assess response to treatment [5, 25]. Handlers received a copy of the Bristol fecal chart provided to owners to aid in fecal scoring and maintained a daily fecal scoring log using the Bristol scoring system. The Bristol Stool Form Scale was chosen based on previously demonstrated substantial validity and reliability [31]. Fecal scores of ≤ 4 were considered to be non-diarrheic [27]. The number of defecations per day was also recorded [32]. The need for any drug to manage diarrhea was registered.

Normality was assessed with a Shapiro–Wilk test. In each evaluation day, groups CIBDAI scores, Bristol stool scores, and percentage of days with diarrhea were compared using a Mann–Whitney test [25, 33]. The paired-samples t-test was used to compare the bodyweight variation between day 0 and + 30d. Multiple regression was run to predict CIBDAI scores, Bristol stool scores, diarrhea from age, sex, breed, mission, and activity level. The Kaplan–Meier test was used to compare the occurrence rate of ≥ 1 day of diarrhea and ≥ 2 days of diarrhea by + 30d with the log-rank test [3]. Cox proportional hazard regression analysis was carried out to investigate interest covariates influence (age, sex, breed, mission, and activity) on the same outcome [4]. On the day

Table 1 Photobiomodulation therapy treatment parameters

Light parameters (dose)	
Wavelength (nm)	980/808 blend (80% of 980nm and 20% of 808nm)
Radiant power (W)	12 total (9.6W 980nm, 2.4W 808nm)
Irradiance (W/cm ²) at skin surface	1.92 for 980nm & 0.48 for 808nm each respectively for the blend
Fluence (J/cm ²)	6.9 for 980nm & 1.7 for 808nm each respectively for the blend
Total Joules	4320
Treatment protocol	Continuously moving grid pattern off contact at a speed of 1-3 inches/second according to manufacturer recommendations
Treatment area (cm ²)	500 (entire abdomen)
Treatment time	6 minutes

the event was recorded, patients were censored. All results were analyzed with IBM SPSS Statistics version 20, and a significance level of $p < 0.05$ was set.

Results

Dogs in this sample had a mean age of 3.6 ± 2.3 years and a bodyweight of 24.6 ± 8.0 kg, representing both sexes (male $n = 20$, female $n = 10$). Three dog breeds were represented: Belgian Malinois Shepherd Dogs (BM, $n = 15$), German Shepherd Dogs (GSD, $n = 10$), and Dutch Shepherd Dog (DSD, $n = 5$). Regarding specific missions, 14 animals were use of force dogs, 10 were product detection dogs (drugs or explosives), and 6 were search and rescue dogs. Fourteen animals had increased defecation frequency (> 3 times a day), 15 had a Bristol stool score corresponding to diarrhea, and 23 had a BCS of 3. Twenty-one dogs were classified as very active, and 9 as extremely active. Results of complete blood counts and serum biochemistry are presented in Table 2. All patients were followed up to the + 30d evaluation moment, and during this period, no additional medications were administered. Since all patients were large dogs, no variation was introduced to the provided irradiance and power. No side effects were recorded following PBMT or psyllium administration.

The results of the conducted evaluations are presented in Table 3. No significant differences were observed between groups at the initial evaluation. While considered evaluation results improved in both scores, TG showed significantly better results in most of them. CIBDAI was significantly predicted by age $F(1, 32) = 9.569$, $p = 0.04$, $R^2 = 0.208$, and activity level $F(1, 32) = 9.449$, $p < 0.01$, $R^2 = 0.228$. The frequency of defecation was predicted by activity level $F(1, 29) = 7.903$, $p < 0.01$, $R^2 = 0.214$,

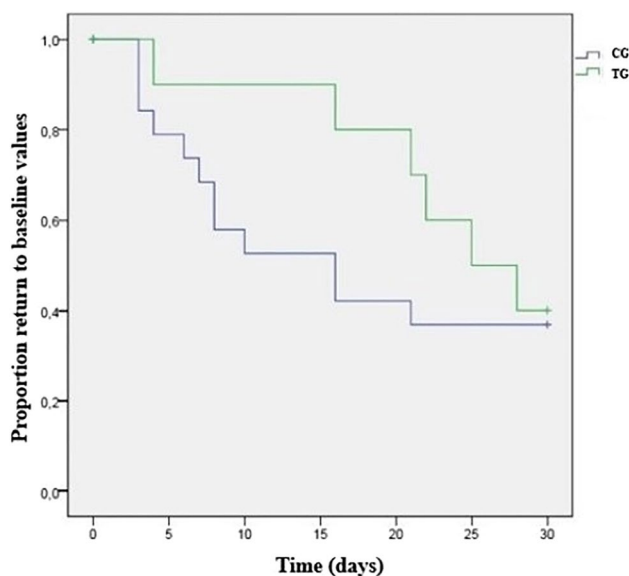
Table 2 Mean (\pm standard deviation) results of complete blood count results and serum biochemistry

Parameter	Mean value	SD	Reference value
RBC ($\times 10^6/\text{mm}^3$)	6.49	1.02	5.5–8.5
Hemogl (g/dL)	14.96	0.00	12.0–18.0
Hemat (%)	44.06	7.70	37.0–55.0
WDC ($\times 10^3/\text{mm}^3$)	10.48	3.82	6.0–17.0
Linfocytes ($\times 10^3/\text{mm}^3$)	2.14	0.94	1.0–4.8
Monocytes ($\times 10^3/\text{mm}^3$)	0.81	0.44	0.2–2
Neutrophils ($\times 10^3/\text{mm}^3$)	7.02	0.71	3.0–11.8
Eosinophils ($\times 10^3/\text{mm}^3$)	0.49	0.71	0.1–1.3
Basophils ($\times 10^3/\text{mm}^3$)	0.03	0.03	0.0–0.5
Platelets ($\times 10^3/\text{mm}^3$)	305.56	86.34	200–500
Urea (mg/dL)	40.52	14.70	15–40
Creat (mg/dL)	0.87	0.31	0.4–1.4
AST (U/L)	47.30	17.66	10–40
ALT (U/L)	51.43	25.95	10–70
PT (g/L)	41.86	24.73	55–75
ALB (g/L)	30.06	14.75	23–31
Colesterol (mg/dL)	189.42	39.14	110–314
Vit. B12 (ng/L)	528.90	267.42	> 190

and breed $F(1, 29) = 9.285$, $p < 0.01$, $R^2 = 0.243$. The Kaplan–Meier test showed no difference in the time of appearance of a first episode of diarrhea (12.6 ± 3.0 for CG and 12.3 ± 3.7 for TG, $p = 0.42$). Still, an increased time of appearance of a second episode of diarrhea has been observed between groups (16.6 ± 2.6 for CG and 23.6 ± 2.5 for TG, $p = 0.42$). Survival curves are presented in Fig. 1. The Cox regression results showed that treatment significantly influenced this outcome, with CG showed a 4.5-fold probability of experiencing the event (95% confidence interval 0.53–3.85, $p = 0.01$) compared with CG. Active dogs showed a 0.23-fold probability

Table 3 Mean (\pm standard deviation) results of performed evaluations in the control group (CG) and PBMT group (TG)

Measurement	Group	T0		p	+ 8d		p	+ 15d		p	+ 30d		p
		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Body Condition Score	CG	3.0	0.0	0.91	3.1	0.3	0.08	3.8	0.4	<0.01*	3.8	4.0	0.02*
	TG	3.2	1.0		3.5	1.2		4.3	1.2		4.0	0.8	
Bodyweight variation	CG	-	-	0.46	0.3	0.9	0.04*	1.3	0.8	0.03*	2.7	0.6	0.11
	TG	-	-		2.0	0.5		2.6	0.6		2.5	0.5	
CIBDAI	CG	4.3	0.5	0.68	3.9	0.8	<0.01*	3.4	1.6	<0.01*	2.1	1.2	0.04*
	TG	4.7	1.8		1.3	0.6		1.1	0.6		1.1	0.6	
Bristol Stool grade	CG	5.1	1.6	0.29	4.1	1.1	0.19	3.4	1.1	1.00	2.4	1.0	0.56
	TG	5.8	1.7		3.4	1.3		3.3	0.9		2.2	1.1	
Defecation frequency	CG	3.9	0.9	0.11	3.5	1.1	<0.01*	3.1	0.8	0.01*	2.6	0.9	0.89
	TG	3.7	0.7		2.5	0.5		2.4	0.5		2.7	0.7	
Diarrhea (%)	CG	50.0	5.0	0.29	30.0	4.0	0.63	30.0	4.0	0.04*	0.0	0.0	1.00
	TG	60.0	5.0		20.0	5.0		10.0	3.0		0.0	0.0	

**Fig. 1** Kaplan–Meier curve demonstrating a significant difference between the control group (CG) and treatment group (PG) in time for the appearance of a the second episode of diarrhea

of experiencing the event (95% confidence interval 0.20–0.70, $p = 0.02$) compared to extremely active dogs.

Discussion

Chronic inflammatory enteropathies are considered the most common cause of chronic gastrointestinal disease in dogs [1, 2]. Our results show that PBMT can reduce clinical signs and scores in working dogs with chronic inflammatory large bowel diarrhea compared to a control.

Although both approaches produced an improvement, PBMT showed better results.

In an induced model of colitis, PBMT has shown a therapeutic effect [21]. We recorded similar results, with TG patients showing an increase in body weight and BCS while reducing CIBDAI scores, defecation frequency, and diarrhea episodes frequency. The previous reports on Psyllium husk's use have described a very good to excellent response to treatment, with effects persisting even after the discontinuation of treatment [5, 8, 13]. An analogous response was observed in the present study, but the results were not as marked as in TG. This difference was still present for BCS and CIBDAI scores at + 30d, while the remaining evaluations recorded similar improvements on the last evaluation day. Still, on this 4th and final week of follow-up, no PBMT treatment session was conducted, showing a possible lasting effect of laser therapy.

For most patients, complete blood counts and biochemistry results are reported as normal [8], without specific findings associated with breed, age, sex, or changes present in other enteropathies, as high ALT and C-reactive protein or Cobalamin [33–35]. We did not record apparent changes in laboratorial findings or during physical examination, other than a low BCS in some cases. As described by activity level and breed, personality traits significantly contributed to predicting CIBDAI scores and frequency of defecation at the initial evaluation. It has been described that the breed of a dog affects digestion, with larger breeds typically having less ability to digest foods [7], and some certain breeds, such as German shepherd dogs (GSD), appear predisposed to some enteropathies [36]. All of the animals included in this sample were large dogs, and of the 9 animals described as very active, 5 were Belgian Malinois, and 4 were Dutch Shepherd Dogs. Belgian Malinois, in particular, are usually described and selected based on a very high drive, which

may account for this association of activity level and breed to CIBDAI scores and frequency of defecation. Although fecal scoring is a subjective approach, with some degree of intra-observer and interobserver variability, there is evidence suggesting that fecal scoring is valid. It has been used before in human and canine trials an adequate performance [3, 27]. All dogs had fecal scores < 5 at the last follow-up, with a reduced frequency of diarrhea episodes. It was also an easy method to keep a daily log of these animals' conditions and improve veterinary-client communication [31]. Recent studies show that the use of PBMT can have a positive effect at the histological level. It can reduce lesion size, reduce inflammation levels, and improve histopathological assessment [23, 24]. These effects were obtained with similar treatment parameters as the ones used in the present study. Although we did not perform histological evaluations, it is reasonable to consider that the observed improvements occur at the same levels, with a decrease of inflammation and cell function reflected in improved CIBDAI and body condition score and increased body weight.

Stress, which may be defined as an external disturbance or threat from the environment that disrupts homeostasis [37], may play an essential role in this disease. In rodent models, chronic stress produces various changes that affect small and large intestines, from epithelial barrier dysfunction, inflammation, and metabolic abnormalities, also increasing fecal output [5]. These effects develop rapidly and can be long-lasting [37]. In working dogs, it may be associated with a specific activity or event or with kenneling [3, 6]. Other canine athletes, like sled dogs, show a high prevalence of diarrhea during athletic events, with a toll on performance [9, 10]. Similar effects were observed in human athletes, and clinical signs include bloating, diarrhea, and flatulence, which can occur more at rest than during exercise [38]. As for human athletes, it is challenging to manage a working/sporting dog's training, stresses, and diet. Psyllium and PBMT were both able to improve clinical signs in these dogs. Still, PBMT may be a better option. It does not require daily administrations, which may be challenging in larger dogs while producing better results, significantly increasing the time between diarrhea episodes. During treatment sessions, animals show obvious signs of comfort and enjoy the treatment. The majority would immediately lie on the treatment table belly up, and some almost fell asleep during the session. This comfort and relaxation may also help, as extremely active dogs were most likely to experience new diarrhea episodes.

We did not observe any side effects in either group. This is in line with what has been described, with side-effects of therapeutic laser usually attributed to misuse and include the potential to be hazards to the eyes and skin [39]. The study presents some limitations, namely the fact that intestinal biopsy and histopathological examination were not

performed. Also, although body weight was recorded and BCS was calculated, it was not possible to determine if the changes recorded accounted for a gain in lean muscle or fat mass. Another limitation is that long-term monitoring was not performed, so we cannot determine the two interventions' long-term benefits. The effect of PBMT in different types of diarrhea should also be determined in future studies.

Conclusion

This study showed that PBMT significantly improved clinical signs of chronic inflammatory large bowel diarrhea and frequency of diarrhea episodes, in police working dogs, compared to psyllium husk. Extremely active animals had an increased frequency of defecation and higher CIBDAI scores. PBMT may present a non-invasive, cost-effective, low-risk approach to the management of working/sporting dogs.

Acknowledgements The authors would like to thank Manuel Pereira for the help in the analysis of the data.

Author contribution JCA designed the protocol, conducted treatments, and prepared the manuscript.

PJ and AS selected the patients and conducted treatments.

All authors have read and approved the manuscript.

Data availability All data generated or analyzed during this study are included in this published article.

Code availability Not applicable.

Declarations

Ethics approval and consent to participate The study protocol was approved by the ethical review committee of the University of Évora (Organismo Responsável pelo Bem-estar dos Animais da Universidade de Évora, approval n° GD/11670/2020/P1), and complies with ARRIVE guidelines. All methods were carried out in accordance with relevant guidelines and regulations. Written, informed consent was obtained from the Institution responsible for the animals (Guarda Nacional Republicana, Portuguese Gendarmerie).

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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