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Topical Review

Swimming Kinematic and Flotation Analysis of Conscious and Sedated Dogs Using 3 Canine Flotation Devices

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Canine flotation devices (CFDs) are very popular; however, their efficacy is still under debate. There is no oversight to standardize device testing, certification, or qualification for use. We set out to assess the biomechanical and behavioral effects of 3 CFDs on swim and flotation characteristics of dogs. High-speed video recordings were used to measure behavior, range of motion (ROM), maximum flexion angle, and cycles of motion per minute while swimming and roll, yaw, and fear or panic scoring while floating. Predictably, swimming with no CFD yielded the largest ROM and flexion angles. CFDINF was associated with the least ROM. During flotation, CFDAB and CFDRW caused significant rolling and fear, whereas CFDINF was the most stable. CFDAB was associated with cranial downpitch in 2 dogs. Interpretation of the kinematics for CFDAB and CFDRW suggests that decreased stability in the water leads to a greater forced ROM when the position of the dog was conducive to swimming. When positioning forced the dog into a downward pitch, ROM was decreased because of the increased effort for the dogs to keep their head above water. CFDINF was most stable overall owing to a decreased swim effort, with most dogs showing the lowest fear scores and absolute relaxation. CFDAB and CFDRW caused the dogs significant rolling, fear, and distress, with obvious fighting of sedation. We hope to disseminate these results to dog owners in the hopes of providing a valid assessment of these devices.

Introduction

Canine flotation devices (CFDs) are designed, produced, marketed, and sold around the world with no regulation that ensures their efficacy and safety. In fact, by our experience and speculation, several of these CFDs may alter and decrease a dog's ability to swim, its ability to maintain stability in still water, and hence its survival, because of a number of design flaws. There are many CFDs available to purchase and most are standard static buoyancy devices or float coats, while one is a rapid on-demand inflatable. Others it seems are designed primarily by intuition and style vs. tested performance. As there is no regulatory board for these devices akin to the US Coast Guard, we feel it necessary to undertake this study to provide soundness of mind to tens of thousands of owners around the world who purchase these "life-saving devices."

The effect of this study may be unclear to those without experience or interest in active sports that may expose dogs to possible life-threatening water environments. Boating, rafting, residential pools, beach, etc. are such environments, as well as working search and rescue or law enforcement dogs. Another fallacy that may cloud the effect is the false common wisdom that all dogs swim well. That thinking is simply without substantiation or merit. BoatUS did a fit trial comparing many CFDs, their fit, and ability to haul the dog from the water. There are no other remotely scientific investigations that evaluate the effects of a flotation device on a swimming dog or document the stability of one on a floating dog, and we hope to address that gap in knowledge.

We chose to analyze CFD performance in a 2-phase study: a kinematics study and a sedated float test with behavioral components. The kinematics study was aimed at identifying how the CFDs altered a dog's range of motion (ROM) while swimming. The second phase called for administration of a sedative at a dose that produced enough tranquilization to test the flotation ability of the CFD during a simulated incapacitation event. Fear was evaluated to objectively assess the observed behavioral changes associated with these devices while dogs are sedated. The intent was to identify if impaired dogs could remain stable in the water, if their nostrils were maintained in a position to sustain life until rescue arrived, and if distress remained low. We cultivated a wide cross section of popular dog breeds for our participants in hopes that a representative sample of the public's pets could test these CFDs. We will disseminate our results to each manufacturer that participated in our study so that we may help to improve the design and testing of CFDs through an ongoing working relationship. The common goal is to have a flotation device that produces

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less swimming impedance and yet is sufficiently buoyant and stable to protect the incapacitated dog while keeping distress at a minimum.

Interestingly, there are many similarities between floating dogs and boats. We chose to employ similar terminology, such as stability, pitch, roll, buoyancy, and center of gravity. When analyzing a dog's position in the water, it seemed apparent that a basic knowledge of marine engineering should be engaged. Although a flotation device manufacturer is not expected to account for the extremes that a pet owner might subject their animal to, such as a Class V rapid series or the open ocean, basic stability in calm water would be an absolute requirement. We expected that wearing any type of flotation device would have some physically restraining effect on the swimming dog's ROM and that the wide beam of the inflatable CFD would be the most stable while floating.

Materials and Methods

Dogs

Seven healthy adult dogs of varying breeds and body types (Table 1) were volunteered by both students and faculty from Western University of Health Sciences, College of Veterinary Medicine, in Pomona, CA. They ranged from 4-8 years old, were of both sexes (4 neutered males and 3 spayed females), and weighed between 18 and 41 kg (40 and 92 lb). They were required to be free from any known orthopedic conditions. They were sound at a trot and on orthopedic examination. They were not being treated with any medication affecting their movement or behavior. To the owner's knowledge, they were also free of any known water aversion. However, 2 dogs had never swum before and none of them had ever been in an indoor therapy tank. All owners signed an informed consent document and sedation forms before participation. The owners were urged to stay and assist during the trials and allowed to stand at the head of the tank to encourage their dogs and help them swim straight. Appointments were scheduled on the hour, with the dogs remaining in their owner's custody until it was their turn to swim. The owners (veterinary students or veterinarians) were also able to assist with sedation and recovery as needed.

Equipment

The study was performed at a canine rehabilitation facility (Tsavo's Canine Rehab, Del Mar, CA) with 5 dogs on day 1 and 2 dogs on day 3. We tested 3 CFDs: CFDAB (Bird Dog Life Jacket, Astral Buoyancy, Asheville, NC), CFDINF (Critter's Inflatable Dog Life Vest, Millersville, MD), and CFDRW (K-9 Float Coat, Ruff Wear, Bend, OR). CFDAB and CFDRW are both classified as float coats, and CFDINF is an active inflatable. A randomized order was used to account for possible confounding by a CFD's effect on swimming. This was modified owing to a needed acclimation period in the tank, and we found it necessary to begin with CFDINF followed by either CFDAB or CFDRW depending on original assignment. The last trial performed for each dog required that it swims with no CFD, as a control, and for comparison.

A high-speed camera (E64 HotShot High-Speed Camera) was used, along with a small handheld digital (Canon PowerShot SD780 IS Digital Elph, Lake Success, NY) camera for phases 1 and 2 respectively. The trials were performed in an underwater treadmill tank system (Oasis, H20 for Fitness, Fort Wayne, IN) (the tank) which used the facility's indoor pool as a water source instead of an exterior tank. The functional space of the tank was 198-cm long, 81.3-cm wide, and 81.3-cm tall with an exercise area of 165-cm long $\times$ 51-cm wide. The jets are capable of pumping at 50 gallons per minute through a 2-in-diameter pipe yielding a water speed of 1.56 m/s. The water is maintained at 85°F and between a pH of 7.2 and 7.4 with a copper ionization system so that chlorine levels can be maintained at 0.5-1.0 ppm instead of the conventional 3-5 ppm. A canopy (10 $\times$ 10 in EZ-UP) was used to block out the incoming light from the facility's skylight and was placed over the affected portion of the tank on both days of data collection. Dual-colored retroreflective tape cut into 1-in square pieces was used and glued to the hair using ethyl-cyanoacrylate (Gorilla Super Glue) to obtain data points, using red on light dogs and silver on dark dogs. A calibration cube was constructed by the author from 1-inch-diameter PVC based on the average participant size and measured 102-cm long, 51-cm wide, and 76-cm tall. Holes were drilled every 6 in to allow for water to fill and drain during calibration in the water. Retroreflective tape squares were glued at each corner and at the top, middle, and bottom center points to position the camera on center line both days. The floor was marked with duct tape for precise camera positioning.

Phase 1

The dogs arrived at the facility and were held by their owner while a designated person affixed them with a 1-in square piece of retroreflective tape (983 Reflective Trailer Tape, 3M, St. Paul, MN) at the lateral humeral epicondyle and the lateral midcarpal area based on flexion, both with Super Glue. As the glue dried, they were fitted with CFDINF and led into the tank and allowed to investigate while water was pumped in. Once the water reached elbow height, the treadmill was started at a slow walking speed to initiate movement. As the dogs became buoyant, the treadmill was halted as the jets were gradually turned on to full capacity. Once the dog began swimming at a constant speed in a straight line, data were collected and the jets were slowed. The water was lowered until the dog could stand again, and the CFD was exchanged for either CFDAB or CFDRW. This was repeated 2 more times until the last trial where the dog swam with no CFD. Once this phase was concluded for each dog, the tank was emptied and the dog was allowed to rest. Dog 7 was dropped from the study because of a smaller stature and no available fitting CFDAB. She performed in all of the other treatments, but her data were not used for any calculations, only observation.

Table 1
Participant Information

Dog	1	2	3	4	5	6	7
Age (y)	4.5	7	8	9	4	7	4
Sex	MN	MN	FS	MN	MN	FS	FS
Breed	German Shepherd	Labrador Retriever	Labrador Mix	English Pointer	Labrador and Shepherd Mix	Pitbull and Terrier Mix	Shepherd Mix
Weight (kg/lb)	31.8/70	29.5/65	41.8/92	34.0/75	18.2/40	27.3/60	20.5/45
Body type comments	Deep chested, thin	Barrel chested, fit	Barrel chested, fit	Deep chested, fit	Deep chested, petite	Barrel chested, stocky	Deep chested, petite