Effect of the use of carprofen in dogs undergoing intense rehabilitation after lateral fabellar suture stabilization

Wanda J. Gordon-Evans, DVM, PhD; Diane Dunning, DVM, MS, DACVS;
Ann L. Johnson, DVM, MS, DACVS; Kim E. Knap, BS

Objective—To determine whether carprofen, a commercially available NSAID, would decrease perceived exertion and signs of pain in dogs and therefore increase muscle mass and hind limb function without decreasing range of motion after lateral fabellar suture stabilization.

Design—Randomized, blinded, controlled clinical trial.

Animals—35 dogs with cranial cruciate ligament rupture and lateral fabellar suture stabilization followed by rehabilitation.

Procedures—All dogs underwent surgical stabilization of cranial cruciate ligament rupture by placement of a lateral fabellar suture. Dogs received carprofen (2.2 mg/kg [1 mg/lb], PO, q 12 h) for the first 7 days after surgery and underwent concentrated rehabilitation exercises during weeks 3, 5, and 7 after surgery. Eighteen dogs also received carprofen (2.2 mg/kg, PO, q 12 h) during the weeks of concentrated rehabilitation. Outcomes were measured by a single investigator, who was blinded to group assignments, using pressure platform gait analysis, goniometry, thigh circumference, and mean workout speed at a consistent level of exertion.

Results—There were no differences between the 2 groups in ground reaction forces, thigh circumference, or exertion (mean workout speed) over time or at any individual time point. However, both groups improved significantly over time for all outcome measures.

Conclusions and Clinical Relevance—Providing carprofen to dogs during concentrated rehabilitation after lateral fabellar suture stabilization did not improve hind limb function, range of motion, or thigh circumference, nor did it decrease perceived exertion, compared with control dogs. Carprofen was not a compulsory component of a physical therapy regimen after lateral fabellar suture stabilization. (*J Am Vet Med Assoc* 2011;239:75–80)

Rehabilitation has been gaining popularity in veterinary medicine in general, specifically as an adjunct to orthopedic surgery.[1,2] Rehabilitation after surgery to stabilize the cruciate deficient stifle joint is accepted as beneficial; however, there is much to be learned about optimizing the rehabilitation protocol.[1,2]

Published[1,2] rehabilitation protocols consistently use a combination of hydrotherapy (underwater treadmill or swimming) and variable exercises promoting muscle strength, ROM, and proprioception. These types of exercises are taken from the literature, with humans used as a model for disease in dogs. Similarly, NSAIDs have been used to decrease pain and inflammation in human patients undergoing physical therapy and are commonly used medications in dogs after orthopedic surgery.[3]

It would seem logical that if the dog experiences less pain during intensive rehabilitation, more exercise can be tolerated, leading to enhanced hypertrophy and faster recovery after surgery. Pain associated with surgical trauma, muscle soreness, and exacerbation of osteoarthritis may be treated with NSAIDs.[4–8] Researchers have found that muscular catabolic enzymes are decreased in humans taking NSAIDs over placebo, but it is unclear as to whether this translates into a clinical difference for the patient.[7] Additionally, perceived exertion is less in a person who takes an NSAID prior to a workout.[4] This may allow a patient to work harder during rehabilitation and therefore build muscle more quickly, facilitating recovery.

In the study reported here, we hypothesized that administration of carprofen, a commercially available NSAID, to dogs following lateral fabellar suture stabilization for cranial cruciate disease would decrease perceived exertion and signs of pain and therefore increase the muscle mass and rate of recovery as measured by use of thigh circumference and ground reaction forces without decreasing ROM.

Abbreviations	
PVF	Peak vertical force
ROM	Range of motion
VI	Vertical impulse

Materials and Methods

Dogs with surgically confirmed cranial cruciate disease that underwent lateral fabellar suture stabilization

From the Department of Veterinary Clinical Medicine, College of Veterinary Medicine, University of Illinois, Urbana, IL 61802. Dr. Gordon-Evans's present address is Wisconsin Veterinary Referral Center, 360 Bluemound Rd, Waukesha, WI 53188. Dr. Dunning's present address is Department of Clinical Sciences, College of Veterinary Medicine, North Carolina State University, Raleigh, NC 27606.

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Address correspondence to Dr. Gordon-Evans (wgordonevans@gmail.com).

were recruited for the study. The study protocol received approval from the institutional animal care and use committee. Owner consent was obtained. Exclusion criteria included systemic illness, renal or hepatic dysfunction as determined on the basis of CBC and serum biochemical analysis, pregnancy, or NSAID or corticosteroid use within 1 week prior to surgery.

Each dog was randomly assigned to the treatment or control group. There were 17 dogs assigned to the control group and 18 dogs assigned to the treatment group. A random number generator was used by the hospital pharmacist to create a group assignment schedule prior to the start of the study. Measurements were performed for dogs in the order of the group assignment schedule. All dogs in the study received carprofen (2.2 mg/kg [1 mg/lb], PO, q 12 h) for the first 7 days after surgery. All dogs were hospitalized and received concentrated rehabilitation exercises by a single certified rehabilitation practitioner during weeks 3, 5, and 7 after surgery.

Dogs in the treatment group received carprofen (2.2 mg/kg, PO, q 12 h) during the weeks of concentrated rehabilitation only and did not receive any NSAID medication at any other time. Medication was administered by a veterinary student. Dogs in the control group did not receive any NSAID medication during the rehabilitation period.

Surgical procedure—Dogs were premedicated with morphine (0.5 mg/kg [0.23 mg/lb], IM), atropine (0.01 mg/kg [0.005 mg/lb], IM), and medetomidine (10 μg/kg [4.5 μg/lb], IM). Anesthesia was induced by use of propofol (3 to 6 mg/kg [1.4 to 2.7 mg/lb], IV) or thiopental (2 to 6 mg/kg [0.9 to 2.7 mg/lb], IV) and maintained with isoflurane. Dogs were administered cefazolin (22 mg/kg [10 mg/lb], IV) perioperatively. For postoperative analgesia, hydromorphone (0.1 mg/kg [0.05 mg/lb], SC, once) was administered immediately after surgery, followed by carprofen (2.2 mg/kg, PO, q 12 h) for 7 days.

Surgeries were performed by multiple surgeons including residents. The residents were supervised by a board-certified surgeon. Although the same surgeon did not perform all surgeries, the procedure was standardized except with regard to meniscal surgery. Standard lateral fabellar suture stabilization was performed after craniolateral arthrotomy and inspection of the joint.[9] The cranial cruciate remnants were removed and the menisci inspected. Medial meniscal injury was treated with a partial meniscectomy. An abaxial medial meniscal release was performed at the surgeon's discretion. An 80-lb test monofilament nylon suture was passed around the lateral fabella, under the patellar ligament, and through a hole in the proximal tibia and fastened with a crimp clamp.[a] The suture was tightened prior to crimping to a level that prevented a cranial drawer sign but allowed at least 90° of stifle joint flexion. A standard closure of the incision was performed.

Rehabilitation—Concentrated rehabilitation exercises were performed in all dogs during weeks 3, 5, and 7 after surgery by a single certified rehabilitation practitioner. An alternating weekly protocol was chosen on the basis of the literature[2,10,11] and to facilitate convenience for owners living considerable distances from the rehabilitation site. All dogs were hospitalized during concentrated rehabilitation weeks. All dogs received the same exercise protocol with regard to timing and type of exercises. Two rehabilitation sessions were performed daily; these included passive ROM exercises in both hind limbs and conventional and underwater treadmill exercises. Passive ROM exercises were performed with the dog in lateral recumbency. The stifle joint was held in alternating flexion and extension for 10 seconds each, for a total of 5 minutes on each hind limb. Dogs were then placed on a conventional treadmill and walked at 0.3 to 2 m/s for 10 minutes, followed by exercise on an underwater treadmill within the same speed range for 15 minutes. Each dog was maintained at a speed at which the perceived exertion score was between 4 and 6 on a children's scale of perceived exertion,[12] modified for use in dogs (**Appendix**). At this level, dogs have moderate signs of exertion, consistent panting but no labored breathing, mild signs of agitation, and no stumbling. The treadmill speed was recorded when the dog was observed to be performing at this level of perceived exertion.

On alternate weeks, the dog was exercised less intensely at home and dogs in the treatment group did not receive carprofen. Owners were instructed to perform passive ROM exercises for 5 minutes twice daily and were encouraged to walk the dog on a leash for up to 30 minutes as tolerated. Dogs were to remain in confinement when not directly supervised by the owner.

Outcome measures—Outcome was measured by use of gait analysis, goniometry, and thigh circumference measured before surgery and at the end of each intense rehabilitation week. Workout speed was also recorded during rehabilitation sessions. Gait analysis was performed by walking the dog over a pressure platform[b] at a speed between 1.1 and 1.3 m/s and an acceleration and deceleration of 0.5 m/s^2. Peak vertical force and VI from 5 footfalls for the affected hind limb from each dog were measured. Mean values for each dog and PVF and VI expressed as percentages of body weight were used for group comparisons.

Thigh circumference was measured at the proximal quarter of the femur and expressed as the measurement of the affected hind limb and as a ratio of the measurement of the affected to unaffected (or contralateral) hind limb to account for morphological differences between dogs and potential weight loss over the study duration. Stifle joint goniometry was performed by use of previously published methods.[13] The greater trochanter, femoral condyle, and lateral tibial malleolus were used as landmarks. Dogs were not sedated for measurements. Three measurements were taken for flexion and extension, the difference was calculated to determine ROM, and the mean of the 3 measurements for each time point was used for analysis.

Workout speed was calculated to provide an indirect measure of perceived exertion. This was done to eliminate the effect of fatigue from conventional treadmill exercise on subsequent underwater treadmill performance. The speed of the treadmill was set at a level where dogs had a perceived exertion score of 4 to 6 on the modified children's scale of perceived exertion.[12] The speeds of the underwater and conventional treadmills were recorded, and the mean value was calculated to determine the workout speed. A single investigator, who was blinded to group assignments, determined perceived exertion and performed measurements on all dogs.

In addition, information on potential confounding factors was recorded for each dog, including age, breed, body weight, body condition score (on a scale of 1 to 9), severity of preoperative lameness, presence of bilateral cruciate disease, meniscal injury and treatment, or postoperative surgical complications.

Statistical analysis—A matched-pairs *t* test was used to compare the change from baseline at each reevaluation between groups. Groups were also compared at each time point by use of a Student *t* test except when there were unequal group variances (as determined on the basis of a Levene test), in which case the Welch ANOVA was used. Potential sources of bias described by nominal data were compared by use of a contingency table and χ^2 analysis with a Pearson test; numeric confounding factors were compared by use of a Student *t* test or a Wilcoxon rank sum test as appropriate. Summary statistics are reported as mean ± SEM. Values of $P < 0.05$ were considered statistically significant.

Results

Results are presented for the potential confounding factors as the mean ± SEM for the treatment and control group. There were no significant differences between groups with regard to age (treatment group, 3.9 ± 0.4 years old; control group, 4.7 ± 0.6 years old), breed (13 mixed-breed dogs and no other dominant breed), body weight (treatment group, 37.3 ± 2.7 kg [82.06 ± 5.94 lb]; control group, 33.8 ± 2.6 kg [74.36 ± 5.72 lb]), body condition score (treatment group, 6.2 ± 0.4; control group, 6.1 ± 0.3; on a scale of 1 to 9), presence of bilateral cruciate disease (treatment group, 3 dogs; control group, 4 dogs), meniscal injury and treatment (treatment group, 13 dogs; control group, 14 dogs), or postoperative complications (treatment group, 1 dog; control group, 0 dogs). There were no adverse effects attributable to drug administration. Peak vertical force and VI were also not significantly ($P = 0.5$) different before surgery between dogs with unilateral and bilateral cruciate disease. At 7 weeks after surgery, thigh circumference was greater in dogs with bilateral disease than in dogs with unilateral disease, but this difference was not significant ($P = 0.09$).

The mean ± SEM for the outcome measures are given (**Table 1**). There were no significant differences between the 2 groups in ground reaction forces, thigh circumference (regardless of normalization to the contralateral hind limb), or exertion (mean workout speed) over time or at any individual time point. However, both groups significantly ($P < 0.01$) improved over time for all outcome measures.

Although groups did not have a different ROM at any individual time point, the control group had significantly ($P < 0.05$) greater improvement over time in ROM from 0 to 5 weeks, 0 to 7 weeks, and 3 to 5 weeks. From weeks 3 to 5, dogs in the treatment group had a mean decrease in ROM by 2.2°, whereas the ROM of dogs in the control group steadily improved through week 5.

Discussion

Overall outcome measures assessed for treatment and control group dogs improved over the study duration. Dogs in the treatment group did not have greater improvement in hind limb function or thigh circumference, compared with dogs in the control group. This result is surprising given the previously published benefits of NSAIDs.[8,14]

Nonsteroidal anti-inflammatory drugs in general and carprofen specifically have been effective in treating acute and chronic osteoarthritic pain.[8,15–18] The dogs in this study were treated with carprofen to improve performance at perceived exertion levels and reduce signs of pain and inflammation after exercise. This was theorized to improve outcome; however, there was no difference between groups in ground reaction forces or thigh circumference.

Although the number of dogs was small, which limited the power of the study, a post hoc power analysis was not performed because the differences in value between the groups were not clinically relevant (ie, a post hoc power analysis would only provide the power on the basis of the difference derived in this study, which is too small to be of consequence clinically).

The inclusion of dogs with bilateral disease may have impacted the results of this study by decreasing the sensitivity of the outcome measures. These dogs were not removed from the analyses because the study was designed to represent the clinical situation. It is reported that up to 48% of dogs rupture the contralateral cruciate within 10 months after evaluation for the first cranial cruciate ligament rupture. In the present study, 20% of the dogs ruptured their cruciate within the first 4 months, a rate consistent with previous findings.[19] It is possible that dogs with bilateral cruciate disease may have had higher ground reaction forces in the hind limb

Table 1—Mean ± SEM values of PVF, VI, ROM, thigh circumference, and mean workout speed at various times before and after surgery in 35 dogs with cranial cruciate ligament rupture that underwent lateral fabellar suture stabilization and concentrated rehabilitation during weeks 3, 5, and 7.

	Before surgery		Week 3		Week 5		Week 7	
Variable	Carprofen	Control	Carprofen	Control	Carprofen	Control	Carprofen	Control
PVF (%BW)	21.8 ± 2.2	18.3 ± 1.9	18.5 ± 2.6	16.6 ± 2.2	26.2 ± 2.8	24.6 ± 2.0	31.3 ± 2.5	27.4 ± 2.2
VI (%BW)	4.9 ± 0.6	4.1 ± 1.0	3.8 ± 0.6	4.3 ± 0.6	5.8 ± 0.6	6.1 ± 1.1	7.5 ± 0.7	6.8 ± 1.2
ROM (°)	95.8 ± 4.9	88.2 ± 4.2	98.3 ± 3.7	97.9 ± 3.3	96.1 ± 3.4	105 ± 2.3	99.2 ± 3.0	105.9 ± 2.8
Thigh circumference (%)*	90.2 ± 1.8	94.7 ± 1.9	91.3 ± 1.5	91.2 ± 1.5	91.4 ± 1.1	93.5 ±1.4	94.5 ± 1.5	97.1 ±1.1
Workout speed (miles/h)	NA	NA	1.8 ± 0.1	1.6 ± 0.1	2.0 ± 0.1	1.9 ± 0.1	2.2 ± 0.2	2.1 ± 0.1

*Percentage of circumference of contralateral hind limb.
%BW = Percentage of body weight. NA = Not applicable.

being measured than did dogs with unilateral disease because a weight shift to the contralateral hind limb would be less comfortable. However, PVFs were not significantly ($P = 0.5$) different when compared between dogs with bilateral (n = 7) and unilateral (28) disease at any time point. It is possible that dogs with bilateral disease shifted weight to the forelimbs rather than to the contralateral hind limb so that no difference was seen in hind limb function between dogs with unilateral and bilateral disease.[10,11,20] However, this was only true in 2 of the 7 dogs with bilateral disease. The remaining 5 dogs had dramatic asymmetry in PVF between the hind limbs despite palpable effusion, signs of pain on extension, and a cranial drawer sign in the contralateral hind limb. Additionally, the results are the same even if the dogs with bilateral disease are removed from the analysis.

Thigh circumference comparison may have been affected by bilateral disease because it was analyzed as a measure of symmetry. At 7 weeks after surgery, thigh circumference was larger in the dogs with bilateral disease, compared with dogs with unilateral disease, but this difference was not significant. It is possible that dogs with bilateral disease have muscle atrophy in the contralateral hind limb, thus allowing a higher degree of symmetry sooner than in those dogs with unaffected contralateral hind limbs. These dogs were included because bilateral cruciate disease is common in veterinary medicine and the present study was designed to be clinically relevant.[19] Additionally, dogs with bilateral disease were balanced across groups. Although symmetry is used to eliminate bias from changes in body condition over time, in this study, the data for the affected hind limb were also analyzed without normalization to the contralateral hind limb. However, there were still no differences between groups.

Range of motion improved faster in the control dogs. This result should be interpreted with caution. It would imply that NSAIDs should be avoided to maximize the ROM. However, it is possible that perceived exertion was lower in the carprofen treatment group and that dogs therefore worked harder, resulting in increased soreness associated with the intense rehabilitation exercises. If this were the case, the indirect measure of exertion used in this study (mean workout speed) did not detect the difference and the increased soreness did not lead to appreciable changes in the degree of lameness. Hind limb function as measured by PVF improved over each time point. If dogs in the carprofen treatment group were working more strenuously, it is logical to think that they should have gained muscle mass and restored symmetry quicker, but this was not the result. A more sensitive method of measuring muscle mass (eg, dual-energy x-ray absorptiometry scan) would be needed to investigate this hypothesis further.

Range of motion was determined at the extremes of flexion and extension at which no signs of pain were observed. Because this is a subjective interpretation, a single investigator performed goniometry. Some variation remained in the technique despite all efforts to eliminate bias. Range of motion for all dogs was much lower than that reported by Jaegger et al,[13] likely because of differences in the populations of dogs. The observation of signs of pain is used as the endpoint for measuring flexion and extension. It is reasonable to assume that the ROM of clinically normal dogs reported by Jaegger et al[13] represents the maximum ROM possible, whereas the population of dogs in the present study had signs of pain and inflammation associated with injury and surgery, which reduced the extent of flexion and extension that could be achieved without signs of pain. Jandi and Schulman[21] and Hoelzler et al[22] found decreases in flexion after stifle joint arthrotomy that improved over time. In addition, lateral fabellar suture stabilization may have also limited flexion in some dogs more than in others.

There were 4 dogs in the treatment group and 2 dogs in the control group with decreases in ROM from weeks 3 to 5. The decrease in ROM was primarily attributable to decreased flexion; however, 1 dog in the carprofen treatment group had marked decreases in flexion and extension amounting to 40°. The ROM results remained the same even if this dog was removed from the analyses. Additionally, none of these dogs had a diagnosis of any specific complication.

The perceived exertion scale used in the present study is modified from a human pediatric scale[12] and has not been validated for use in dogs. Unfortunately, it is highly subjective and based on observation because the dog cannot communicate its own perceived exertion level. The guidelines use respiration as the main sign of exertion. For instance, the dogs were maintained at a speed at which they were consistently panting but did not have labored breathing. There are many other reasons for panting besides exertion, including heat, anxiety, pain, and nasal occlusion, that can make determining the exertion level difficult. In an effort to be as accurate and precise as possible, only 1 evaluator determined the exertion level of the dogs. This evaluator was blinded to the group assignments. This method of determining exertion is insensitive for picking up the small changes expected from NSAID use. Other more sensitive and direct methods of determining exertion or quantifying metabolism, such as blood pressure, heart rate, tidal volume, and biochemical metabolic waste (ie, lactate), were not used because of the clinical nature of the study. These types of direct measures would have been preferable to the indirect method (speed at a static perceived exertion) used because indirect measures are subject to additional bias. However, it was not practical to attach invasive and unwieldy monitoring equipment to the dogs, which were uncooperative, during underwater exercises.

Signs of pain were not scored directly in this study. However, it is common to use ground reaction forces as an objective alternative to subjective pain scoring techniques. It is assumed that the degree of lameness is associated with the degree of pain.[10,11,14,20,23,24] Peak vertical force and VI are the ground reaction forces most commonly used to quantify lameness. Peak vertical force alone is 89% accurate in identifying dogs with lameness attributable to cranial cruciate disease.[20] This method is commonly used to determine the efficacy of pharmaceuticals in reducing acute and chronic pain and has been shown to be more accurate than subjective lameness or pain scoring.[14,15,17,20,23,24] Nonsteroidal

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anti-inflammatory drugs did not decrease soreness after exercise in several studies[25,26] involving human patients. Additionally, studies[14,27–29] evaluating inflammation after exercise have not proven the usefulness of NSAIDs. The dogs in the present study started intense rehabilitation 3 weeks after surgery. By this time, the signs of acute pain associated with the arthrotomy should be waning, and the rehabilitation protocol was carefully developed to minimize the potential for exacerbating osteoarthritis by incorporating low-impact exercises that promote muscle building, proprioception, and ROM.

Carprofen was administered only during the weeks of rehabilitation rather than during the entire study period because there was no placebo for owners to give the control group. A third party (ie, a veterinary student) administered the medication to the treatment group during hospitalization. Additionally, in human studies[26–29] evaluating muscle hypertrophy and NSAID use, the NSAID is given at the time of exercise rather than for prolonged periods after the end of the exercise session. In the present study, pain medication was not withheld between rehabilitations sessions; however, neither the owners nor the attending clinician believed that signs of pain in the dogs warranted medication.

The short study duration may not have elucidated a long-term effect of NSAID administration during rehabilitation in dogs. Investigation of a long-term effect was not a goal of the present study. Instead, this study focused on much more immediate results (ie, the end of each week of intensive rehabilitation). This is similar to human studies[26–29] that focused on the effects of NSAIDs on muscle hypertrophy. The results of the present study indicate that administration of carprofen during concentrated rehabilitation after lateral fabellar suture stabilization does not clinically improve hind limb function, ROM, or thigh circumference, compared with control dogs following the same rehabilitation protocol.

a. Securos Inc, Fiskdale, Mass.
b. 7100 QL Virtual Sensor 4 Mat System, Tekscan, Boston, Mass.

References

1. Monk ML, Preston CA, McGowan CM. Effects of early intensive postoperative physiotherapy on limb function after tibial plateau leveling osteotomy in dogs with deficiency of the cranial cruciate ligament. *Am J Vet Res* 2006;67:529–536.
2. Marsolais GS, Dvorak G, Conzemius MG. Effects of postoperative rehabilitation on limb function after cranial cruciate ligament repair in dogs. *J Am Vet Med Assoc* 2002;220:1325–1330.
3. Baydar M, Akalin E, El O, et al. The efficacy of conservative treatment in patients with full-thickness rotator cuff tears. *Rheumatol Int* 2009;29:623–628.
4. Hudson GM, Green JM, Bishop PA, et al. Effects of caffeine and aspirin on light resistance training performance, perceived exertion, and pain perception. *J Strength Cond Res* 2008;22:1950–1957.
5. Paulsen G, Egner IM, Drange M, et al. A COX-2 inhibitor reduces muscle soreness, but does not influence recovery and adaptation after eccentric exercise. *Scand J Med Sci Sports* 2010;20:e195–e207.
6. Rahnama N, Rahmani-Nia F, Ebrahim K. The isolated and combined effects of selected physical activity and ibuprofen on delayed-onset muscle soreness. *J Sports Sci* 2005;23:843–850.
7. Pizza FX, Cavender D, Stockard A, et al. Anti-inflammatory doses of ibuprofen: effect on neutrophils and exercise-induced muscle injury. *Int J Sports Med* 1999;20:98–102.
8. Aragon CL, Hofmeister EH, Budsberg SC. Systematic review of clinical trials of treatments for osteoarthritis in dogs. *J Am Vet Med Assoc* 2007;230:514–521.
9. Johnson AL, Schultz K. Diseases of the joints. In: Fossum TW, ed. *Small animal surgery*. 3rd ed. St Louis: Mosby Elsevier, 2007;1143–1315.
10. Conzemius MG, Evans R, Besancon MF, et al. The effect of surgical technique on limb function after surgery for rupture of the cranial cruciate ligament in dogs. *J Am Vet Med Assoc* 2005;226:232–236.
11. Au KK, Gordon-Evans WJ, Johnson AL, et al. Comparison of short and long term function and radiographic osteoarthrosis in dogs receiving postoperative physical rehabilitation and tibial plateau leveling osteotomy or lateral fabellar suture stabilization. *Vet Surg* 2010;39:173–180.
12. Robertson RJ, Goss FL, Boer NF, et al. Children's OMNI scale of perceived exertion: mixed gender and race validation. *Med Sci Sports Exerc* 2000;32:452–458.
13. Jaegger G, Marcellin-Little DJ, Levine D. Reliability of goniometry in Labrador Retrievers. *Am J Vet Res* 2002;63:979–986.
14. Horstman CL, Conzemius MG, Evans R, et al. Assessing the efficacy of perioperative oral carprofen after cranial cruciate surgery using noninvasive, objective pressure platform gait analysis. *Vet Surg* 2004;33:286–292.
15. Hanson PD, Brooks KC, Case J, et al. Efficacy and safety of firocoxib in the management of canine osteoarthritis under field conditions. *Vet Ther* 2006;7:127–140.
16. Mansa S, Palmer E, Grondahl C, et al. Long-term treatment with carprofen of 805 dogs with osteoarthritis. *Vet Rec* 2007;160:427–430.
17. Pollmeier M, Toulemonde C, Fleishman C, et al. Clinical evaluation of firocoxib and carprofen for the treatment of dogs with osteoarthritis. *Vet Rec* 2006;159:547–551.
18. Sanderson RO, Beata C, Flipo RM, et al. Systematic review of the management of canine osteoarthritis. *Vet Rec* 2009;164:418–424.
19. Buote N, Fusco J, Radasch R. Age, tibial plateau angle, sex, and weight as risk factors for contralateral rupture of the cranial cruciate ligament in labradors. *Vet Surg* 2009;38:481–489.
20. Evans R, Horstman C, Conzemius M. Accuracy and optimization of force platform gait analysis in Labradors with cranial cruciate disease evaluated at a walking gait. *Vet Surg* 2005;34:445–449.
21. Jandi AS, Schulman AJ. Incidence of motion loss of the stifle joint in dogs with naturally occurring cranial cruciate ligament rupture surgically treated with tibial plateau leveling osteotomy: longitudinal case study of 412 cases. *Vet Surg* 2007;36:114–121.
22. Hoelzler MG, Millis DL, Francis DA, et al. Results of arthroscopic versus open arthrotomy for surgical management of cranial cruciate ligament deficiency in dogs. *Vet Surg* 2004;33:146–153.
23. Waxman AS, Robinson DA, Evans RB, et al. Relationship between objective and subjective assessment of limb function in normal dogs with an experimentally induced lameness. *Vet Surg* 2008;37:241–246.
24. Quinn MM, Keuler NS, Lu Y, et al. Evaluation of agreement between numerical rating scales, visual analogue scoring scales, and force plate gait analysis in dogs. *Vet Surg* 2007;36:360–367.
25. Doi T, Akai M, Fujino K, et al. Effect of home exercise of quadriceps on knee osteoarthritis compared with nonsteroidal antiinflammatory drugs: a randomized controlled trial. *Am J Phys Med Rehabil* 2008;87:258–269.
26. Krentz JR, Quest B, Farthing JP, et al. The effects of ibuprofen on muscle hypertrophy, strength, and soreness during resistance training. *Appl Physiol Nutr Metab* 2008;33:470–475.
27. Lapointe BM, Fremont P, Cote CH. Influence of nonsteroidal anti-inflammatory drug treatment duration and time of onset on recovery from exercise-induced muscle damage in rats. *Arch Phys Med Rehabil* 2003;84:651–655.
28. Peterson JM, Trappe TA, Mylona E, et al. Ibuprofen and acetaminophen: effect on muscle inflammation after eccentric exercise. *Med Sci Sports Exerc* 2003;35:892–896.
29. Trappe TA, White F, Lambert CP, et al. Effect of ibuprofen and acetaminophen on postexercise muscle protein synthesis. *Am J Physiol Endocrinol Metab* 2002;282:E551–E556.

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Appendix

Children's scale of perceived exertion modified for dogs.

Score	Level of exertion	Signs of exertion
0	No signs of exertion	No panting, signs of agitation, or abnormal gait.
1	Early signs of exertion	No panting, no signs of agitation, and no change in gait.
2	Early signs of exertion	Early panting, no to minimal signs of agitation, and no change in gait.
3	Early signs of exertion	Panting, no to minimal signs of agitation, and no change in gait.
4	Moderate signs of exertion	Consistent panting but no labored breathing, mild signs of agitation, and no change in gait.
5	Moderate signs of exertion	Consistent panting but no labored breathing, mild signs of agitation, and no change in gait.
6	Obvious signs of exertion	Hard panting, mild labored breathing, moderate signs of agitation, and slow or reluctant movement.
7	Obvious signs of exertion	Very hard panting, moderate labored breathing, moderate signs of agitation, and occasional stumbling (< 35% of strides).
8	Obvious signs of exertion	Very hard panting, moderate labored breathing, moderate signs of agitation, and frequent stumbling (35% to 75% of strides).
9	Obvious signs of exertion	Severe labored panting and labored breathing, severe signs of agitation, and near constant stumbling (> 75% to 100% of strides).
10	Obvious signs of exertion	Open-mouth breathing, extreme signs of agitation, and collapse.

(Adapted from Robertson RJ, Goss FL, Boer NF, et al. Children's OMNI scale of perceived exertion: mixed gender and race validation. *Med Sci Sports Exerc* 2000;32:452–458. Reprinted with permission.)[12]

From this month's *AJVR*

Determination and application of cut points for accelerometer-based activity counts of activities with differing intensity in pet dogs

Kathryn E. Michel and Dorothy Cimino Brown

Objective—To investigate whether an accelerometer-based activity monitor could be used in pet dogs to differentiate among and delineate the amount of time spent in activities of differing intensity.

Animals—104 dogs.

Procedures—For the first phase of the study, each dog (n = 104) wore an accelerometer-based activity monitor and was led through a series of standard activities (recumbency [sedentary], walking, and trotting). Receiver operating characteristic curves were generated to determine the optimal activity counts for predicting whether a dog was sedentary, walking, or trotting. For the second phase of the study, dogs (n = 99) wore an activity monitor on their collars continuously for 14 days at home; intensity of activity for each dog was classified by use of cut points determined on the basis of results obtained during the first phase of the study.

Results—Analysis of receiver operating characteristic curves indicated that there was 100% specificity and 100% sensitivity in distinguishing sedentary activity from walking activity and 92% specificity and 92% sensitivity in distinguishing trotting activity from walking activity. Analysis of data collected during the 14-day period at home indicated that dogs were sedentary most of the time (median, 87%; range, 65% to 95%).

Conclusions and Clinical Relevance—Counts recorded by an accelerometer-based activity monitor could be used to discriminate effectively among standardized activities in pet dogs. There is potential for use of the method to improve the ability of clinicians and researchers to accurately estimate a pet dog's daily energy requirement. (*Am J Vet Res* 2011;72:866–870)

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