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Low-cost do-it-yourself (DIY) mannequin for blood collection: A comprehensive evaluation about its use in teaching

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ABSTRACT

The use of mannequins to practice different clinical procedures in undergraduate students complies with the 3R principle (Replacement, Reduction, Refinement) without affecting professional competencies. However, commercial solutions are often expensive and therefore, not available for many schools.

The main aim of this study was to describe the development and validation of an economical Do-It-Yourself mannequin for jugular blood collection from dogs. The use of the mannequin was evaluated by (1) assessment of the opinion of students and experts and (2) by conducting a pilot study where salivary biomarkers of stress were determined in students and dogs.

The costs of the materials needed for the mannequin confection were less than 60 Euros and it was easily built in less than 1 h. The mannequin was very well accepted and scored by both, students and experts, being mostly liked a lot and considered it to be very useful for the practices (Scored 8, 9 or 10/10). Students that could first practice with the mannequin reported a self-perceived higher level of confidence and had lower levels of alpha-amylase in saliva after the procedure.

Overall, the mannequin enables the initiation of blood sampling skills in agreement with 3R principles and is easy to perform, economically affordable and sustainable. This model could be adapted to other vein simulations and animal species, and has the potential to help students deal with stressful situations such as taking blood samples from a live animal.

1. Introduction

Veterinary medical propaedeutic is the discipline that deals with the teaching of animal clinical examination techniques, interpretation of the obtained data and establishment of clinical judgments. Therefore, Veterinary medical propaedeutic is one of the core courses in the Veterinary curricula. Traditionally, in Veterinary Schools, live animals were employed in this course in order to familiarise students with animal handling during exploration, physical evaluation and sampling. However, in many educational facilities, only a limited number of animals could be maintained for these aims due to mainly space and economic issues, resulting in repeated manipulation of the same animals for different procedures by a number of inexpert students for obtaining needed skills. In this way, the well-being and welfare of these animals could be affected. To improve this situation in compliance with the 3R principle (Replacement, Reduction, Refinement) without affecting professional competences acquired by the students, new didactic materials including models, mannequins, and simulators among others have begun to be employed (Flecknell, 2002; Martinsen and Jukes, 2005).

In the last years, different commercial mannequins appeared in the veterinary market offering the opportunity to familiarise students with different clinical procedures such as blood extraction, intubation and

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rectal exploration among others. The employment of the mannequins improves ethical, curricular, financial, and logistic factors (Noyes et al., 2021). However, commercial solutions are often expensive and therefore, not available for many schools, or in the best of cases, schools must decide and select the most necessary model leaving behind others. To improve this situation, different open-source DIY (do-it-yourself) solutions were reported such as a simulator for feline cephalic vein cannulation (Silva et al., 2021), canine prostate palpation (Capilé et al., 2015), and mannequin for canine abdominal and vaginal palpation (Anciuti et al., 2021). The standout of inexpensive DIY models is that they are available to everyone and everywhere. In addition, they are built on-site and recycled materials can be used for their development. Therefore, these models are greener and more sustainable.

The main aim of this study was to describe the development and validation of a mannequin for blood collection. The novelty of this report is that although it is focused in jugular blood collection from dogs, the materials employed could be used to develop a mannequin for any other vein simulation or veterinary species. In addition, a special emphasis has been placed on the evaluation of the mannequin, which has been carried out by the (1) assessment of the opinion of students and experts and (2) by conducting a pilot study using biomakers of stress in saliva in students and dogs.

2. Material and methods

2.1. Materials

The materials used to develop the mannequin are detailed in Table 1. They all were acquired in the local or online shops.

2.2. Mannequin confection

To perform the mannequin, first, the seam that joins the head with the rest of the stuffed dog's body has been undone and a piece of cloth has been sutured to prevent the stuffing from coming out of the head. Afterwards, the neck structure was performed by cutting to adapt the shape of the floral sponge. The floral sponge was selected due to its rigidity, easy modulation and lightweight. That, to achieve a touch that resembles the touch of neck muscularity, the neck structure made from a floral sponge was then covered by two layers of protective roll: the first placed horizontally and the second vertically. In the second layer, 5 holes were made - four to pass the latex tube to simulate the veins and one to pass the "trachea" tube. After incorporation of the vein (latex) tube and the trachea tube, the entire block was inserted into the stuffed animal neck area, the top of the trachea tube has been sewn to the cloth that separates the head and the endings of the "vein" tube were pulled out through the holes made in the back of the stuffed animal (Fig. 1). At one end of the tube, a Y-shaped connector has been incorporated to thus connect the transparent tube making a loop so that the liquid does not come out and the pressure is maintained. While at the second end of the "vein" tube, the I-shaped connector was placed to connect the mannequin with the water bottle filled with coloured water mitigating blood. The different types of tubes were used since the transparent flexible PVC tube was easier to obtain and were more economic than the latex tube. Finally, to facilitate easy access to the confectioned neck block, a piece of cloth (similar to the stuffed cape) has been sutured on one side of the neck, while on the other side the Velcro has been incorporated. In total it took less than 1 h to make the mannequin.

Table 1
Material used for mannequin confection.

Mannequin part	Material	Trademark or place of acquisition	Cost* (eur)
Body (Fig. 1A)	Stuffed dog (can be recycled toy)	Local Toy Shop	11.00
Prevent stuffing	Piece of cloth (recycled)		0.00
Musculature (Fig. 1B)	Protective roll for corners, 1 m	ARREGUI, Gipuzkoa, Spain	9.50
Trachea (Fig. 1C)	Flexible light grey PVC bend for tube (20 × 300 mm)	Leroy Merlyn	1.39
Neck Structure (Fig. 1D)	Floral Sponge	Local Flower Shop	2.99
Veins (Fig. 1E)	6x9mm Latex Tube	Ritte; Amazon	15.00
Connectors (Fig. 1F)	Connectors for rubber and plastic tubes (8 mm, 8 pieces)	BGS technic, Amazon	7.02
Transparent Tube (Fig. 1G)	7x9mm Flexible PVC Tube, 3 M	Kesote, Amazon	8.99
Reservoir (Fig. 1H)	Empty plastic water bottle (recycled)		0.00
Neck skin	Piece of cloth like the stuffed dog (recycled)		0.00
		Total	55.89

* The goods were acquired in Spanish market (2021), thus the costs can vary depending of the country and year of acquisition.

2.3. Evaluation

Three studies were performed to assess the utility of the performed mannequin, in which the following aspects were evaluated:

1) Use of mannequin as supplementary material for undergraduate practical classes. The performed mannequin was included in a practical lesson of third-year students registered at the compulsory subject 'Clinical Propaedeutic' of Veterinary Medicine Degree of the University of Murcia, Spain, academic year 2019/2020. After the end of the course, all students ($n = 80$) were asked to fill out an online anonymous survey consisting of two questions. The questions aimed to assess if students liked the developed mannequin (Question students 1, $Q_{st}1$) and they thought it to be useful to learn blood sampling from dogs (Question 2, $Q_{st}2$) on a scale from 1 to 10, where 1 was the lowest score indicating that student did not like the mannequin and they considered it to not be useful at all; and 10 the highest score indicating that student liked it very much and considered it to be very useful.
2) Effect on stress biomarkers of students and dogs. Ten volunteer students (all women, with ages between 19 and 22 years (mean, 20 years)) that have never sampled blood from the jugular vein of the dog and did not participate previously in the practical lesson described above, were recruited for this study. The students were randomly grouped into two groups ($n = 5$ each). Each student from Group 1 had to collect a sample from one alive dog; while students from Group 2, previously to sample collection from one alive dog, could practice with the mannequin. In all cases, students were supervised by the educators (AT, SM-S, CPR).

For each student, the time (min) needed to collect the sample, the total number of attempts, and the technique employed were noted. The number of attempts was defined as a number of times students punctured the skin of the dog with the needle before obtaining 1 mL of blood sample (due to ethical issues, maximum permitted attempts were three). Needles of 23G and 2 mL syringes were used. Before and after the procedure, all participants were asked to fill out surveys that included questions to assess their perception of the stress and confidence they felt, also after the procedure, participants of Group 1 were asked if they would have preferred use first a simulator, and those of Group 2 were asked if they find it useful practice first with the simulator. In addition, saliva samples were collected from all students and dogs pre and post blood collection.

Dogs were adult Beagle dogs (5 females and 5 males with ages between 6 and 10 years old, BCS 4–5/9) belonging to University of Murcia. The study was approved by the University of Murcia Ethical committee (CEEA-OH 288/2017) and was conducted conformed to the standards

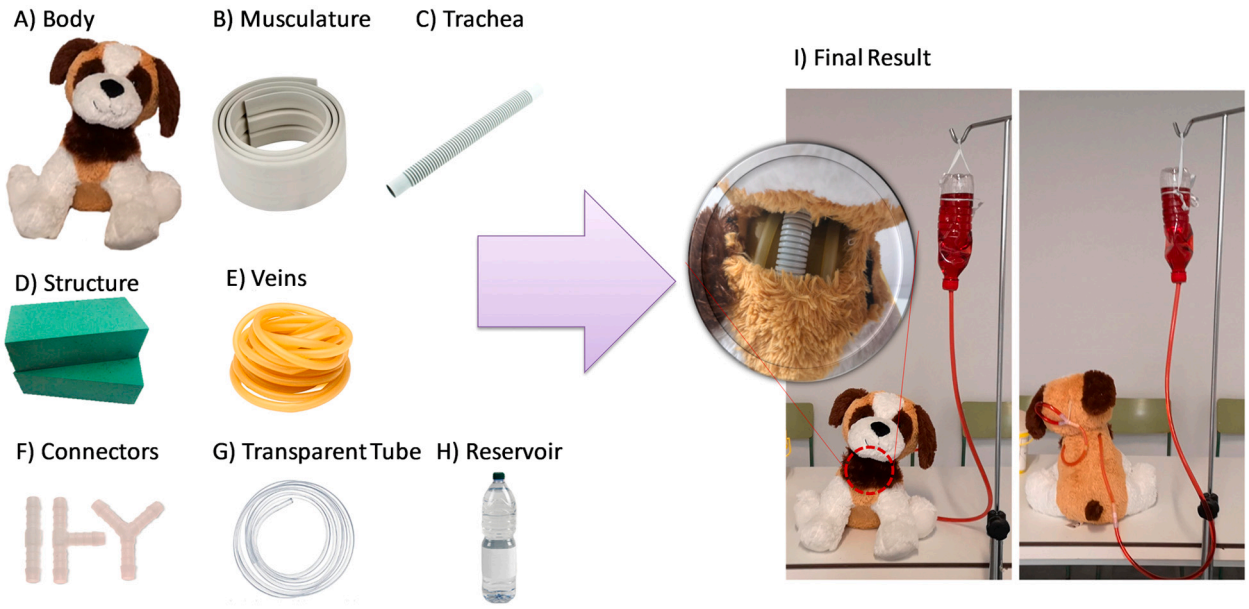

Fig. 1. The material employed and final version of the mannequin.

set by the Declaration of Helsinki.

3) Experts' opinions. Dog medicine practitioners ($n = 10$), 5 women and 5 men with ages between 25 and 54 years (mean, 38 years), who perform blood extraction from the dogs during their daily praxis and had an experience of at least 1 year, were asked to try the developed mannequin and fill an anonymous survey. The survey consisted of three questions to assess their opinion on the mannequin (Question experts 1, Q_e1), its possible utility for student education purposes (Question experts 2, Q_e2) and if they considered that mannequin resembles reality (Question experts 3, Q_e3). The answers were based on a scale from 1 to 10 (being 1 the lowest and 10 the highest grades). In addition, experts were asked to indicate the positive and negative aspects of the mannequin and make any suggestions.

2.4. Saliva collection and analysis

Human saliva samples were collected by passive drool (Lopez-Jornet et al., 2016) for 1 min before and after canine blood sampling. Canine saliva specimens were obtained by placing a sponge in the dog's mouth for 1–2 min as previously described (Parra et al., 2005). Then the sponge was placed into the Salivette disposal (Salivette®, Sarstedt AG &Co., Nümbrecht, Germany). Immediately after collection, all samples were stored on wet ice till the arrival to the laboratory (less than one hour in all cases). Once in a laboratory, saliva samples were homogenized and centrifuged (3000 *g*, 4 °C, 10 min). Afterwards, the supernatant was transferred to Eppendorf tubes and frozen to −80 °C until analysis (less than a month in all cases). All samples were free of visible blood contamination and were measured in one batch.

Cortisol was analysed with an immunoassay system (IMMULITE, Siemens Healthcare Diagnostics, Deerfield, IL). Salivary alpha-amylase (sAA) activity was measured using a commercial kit (a-Amylase. Beckman Coulter Inc. Fullerton, CA) in an automated biochemistry analyzer (Olympus UA600 automated biochemical analyzer, Olympus Diagnostica GmbH, Ennis, Ireland). The two methods were previously validated for use with saliva samples (Tecles et al., 2014). Total salivary protein content was determined using a colorimetric assay (protein in urine and CSF, Spinreact, Spain) adapted for its use in automatic analyzers (Olympus UA600) following the manufacturer's instructions.

2.5. Statistical analysis

In addition to using cortisol and sAA values without correction, to evaluate the possible influence of protein content of each sample on the sAA results, sAA concentration in samples was corrected by its protein content (Dolores Contreras-Aguilar et al., 2017). Data are presented as means, SD, median and interquartile data. Distribution of data was checked using D'Agostino & Pearson omnibus normality test, and since data were not normally distributed, Mann Whitney *U* test was used to evaluate the possible differences between and within the groups for quantitative variables. While to assess possible differences between groups for qualitative variables, Chi-square test was employed. The significance level was established as $P < 0.05$. Statistical analyses were performed with the statistical software Excel Microsoft Office 2016 and GraphPad Prism 6.0.

3. Results

The final version of the mannequin can be seen in Fig. 1.

3.1. Mannequin as a supplementary material for practical classes

Twenty-seven students (34%) participated in the anonymous online survey. The mean (SD) score for $Q_{st}1$ was 8.9 (2.1) and for $Q_{st}2$ was 8.3 (2.3). The distribution of student scores for the two questions is visualised in Fig. 2.

3.2. Effect on stress of students and dogs

The data recorded during the sampling procedure and the survey in the two groups did not differ statistically in any of the evaluated items (Table 2). In a similar manner, no statistically significant differences were detected between the two groups during the evaluation of self-perceived stress, sense of calm and trust. Higher levels of self-perceived level of preparation before the procedure were recorded in Group 2 in comparison with Group 1 ($P < 0.05$).

When salivary biomarkers were assessed, statistically lower median (25–75%) concentrations of salivary sAA (60,109 (29334–140,118) IU/L) and sAA/PT (621.7 (217.0–810.3) IU/g) were detected after blood extraction in students who practiced with the mannequin before the procedure (Group 2) when compared to those who did not practice

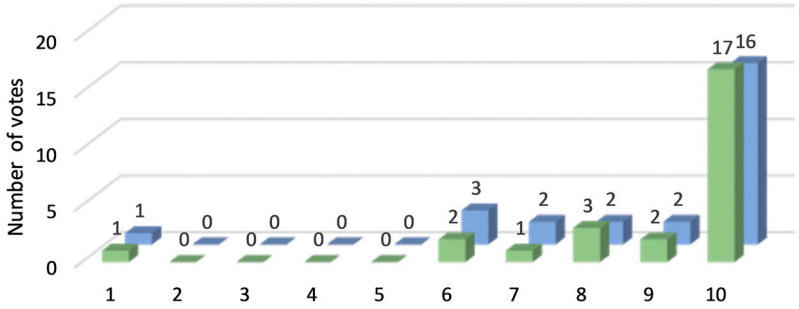

Fig. 2. Student scores for questions – Do you like the mannequin? (Green columns); Do you think the mannequin is useful for canine blood extraction teaching? (Blue columns). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
Sampling-related and survey data of participants that participated in the study. Group 1 did not practice with the mannequin and did their practical work directly with the alive dog, while participants of the Group 2 practiced with the mannequin before sampling from an alive dog.

	Group 1	Group 2	*P*
	Median (range)	Median (range)	
Sampling			
Time (min)	7.3 (1.5–12.0)	6.9 (3.7–12.0)	0.971[a]
Number of punctures made	2.5 (1–4)	2 (2–4)	0.905[a]
Succeed obtain sample (Yes/No)	3/2	4/1	0.490[b]
Needed help (Yes/No)	4/1	5/0	0.292[b]
Survey			
Level of a stress (BS)	2.5 (2–7)	3.5 (3–6)	0.452[a]
Level of a stress (AS)	4 (0–8)	6.5 (4–9)	0.291[a]
Level of preparation (BS)	3 (1–4)	5 (4–6)	0.019[a]
Feeling quiet (AS)	2 (1–5)	2 (1–3)	0.771[a]
Feeling confident (AS)	2 (1–3)	2.5 (1–4)	0.486[a]
Feeling Sure (AS)	2 (1–3)	2.5 (1–5)	0.571[a]
Utility of mannequin (Yes/No)	3/2	4/1	0.490[b]

BS, before sampling; AS, after sampling. a, Mann Whitney U test; b, Chi-square test. Number in bold highlight statistical significance.

(Group 1) (sAA, 189,559 (121256–288,861) IU/L; sAA/PT, 1195 (1046–1549) IU/g) ($P < 0.05$ in both cases) (Fig. 3). No other statistically significant differences were detected within or between groups of students. In the case of dogs, none of the groups showed statistically significant differences in salivary biomarkers of stress before vs after procedure, nor when compared between the two groups of dogs (Fig. 4).

3.3. Experts' opinion

Ten experts (five men and five women) with ages between 27 and 56 years participated in the evaluation of the mannequin. The mean (SD; range) score of experts for Q_e1 (Do you like the mannequin?) was 9.2 (1.1; 7–10), for Q_e2 (Do you think it is useful for the training of students?) was 9.4 (0.9; 8–10) and for Q_e3 (Do you think the model resembles reality?) was 8.3 (1.6; 5–10) on a 10-score system.

The advantages and disadvantages of the mannequin stated by the group of experts are summarized in Table 3. The only suggestion that was repeatedly indicated by 3 experts was the use of various vein sizes and one expert suggested replacing the vein tube used with a thinner and smoother rubber tube.

4. Discussion

This report describes the methodology for developing a model to practice blood collection in dogs and its evaluation. Although the model described has been made to simulate the canine jugular vein, the same materials could be used to simulate other veins that are commonly used in the veterinary clinic, both for drawing blood, cannulation, and injection of drugs. This is possible because the floral sponge is easy to mold into whatever shape is needed. In addition, this material gives rigidity to the structure, without adding weight and is not sensitive to extravasated water during the manipulation of "veins" and needle sticks. Meanwhile, the protective roll englobes the sponge and provides uniformity, consistency, and a touch similar to muscle tissue and that is also resistant to water and punctures. Finally, the diameter of the tube can be adapted according to the size of the mannequin, the vein to be simulated and the level of difficulty to be performed. To increase the difficulty of this model, additionally, a piece of bath sponge can be inserted between the vein and the outer tissue ("skin") of the mannequin. In this way, the subcutaneous adipose tissue is simulated, hindering the vein localization during palpation, and forcing the employment of different angles for needle injection as it is necessary for animals with different body conditions.

Overall, the costs of the materials needed for the mannequin confection were less than 60 Euros, being one-eighth of the price of some commercial mannequins for teaching jugular vein blood sampling from dogs. Nevertheless, some material acquired such as a tube, flower sponge or protective roll, has been leftover and could be used for another model or used as spare parts. Thus, the actual price of the mannequin is lower than the spent money to acquire the needed materials. In addition, costs could be reduced by using a recycled stuffed dog. While regarding the difficulty of the elaboration, the needed time was minimum (less

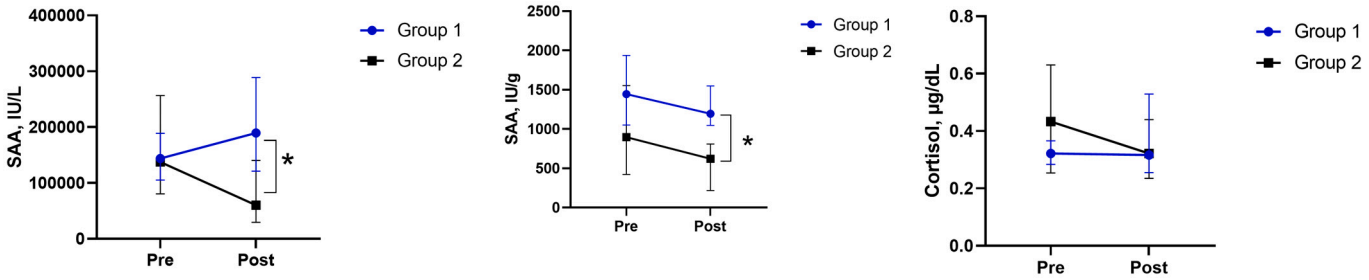

Fig. 3. Salivary alpha amylase (SAA) without correction (IU/L) and corrected by salivary total protein content (IU/g) and cortisol (ug/dL) in students before (Pre) and after (Post) blood sampling from alive dog.

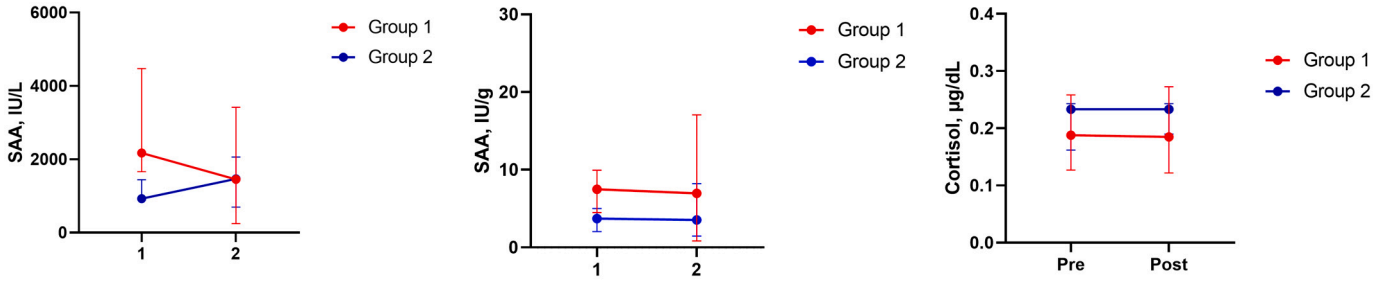

Fig. 4. Salivary alpha amylase (SAA) without correction (IU/L) and corrected by salivary total protein content (IU/g) and cortisol (ug/dL) in dogs before (Pre) and after (Post) blood sampling.

Table 3
The advantages and disadvantages of the mannequin stated by the group of the experts.

Advantages	Location and handling of the needle and syringe Good approximation to the usual clinical practice Practice handling the needle when drawing blood, I liked it a lot. Very useful Anatomical location is essential, and the model is fairly accurate Bloodless It resembles the real conditions. Allow prior training. Possibility of multiple attempts.
Disadvantages	The animal does not move, no mobility of the vessel Those of an inanimate object (movement for example) It is not possible to simulate situations of difficult location or poor support It helps but it's not real It cannot resemble immobilization of the animal Something far from reality. Not fat

than 1 h) and the only needed previous skill – sewing. Therefore, the described mannequin is easy to perform, economically affordable and sustainable and enables the initiation of blood sampling skills for everyone and everywhere.

The mannequin was very well accepted and scored by both, students and experts. In the case of students, 81% and 74% of respondents liked a lot the mannequin and considered it to be very useful for the practices, respectively (Scored 8, 9 or 10). However, one student did not like at all the performed mannequin nor considered it to be useful for practices (scored 1 in both cases), and three respondents scored it 6 for utility. Unfortunately, no comments were received from any of them. On the other hand, the lowest score given by the experts for the same questions were 7, for both questions. The experts featured the adequate anatomical approximation to the reality. In addition they consider positive its utility for teaching needle and syringe handling and overall techniques and procedures for blood sampling from dogs, without animal suffering, stress, or fear. On the other hand, the main disadvantages stated by the experts were related to this mannequin being an object and not a live animal – no movements, no squirm, no struggling.

According to the experience of the authors, the use of the mannequin in a very first class to teach how to hold the syringe, where to place the hand to engorge the vein, how to palpate the vein, at what angle to prick the needle, and in general the procedure of blood collection, was very useful and all (80 students, 8–11 students per practical class) could practice the blood sampling technique and puncture several times. This would not be possible if live animals are used.

The data obtained from the experimental pilot study showed that the previous use of the mannequin did not have a significant impact on the outcomes of the first sampling from live dogs by the students (time needed to obtain 1 mL of sample, number of punctures, methodology). Possibly, this fact is in line to the absence of statistically significant differences in stress biomarkers in dogs used by the two groups of students. Nevertheless, students that could first practice with the mannequin reported the self-perceived higher level of confidence and also had lower levels of sAA (both not corrected and corrected by total protein content) after the collection procedure with live dogs. Veterinary students suffer in general high levels of stress (Langebæk et al., 2012). Therefore, all attempts to reduce stress and improve well-being of the students are necessary (Tecles et al., 2014) and the use of mannequins can contribute to this. However, further studies must be performed to confirm our findings and assess if differences among mannequin utility could differ between men and women.

In conclusion, this study reports the development and validation of a low-cost DIY mannequin for jugular vein blood collection from dogs. Nevertheless, the same materials could be used to assemble mannequins for blood collection practices from different locations and different animal species. Overall, the mannequin was very well accepted by students and specialists and showed its potential to help students deal with stressful situations such as taking blood samples from a live animal.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

AT, JDC-S, and SM-S, conceived and designed research. All participated in the experimental pilot study execution. LP-M, processed and analysed saliva samples. LF-M, AT and SM-S analysed data. All authors participated in writing and revising the manuscript. All authors read, correct, and approved the final version of the manuscript.

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Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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