SMALL ANIMALS/ EXOTIC

Effects of caloric restriction and a moderate or intense physiotherapy program for treatment of lameness in overweight dogs with osteoarthritis

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Objective—To evaluate the effects of a weight reduction program combined with a basic or more complex physical therapy program including transcutaneous electric nerve stimulation on lameness in overweight dogs with osteoarthritis.

Design—Nonblinded prospective randomized clinical trial.

Animals—29 adult overweight or obese dogs with a body condition score of 4/5 or 5/5 and clinical and radiographic signs of osteoarthritis.

Procedures—A weight-loss program was initiated for all dogs. One group received caloric restriction and a home-based physical therapy program. The other group received the identical dietetic protocol and an intensive physical therapy program including transcutaneous electrical nerve stimulation. Lameness was assessed clinically and by kinetic gait analysis on a treadmill with 4 force plates to measure symmetry of ground reaction forces (GRFs) of the affected and contralateral limbs in bimonthly intervals for 6 months.

Results—Significant weight loss was achieved in both groups; however, greater weight reduction was attained by dogs treated with caloric restriction and intensive physiotherapy. Mobility and symmetry indices of GRFs were improved after 6 months; the best outcome was detected in the group receiving energy restriction combined with intensive physical therapy.

Conclusions and Clinical Relevance—Caloric restriction combined with intensive physical therapy improved mobility and facilitated weight loss in overweight dogs. The combination of dietetic and physical therapy may help to improve the health status more efficiently than dietetic treatment alone. (*J Am Vet Med Assoc* 2006; 229:1756–1760)

Abbreviations

ROM	Range of motion
TENS	Transcutaneous electrical nerve stimulation
BCS	Body condition score
GRF	Ground reaction forces
PFz	Peak vertical force
IFz	Vertical impulse
SI	Symmetry index
MER	Metabolizable energy requirement

Obesity has been reported as the most common form of nutritional disorder in dogs, with an estimated prevalence of 28%.[1-3] The negative impact of obesity on health is well documented. In addition to an association with various medical disorders such as compromised immune function,[4,a] abnormal glucose tolerance,[5,6] acute pancreatitis,[7] greater risk for anesthetic and surgical complications,[8] heat and exercise intolerance, and cardiovascular disease,[2,9] obesity in dogs is thought to be a risk factor for the development and progression of osteoarthritis.[10] In humans, a correlation between osteoarthritis and obesity has already been detected[11,12]; however, the exact role in dogs has not been fully investigated. The theory pertaining to the pathogenesis of osteoarthritis is that excessive body weight causes additional mechanical stress on joints, thus promoting their degeneration.[13] Treatment of obesity is based on a restriction of caloric intake. Restricting calories to 60% of the calculated maintenance energy requirements for a dog's target body weight has been recommended.[8,14-17] Restriction of caloric intake and maintenance of lean body condition can not only increase median life span but can also prevent the manifestation of chronic diseases such as osteoarthritis.[13,18] In overweight dogs, osteoarthritic changes appear earlier in life and are more severe, compared with their restricted-fed siblings.

Clinical signs associated with osteoarthritis include signs of pain and discomfort, muscle atrophy, decreased ROM, and restricted ability to perform.[19,20] In humans, a combination of weight loss programs and physical therapy modalities has been found to reduce the severity of symptoms and reliance on medication to control pain and discomfort.[21,22] In dogs, weight reduction alone has been found to positively influence clinical signs of osteoarthritis. Overweight dogs with osteoarthritis of the hip joints had significant improvements in the severity of hind limb lameness after a loss of at least 11% of body weight.[23] Weight loss, physical modalities, and exercise programs can lead to increased muscle strength and endurance, increased joint ROM, decreased signs of pain and muscle spasm, and improved function as well as quality of movement.[20]

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Transcutaneous electrical nerve stimulation can support mobility in humans and dogs with mild osteoarthritis.[24,b] The purpose of the study reported here was to evaluate the effects of a combined program consisting of caloric reduction and physical therapy for the treatment of lameness in overweight dogs with osteoarthritis. Two groups of dogs, one receiving a treatment program consisting of weight loss and home-based physical therapy and the other treated additionally with intensive physical therapy including TENS, were compared. Clinical examination and kinetic gait analysis were performed to evaluate the impact on health and mobility.

Materials and Methods

Dogs—Twenty-nine client-owned overweight dogs evaluated because of lameness at the Clinic of Surgery and Ophthalmology, Veterinary University of Vienna, from December 2003 to December 2004 were enrolled in the study. In group 1, there were 9 neutered females, 1 sexually intact female, 2 sexually intact males, and 2 neutered males; breeds included Golden Retriever (n = 5), Labrador Retriever (1), English Setter (1), German Shepherd Dog (1), Bernese Mountain Dog (1), Rottweiler (1), and mixed breed (4). In group 2, there were 7 neutered females, 3 sexually intact females, 2 sexually intact males, and 3 neutered males; breeds included Golden Retriever (n = 3), Labrador Retriever (1), German Shepherd Dog (2), Bernese Mountain Dog (1), Rottweiler (2), German Wirehaired Pointer (1), Dalmatian (1), Small Munsterlander (1), American Staffordshire Terrier (1), and mixed breed (2). Mean ± SD body weight and age of all dogs were 41.4 ± 7.4 kg (91 ± 16 lb) and 8.4 ± 3.2 years, respectively. Inclusion criteria included a BCS of 4 or 5 based on a 5-point scale (a BCS of 4 is considered overweight, and a score of 5 is considered obese),[23] clinical evidence of lameness in only 1 limb, and radiographic evidence of osteoarthritis in the affected limb. Diagnosis was determined by orthopedic and radiographic examination findings. Exclusion criteria included abnormal findings on CBC or serum biochemical analysis[25] and a diagnosis of diseases other than obesity and osteoarthritis.

Experimental protocol—The study protocol was reviewed and approved by the Austrian governmental committee according to the Austrian guidelines for research on animals (file reference GZ 68.205/136-BrGt/2003). Informed consent was obtained from owners of dogs before enrollment in the study.

Dogs were randomly allocated to groups 1 or 2, alternating between groups. Prior to initiation of treatment (day 0), clinical examinations; CBC and serum biochemical analysis; orthopedic, neurologic, and radiographic examinations; and kinetic gait analysis were performed in each dog to assess baseline values. Degree of lameness and signs of pain elicited on palpation of the affected joint were scored on a 5-point scale.[26] The lameness score ranged from 0 (no visible lameness) to 4 (no weight bearing on the affected limb); accordingly, the pain score ranged from 0 (no pain during palpation of the affected joint) to 4 (dog does not permit examiner to palpate the joint). Dogs were weighed, and their body condition was scored according to a 5-point BCS system.[23] Target body weight was defined as 85% of initial body weight.

All dogs were clinically reevaluated monthly. At each evaluation, body weights were recorded and an orthopedic examination was performed to assess lameness and pain scores. The kinetic gait analysis was performed bimonthly. Changes in BCS and results of CBC and serum biochemical analyses were assessed 6 months after the study began.

Equipment and measurement procedure of GRFs—Kinetic gait analysis was performed by use of 4 biomechanical force platforms[c] mounted into a treadmill[d] specially adapted for use in small animals (**Figure 1**).[27] The force plates had a dimension of 250 × 500 mm. Four piezoelectric sensors permitted measurement of the vertical GRFs. In this measurement setup, the dog walked on the treadmill, handled by the owner, who stood directly in front of the dog.

All dogs were allowed to walk at the speed that was comfortable for them.[28] The treadmill was started slowly, and the velocity was increased gradually until the dog had a well-coordinated gait pattern. The dog's velocity was determined by the set speed of the treadmill. Once a speed was determined for an individual dog, subsequent evaluations were performed exactly at that speed.

Ground reaction forces were measured at a frequency of 300 Hz and analyzed by use of a software program.[e] For the evaluation, 5 steps of the affected and contralateral limb were chosen. A step was considered valid if the force plate was hit only by its corresponding limb without any passovers. Dogs did not undergo a training period on the treadmill before initiation of measurements.

The PFz and IFz of the affected and contralateral limb were evaluated. All values were normalized by the dog's body weight and expressed in percentage of body weight.[29,30] The means of PFz and IFz over 5 valid steps of each trial were calculated.

At the beginning of the study, PFz and IFz values were categorized according to the affected body side (better [B]/worse [W]) and values were labeled accordingly (PFzB/IFzB for the contralateral [more weight-bearing side] and PFzW/IFzW for the affected body side). In the ensuing step, an SI was calculated for PFz

$$(\mathrm{SIPFz} = \frac{\mathrm{PFzB}}{\mathrm{PFzW}})$$

and IFZ

$$(\mathrm{SIIFZ} = \frac{\mathrm{IFzB}}{\mathrm{IFzW}}),$$

dividing values of the limb with high values by the limb with low values.[31]

Weight-reduction program and diet and energy allowance—Owners of dogs in both groups were instructed to feed their dogs 60% of the daily MER at a body weight that was arbitrarily set at 15% less than body weight recorded during the first evaluation. For this purpose, the MER was calculated according to the following formula: MER (MJ) = $0.6 \times 0.42 \times BW^{0.75}$. The goal was to achieve a weekly weight

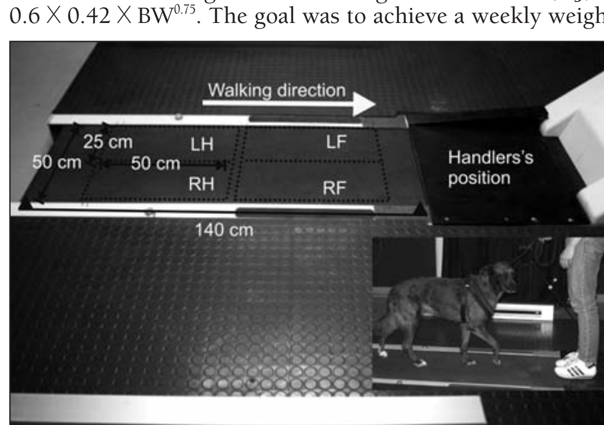

Figure 1—Photograph of a treadmill system for measurement of GRFs in overweight dogs with osteoarthritis. Black dotted lines indicate the position of 4 biomechanical force platforms. The inset indicates the position of the handler. LF = Left forelimb. RF = Right forelimb. LH = Left hind limb. RH = Right hind limb.

reduction of 1%. All dogs were fed the same reduced-calorie dog food[f] for 6 months.

Physical therapy treatment—At the beginning of the study (day 0), owners of dogs in both groups were introduced to the principals of massage (including stroking and kneading of the lumbar muscles and limbs, with special regard to the affected limb for 10 to 15 minutes) and passive ROM exercises of all limb joints with 10 to 15 repetitions.[32] Owners were requested to perform these exercises 3 times daily. Furthermore, owners were advised to leash walk their dogs 3 times/d for 20 minutes at the beginning of the study, increasing the impact stepwise in accordance to the clinical state of the dog. During the first 2 months of the study, dogs in group 1 were treated in the clinic twice a week with physical therapy. During these sessions, the correct performance of the home-based physical therapy program was evaluated and repeated together with the owners and TENS treatment[g] was performed. During TENS treatment of the elbow and stifle joints, 2 electrodes were applied laterally and medially; for the hip joint, 2 electrodes were applied dorsally and ventrally. Each treatment lasted for 15 minutes. After the first 2 months until the study's end at 6 months, further treatments were applied according to the individual needs of each dog with respect to the dog's clinical signs. During the study, additional analgesics were not administered to dogs in either group.

Statistical analysis—Data are given as arithmetic mean ± SD. Changes in the symmetry indices with time within groups were evaluated by use of a paired *t* test; differences between groups were evaluated by use of an unpaired *t* test. Changes in lameness and pain scores during the study were calculated by use of a χ^2 test.[h] Values of $P < 0.05$ were considered significant.

Results

No abnormalities were detected on CBC and serum biochemical analyses, compared with the initial examination. Treadmill velocity was 2.5 ± 0.3 mph and 2.5 ± 0.2 mph in groups 1 and 2, respectively, at each evaluation point. In group 1, 3 animals did not have a need for further treatments until the end of the study, whereas the remaining dogs received between 5 to 17 (8.8 ± 4.2) treatments with a frequency of 1.4 ± 0.3 treatments/wk.

Initial (day 0) body weights were not significantly different between groups 1 (41.3 ± 7.6 kg [90.9 ± 16.7 lb]; n = 14) and 2 (41.5 ± 7.5 kg [91.3 ± 16.5 lb]; 15). Mean weight loss after 6 months was 13.6% in group 1 and 9.3% in group 2 (**Figure 2**). Body weights of dogs in both groups were significantly ($P < 0.01$) lower than initial values obtained at each monthly control point during the study. However, dogs in group 1 had greater weight loss than dogs in group 2 on days 90 through 180.

Baseline BCS values were 4.6 ± 0.5 in group 1 and 4.5 ± 0.5 in group 2. Mean changes in BCS at day 180 (relative to day 0) were –1.4 ± 0.6 in group 1 and –0.9 ± 0.5 in group 2. Therefore, 86% of dogs in group 1 and 53% of dogs in group 2 reached BCSs of 3, which was considered as ideal body condition.

At the time of enrollment, 11 dogs in group 1 had locomotory disorders of the hind limbs and 3 dogs were evaluated because of forelimb lameness. In group 2, 8 dogs were evaluated for forelimb lameness and 7 dogs had hind limb lameness. Radiography revealed abnormalities of the elbow joints in 3 dogs, stifle joint in 1 dog, and hip joints in 10 dogs in group 1 and abnormalities of the elbow joints in 7 dogs, shoulder joint in 1 dog, stifle joints in 2 dogs, and hip joints in 5 dogs in group 2.

No significant differences in lameness and pain score values were detected between groups on day 0. On day 0, 9 dogs in group 1 had a lameness score of 1 and 5 dogs had a lameness score of 2. On day 0, 11 dogs in group 2 had a lameness score of 1 and 4 dogs had a lameness score of 2. In group 1, six dogs had a pain score of 1, 6 had a score of 2, and 2 dogs had a score of 3. One dog in group 2 did not have signs of pain during palpation, 7 dogs had pain scores of 1, 6 had pain scores of 2, and 1 dog had a pain score of 3. At the end of the study, only 1 dog in group 1 was visibly lame (lameness score, 1), whereas 1 dog had signs of pain (pain score, 2) and 6 dogs had a pain score of 1 during manipulation of the affected joint. Lameness scores in dogs in group 1 were significantly ($P \leq 0.04$) different from initial values at each monthly control point during the study, and dogs in group 1 had significantly ($P \leq 0.01$) lower pain scores on days 60, 90, 120, 150, and 180, compared with day 0. In group 2, 8 dogs had a lameness score of 1 and 3 dogs had a lameness score of 2. Six dogs in group 2 did not have signs of pain during palpation; 7 dogs had a pain score of 1 and 2 had a pain score of 2 during examination of the affected joint. In group 2, significant ($P \leq 0.05$) differences in lameness scores, compared with day 0, were detected at all monthly control points during the study, except day 30. Pain scores in group 2 improved significantly at days 90 ($P = 0.01$) and 120 ($P = 0.04$). Concerning lameness scores, significant differences between groups were detected on days 30 ($P = 0.05$) and 180 ($P = 0.01$). A significant difference in pain scores was not detected between groups during the study.

At day 0, no significant differences in either SI were detected between groups. The SIPFz in groups 1 and 2 on day 0 was 1.15 ± 0.07 and 1.15 ± 0.16, respectively. Mean SIIFz was 1.23 ± 0.13 and 1.22 ± 0.32 in groups 1 and 2, respectively. A significant ($P \leq$

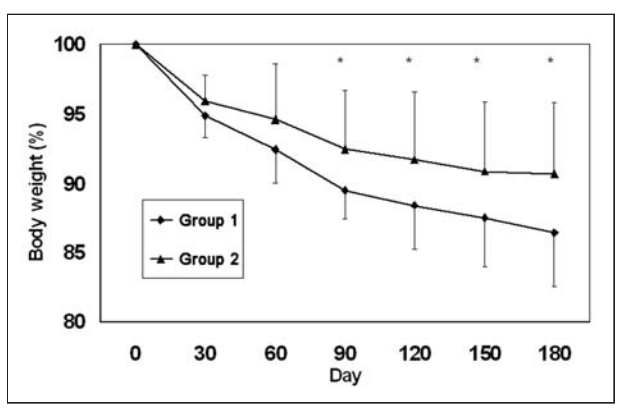

Figure 2—Body weight changes relative to initial weight (100%) in overweight dogs with osteoarthritis receiving treatment programs consisting of weight loss, home-based physical therapy, intensive physical therapy performed in a clinic, and TENS (group 1; n = 14) or weight loss and home-based physical therapy only (group 2; 15). *Significantly ($P < 0.05$) different from group 1.

Table 1—Mean ± SD SIPFz and SIIFz in overweight dogs with osteoarthritis receiving treatment programs consisting of caloric reduction, home-based physical therapy, intensive physical therapy performed in a clinic, and TENS (group 1; n = 14) or caloric reduction and home-based physical therapy only (group 2; 15).

	Group 1		Group 2	
Evaluation day	SIPFz	SIIFz	SIPFz	SIIFz
0	1.15 ± 0.07	1.23 ± 0.13	1.15 ± 0.16	1.22 ± 0.32
60	1.04 ± 0.04*†	1.14 ± 0.14*	1.10 ± 0.09	1.16 ± 0.12
120	1.03 ± 0.02*†	1.13 ± 0.13*	1.10 ± 0.11*	1.14 ± 0.13
180	1.01 ± 0.01*†	1.11 ± 0.10*	1.12 ± 0.08	1.16 ± 0.13

No significant differences in SIPFz and SIIFz were detected between groups at the beginning of the study (day 0).

*Significant improvement in SIPFz ($P < 0.01$) and SIIFz ($P < 0.02$) in dogs in group 1, compared with day 0. †Significant ($P < 0.05$) differences in SIPFz between groups on days 60, 120, and 180.

0.02) improvement in SIPFz and SIIFz was detected in dogs in group 1 at each evaluation during the study. In group 2, SIPFz and SIIFz appeared to improve with time; however, this finding was only significant (P = 0.02) for SIPFz on day 120. Findings for SIPFz indicated significantly higher symmetry of the affected limbs in dogs in group 1, compared with those in group 2, from day 60 until the end of the study. In contrast, there was no significant difference in SIIFz between groups during the study (**Table 1**).

Discussion

Results of the study reported here suggested that in overweight dogs with gait abnormalities attributable to osteoarthritis, weight reduction combined with physical therapy resulted in an improvement in clinical signs associated with osteoarthritis. An overall better outcome in weight reduction and improvement of clinical signs was attained with a combination of calorie restriction and intensive physical therapy. The study was not performed as a blinded study. The protocol was designed so that the principal investigator (EM) was applying the adequate treatment and physiotherapy depending on results of the clinical examination. The force plate was used as an objective method that should have eliminated subjective errors. Force plate analysis and data evaluation were performed by different investigators. Data evaluation relied on clinical scores that were performed according to a standardized protocol and the force plate analysis. This combination of various methods and the involvement of various investigators should have eliminated any bias in the results.

The principal difference between the 2 experimental groups was the intensity of the physical therapy program. Compared with dogs in group 2, the more favorable clinical results in dogs in group 1 may have resulted from more effective weight reduction, improvement of joint mobility, and a higher level of owner compliance. Dogs in both groups lost significant amounts of weight during the 6-month study. Although the same calorie-restriction protocol was used in both groups, weight reduction was more pronounced in dogs in group 1 than that in group 2. This finding may have been attributable to increased owner compliance, especially during the intensive treatment period during the first 2 months of the study. Additionally, the improvement in lameness and the reduction in pain sensations may have facilitated weight loss caused by increased physical activity. Another factor may have been that a loss of at least 0.5% of initial body weight/wk improved owner interest and therefore compliance.[14] This was apparent for dogs in group 1 throughout the study.

In our study, force plate analysis was used to investigate as objectively as possible the effects of weight reduction and physical therapy on the clinical outcome and to verify results of orthopedic examinations. Clinical scoring is subjective and strongly influenced by the experience of the examiner and may therefore be confounded by evaluator bias. This individual bias cannot be ruled out completely, even when strict standardized examination protocols are used. In contrast, the evaluation of GRFs provides an objective and reproducible method in outcome studies. Ground reaction forces strongly depend on various morphometric parameters (body mass, breed, and height), treadmill velocity, and inter- and between-day variation.[30,33,34]

The inclusion of dogs with several degrees of lameness in various locations impairs interpretation. This difficulty was overcome by calculating SIs. Results of gait analyses in dogs in group 1 indicated a significant improvement during the study, whereas dogs in group 2 appeared to result in an improvement that, however, was significant only for SIPFz after 4 months. The SIPFz of dogs of group 1 was nearly symmetric and nearly reached values of healthy dogs[31] at the end of the study, whereas SIIFz, which significantly improved with time, did not reach a comparable level. This can be explained through the nature of the evaluated parameters: peak maximal force is a singular value at the beginning of the stance phase, whereas the maximal impulse describes an integral during the entire stance phase. Furthermore, the results indicated how important the evaluation of more than 1 GRF parameter is to avoid misinterpretations of GRF results. Differences in results of kinetic gait analysis between both groups could have been because of the different weight loss detected between groups. Dogs in group 2 lost less weight. Eventually, a weight reduction of 9.3% of initial body weight was not enough to result in the same significant improvement of lameness as in group 1. However, during the first 2 months, weight reduction was almost identical in both groups. Therefore, it appears that intensive physical therapy, including TENS, was the main factor associated with improvement in the clinical signs and results of kinetic gait analysis in group 1, compared with group 2.

In the study reported here, the combination of caloric restriction with intensive physical therapy appeared to be more efficient in facilitating weight loss in overweight dogs and improving the clinical outcome than dietetic treatment alone.

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c. Type 9011 A, Kistler Instruments AG, Ostfildern, Germany.

d. University of Sports Science, Cologne, Germany.
e. SIMI Motion, version 6.5, SIMI Reality Motion Systems, Unterschleissheim, Germany.
f. Eukanuba Veterinary Diets Restricted-Calorie/Canine Dry Formula, P&G Pet Care, Dayton, Ohio.
g. PT 2000, S+B med VET GmbH, Babenhausen, Germany.
h. SPSS, version 11.5.2.1, SPSS Inc, Chicago, Ill.

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